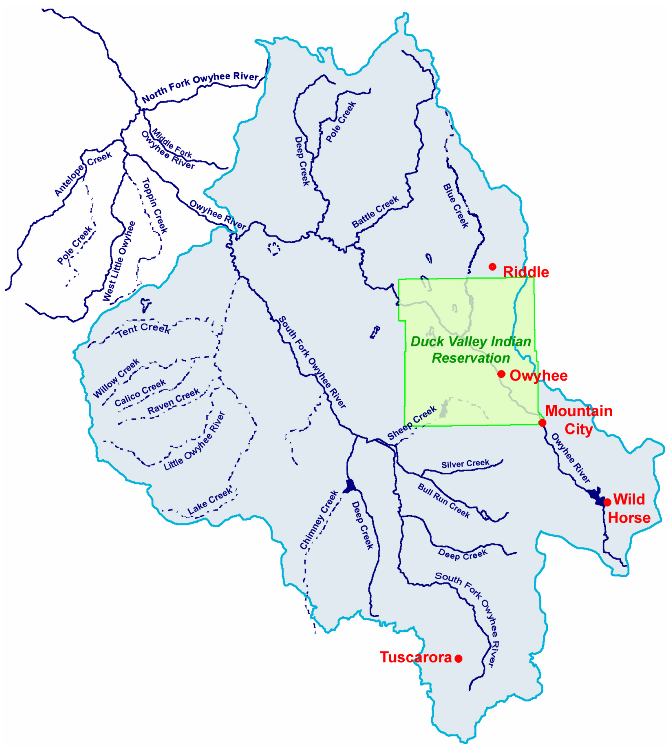
# Upper Owyhee Watershed Assessment

Prepared for
**The Owyhee Watershed Council**




Prepared by
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This assessment was funded by a grant from the
Oregon Watershed Enhancement Board

# Upper Owyhee Watershed Assessment



A survey was conducted of the existing information about multiple interrelated aspects of the Upper Owyhee Watershed. The completed assessment consists of eleven components and nine appendices.

## Components



## Appendices



Prepared by Scientific Ecological Services for the Owyhee Watershed Council.
Funded by a grant from the Oregon Watershed Enhancement Board.
Written by C. B. Shock, M. P. Shock, B. M. Shock, and C. C. Shock

# Upper Owyhee Watershed Assessment

## I. Overview



### I. Overview *

The upper Owyhee subbasin is located in parts of three states: the southeastern corner of Oregon, the southwestern corner of Idaho, and north central Nevada (Figure 1.1). It covers 3,175,153 acres (4,961 square miles). Parts of the subbasin lie in four different counties: Malheur County in Oregon, Owyhee County in Idaho, and Elko and Humboldt Counties in Nevada.

The headwaters of three forks of the Owyhee River are in the subbasin: Little Owyhee River, South Fork Owyhee River, and Owyhee River. The water collected by these rivers and their tributaries flows into the Owyhee River, down that river to the Snake River, and eventually into the Columbia River system.

Recognizing that the Duck Valley Tribal Council operates as a sovereign entity, this assessment does not include the reservation lands that are within the upper Owyhee subbasin.

**Photo 1.1 The Owyhee River southwest of the confluence with Battle Creek in Idaho**

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* Consult the other sections of this Upper Owyhee Watershed Assessment for a more complete discussion of the information summarized in this overview.

## A. Geography

The upper Owyhee subbasin has complex geography. It includes the Bull Run Mountains and the west side of the Independence Mountains. McAfee Peak and Jacks Peak tower over 10,000 feet. To the west, the more level Owyhee uplands gradually slope down to 4,800 feet elevation.

### 1. Owyhee Uplands

The majority of the upper Owyhee subbasin lies within the Owyhee uplands. The Owyhee uplands were formed by volcanic activity, some faulting, and sediment deposited by large lakes, leading to fairly flat topography.

The Owyhee uplands is a region of mesa lands of southeastern Oregon, southwestern Idaho and northern Nevada that is defined by the drainage of the Owyhee River. These mesa lands are part of a plateau which slopes gradually down from the south to the north. Complex geological forces created the land underlying the Owyhee uplands plateau. The majority of the rocks have an igneous or sedimentary origin in fairly recent geological history. Covering these rocks, the soils of the mesas are generally shallow and in some areas were stripped away by wind and water to expose bare rock. The mesa lands are actively, but very slowly, eroding. The large expanse of the plateau has been deeply dissected by river canyons of the Owyhee and its tributaries. This down cutting has resulted in deep, precipitous river canyons 50 to 1300 feet below the level of the mesas.

**Photo 1.2. The canyon cliffs of the Owyhee River snake into the distance.**

### 2. Bull Run and Independence Mountains

The Bull Run and Independence Mountains are an extension of the basin and range geological province. The basin and range was named for the north-south orientation of multiple valleys and mountain ranges. The region has grown as the Earth's crust has been stretched to the west. The extension thinned and cracked the crust as it was pulled apart, creating large faults. Along these roughly north-south trending faults valleys down-dropped and mountains were uplifted, producing the distinctive pattern of linear mountain ranges and alternating valleys of the Basin and Range province.

Geologically the rocks of the Basin and Range province are very old, Many of these rocks have been transformed by metamorphism, the process where rock under great temperature and pressures is altered from its original state. For the upper Owyhee subbasin this means that a greater variety of rocks are found within Bull Run and Independence Mountains than in the Owyhee uplands. Additionally many soils on the mountain slopes are older and more highly developed than those on the mesa lands.

## B. Climate

As the topography of the upper Owyhee subbasin varies, so does the climate. The measured rainfall at the few weather stations within the subbasin varies from an average annual rainfall of 12.6 inches at the Tuscarora weather station to 15.8 inches at the North Fork 7NW station. However, at some higher locations greater rainfall is expected. The scarcity of precipitation is a major determining factor in the functioning of the subbasin. The least rainfall occurs in the months of July and August.

The months of July and August are also the hottest. The average maximum temperature at the weather stations varied from 80.8 to 88.1 in July and from 75.5 to 87.4 in August. The lowest average July and August temperatures were at North Fork 7NW, the station at the highest altitude, 6,600 ft; whereas the highest temperatures were at the station at the lowest altitude, I-L Ranch at 5,200 ft..

## C. Hydrology

The South Fork of the Owyhee River is fed by runoff from the west side of the Bull Run and Independence Mountains. The Owyhee River (also identified as the east fork) captures water from the east side of the Bull Run Mountains. Wildhorse Reservoir on the Owyhee River holds runoff from the northern portion of the east side of the Independence Mountains. The southern portion of the east side of the Independence Mountains drains into the Humboldt Basin. Much of the water which flows east from the mountains into the Owyhee River is utilized before it reaches the Idaho portion of the subbasin beyond the Duck Valley Reservation.

Snow which accumulates on Mud Flat in the upper Owyhee subbasin melts in the spring and flows down Deep and Pole Creeks. Although years vary considerably, on average it provides 35 to 40 percent of the water which eventually flows into the Owyhee Reservoir.

Since the Owyhee uplands are a semiarid desert with very few sources of perennial water, many canyons in the landscape have been formed by intermittent drainages and ephemeral streams which flow only following rainstorms or snow melt. The erosion which continues to create the landscape is episodic; most erosion occurs during major storm or storm on snow events. Runoff events have a greater impact when the soil is frozen because little of the water is absorbed by the soil. The availability of surface water to grazing animals is quite low because access to major rivers is largely constrained by cliffs. Although most of the water in the drainage comes as precipitation in the winter and spring months, there are a few springs. Surface water availability has been enhanced by stock ponds, pipelines, and reservoirs.

## D. Vegetation

Across the rolling lands of the Owyhee uplands, vegetative communities are shaped by aridity, the low quantities of water and the infrequent nature of its availability.

The land is predominately covered with sagebrush steppe communities consisting of sagebrush (*Artemisia* spp.), scrub, and perennial bunchgrass with a scattering of annual and perennial herbs. The semiarid environment has supported sagebrush steppe/desert scrub communities for at least the last 8000 years.

In the deeper valleys and on the north slopes of the Bull Run and Independence Mountains, vegetative communities transition to pinyon/juniper around 6,000 feet. Within the pinyon/juniper, primary vegetation other than juniper consists of curl-leaf mountain mahogany, snowberry, and ceanothus. At higher elevations there are western hardwood and mixed deciduous/coniferous forests. Aspen and mountain mahogany may be mixed with whitebark pine, Douglas-fir, limber pine, Engelmann spruce, subalpine fir, or bristlecone pine.

Along the western border of the watershed, the south slope of Juniper Mountain above 5,000 feet elevation also has pinyon/juniper forest. The mountains west of Tuscarora have patches of pinyon/juniper above 6,000 feet on the western slopes and at higher elevations western hardwoods.

## E. Animals

The availability of water determines to some extent where and what type of wildlife will be found in the area. The species present are similar to those found in surrounding regions. Large mammals of the upper Owyhee subbasin today include pronghorn, mule deer, white-tailed deer, elk, and cougar. Bighorn sheep have been reintroduced to the rugged canyons. Wild horses, introduced to America by the Spanish in the 1500s, roam the uplands.

## F. Native Americans

At the time of Euro-American contact, the upper Owyhee subbasin contained parts of the territories of the traditional Northern Paiute, Western Shoshone, and Northern Shoshone groups. Prior to the these tribes occupying the area, other groups had inhabited the Owyhees since at least 12,000 BP (years before the present).

## G. Population

In the 2000 census of population, 447 people were shown as living in the area of the upper Owyhee subbasin outside Duck Valley Indian Reservation. Another 1,265 people were living on the reservation.

## H. Access

Few improved roads cross the great expanse of the high plateau. A few rafters view the canyon lands when floating down the Owyhee River by rubber raft, but very few people explore the area. A paved highway, Idaho 55 - Nevada 225, traverses the subbasin to the east of the Bull Run and Independence Mountains. Two improved roads cross the mountains to Nevada Highway 226 which runs to the west of the mountains.

## I. Use of the subbasin

Small patches of the upper Owyhee subbasin are privately owned or state lands. The remainder is federal land administered by the Bureau of Land Management or the National Forest Service.

The majority of the subbasin is rangeland and is grazed by cattle. For winter feed, hay is grown on irrigated land to the west of the Bull Run and Independence Ranges, utilizing water captured during spring runoff. Ranching in the subbasin is conducted both by ranchers living on the land and by ranchers whose primary home is outside the watershed.

Besides ranching and farming, the subbasin is also used for recreation, capture and distribution of water, and preservation of wildlife and native plants. The public has special interest in the upper Owyhee subbasin due to the wide diversity of uses, importance of water resources, and natural beauty.

**Photo 1.3. Clockwise from upper left hand corner: a mountain meadow in the Bull Run Mountains, grasslands on the plateau below Juniper Mountain, in the Independence Mountains, spring flowers near Wildhorse Reservoir, looking west across the Owyhee uplands from the foothills of the Independence Mountains, near the upper end of Deep Creek in Idaho, wild horses leaving a watering hole in the Oregon section of the upper Owyhee subbasin.**

## J. Conclusion

During the summer months in the upper Owyhee subbasin, the temperatures are high and the rainfall very low. Most of the upper Owyhee subbasin is uninhabited rangeland. Creeks and the Owyhee River run in deep canyons with little water access on the mesas. The water which leaves the subbasin continues downstream through the rest of the Owyhee basin, eventually joining the Columbia River. The upper Owyhee has areas with great beauty, geological complexity, and diverse uses.

# Upper Owyhee Watershed Assessment

## II. Background



### Contents

The Oregon governor's strategic initiative for ensuring sustainable water resources for Oregon's future, Headwaters 2 Ocean, considers all water resources from the hilltops to the Pacific Ocean. The completion of the assessment of the upper Owyhee subbasin is consistent with the governor's initiative. The upper Owyhee subbasin contains the headwaters of the Owyhee River and two of its principal tributaries.

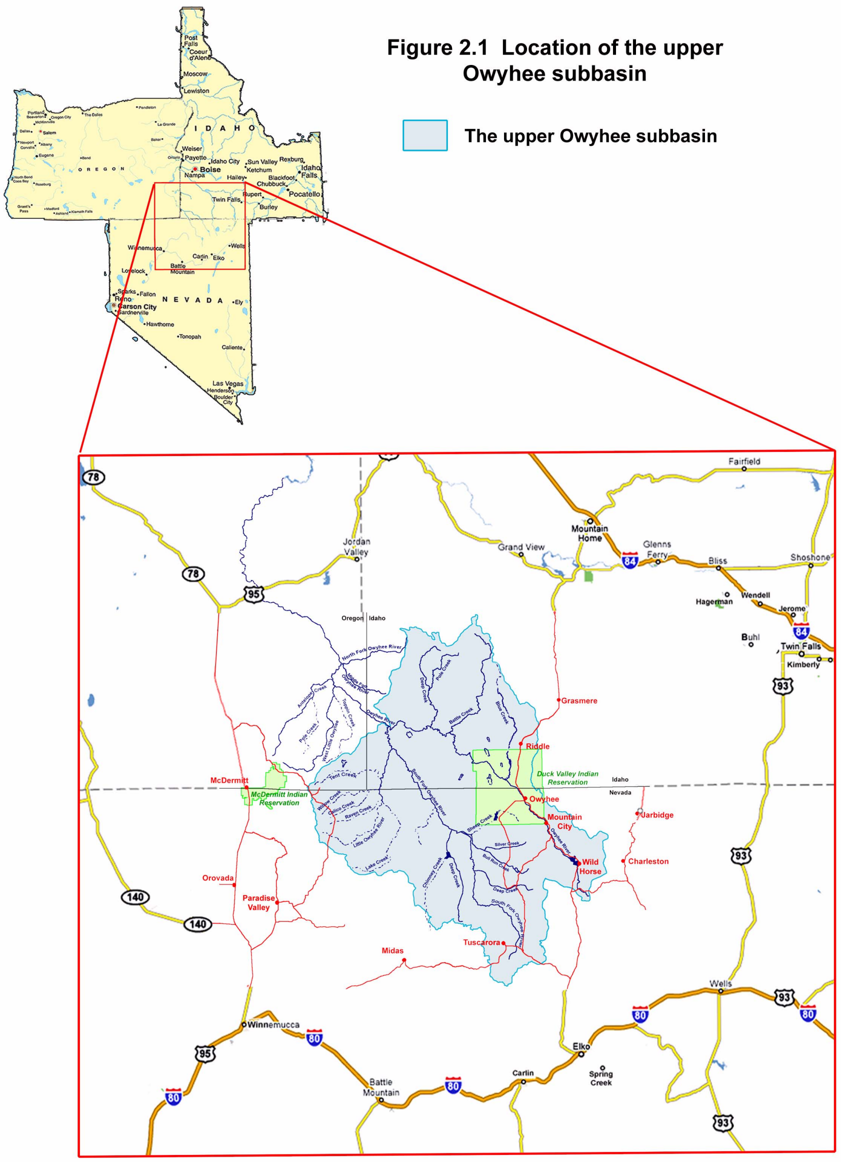


Figure 2.1 Location of the upper Owyhee subbasin

# II. Background

## A. The upper Owyhee subbasin

### 1. Location

The upper Owyhee subbasin is located in parts of three states: the southeastern corner of Oregon, the southwestern corner of Idaho, and north central Nevada (Figure

2.1). It covers 3,175,153 acres (4,961 square miles). Parts of the subbasin lie in four different counties: Malheur County in Oregon, Owyhee County in Idaho, and Elko and Humboldt Counties in Nevada.

## 2. What is the upper Owyhee subbasin?

The upper Owyhee subbasin is a geographic region designated by the United States Geological Survey (USGS). The United States is divided into geographic regions called hydrologic units based on the drainage areas of rivers. The largest units, given first-order hydrologic unit codes (HUC), are areas drained by a major river or series of rivers, such as the Columbia River drainage. These regions are further subdivided into areas drained by a river system. These areas in turn are split into smaller units.[115]

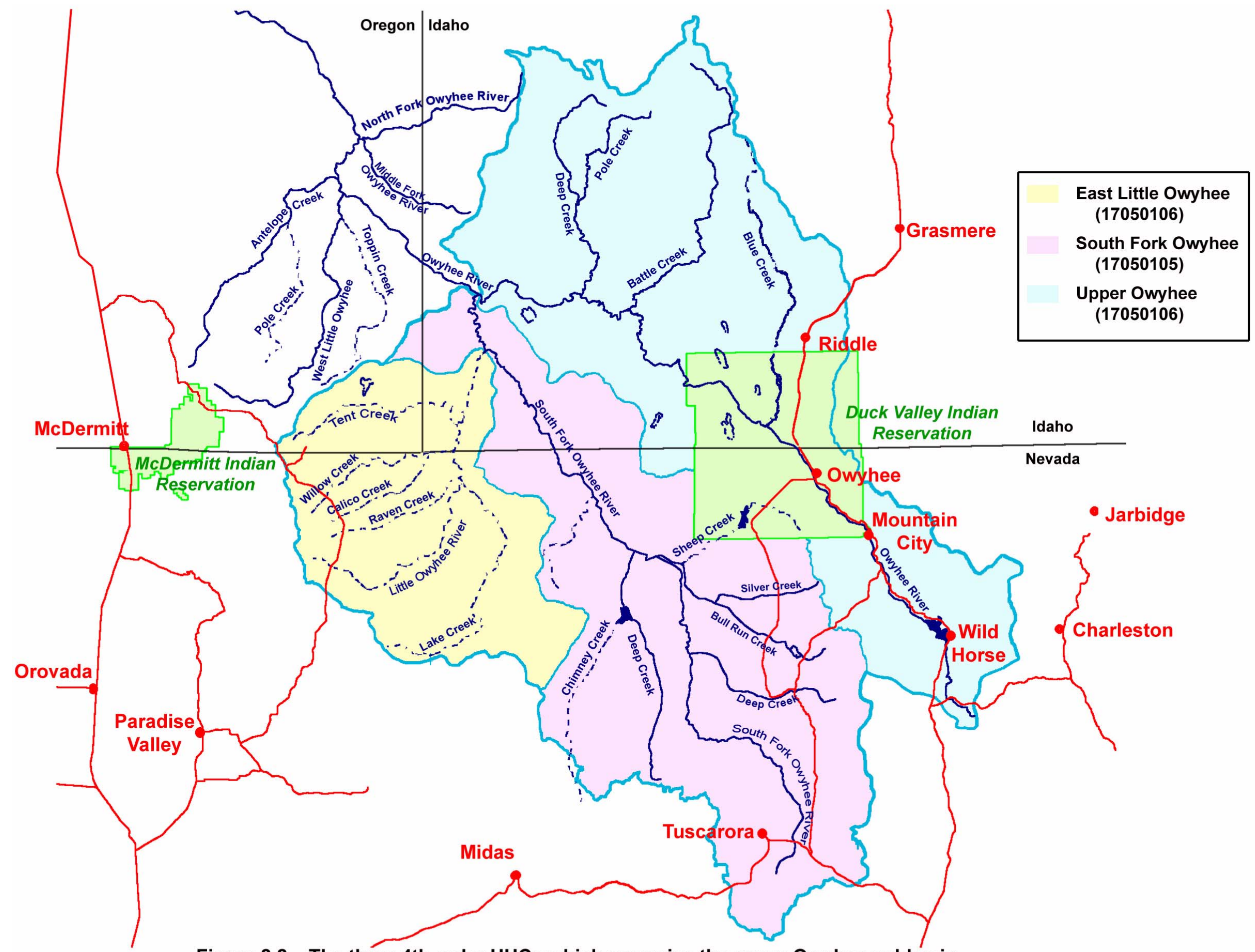


Figure 2.2. The three 4th order HUCs which comprise the upper Owyhee subbasin.

The upper Owyhee subbasin is part of the Columbia River, Snake River, and Owyhee River drainages. Within the Owyhee River drainage, the drainages of several tributary rivers have been designated as fourth-order or eight-digit HUCs. The area considered as the upper Owyhee subbasin for this assessment consists of three of these fourth-order HUCs: the East Little Owyhee (the Little Owyhee River drainage), the South Fork Owyhee, and the Upper Owyhee (Figure 2.2). Within the Owyhee River

Watershed, apart from the upper Owyhee subbasin, there are four other fourth-order HUCs. These are the Lower Owyhee, Crooked/Rattlesnake, Middle Owyhee, and Jordan HUCs (Figure 2.3). These HUCs are all downstream from the upper Owyhee subbasin.

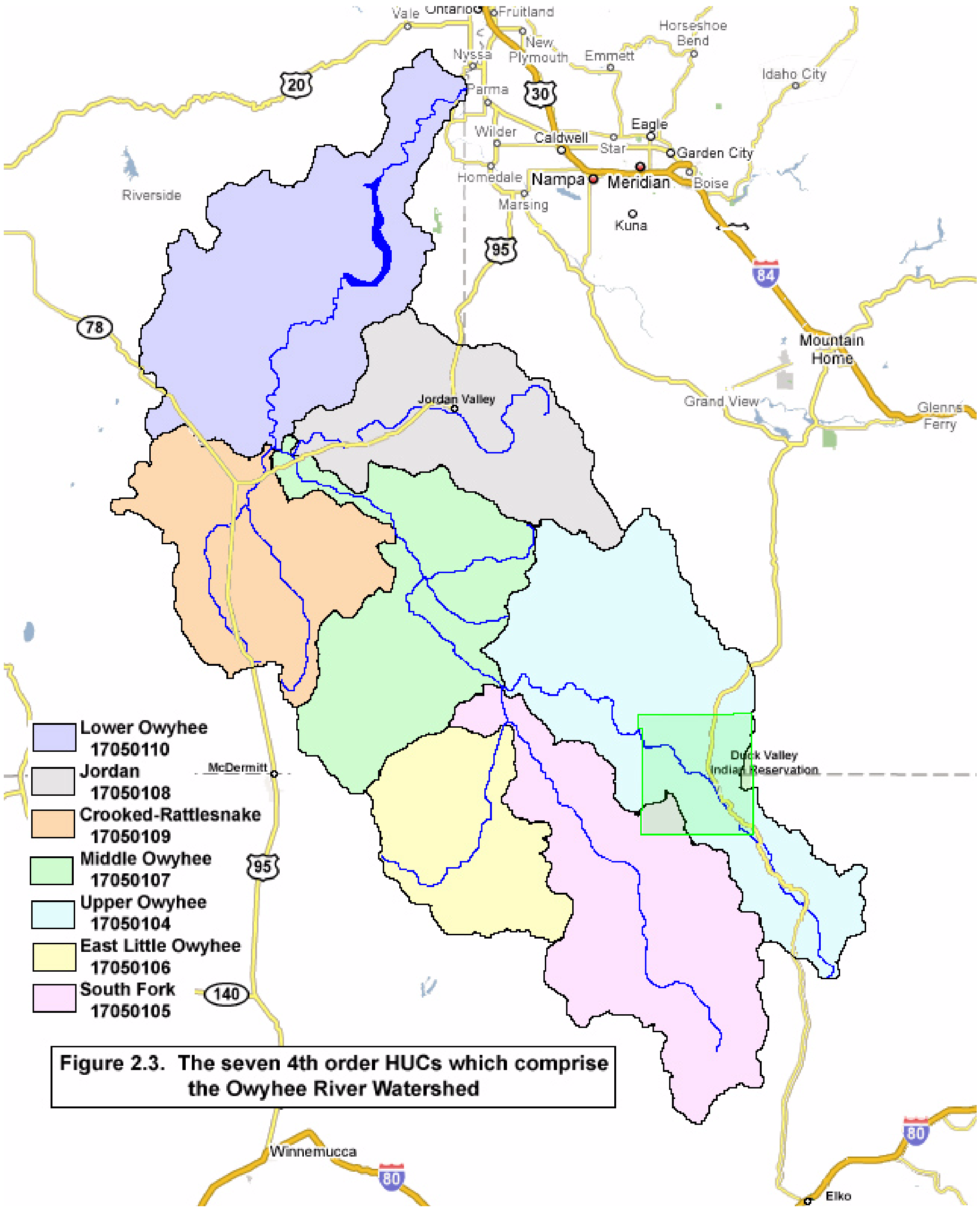


**Figure 2.3. The seven 4th order HUCs which comprise the Owyhee River Watershed**

## 3. Geography

Within the geographical area drained by the Little Owyhee River, the South Fork Owyhee River and the Owyhee River, the topography varies. The majority of the land is a gradually sloped plateau. The rivers lie in deep canyons far below the level of the plateau or mesas. The number of perennial streams crossing the landscape is limited and there are numerous intermittent and ephemeral streams.

To the east, the Bull Run and Independence Mountains contain several peaks around 10,000 feet in elevation. Perennial streams drain out of these mountains into the South Fork Owyhee River. To the west, a number of intermittent streams drain into the Little Owyhee River from the east side of the 8,364-foot-tall Capitol Peak in the Calico Mountains.

Gradual rises separate the subbasin from the Humboldt River basin to the south and from the Bruneau River Basin to the northeast. To the northwest, Juniper Mountain separates the subbasin from the drainages of the Middle Fork and North Fork of the Owyhee River (Figure 2.4).

**Photo 2.1. Looking southeast across the Owyhee plateau from Juniper Mountain.**

## 4. Ecoregions

Part of the reason for dividing the United States into small units based on some natural feature is the interest by government agencies at all levels in having a way to monitor, inventory, assess and manage resources.[83] The use of HUCs or watersheds was developed because water is a major resource and concern. It is also easy to delineate the boundaries of most watersheds. However, the area within the boundaries of a watershed is not necessarily homogeneous in environment, climate or other aspects. For example, the upper Owyhee subbasin includes forested areas on the Independence Mountains, barren playa lakes, deep river canyons and irrigated hay crop land.

Within a watershed there are not only natural variations but differing impacts from human activities. Ecology is the study of how all the different factors in an area interact. An "ecoregion" includes both abiotic (non-living) and biotic (living) factors. An ecoregion assessment approach to an area recognizes that the different components of a region interact and exist in association with one another.[83] There are potential

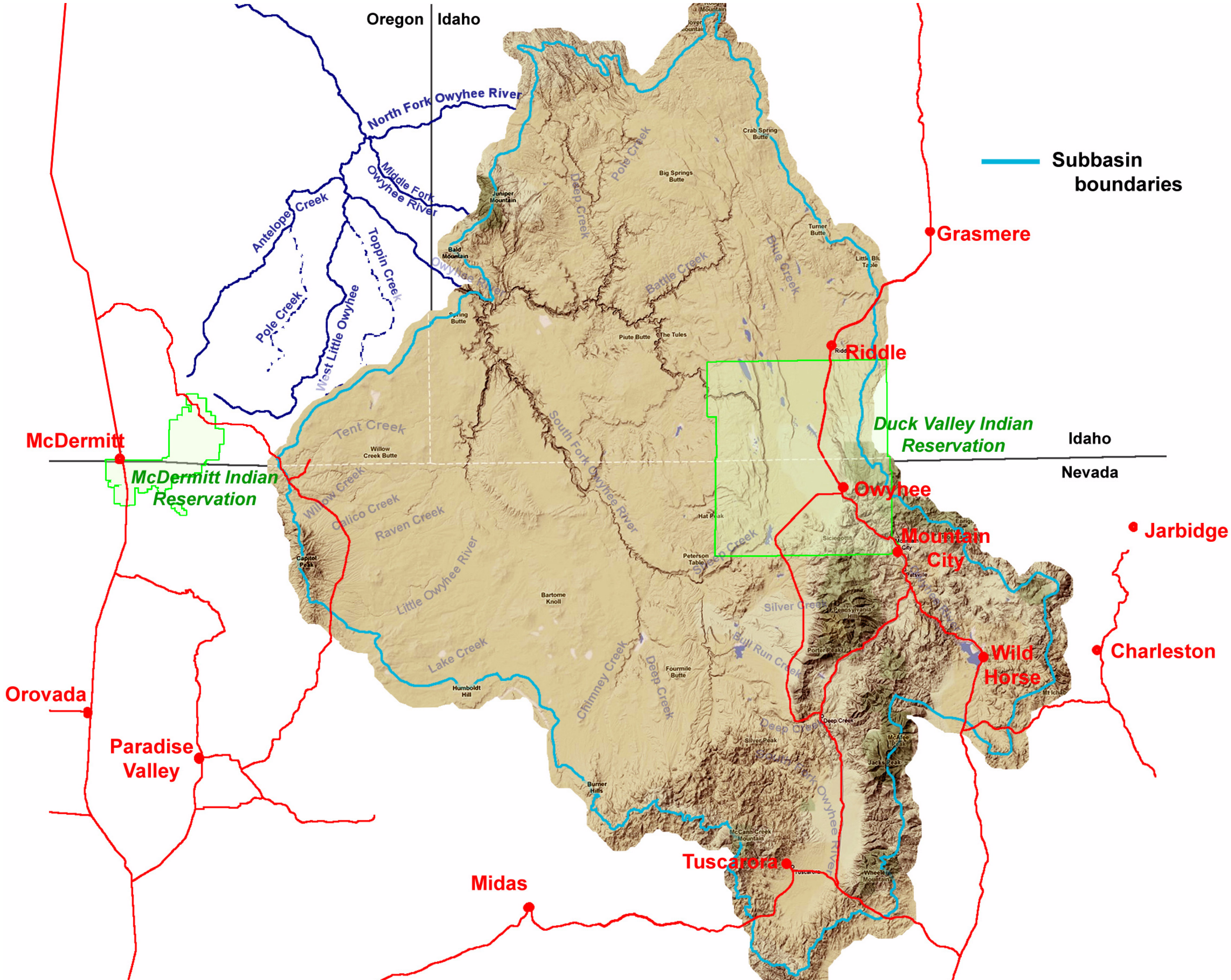


Figure 2.4. Topography of the upper Owyhee subbasin.

misunderstandings as to how watersheds can be used to structure ecological management.[84]

James Omernik of the USGS points out that basins are appropriate units for assessing the relative contribution of human activities at specific points on streams or of evaluating the relative contribution of point and nonpoint source pollutants.[83] However, determining the capacity and potential of a watershed depends on the characteristics of the ecoregions within it. Each ecoregion is defined by a mosaic of factors including climate, geology, soils, land cover including vegetation, human use, wildlife, water chemistry, and topography.[83]

There is a great difference between the geographic unit designated by the watershed and a region based on some other factor such as geology, land use, or vegetation. An ecoregion description includes multiple factors. There is no one accepted definition of the term ecoregion nor one opinion on how they should be delineated.[83] In general an ecoregion is defined as an area with relative homogeneity of biotic and abiotic components which are distinct from adjacent areas.[83,96] Many of the classification systems for ecoregions give preference to specific factors for separating areas. Below we discuss three approaches to describing ecoregions within the upper Owyhee subbasin.

In assessing the upper Owyhee subbasin, the existence of different ecosystems needs to be taken into consideration; recognition and knowledge of these ecosystems enhances the ability to assess, inventory, monitor, and manage the resources of the region. Ecoregions within the upper Owyhee subbasin have been described by the Natural Resources Conservation Service (NRCS), Environmental Protection Agency (EPA), USDA Forest Service, and Bureau of Land Management (BLM).

### *a. NRCS*

The NRCS has developed a land classification system as a resource for farming, ranching, forestry, engineering, recreation, land management, conservation programs, and other uses.[80] This classification divides the United States into land resource regions (LRR), major land resource areas (MLRA), and common resource areas.[80,82] Within each LRR, the major land resource areas are defined as uninterrupted geographical areas without considering political boundaries. The dominant characteristics which determine an MLRA are location and climate, with consideration given to generalized geology, water, soils, biological resources and land use in each area.[80,82] The NRCS has identified 278 major land resource areas in the United States.[82] The upper Owyhee subbasin is part of the Owyhee High Plateaus MLRA.[80]

The MLRAs are further broken down into common resource areas. A common resource area "is defined as a geographical area where resource concerns, problems, or treatment needs are similar."[81] They are created by subdividing MLRAs with consideration for topography, hydrologic units, landscape features, soil, climate, resource concerns, resource uses and conservation needs.[80,81] There are parts of five common resource areas in the upper Owyhee subbasin (Figure 2.5) (Table 2.1).

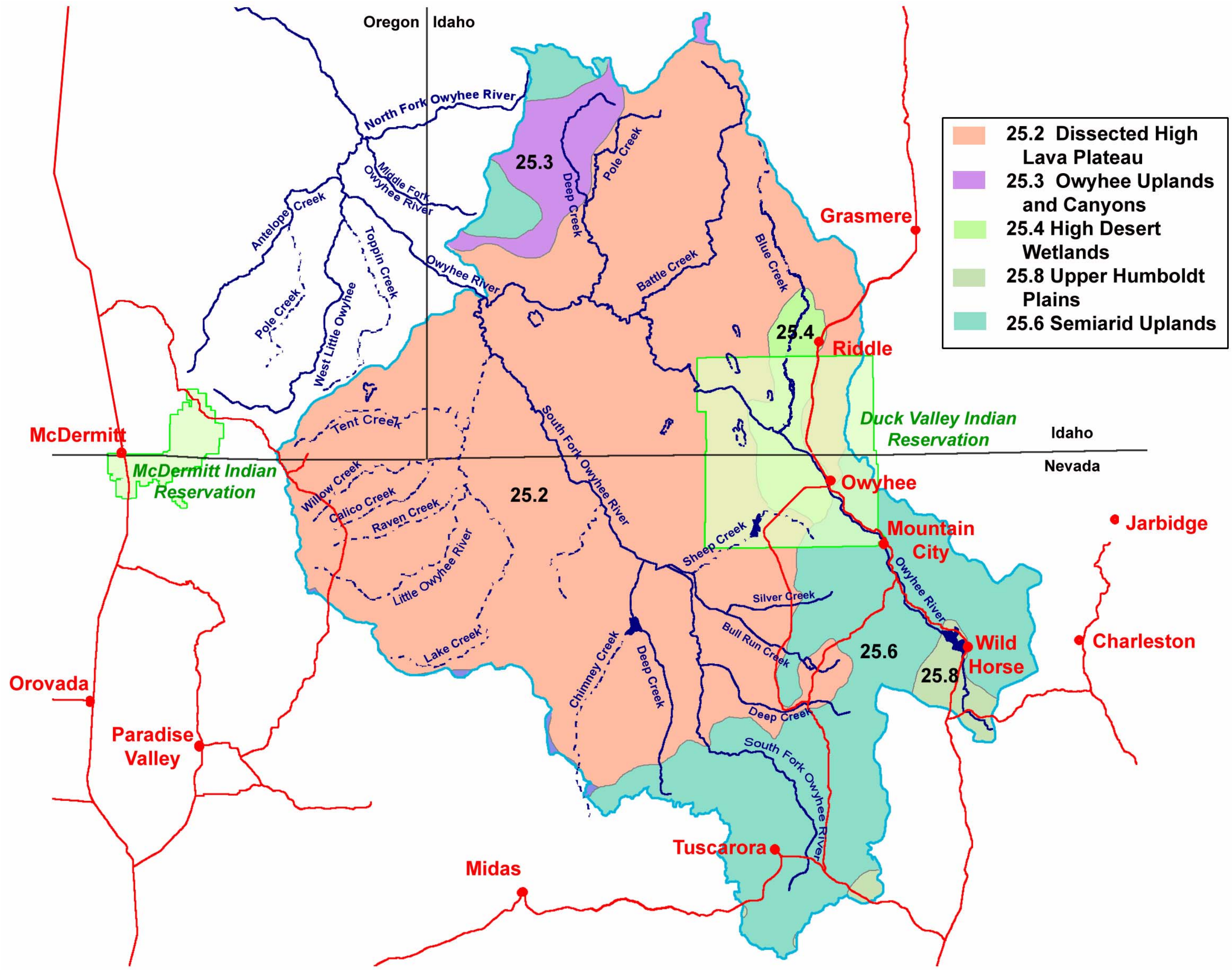


**Figure 2.5. NRCS common resource areas in the upper Owyhee subbasin (see Appendix C).**

Table 2.1. The NRCS common resource areas in the upper Owyhee subbasin. For descriptions of each ecoregion see Appendix C.[55,79]

| | |
|---|---|
| 25.2 | Owyhee High Plateau - Dissected High Lava Plateau |
| 25.3 | Owyhee High Plateau - Owyhee Uplands and Canyons |
| 25.4 | Owyhee High Plateau - High Desert Wetlands |
| 25.6 | Owyhee High Plateau - Semiarid Uplands |
| 25.8 | Owyhee High Plateau - Upper Humboldt Plains |

### *b. EPA*

The Environmental Protection Agency developed a system of ecoregions to serve as a framework for designing and implementing "ecosystem management strategies across federal agencies, state agencies, and non-governmental organizations that are responsible for different types of resources in the same geographical areas."[110]

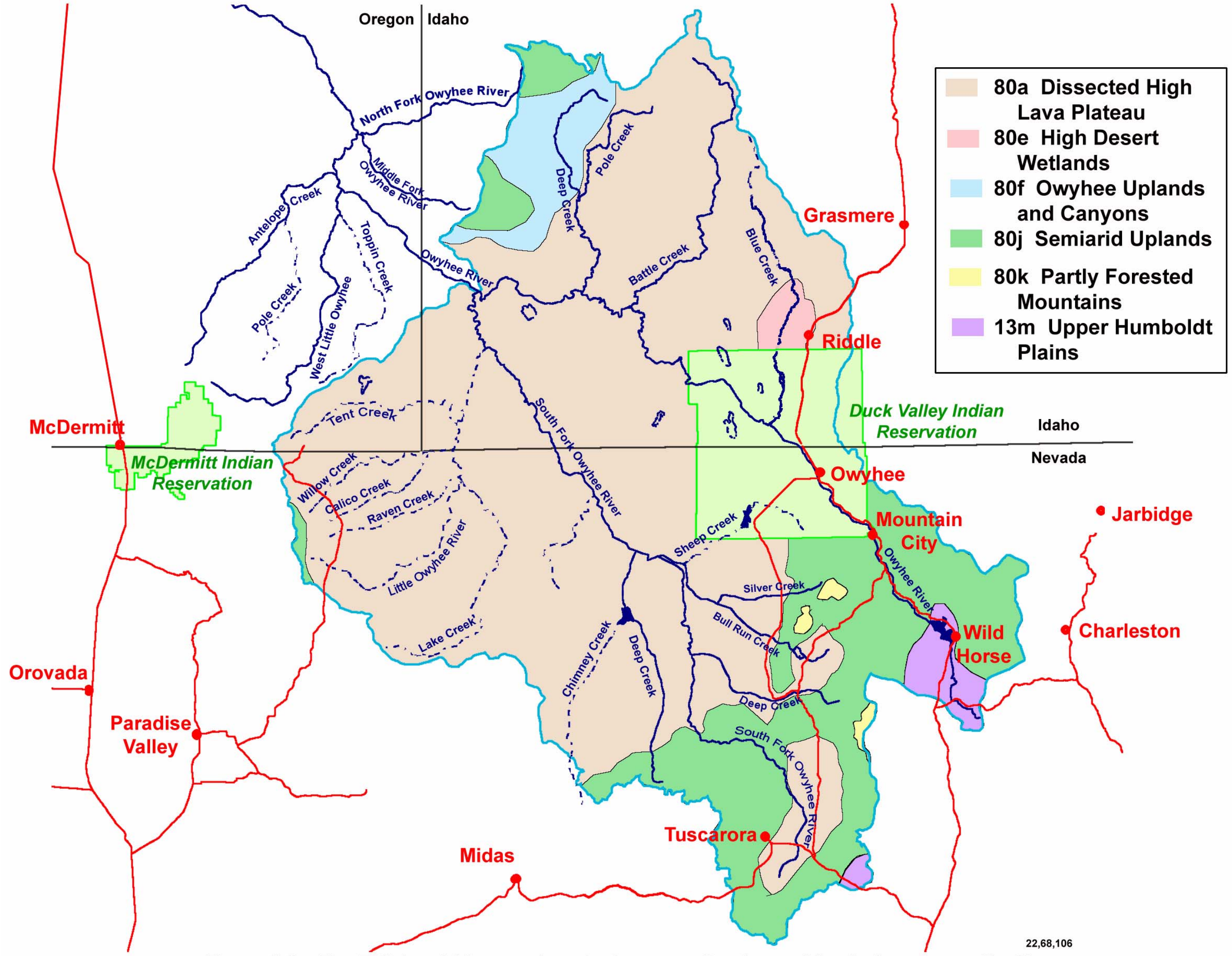


**Figure 2.6. The EPA level IV ecoregions in the upper Owyhee subbasin (see Appendix C).**

The ecoregion system is intended to provide a structure for research, assessment, monitoring, and management of ecosystems and ecosystem components. The ecoregion boundaries are drawn to delineate areas with a similar response to environmental disturbance. Components considered in determining the location of ecoregion boundaries include geology, vegetation, climate, soils, land use, wildlife, water quality, hydrology, and physiography*. However, the relative importance of each component may vary from one ecoregion to another.[75,110]

The EPA ecoregion system divides North America into 15 broad Level-1 ecoregions which are in turn subdivided into Level II, Level III, and Level IV ecoregions. Level III ecoregions are considered appropriate for regional analysis and decision-making. Most of the upper Owyhee subbasin lies in Level III ecoregion 80, the Northern Basin and Range. A small section of the subbasin at the southern extent lies

*Physiography is the study of the natural features of the earth's surface, especially in its current aspects, including land formation, climate, currents, and distribution of flora and fauna.

in Level III ecoregion 13, the Central Basin and Range. There are parts of six Level IV ecoregions in the subbasin (Figure 2.6) (Table 2.2). [75,110]

Table 2.2. The EPA ecoregions in the upper Owyhee subbasin. For descriptions of each ecoregion see Appendix C.[22,68,106]

| | |
|---|---|
| 80a | Northern Basin and Range - Dissected High Lava Plateau ecoregion |
| 80e | Northern Basin and Range - High Desert Wetlands ecoregion |
| 80f | Northern Basin and Range - Owyhee Uplands and Canyons ecoregion |
| 80j | Northern Basin and Range - Semiarid Uplands ecoregion |
| 80k | Northern Basin and Range - Partly Forested Mountains ecoregion |
| 13m | Central Basin and Range - Upper Humboldt Plains ecoregion |

**Photo 2.2 Area of the Independence Mountains in the upper Owyhee subbasin identified under both NRCS and EPA classifications as semi-arid uplands.**

### *c. USDA Forest Service*

The United States Forest Service developed a system of classifying ecoregions to provide a tool and scientific basis to plan for and implement ecosystem management.

Their expressed goal is to consider those factors most likely to "directly affect or indirectly express energy, moisture, and nutrient gradients which regulate the structure and function of ecosystems." Ecological units are delineated considering the associations of the primary factors: climate, water, soils, air, hydrology, physiography, and potential natural communities.[112]

The system breaks down the United States into seven progressively smaller types of units. Domain is the largest, followed by Division, Province, Section, Subsection, Landtype association, and Landtype phase.[113] The section level is considered appropriate for forest-wide planning and watershed analysis. This is the smallest unit that is typically defined at present. There are parts of two sections in the upper Owyhee subbasin (Table 2.3).[112]

Table 2.3. The Forest Service ecoregions in the upper Owyhee subbasin. Both sections are in the Temperate Desert Division. For descriptions of each ecoregion see Appendix C.[70,112]

| | |
|---|---|
| 342B | Intermountain Semidesert Province - Northwestern Basin and Range Section |
| 342C | Intermountain Semidesert Province - Owyhee Uplands Section |

### *d. Owyhee Uplands ecoregion*

On a different scale, the Bureau of Land Management and the Nature Conservancy have described an Owyhee Upland ecoregion which includes all the drainage area of the Owyhee River, all of Malheur County, parts of Harney and Baker Counties, parts of southwestern Idaho, and part of Nevada north of McDermitt. They are trying to distinguish the Owyhee Upland ecoregion at the regional and national level from the ecoregions of the Great Basin and the Snake River Plain. This is a more general regional distinction on a scale similar to that of a first-order HUC or a land resource unit. The discussion of the characteristics of the Owyhee Upland ecoregion is broad and unspecific.[96]

### *e. Discussion*

It is apparent from the above approaches to describing ecoregions within the upper Owyhee subbasin that factors used in defining an ecoregion depend to some extent on the use to be made of the distinctions. The descriptions of the different ecoregions within the subbasin (Appendix C) illustrate the tremendous variability within the subbasin.

Within each component of this assessment the complexity of the factors which affect that component will determine what combination of geographical and ecological factors needs to be taken into consideration rather than using a predetermined scheme.

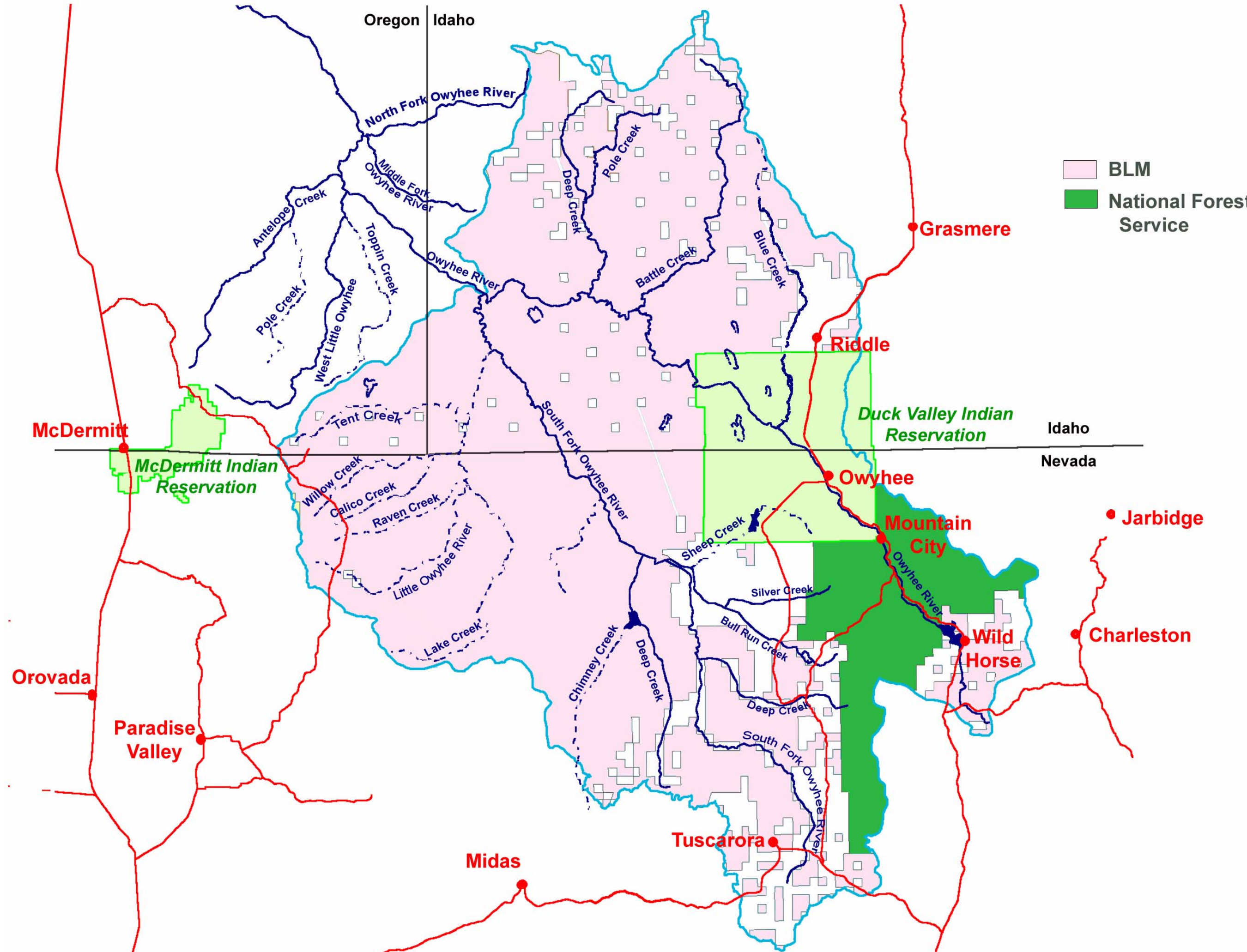


Figure 2.7. Federal land ownership in the upper Owyhee subbasin.

## 5. Ownership of land

Federal ownership represents 76.8% of the land in the upper Owyhee subbasin. The Bureau of Land Management manages 68.4% of the land in the subbasin, while 8.4% of the land in the subbasin is under the management of the Humboldt National Forest (Figure 2.7).

Of the remaining lands, 8.4% of the total subbasin area is owned and governed by the sovereign Duck Valley Tribal Council. The other 14.8% of the subbasin area is owned by other entities including private landowners and the State of Idaho (Figure 2.8).

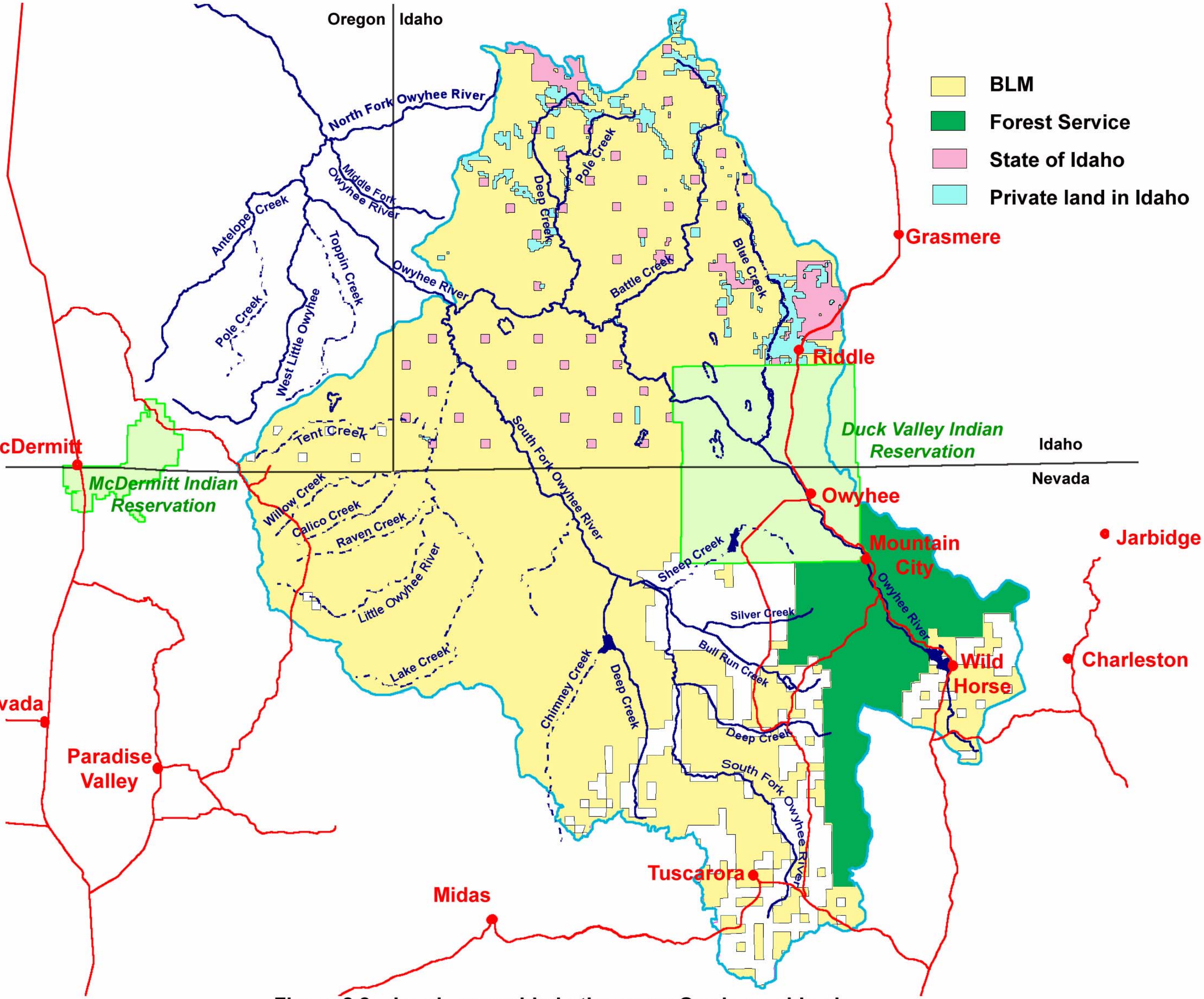


**Figure 2.8. Land ownership in the upper Owyhee subbasin.**

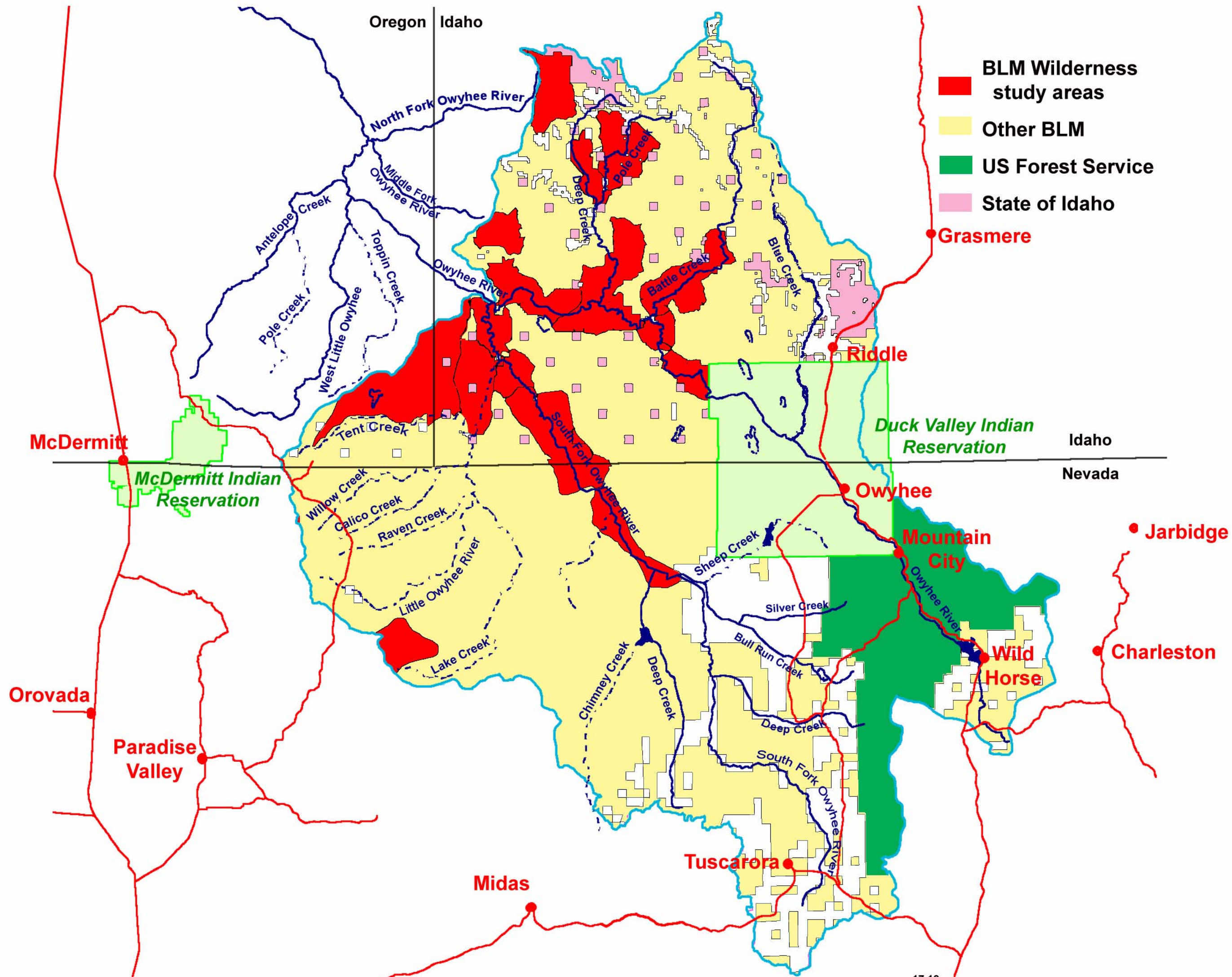


**Figure 2.9. Wilderness study areas in the upper Owyhee subbasin.**[17,19]

### *a. Wilderness study areas*

Table 2.4. Names of the wilderness study areas in the upper Owyhee subbasin by state.

In Idaho:[19]

| | | |
|---|---|---|
| Battle Creek | Juniper Creek | Yatahoney Creek |
| Owyhee River Canyon | South Fork Owyhee River | Little Owyhee River |
| Upper Deep Creek | Deep Creek | West Fork Red Canyon |
| Lookout Butte | Pole Creek | North Fork Owyhee River |
| Owyhee River | | |

In Oregon:

Lookout Butte

In Nevada:[17]

| | | |
|---|---|---|
| South Fork Owyhee River | Owyhee Canyon | North Fork of the Little Humboldt River |

Within the BLM managed land, there are a number of wilderness study areas (WSAs). As of the time this assessment was written, the Idaho section of the upper Owyhee subbasin contained all or part of 15 WSAs, there was part of one WSA in the Oregon section, and all or part of three WSAs were in the Nevada section (Figure 2.9) (Table 2.4).

### *b. Owyhee initiative*

The Owyhee initiative is an agreement worked out between the Owyhee County government, the BLM, and the Shoshone Paiute Tribal government to "develop and implement a landscape-scale program in Owyhee County that preserves the natural processes that create and maintain a functioning, un-fragmented landscape supporting and sustaining a flourishing community of human, plant and animal life, that provides for economic stability by preserving livestock grazing as an economically viable use, and that provides for protection of cultural resources."[89]

The three entities have agreed to a process and proposal which includes all of the Idaho section of the upper Owyhee subbasin. If the terms of the proposal were to be implemented as currently written, three wilderness areas would replace the wilderness study areas. Some of the current WSA area would be released from WSA status while the remainder of the current WSAs and some non-WSA land would be included in the new wilderness areas (Figure 2.10).

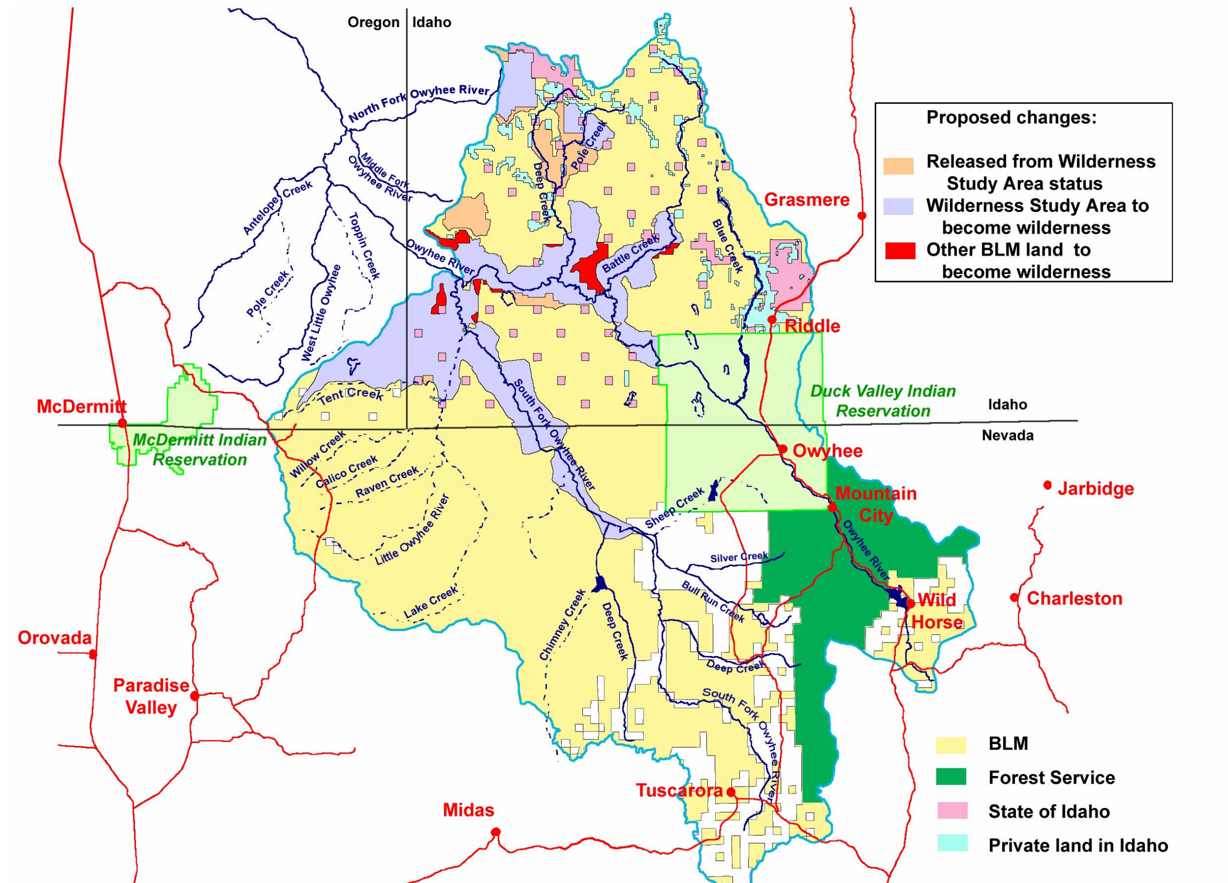


Figure 2.10. Proposed changes in the Owyhee Initiative to WSAs in the upper Owyhee subbasin.[89]

As of the writing of this assessment, the proposal was awaiting congressional action to be implemented. As of the publication of this assessment, congress had approved the proposal and some of the agreements were being implemented.

### *c. Wild and Scenic Rivers*

The National Wild and Scenic River System was established by Congress In 1984. One hundred and twenty miles of the Owyhee River downstream from the upper Owyhee subbasin were designated as a wild river component of the National Wild and Scenic River System. BLM's website states that the "Idaho portions of the Owyhee River have been found to have the same values and await Congressional action."[18]

Within the upper Owyhee subbasin, the BLM has completed wild and scenic river studies. A number of rivers were identified by BLM as fitting the criteria of wild and scenic rivers, possessing "outstandingly, remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values."[122] Rivers included in the wild and scenic river system are preserved in their free-flowing condition. The Owyhee Initiative recommends a number of rivers for inclusion in the system (Figure 2.11) (Table 2.5).

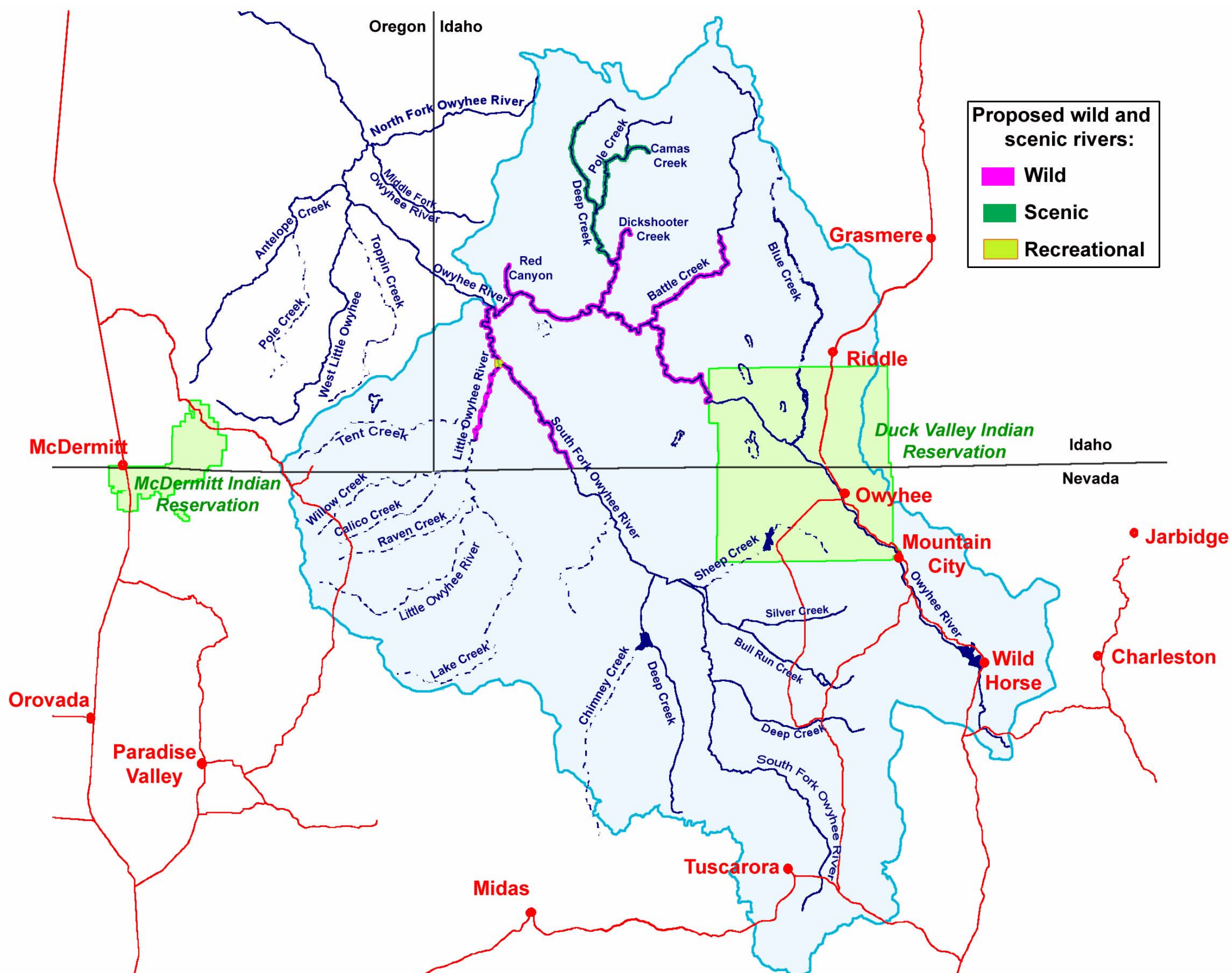


Figure 2.11. Proposed wild and scenic rivers in the Owyhee Initiative.[88]

Table 2.5. Rivers recommended in the Owyhee Initiative for wild and scenic designation in the upper Owyhee subbasin.[88]

| River | | Outstandingly Remarkable Values |
|---|---|---|
| Little Owyhee River | Wild | Wildlife |
| Battle Creek | Wild | Scenic, recreation (backpacking), geologic |
| Camas Creek | Scenic | Scenic, recreation, geology, wildlife, prehistoric cultural clues |
| Deep Creek | Wild | Scenic, recreation (float boating and backpacking), geologic, wildlife |
| Deep Creek | Scenic | Scenic, recreation (float boating and backpacking), geologic, wildlife |
| Dickshooter Creek | Wild | Scenic, recreation, geology, wildlife, prehistoric cultural clues |
| South Fork Owyhee River | Wild | Scenic, recreation (float boating), geology, wildlife |
| South Fork Owyhee River | Recreational | Scenic, recreation (float boating), geology, wildlife |
| Owyhee River | Wild | Scenic, recreation (float boating and backpacking), geologic, wildlife, Tules ancient river bed |
| Pole Creek | Scenic | Scenic, recreation, geology, wildlife, prehistoric cultural clues |
| Red Canyon | Wild | Scenic, recreation, geology, wildlife |

## 6. Population

US census divisions cut across the boundaries of hydrologic units. The US census does not use hydrologic units as the basis for the data that it analyses. To determine the number of people living within the upper Owyhee subbasin, the smallest census unit, the block was used. Any block which fell at least partly in the subbasin was counted. For purposes of estimation, the boundary of the blocks used roughly follows the subbasin boundary. Since some of the area included in these counts is outside the subbasin there is a chance of overestimating the population. Census under- and over-reporting also may affect these estimates.

Table 2.6. Population distribution in the upper Owyhee subbasin.

| Political division within the subbasin | Population counted, 2000 census |
|---|---|
| Humboldt County, NV | 14 |
| Malheur County, OR | 0 |
| Owyhee County, ID excluding Duck Valley Indian Reservation | 37 |
| Elko County, NV excluding Duck Valley Indian Reservation | 396 |
| Total excluding Duck Valley Indian Reservation | 447 |
| | |
| Duck Valley Indian Reservation, NV | 1,017 |
| Duck Valley Indian Reservation, ID | 248 |
| Total Duck Valley Indian Reservation | 1,265 |

In the 2000 census of population, 1,712 people were shown as living in the upper Owyhee subbasin or in census blocks partially within the subbasin. Of these only 447 were not residents on Duck Valley Indian Reservation (Table 2.6). Therefore, the population density in the upper Owyhee subbasin is one person per ten square miles.

## B. Climate

### 1. Historical data

Beginning in 1888, data were recorded from a weather station at Tuscarora Andrae Ranch in the upper Owyhee subbasin. In the areas surrounding the upper Owyhee subbasin, weather stations began recording data at McDermitt in 1892, at Paradise Valley in 1894, on the North Fork of the Humboldt River just south of the subbasin in 1901, at Paradise Hill in 1902, and at Orovada in 1911. There were no other weather stations established either within or around the subbasin until 1948 (Table 2.7).[121]

There have been a number of weather stations established in and around the upper Owyhee subbasin over the years. Within the subbasin, only six weather station have operated for more than ten years (Figure 2.12) (Table 2.7). The first weather station to begin operating, at Tuscarora Andrae Ranch, continued recording data until 1942. Only precipitation was measured from 1942 until 1956 when it ceased operation.

Table 2.7. Periods of operation of weather stations measuring temperatures (T) or precipitation (P) within and near the upper Owyhee subbasin.[121]

| Within the upper Owyhee subbasin | | | | | | | |
|---|---|---|---|---|---|---|---|
| Station | Operational | Years | | Station | Operational | Years | |
| Tuscarora Andrae | 1888 - 1956 | 68 | P | Wild Horse Rsvr | 1982 - 2009 | 27 | T,P |
| Tuscarora Andrae | 1888 - 1942 | 54 | T | Mendive Ranch | 1955 - 1960 | 5 | P |
| Tuscarora | 1957 - 2009 | 52 | T,P | North Fork 7NW | 1974 - 1982 | 8 | T,P |
| Mountain City RS | 1955 - 2005 | 50 | T,P | I-L Ranch | 1962 - 1969 | 7 | T,P |
| Owyhee | 1948 - 1985 | 37 | T,P | North Fork 13N | 1973 - 1973 | <1 | T,P |
| Around the upper Owyhee subbasin | | | | | | | |
| McDermitt | 1892 - 2009 | 117 | T,P | Midas | 1961 - 1969 | 8 | T,P |
| Paradise Valley 1NW | 1894 - 2008 | 114 | T,P | Saval Ranch | 1960 - 1967 | 7 | T,P |
| Orovada 3 W | 1911 - 2009 | 98 | T,P | Cliffs | 1954 - 1958 | 4 | T,P |
| N Fork MNTC STN | 1901 - 1970 | 69 | P | Fairylawn | 1954 - 1958 | 4 | T,P |
| Paradise Hill | 1902 - 1968 | 66 | T,P | Orovada 9SSW | 1971 - 1974 | 3 | T,P |
| McDermitt 26 N | 1955 - 2008 | 53 | T,P | Triangle Ranch | 1961 - 1964 | 3 | T,P |
| Rome ST AP | 1949 - 2009 | 50 | T,P | McDermitt Indian | 1948 - 1949 | 1 | P |
| Charleston | 1961 - 2009 | 48 | T,P | N Fork Spring Ck | 1951 - 1952 | 1 | P |
| Grasmere | 1953 - 1974 | 21 | T,P | N Fork 10 S | 1971 - 1971 | <1 | T,P |
| Paradise Valley | 1948 - 1960 | 18 | T,P | | | | |

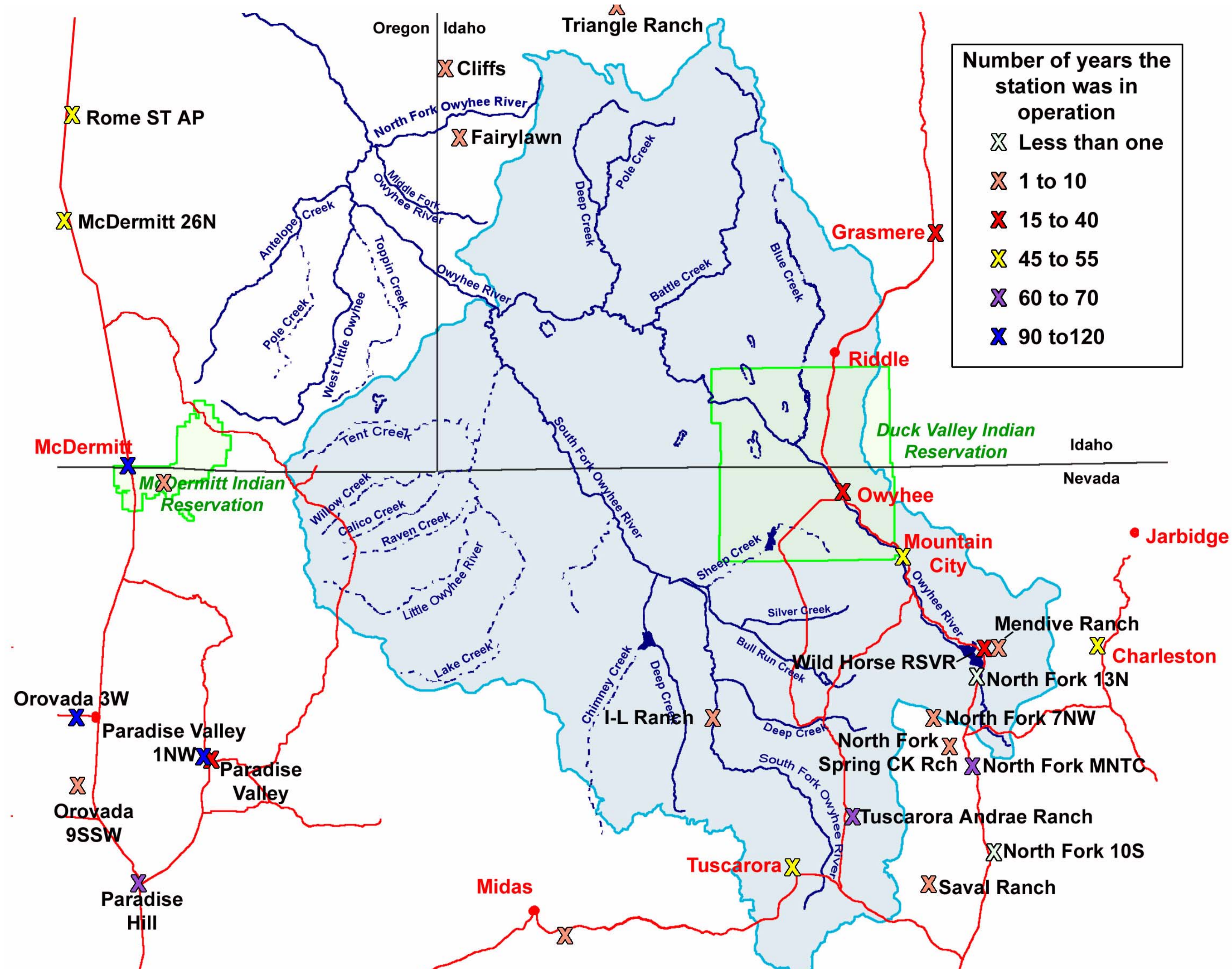


**Figure 2.12. Location of all current and historical weather stations around the upper Owyhee subbasin showing the number of years they recorded data.**[121]

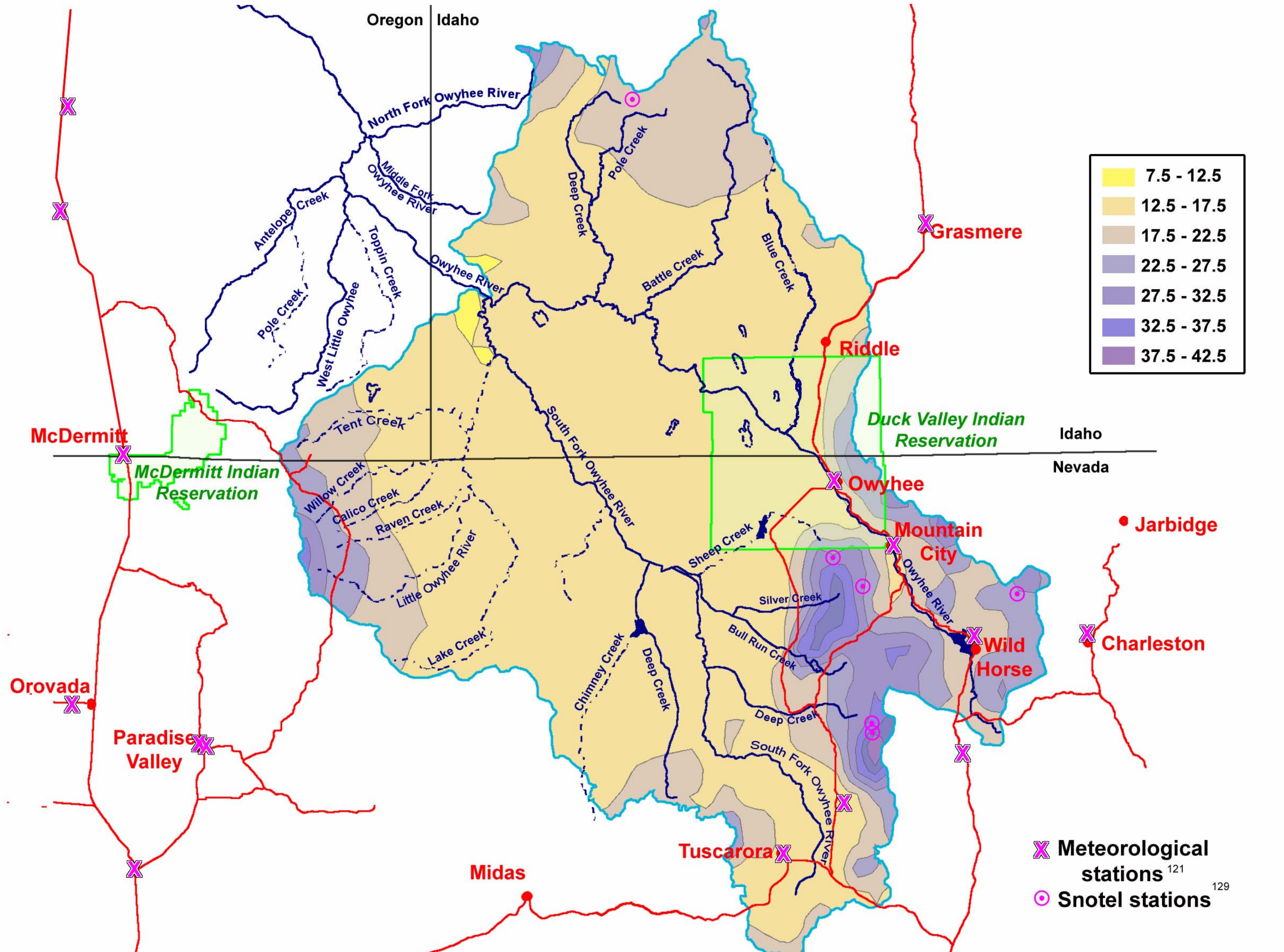


**Figure 2.13.** Calculated annual rainfall in inches in the upper Owyhee subbasin showing the location of snotel stations in the subasin and of weather stations around the upper Owyhee subbasin with ten or more years of records.

## 2. Precipitation

### *a. PRISM model*

A research group at Oregon State University have developed a model, PRISM, for using meteorological data to extrapolate to the areas between the data points. The map in Figure 2.13 shows the approximate annual rainfall across the upper Owyhee subbasin developed using PRISM.

Cristopher Daly, one of the developers of the PRISM model, explains that except for the most densely populated regions of developed countries, meteorological stations will be so sparse that they are spaced farther apart than the scales at which elevation, large topographic features and cold air drainage are most important. "This means that climate patterns caused by these factors will likely be incorrectly located, inaccurately represented, or not represented at all, if interpolated with simple methods . . . While PRISM explicitly accounts for more spatial climate factors than other methods, it also requires more effort, expertise, and supporting data sets to take advantage of its full capability."[28]

The PRISM model takes meteorological data from the different stations and transforms the data to account for elevation, climate changes due to topography, and cold air drainage. Cristopher Daly, however, cautions that there are general relationships, such as temperature predictably dropping with elevation, which do not apply on a local scale, for example in temperature inversions when temperature increases rather than decreases with elevation. The relationship of elevation to precipitation is more complex although generally precipitation increases with elevation.[28] Other factors which affect climate include slope and aspect, riparian zones, and land use / land cover. These are not accounted for in PRISM or other statistically interpolated data sets. Slope and aspect influence local precipitation and temperature.[28]

No model like PRISM can be perfect. Since there are no known points between the data points used in the interpolations, there is no satisfactory method for estimating error. Error can also be introduced by errors in the original measuring equipment.[28]

Cristopher Daly concludes "Users are encouraged to think critically when evaluating a spatial climate data set for their needs. None are perfect, but many are useful for a variety of regions and applications, if their limitations and assumptions are understood and respected."[28] The limitations of the annual precipitation map (Figure 2.13) are that it uses data from sparsely located meteorological stations. Local aspects that might affect climate in a given locale are not reflected. Since the map is only the most general representation of rainfall patterns, rainfall at a specific point within the area may differ.

From the PRISM map of average annual precipitation (Figure 2.13), most of the area of the upper Owyhee subbasin averages 15 inches of precipitation per year. However, the Bull Run and Independence Mountains are shown as receiving much greater amounts, up to 42.5 inches of precipitation per year at the highest elevations.

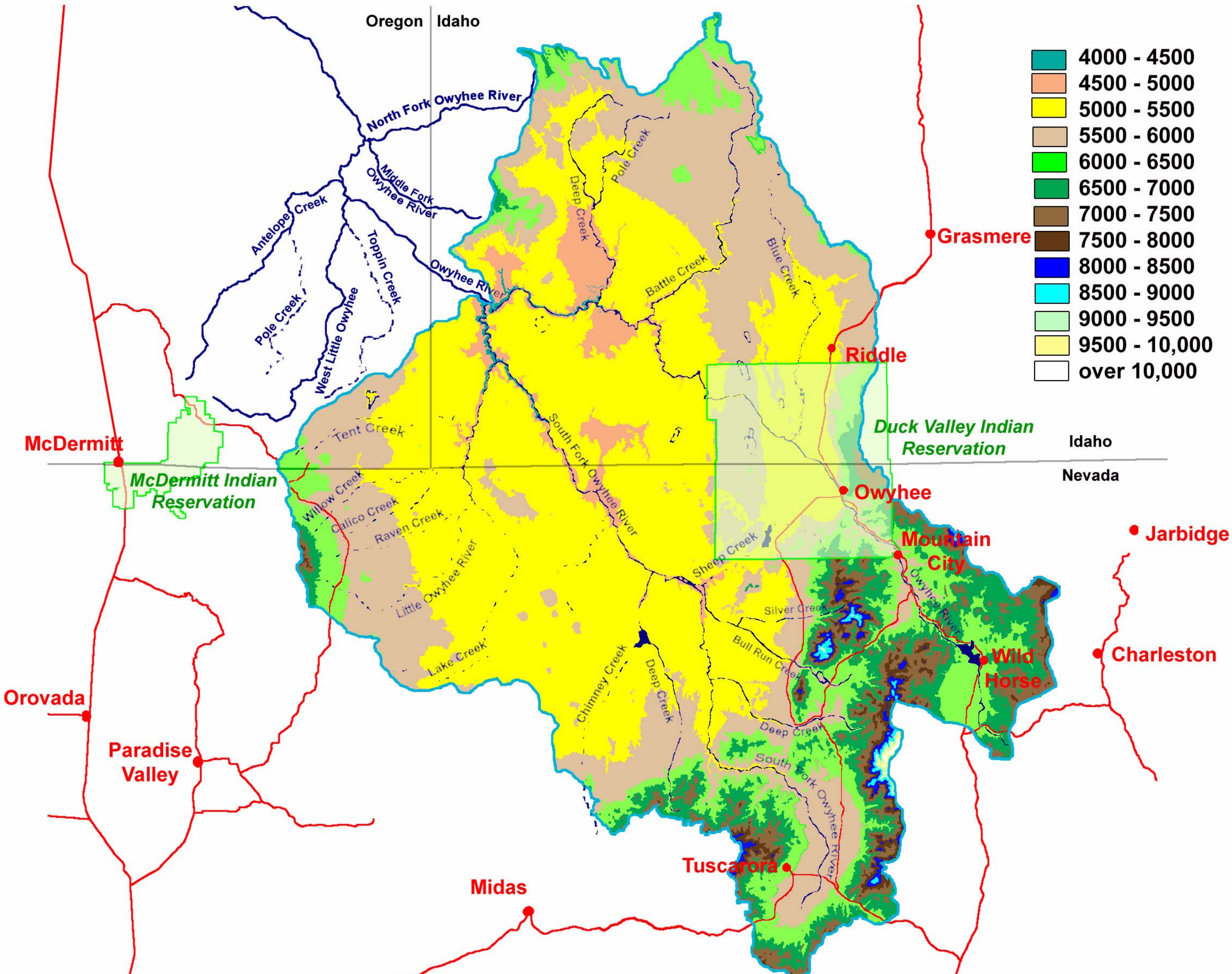


Figure 2.14. 500 foot elevation contours in the upper Owyhee subbasin.

### *b. Elevation dependent*

There have been no weather stations in the mountains with ten or more years of records. However, the Snotel stations at Jacks Peak and upper Jack Creek have been recording precipitation for the last 30 years. In areas shown as receiving less than 17.5 inches of precipitation, there are only two weather stations with at least ten years of data. A comparison of the calculated rainfalls (Figure 2.13) with elevations within the subbasin (Figure 2.14) demonstrates how the calculations of rainfall are largely influenced by elevation using data from scattered weather stations within and around the subbasin.

### *c. Semi-arid desert*

Only an area which generally receives less than 10 inches of precipitation a year is defined by some sources as a desert.[31,82] Other sources define a desert as only areas receiving less than 12 inches of precipitation a year.[111] Many ecologists studying ecosystems classify an area receiving less than 10 inches of precipitation as an "arid" desert, whereas those areas receiving 10 to 20 inches are classified as "semi-arid" deserts.[52,78] The majority of the upper Owyhee subbasin to the west of the Bull Run and Independence Mountains can be classified as semi-arid desert.

Within a desert there is a random spatial variation in rainfall in time and space with differences occurring not only on a regional scale but also on scales of 350 feet to half a mile. Here the direction and speed of wind, the degree of slope, and the angle of the rainfall are important in hilly regions.[78] The random variation in where precipitation falls is greater for summer thunderstorms than for general winter storms. Daily rainfall may be localized to areas less than 1½ to 5 miles across with rain falling on a patch or strip of land. This variability can "hardly be ignored in ecological modeling in arid zones."[78]

## 3. Meteorological stations

Currently, only meteorological stations at Tuscarora and Wild Horse Reservoir operate within the upper Owyhee subbasin, both within the Nevada section of the subbasin. There are currently operating meteorological stations at four other locations in close proximity around the subbasin (Figure 2.15).[121]

For purposes of looking at weather patterns within the subbasin, it is relevant to consider information not only from the currently operating meteorological stations, but also from stations that are no longer operating. Stations with a greater number of years of records should provide the most representative data (Figure 2.12). There are no stations located at elevations greater than the station at Wild Horse Reservoir, at 6,239 feet.

In the upper Owyhee subbasin, automated SNOpack TELemetry (SNOTEL) stations which record both temperature and precipitation were installed at seven sites: Mud Flat, Fawn Creek, Laurel Draw, Jack Creek Upper, Jacks Peak, Big Bend, and Taylor Canyon (Figure 5.1).[133,134] All of the Snotel stations currently operating in the subbasin have recorded temperatures since at least 1990. The data from Snotel stations is not available in a summary format.[129]

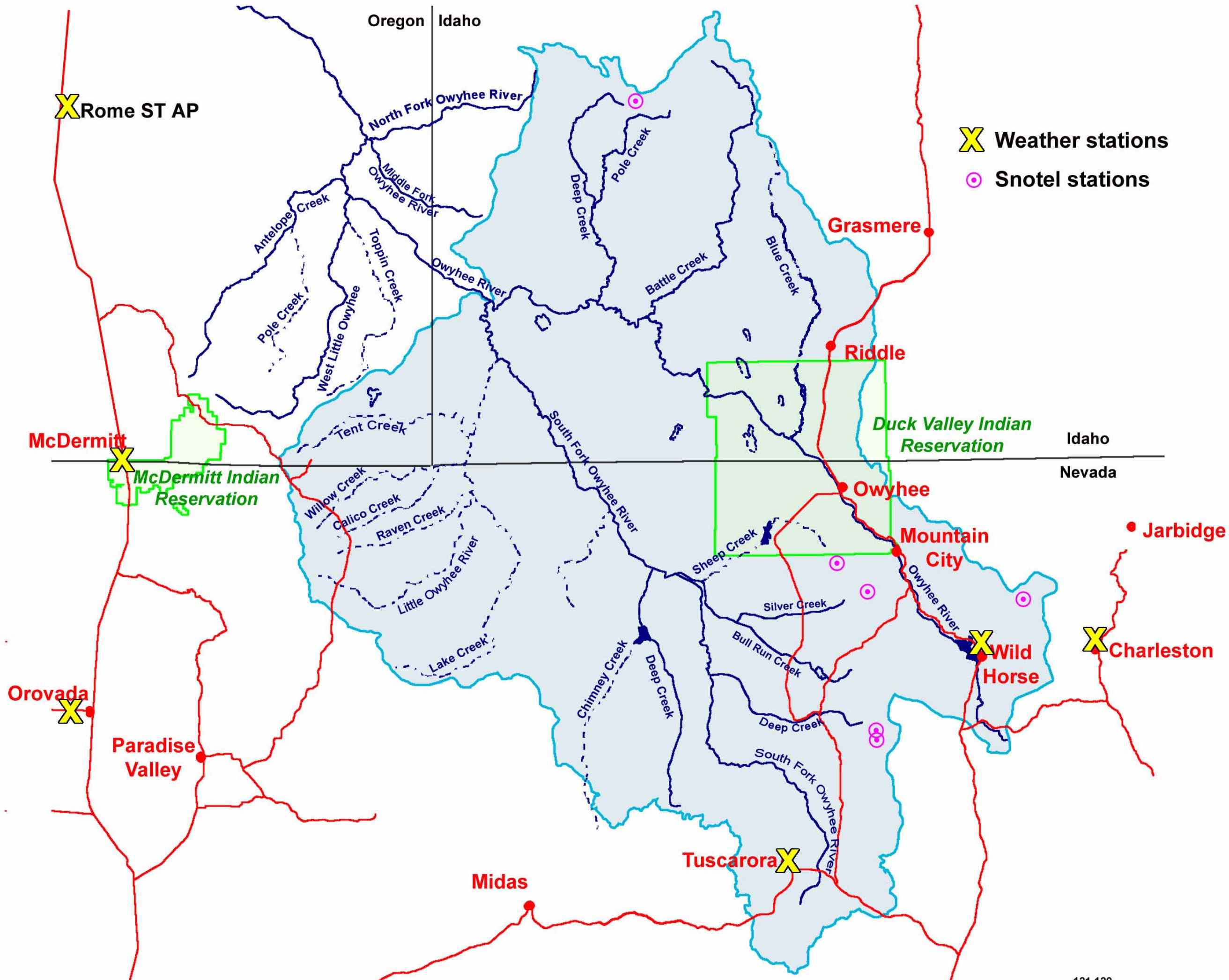


Figure 2.15. Currently operating weather stations in and around the upper Owyhee subbasin.[121,129]

## 4. Temperature

The data from four meteorological stations within the upper Owyhee subbasin (Tuscarora, Tuscarora Andrae Ranch, Mountain City, and Wild Horse Reservoir) were analyzed for this assessment. In addition, the data from the Owyhee station were included, since it is within the geographical boundaries of the subbasin although it is located within the Duck Valley Indian Reservation (Figure 2.16).[121]

To calculate the mean monthly average, the daily average for each month is calculated for each year. Then, the averages for each month (say for March) are again averaged across the different years to obtain the mean monthly average (for March) at a given station.

### *a. Elevation differences*

The mean monthly temperatures at two stations outside the subbasin, Grasmere and McDermitt 26 N, were compared with the mean monthly temperatures at three stations within the subbasin. These five stations were chosen over a range of elevations: McDermitt 26 N at 4,464 feet, Grasmere at 5,144 feet, Owyhee at 5,397 feet, Tuscarora Andrae Ranch at 5,863 feet, and Wild Horse Reservoir at 6,239 feet (Figure 2.16). The mean monthly temperatures at the five stations increased and decreased through the year in a similar pattern. The station at the highest elevation had the lowest temperatures, with increasing temperatures recorded at the stations located at successively lower elevations (Figure 2.17). This extremely small set of locations indicate that elevation is a major factor in the temperature variations within the subbasin, as would be expected.[12]

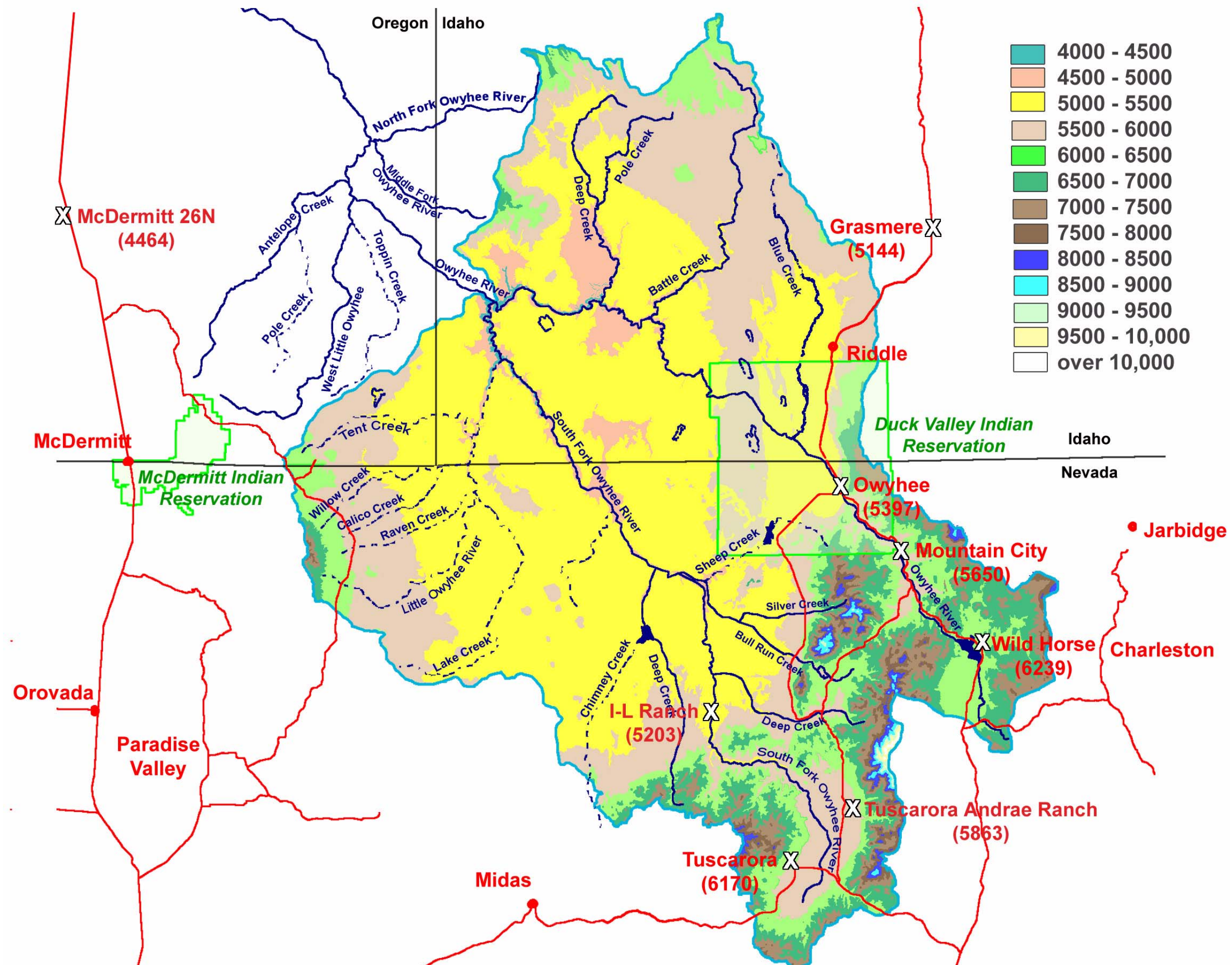


**Figure 2.16. Elevation in feet of meteorological stations around the upper Owyhee subbasin.**[226]

### *b. Maximum and minimum temperatures*

The monthly average maximum temperatures at the five meteorological stations within the subbasin, Tuscarora at 6,170 feet, Tuscarora Andrae at 5,863 feet, Mountain City at 5,650 feet, Wild Horse at 6,239 feet, and Owyhee at 5,397 feet, not only closely track each other but are almost identical from May through September (Figure 2.18). The average maximum temperatures begin to rise in January, peak in July, and fall between August and January. In July they vary between 83.7°F at Wild Horse Reservoir to 85.5°F at Tuscarora Andrae Ranch.[121]

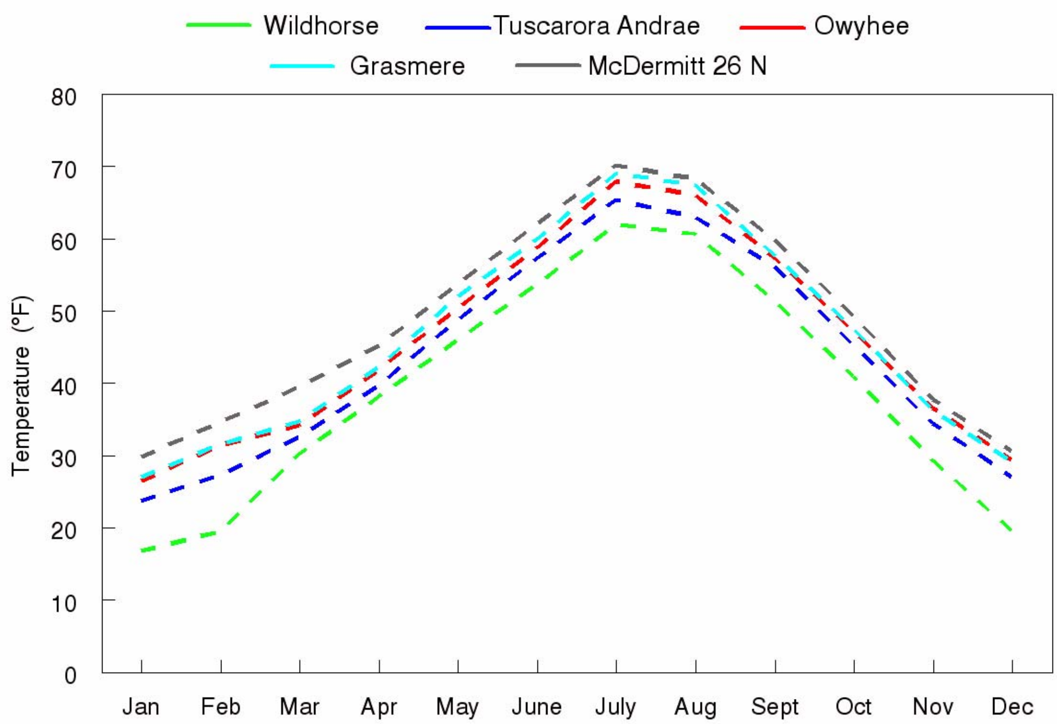


Figure 2.17. Mean monthly temperatures at five weather stations at different elevations.

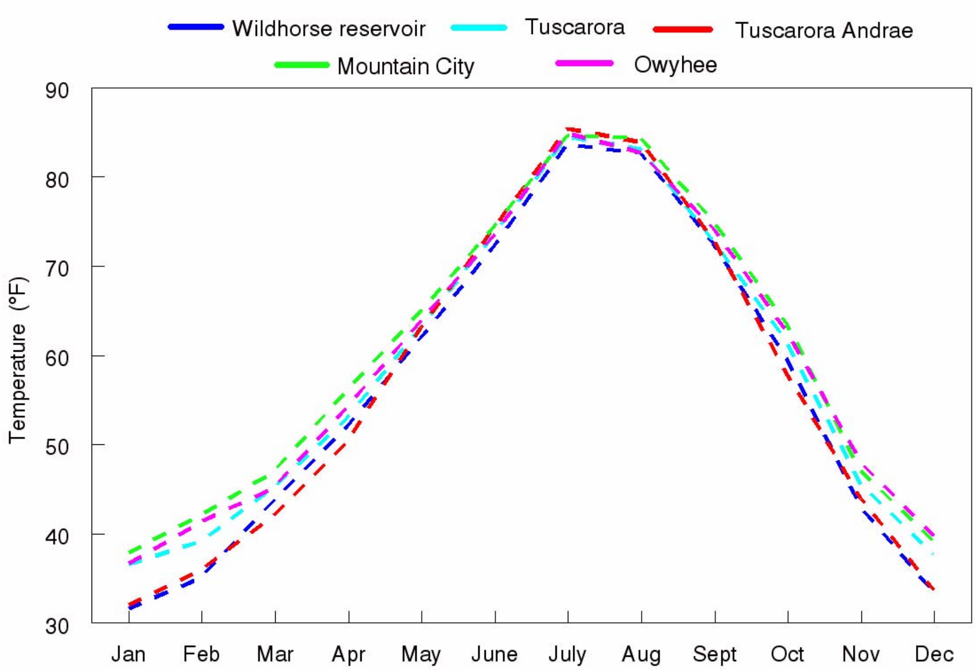


Figure 2.18 Mean monthly maximum daily temperatures at five meteorological stations in the upper Owyhee subbasin.

The average minimum temperatures at the five stations also rise and fall in a similar manner (Figure 2.19). Although the minimum temperatures from the different stations parallel each other, there is a greater spread in the temperatures between different locations. They show a difference roughly corresponding to their elevations. In January the average minimum temperature varies from 2.2°F at Wild Horse Reservoir to 16.6°F at Owyhee. [121]

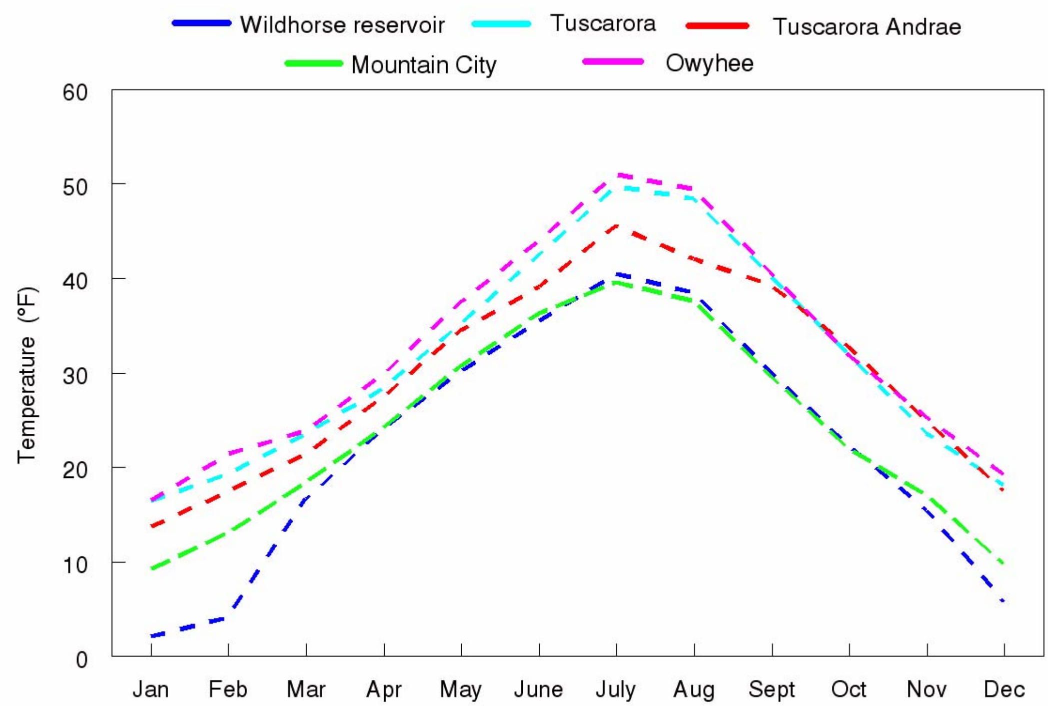


Figure 2.19. Mean monthly minimum daily temperatures at five meteorological stations in the upper Owyhee subbasin.

Factors other than elevation are affecting the average minimum temperature at Tuscarora. At the second highest elevation of the five, it most closely mirrors Owyhee at the lowest elevation.

### *c. Hottest and coldest*

Average monthly maximum temperatures over 90°F are considered to be hot. There is another way of looking at how hot the area gets. On average, how many days each month does the temperature reach 90°F? Figure 2.20 shows the average number of days each month when the maximum temperatures are 90°F or greater. For all five stations in the upper Owyhee subbasin, July is the month with the greatest average number of days when the maximum temperature exceeds 90°F. Only the Tuscarora Andrae station exceeds an average of 7.5 days per month over 90°F.[121] For comparison, in July several stations in the Lower Owyhee fourth-order HUC average in excess of 20 days with maximum temperatures above 90°F in July.[100]

All five of the meteorological stations in the upper Owyhee subbasin show average minimum temperatures below 32°F from October to April (Figure 2.19). In July

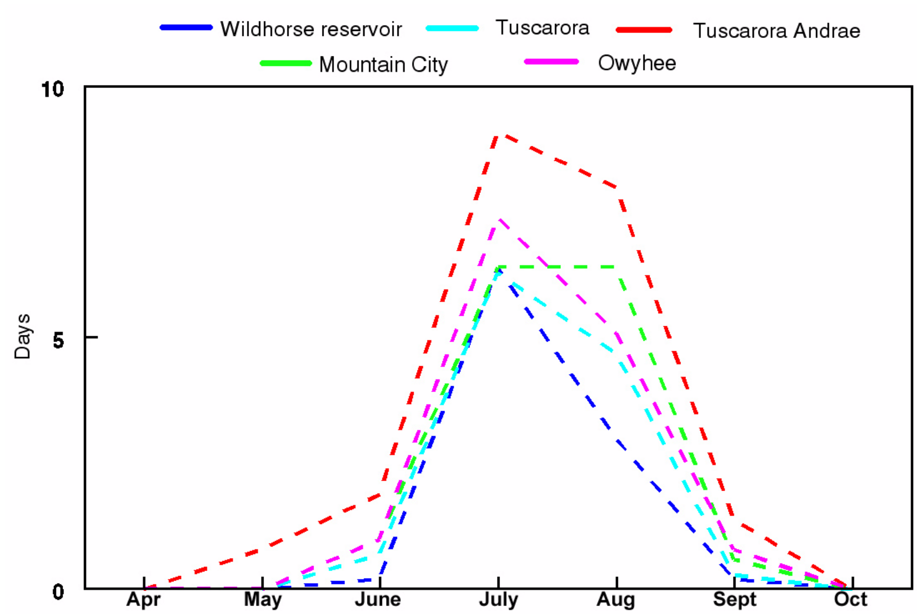


Figure 2.20. Average number of days each month with maximum temperatures greater than or equal to 90°F.

and August, only the Owyhee and Tuscarora stations do not average at least one night per month when the temperature falls below 32°F (Figure 2.21). The dip in the average number of freezing nights in February is due to February only having 28 or 29 days. At Wild Horse Reservoir, January averages 30.7 days (out of a 31 day month) with minimum temperatures below 32°F and February averages 28 days with minimum temperatures below 32°F.[121]

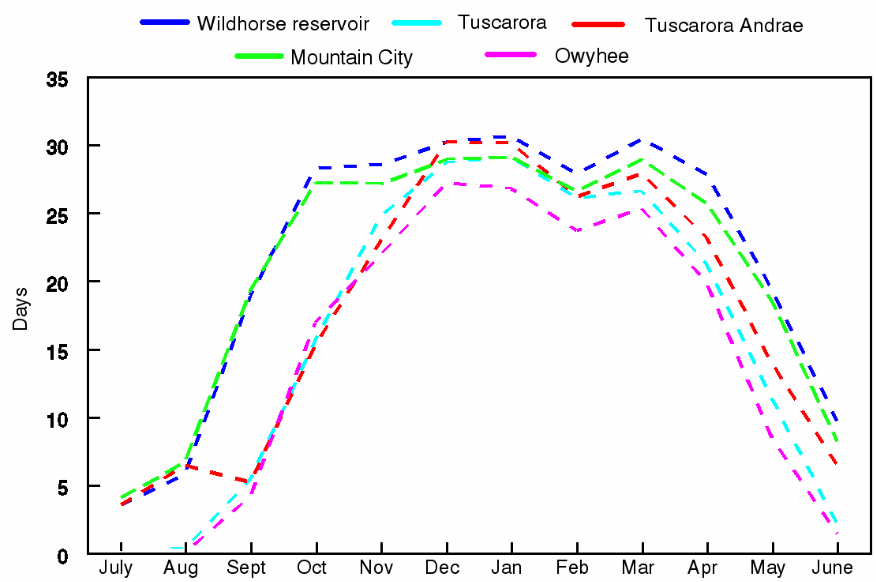


Figure 2.21. Average number of days each month with minimum temperatures less than or equal to 32°F.

Although the average temperatures tend to follow similar patterns, Table 2.8 indicates a greater variability from year to year between the stations. The highest and lowest temperatures at each station don't even occur in the same years at the different stations. Some of this is due to the difference in the years when the stations were operating (Table 2.7). The Tuscarora Andrae station stopped recording temperatures before any of the others commenced recording.

Table 2.8. Extreme daily temperatures at five meteorological stations in the upper Owyhee subbasin.[121]

| Station | High | Date | Low | Date |
|---|---|---|---|---|
| Wild Horse Reservoir | 102 | July 23, 2003 | -42 | Dec. 12, 2004 |
| Tuscarora | 99 | July 13, 2002<br>Aug. 1, 2000 | -25 | Jan. 12, 1963<br>Dec. 10, 1962 |
| Tuscarora Andrae Ranch | 104 | June 27, 1892<br>July 22, 1890<br>Aug. 6, 1892 | -27 | Feb. 27, 1890 |
| Mountain City | 99 | Aug. 5, 1994 | -48 | Jan. 1, 1974 |
| Owyhee | 98 | July 19, 1960<br>Aug. 5, 1983 | -34 | Jan. 25, 1949 |

### 5. Semi-arid, cold-winter desert

For most of the upper Owyhee subbasin the average annual precipitation is calculated to be less than 20 inches per year. This area can therefore be classified as a semi-arid desert. Since the winter temperatures in this semi-arid desert section drop as low as they do and there are stark temperature differences from season to season, the area is also classified as a cold-winter desert.[52,120] The majority of the upper Owyhee subbasin is a semi-arid, cold-winter desert.

Since there are few meteorological stations, all that can be done to estimate the temperature and precipitation in the other sections of the subbasin is to extrapolate from the known data. Extrapolations and calculations probably result in figures close to the actual average weather patterns, but the lack of actual records is a data gap.

## C. Vegetation

The vegetation distributions in the upper Owyhee subbasin are shaped by the geology, soils, aspect, temperature, and, at the lower elevations, the low quantities and infrequent nature of water availability. The primary plant community at the lower elevations is steppe vegetation dominated by sagebrush scrub and perennial bunchgrass.[101] Among other plant communities are playa vegetation, sagebrush on lava beds and the high-elevation community containing mountain big sagebrush scrub and both mahogany and juniper woodlands. Depending upon soil depth and elevation, different subspecies of sagebrush (*Artemisia tridentada*) flourish.[7,101] Paleobotanical research reflects an environment which has supported *Artemisia* steppe / desert scrub communities for the last 8000 years.[101]

Willows, sedges, rushes, cottonwood trees and other riparian vegetation are found along perennial streams and some intermittent streams.

Throughout a desert environment, there is high spatial variability of plants. Vegetation can differ significantly between patches; patches in close proximity to one another may contain different species compositions.[101] Not all the vegetation is native. Cheat grass has spread over much of the rangeland and other invasive "weed" species are also altering the vegetative communities. The vegetation in the upper Owyhee subbasin is covered in more detail in the rangeland section of this assessment.

## D. Wildlife

There are limited perennial sources of water in the upper Owyhee subbasin. Some of these perennial streams and rivers have steep canyon walls which limit wildlife and livestock access to the water. Just like the vegetative distributions, the animal distributions are shaped by the low quantities and infrequent nature of water availability. Since the elevation of the subbasin varies from less than 4,500 feet to over 10,000 feet (Figure 2.14), there are many different ecological niches, which support different species of wildlife.

Other than insects, birds represent the greatest number of animal species found in the upper Owyhee subbasin. Water birds and migratory ducks and geese are not only found in the marshland playas around Duck Valley, but also have been spotted on a playa north of Tent Creek in Malheur County in very wet years. Some bird species are limited to river canyons and others require the open grass and sagebrush lands. Although distant from each other, the Independence and Bull Run Mountains and Juniper Mountain are home to similar bird species found only in more forested areas.

**Blackbirds chasing a sand hill crane near Mountain City**

**Doe and fawn near Rio Tinto**

**Pronghorn ducking under a barb wire fence along SSR-11**

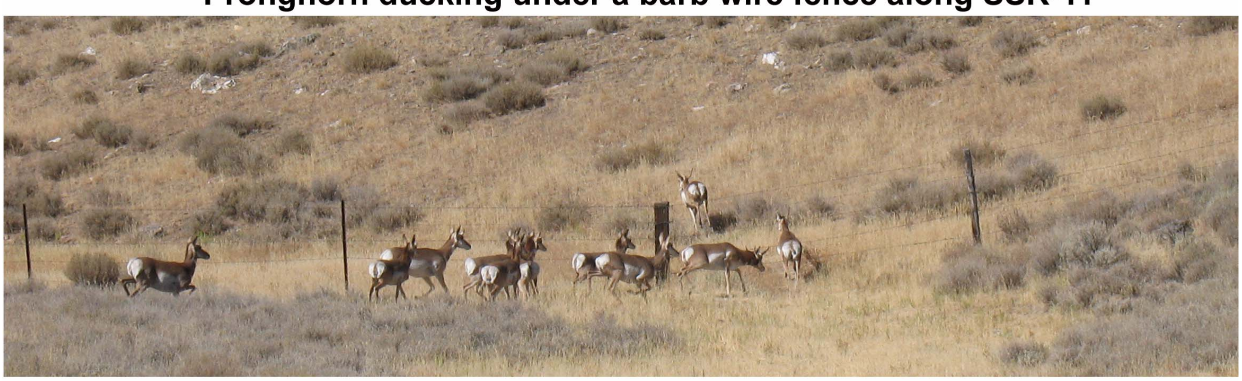

**Photo 2.3. Some of the wildlife photographed in the upper Owyhee subbasin**

Large animals such as the mule deer, pronghorn, and cougar are found throughout the subbasin. Elk primarily live in the more forested higher elevations. The sparse populations of reintroduced bighorn sheep are restricted to rugged canyons. Beaver and river otter are confined to streams. Smaller mammals such as rabbits, ground squirrels, mice, and voles may be found in grasslands or in sagebrush vegetation complexes. Abandoned mines provide habitat for some of the bat species. Table 2.9 lists some of the wildlife species which are known to inhabit some portion of the upper Owyhee subbasin.

Table 2.9. Some species of wildlife in the upper Owyhee subbasin.

| Mammals[27,76,77,99,103] | | | |
|---|---|---|---|
| elk | long-tailed weasel | muskrat | Merriam's shrew |
| mule deer | mink | desert woodrat | Preble's shrew |
| pronghorn | mountain cottontail | bushy-tailed woodrat | vagrant shrew |
| bighorn sheep | white-tailed jack rabbit | Ord's kangaroo rat | hoary bat |
| feral horses | yellow-bellied marmot | chisel-toothed kangaroo rat | big brown bat |
| mountain lion | Townsend's ground squirrel | western harvest mouse | silver-haired bat |
| bobcat | Belding's ground squirrel | canyon mouse | spotted bat |
| coyote | Wyoming ground squirrel | northern grasshopper mouse | pallid bat |
| kit fox | Merriam's ground squirrel | great basin pocket mouse | little brown myotis |
| red fox | piute ground squirrel | Townsend's pocket gopher | long-eared myotis |
| American badger | white-tailed antelope squirrel | northern pocket gopher | Yuma myotis |
| common raccoon | least chipmunk | montane vole | long-legged myotis |
| common porcupine | | sagebrush vole | western small-footed myotis |
| western spotted skunk | | pika | California myotis |
| striped skunk | | | western pipistrelle |
| beaver | | | Townsend's big-eared bat |
| northern river otter | | | |

| Amphibians and Reptiles[25, 26,27,76] | | | |
|---|---|---|---|
| western toad | sagebrush lizard | long-nosed leopard lizard | great basin rattlesnake |
| pacific treefrog | western fence lizard | rubber boa | western rattlesnake |
| northern leopard frog | side-blotched lizard | racer | western terrestrial garter snake |
| Columbia spotted frog | western whiptail | gopher snake | night snake |
| short-horned lizard | western skink | | striped whipsnake |

| Birds[15,27,56,58,99] | | | |
|---|---|---|---|
| pied-billed grebe | sage grouse | willow flycatcher | orange-crowned warbler |
| American bittern | sharp-tailed grouse | dusky flycatcher | MacGillivray's warbler |
| great blue heron | California quail | ash-throated flycatcher | yellow warbler |
| black-crowned night-heron | Virginia rail | Say's phoebe | black-throated gray warbler |
| sandhill crane | sora | western kingbird | warbling vireo |
| turkey vulture | American coot | western wood-pewee | common yellowthroat |
| Canada goose | killdeer | gray flycatcher | yellow-breasted chat |
| green-winged teal | black-necked stilt | eastern kingbird | green-tailed towhee |
| mallard | American avocet | horned lark | spotted towhee |
| northern pintail | willet | tree swallow | |
| | spotted sandpiper | violet-green swallow | |

| | | | |
|---|---|---|---|
| blue-winged teal | common snipe | bank swallow | Brewer's sparrow |
| cinnamon teal | Wilson's phalarope | northern rough-winged swallow | lark sparrow |
| northern shoveler | mourning dove | cliff swallow | sage sparrow |
| gadwall | common barn-owl | barn swallow | song sparrow |
| American wigeon | western screech-owl | American crow | chipping sparrow |
| canvasback | great horned owl | black-billed magpie | vesper sparrow |
| redhead duck | burrowing owl | common raven | house sparrow |
| ruddy duck | long-eared owl | black-capped chickadee | lazuli bunting |
| lesser scaup | short-eared owl | bushtit | western meadowlark |
| common merganser | northern saw-whet owl | rock wren | Brewer's blackbird |
| golden eagle | common nighthawk | house wren | red-winged blackbird |
| northern harrier | common poorwill | marsh wren | yellow-headed blackbird |
| Cooper's hawk | white-throated swift | canyon wren | brown-headed cowbird |
| Swainson's hawk | black-chinned hummingbird | blue-gray gnatcatcher | Bullock's oriole |
| red-tailed hawk | calliope hummingbird | mountain bluebird | pine siskin |
| ferruginous hawk | belted kingfisher | American robin | American goldfinch |
| American kestrel | Lewis' woodpecker | loggerhead shrike | house finch |
| prairie falcon | red-naped sapsucker | European starling | cedar waxwing |
| gray partridge | downy woodpecker | sage thrasher | gray catbird |
| ring-necked pheasant* | hairy woodpecker | | ring-necked turtle dove* |
| chukar* | | | |

*introduced

## E. Geology

This section discusses various aspects of geology. The geological history of the upper Owyhee subbasin describes how the rock formations got to be where and what they are today. The rocks found within the upper Owyhee subbasin can be the source for ores and minerals sought by prospectors and rockhounds. The bedrock has weathered to form the soils found within the subbasin. Rocks not only can contain naturally occurring metallic ores, like those of gold and silver, but also can contain chemicals such as mercury and arsenic. Knowing what rocks are found in the subbasin tells us some of the chemicals that will naturally erode and enter the soils and waters.

The discussion will show that the rocks in the upper Owyhee subbasin are part of two geographic provinces (areas): the Basin and Range, and the Owyhee Plateau. Rocks in the Basin and Range are very old and have been faulted to form north-south trending valleys and mountain ranges. In the Basin and Range province, the valleys have filled with sediments eroded from the adjoining mountains. Rocks from the Owyhee Plateau are much newer and were formed by volcanic activity in the recent geological past. Atop the recent geological rock formations of the Owyhee Plateau, the soils have not had time to develop and tend to be shallow and rocky. In older geological areas in the Basin and Range, soils tend to be deeper and richer in nutrients because they have been forming for longer.

### 1. Basic Geology

Geology is the study of the rocks that are found within a region, what the rocks are made of and how the rocks got to be where they are today. Geology explains scenic vistas, the source of precious metals, and the source of sediments within the watershed.

### *a.* Minerals and rock formations

The term **mineral** is used for naturally occurring, solid compounds with a specific crystalline structure. Minerals can be found in their pure form, like a quartz crystal or gold vein, but more frequently they are mixed together to form rocks.

**Rocks** are named on the basis of texture, mineral composition and formation processes. Basalt and sandstone are examples of common rocks. Two sandstones may have the same basic mineral composition and similar texture, but they will normally vary in the quantities of trace elements.

"The geologic record is made up of many different kinds of rock layers, some thick, some thin, some widespread, and some extending only a few feet. It is impossible and unnecessary to understand completely the relationships among all individual layers. Instead, geologists mentally gather layered rocks together into manageable units that are called formations. A formation may be a single thick layer or, more commonly, a group of individual layers with more or less consistent characteristics which are recognizable throughout a wide area."[61:3] For example, the lava flows from one volcano or the sediments accumulated in one lake bed may be called a **formation** as they have a similar source, composition and age. Rock formations are given proper names such as “Jordan Craters Basalt”.

### *b.* Rock classes

Geologists classify rocks into three major groups based on how the rocks are formed on the earth.

**Igneous rocks** are those formed by the cooling of magma. Basalt and granite are both igneous rocks as they are formed from magma: basalt by cooling on the surface of the earth or under the ocean in a lava flow and granite by magma cooling more slowly within a mountain.

**Sedimentary rocks** are those formed by the accumulation of sediment in layers. Most sediment accumulates on the bottom of the ocean, but it also accumulates in lake beds, on floodplains, on playas and as layered ash.

**Metamorphic rocks** are those formed when existing rocks or sediments are transformed by extreme pressure and heat, usually deep within the earth’s mantle.

Most of the rocks found within the upper Owyhee subbasin are igneous or sedimentary rocks.

### *c.* Weathering of rocks

Weathering is the process by which rocks are turned into smaller rocks and eventually into soil or sediment.

**Physical weathering** is the breaking of rock by natural forces such as frost wedging (water in cracks freezing and expanding), exfoliation (outer slabs detaching like onion peels), or wind or water breaking particles off of a rock. The amount of physical weathering depends upon weather conditions and the action of wind and water.

**Chemical weathering** is when a rock is altered or dissolved by chemical reactions such as the oxidation (rusting) of iron or dissolution of rock from acid produced by fungi. The rate of chemical weathering is determined by heat and humidity, making weathering more rapid in the humid tropics than in cold temperate regions.

In deserts the most common form of weathering is physical weathering. Chemical weathering affects unstable minerals such as halite (common table salt) which dissolves easily in water. By understanding qualities of the original bedrock as well as the forms weathering takes, it is possible to predict the effects of natural weathering processes on a region's rock features.

***d. Rocks common in the upper Owyhee subbasin***

A variety of igneous rocks are found in the Owyhee watershed because of the active volcanism in the recent geological past. **Basalt** is a common rock of lava flows. It is generally black or dark-gray. Basalt pours out of vents (cracks) in the earth, so the final form looks like the syrup you pour on a pancake: it forms fairly level sheets of rock. Within the sheet the lava can crystallize into hexagonal columns.[10] The dark colors in basalt come from high concentrations of iron and magnesium. **Rhyolite** is the same composition as granite but it cools on the surface; it is composed almost entirely of silica.[90] In a pure form rhyolite will be a white rock; however, it often has small mineral inclusions of iron or magnesium that turn the color reddish brown. Rhyolite doesn't flow as easily as basalt so it moves more like molasses. Often rhyolite is associated with explosive volcanism, like the building of cinder cones. When rhyolite forms, lava flows so slowly that the surface cools and then breaks into chunks that are incorporated within the flow so the surface of rhyolitic flow is not as flat as a basalt lava flow.

**Photo 2.4. Rhyolite canyon walls of the Little Owyhee River.**

Within the Owyhee uplands some of the volcanic activity was bimodal, with both rhyolite and basalt erupting from the same volcanic vent at different times of activity. There are also many rocks that have a composition between that of basalt and rhyolite due to mixing of the two types of magma. The most recent volcanism at Jordan Craters northwest of the upper Owyhee subbasin provides a nice example of bimodal volcanism because both aspects of the volcanic activity are visible. The cinder and spatter cones are composed of rhyolite. First the cinder cone (Coffeepot Crater) and spatter cones formed on a hill. Then basalt lava flows broke through one wall of the cinder cone, flowing downhill, leaving the earlier phase of explosive rhyolite exposed.[16,87,94]

Molten lava pushes to the surface through already existing rocks. Cracks in rocks often provide a route for the lava. After lava stops flowing on the surface, the lava still within the cracks will cool. These vertical pathways for lava are called **dikes**.[33] Sometimes the lava in cracks will never reach the surface, but it may form a dike underground that is later exposed by erosion. An example of dikes in the upper Owyhee subbasin are those at Capitol Peak in the Calico Mountains of Nevada. Other impressive dikes of basalt are visible along the road through Leslie Gulch and occasionally crossing the Owyhee River upstream in the upper Owyhee subbasin.

**Tuff** is the term applied to all rocks formed from volcanic ash. When gasses and steam escaping from a volcanic vent come in contact with lava they can blow the lava apart. If these particles are as small as sand or silt they are called ash. This ash can then be moved long distances as flows or may become airborne.[109] When the ash flowing out of a volcanic vent stays very hot it will cool on the surface of the land, becoming a **welded tuff**. In a welded tuff, the heat of the ash particles is sufficient for them to stick, or weld, to each other.[109] Tuffs and welded tuffs are described on the basis of the type of igneous rock from which they are formed. Therefore a rhyolitic tuff is one that has the same minerals found in rhyolite but is in ash form.

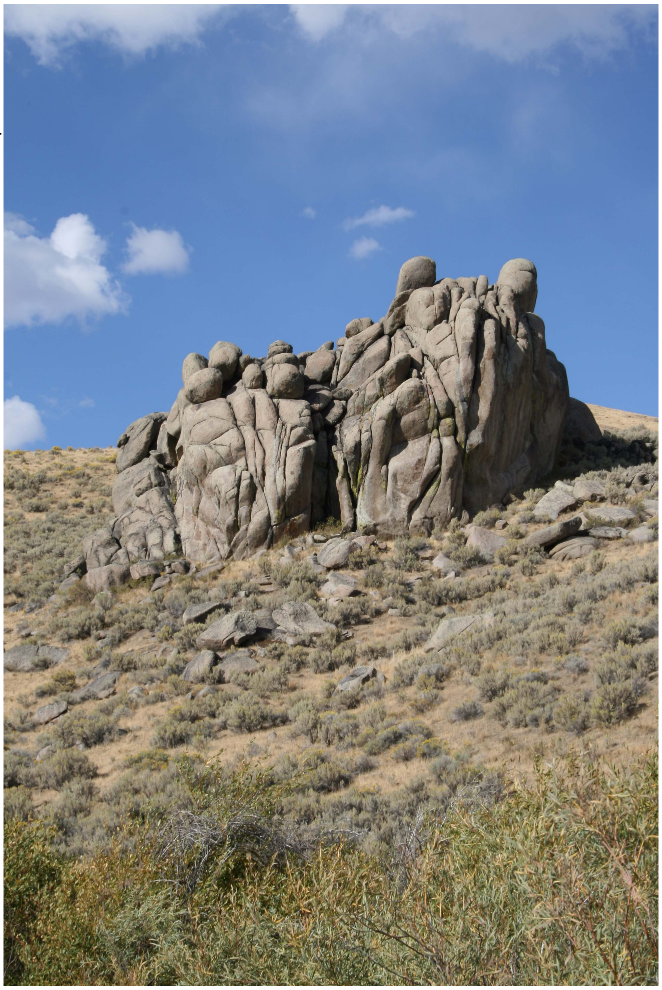

**Photo 2.5. Granite outcroppings below Wild Horse Reservoir**

**Granite** is a volcanic rock similar in mineral composition to rhyolite. It is high in silica. However, the formation of granite occurs beneath the earth's surface. Granite forms within large underground reservoirs. The magma cools very slowly and forms large crystals. Granite high in silica will be light, almost white in color. However, granite is often a mix of many minerals. The other common minerals within granite are mica (muscovite and biotite) and feldspar (plagioclase and orthoclase). Granite is a tough rock that isn't very easily eroded. A common location where granite forms is within mountain chains that have formed from intrusive magma such as the Independence Mountains.

Sedimentary deposits important within the Owyhee uplands are primarily lacustrine and alluvial deposits.

**Lacustrine** sediments are those deposited within a lake. Generally lake sediments are fine grained because they come from material carried by the water. The types of minerals within lake deposits depend upon the rocks eroding around the lake. When a lake bed dries out it is called a playa lake and the minerals within the water are precipitated. The minerals that settle out are generally white in appearance like gypsum; they are salts of sodium, calcium, magnesium and potassium. **Alluvial** sediments are those deposited by running water. Rivers move gravel in their beds and carry small particles in suspension, making them look dirty. The gravel is left in old river courses as the river moves and smaller particles are deposited on floodplains or on lake bottoms where rivers enter lakes.[3] Like lake deposits, the rock materials found in alluvium are derived from other rocks in the area. In many cases these deposits will contain larger chunks, namely gravel and boulders.

Faulting is the process whereby pieces of the earth's surface change position in relationship to one another. Faulting can be caused by large-scale processes such as the movement of tectonic plates on the earth's surface and local processes like the emptying of magma chambers below the ground resulting in an area subsequently dropping. Faults are the lines along which we can see the movement that has occurred. When faulting causes vertical movement of the earth, multiple parallel fault lines can cause areas to rise into mountains while beside them basins are formed. The Basin and Range province is a large series of valleys and mountains formed by faulting. The Bull Run and Independence Mountains in the upper Owyhee subbasin are part of the Basin and Range.

### *e. Weathering of common rocks*

Ash tuffs are soft rocks easily sculpted by wind and water.[16] Basalt lava flows are significantly harder but can be broken down more easily than rhyolitic lava which is mainly silica. All rocks exposed in the Owyhee uplands are susceptible to weathering; however, they will break down more if they are soft or have been exposed for a longer time. It can be expected that soils and water will contain minerals common in the rocks, especially those found in volcanic ash or basalt because these rocks are more easily broken down.

### *f. History, as geology tells it*

Geologists look at the placement of rock formations on the earth's surface to discover in what order events happened. For layered rocks geologists start with the principle of **stratigraphy**, that newer layers accumulate on top of older layers of rocks. This means that in a canyon like those cut by the Owyhee River the rocks at the bottom of the canyon are the oldest and those closest to the rim are the newest.

The geological record can be patchy as the creation of rocks is often followed by periods of erosion. This can be seen when a group of tilted rocks get covered by new flat deposits (Figure 2.22). Past erosional surfaces can also be flat and hard to identify. Geologists call the gaps of time caused by erosional events **unconformities**.

Things on the earth's surface don't always stay in the same place. **Faults** move pieces of the earth's crust past each other or up and down. The well known San Andreas fault in California is one in which the two pieces of the crust are moving past

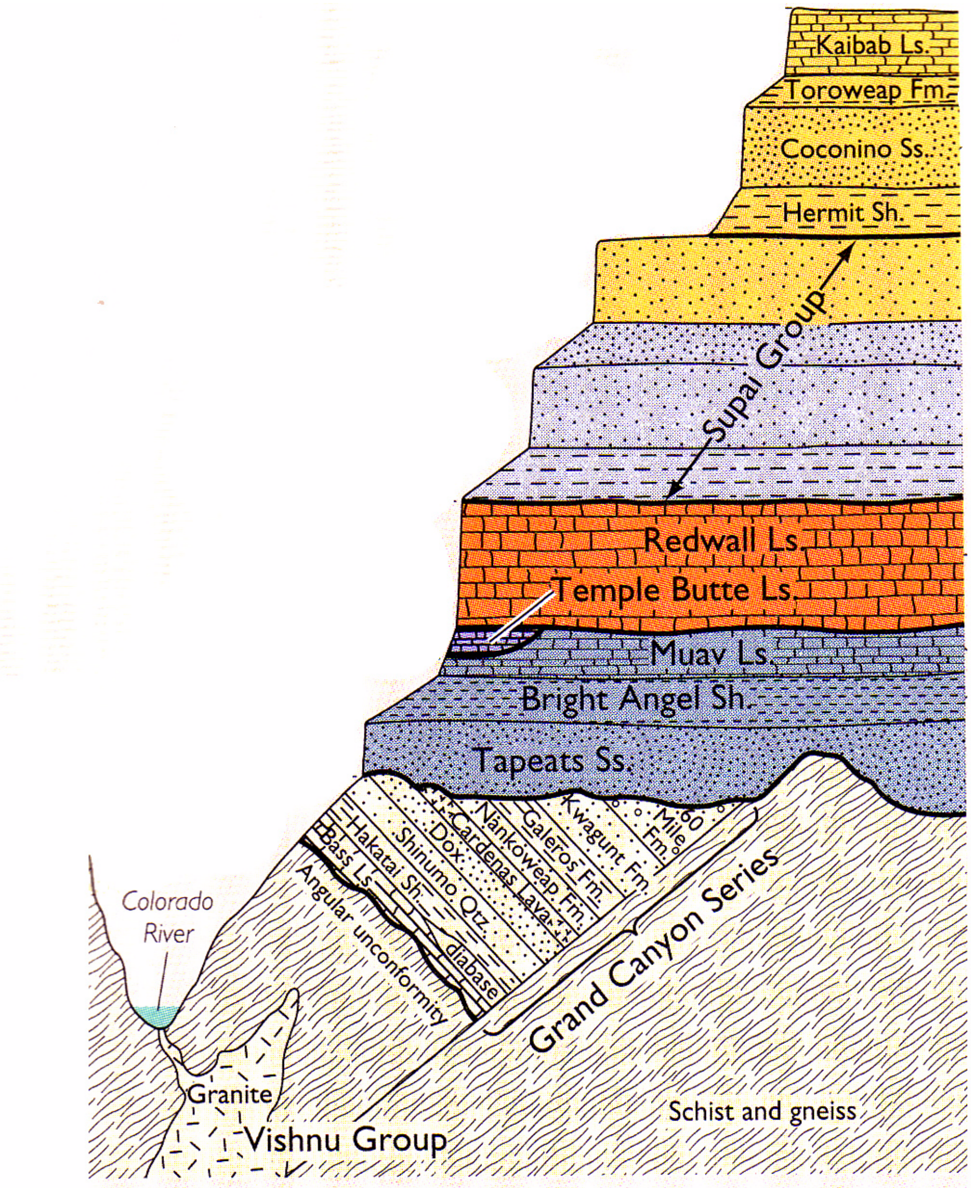


**Figure 2.22. Geological series of the Grand Canyon is broken by erosional events (unconformities) seen as darker black lines.**
**(Adapted from 126:198)**

each other. Faults where the crust moves up and down often form mountains and valleys, like Death Valley which has dropped below sea level while the mountains on both sides have moved upwards. Geologists use the rock formations moved by faults to help date when the faults were active.

### *g. Geological time scale*

To compare historical events like the formation of the Grand Canyon or the Owyhee Canyon and the building of the Bull Run, Independence, and the Owyhee Mountains, geologists have developed their own time scale. They divide time into very large periods, **eons**, then **eras**, **periods** and the smallest subdivisions, the **epochs**.[116]

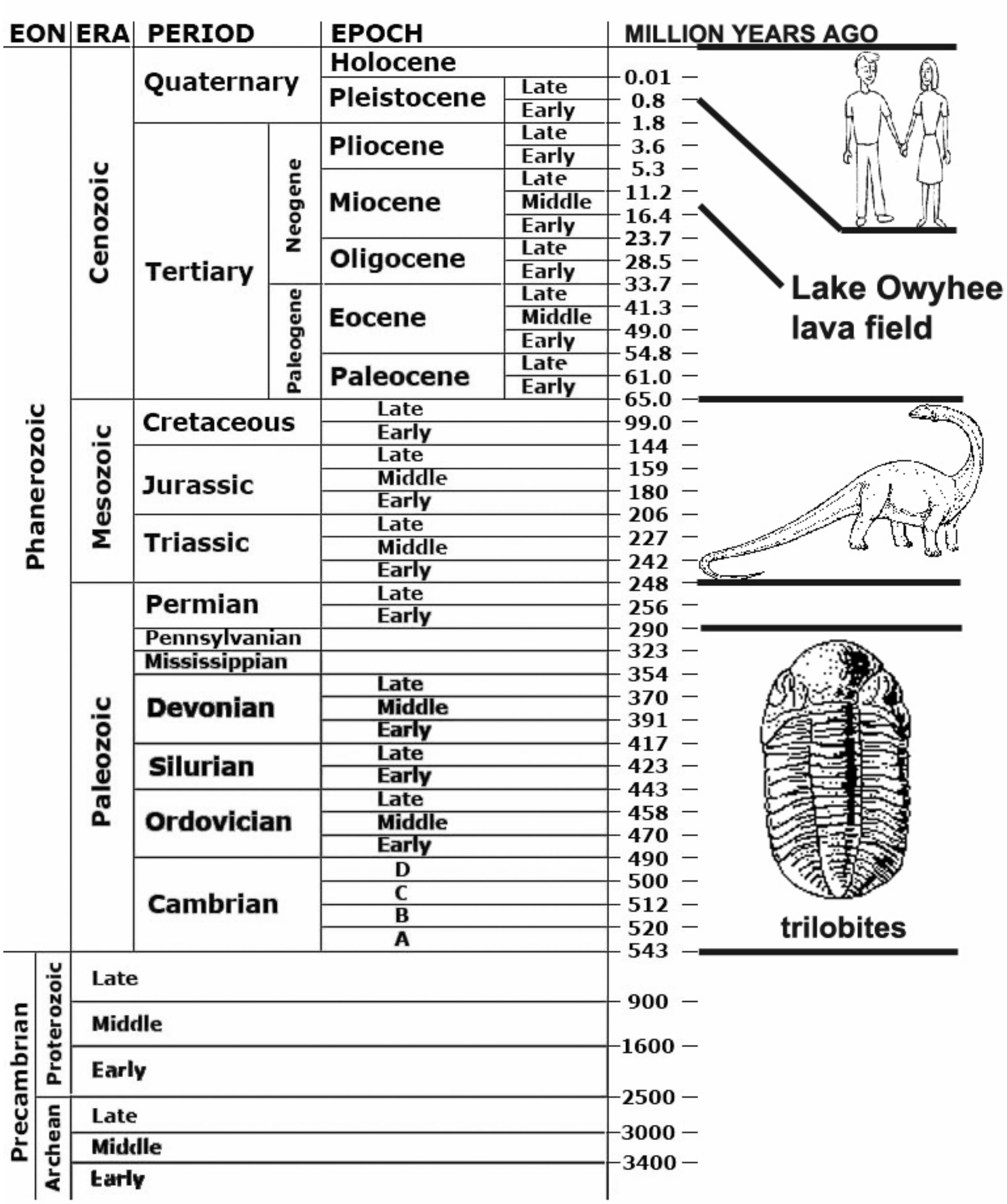


**Figure 2.23. Geologic time scale.**
(Adapted from 116)

These divisions are marked by major changes in the earth's environment or animal extinctions.[119] In Figure 2.23 you can see that the die off of the dinosaurs at 65 million years ago marks the end of the Cretaceous period and the Mesozoic era. All mammals are thought to have evolved in the last 65 million years, during the Tertiary and Quaternary periods. The Quaternary period, 1.8 million years ago through the present, includes the entire history of modern humans. Together the Tertiary and Quaternary make the Cenozoic era.

After documenting major changes in climate and fossils within the rocks, geologists date the divisions using radioactive decay of naturally occurring minerals within the rocks. Radiocarbon, or C14, is often used to date charcoal from human fires because the rate of radioactive decay is predictable. For example, this is how we know that Native Americans killed mastodon in New Mexico 12,000 years ago. Other radioactive elements also decay at predictable rates but much more slowly so they can be used to date the formation of rocks. The radioactive elements used to date rock formations are potassium 40, rubidium 87, thorium 232, uranium 235, and uranium 238.[47,119]

On the geological time scale the upper Owyhee subbasin is very young. Most of the surface rocks date to the Cenozoic era after the dinosaurs died out 65 million years ago. The high plains north and west of Mountain City, Nevada were formed only 15 million years ago by volcanic activity of the Yellowstone hot spot.

## 2. Geological data

### *a. Regional geological background*

Before looking at how the Basin and Range and the Owyhee Plateau came to be, we must step back in time to the origin of the rocks within the upper Owyhee subbasin.

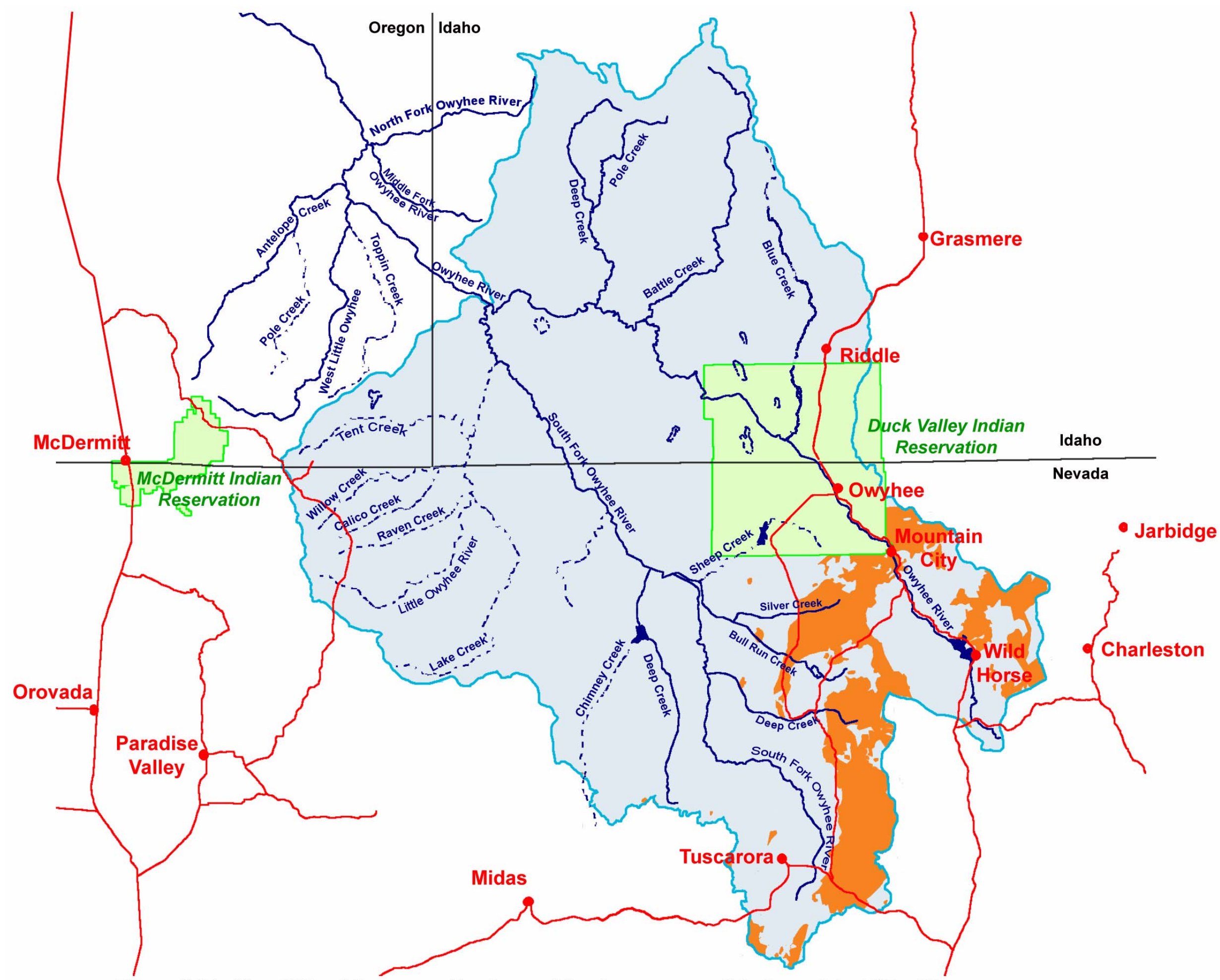


Figure 2.24. Very little of the upper Owyhee subbasin as we see it today existed 65 million years ago. The only portions that existed then are in orange in this figure.[69]

The events in the surrounding region and the western US discussed below are chronologically related to each other on a timeline included just before the bibliography.

In the era of the dinosaurs (Mesozoic) two mountain complexes were forming in what is now the western United States. The boundary of the North American tectonic plate was not at the edge of California, but farther inland. As the oceanic plate to the west collided with the North American continent mountains were formed by the edge of the oceanic plate being forced downward into the mantle below the North American tectonic plate (subduction). The Nevadan Mountains formed between 150 and 90 million years ago.[104] The few areas where rocks from this era are exposed in the upper Owyhee subbasin are shown in Figure 2.24. Along with the volcanism and mountain growth, the subducting oceanic plate brought some islands which stuck to the western shore. These islands are aggregates, rocks consisting of a mixture of minerals.

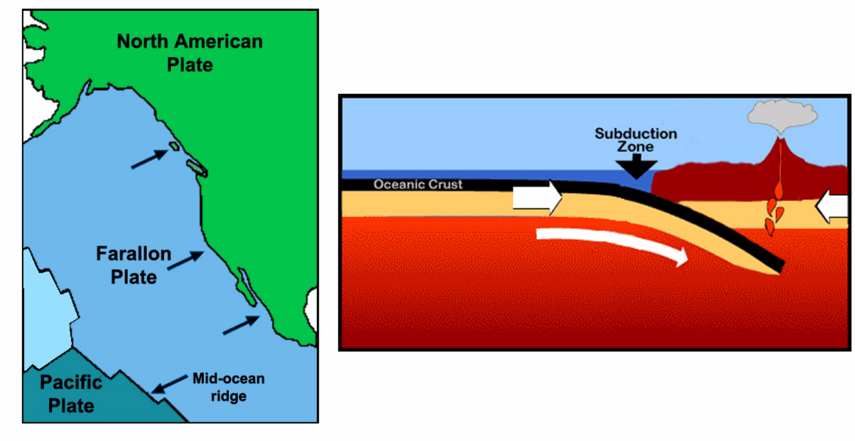


**Figure 2.25. The Farallon plate as it would have been before it subducted under the North American plate. Schematic shows subduction.[14,30]**

Later in time and farther to the west another set of mountains were built. This was caused by the subduction of the Farallon plate of ocean floor under the North American plate (Figure 2.25).[14,30,69] From 70 to 40 million years ago the Farallon plate was subducted from southwest to northeast under the North American plate, building the Colorado Plateau and Rocky Mountains.[14,69] Farther to the north the Farallon subduction was responsible for some of the granite formed in the Idaho Batholith.[30] This plate is easier to trace than earlier ones because it subducted more recently and geologists have seismically mapped the cold remnants of the plate that are still sinking into the mantel of the earth under eastern North America.[92]

Meanwhile the warm and wet climate had been eroding the Nevadan mountains down into hills, similar to the current day Appalachians. Large rivers associated with the warm and moist climate distributed mountain sediments including many of Nevada's gold bearing gravels.[57] And it was atop these hills that lava and tuffs erupted in association with the subduction of the Farallon plate. These lavas were rich in calcium, a component of the sea floor that was being melted below the surface.[69,85] The location of active volcanism changed over time. In Nevada the dates of the lava have been used to construct regions of activity. The upper Owyhee subbasin lies within a region that had active volcanism around 41 million years ago (Figure 2.26).[66,69] This volcanism is expressed locally at the Tuscarora volcanic field.[49]

The Farallon plate was on the western side of an ocean floor spreading center, similar to that in the center of the Atlantic Ocean today. When the Farallon plate was entirely under the North American plate between 28 and 25 million years ago the

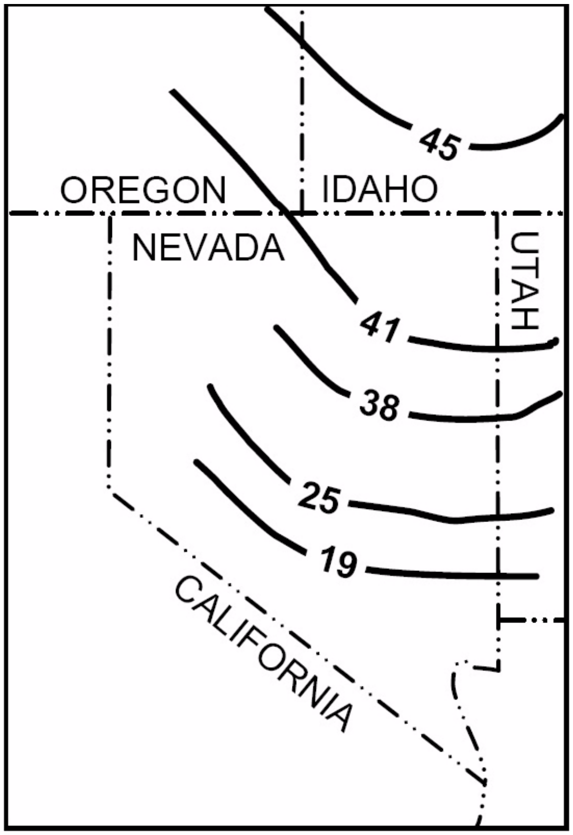


Figure 2.26. Ages in million years ago of volcanism related to the subduction of the Farallon plate.
(Adapted from 69:6-2)

spreading center changed in nature.[14,69] The current contact between the Pacific and North American plates is the San Andreas fault. The spreading force was transferred to another part of the system. Crustal thinning of the North American plate was the result. This crustal thinning formed the Basin and Range province. What became thinned was the earth's crust under a mixture of a part of the Nevadan Mountains, aggregate rocks, and part of the Rocky mountains.

Within the arid areas of the Owyhee River watershed, there are striking similarities between the mountains in the area of Silver City and those around Tuscarora and Mountain City. These similarities are tied to regional geology. All of the underlying rocks that are now found in these mountain ranges were formed before Basin and Range spreading began. These mountains and many others in northern Nevada and south-central Idaho are similar because of their shared history.

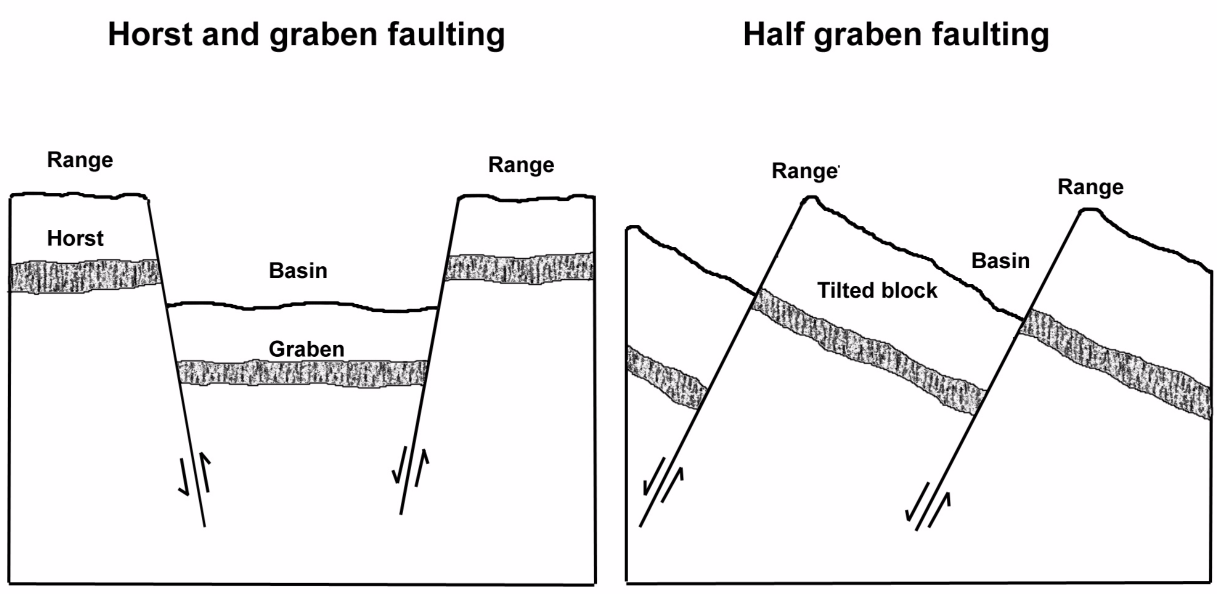


Figure 2.27. These two types of extensional faulting are common in the Basin and Range province.[11,48]

### *b. Geology of the upper Owyhee subbasin*

The upper Owyhee subbasin is in a region where the underlying geology is Nevadan Mountains and aggregate rocks. The Tuscarora volcanic field was active during subduction of the Farallon plate. The Basin and Range province formed and was subsequently covered by volcanic rocks of the Owyhee Plateau.

The Basin and Range province, characteristic of much of the state of Nevada, was formed through crustal thinning. The thinning in the region occurred through two types of faulting. One is where a graben drops between two remaining pieces of land (horsts) and the other is where tilting occurs and a "half graben" is formed creating a series of mountains and valleys (Figure 2.27).[11,48] In either case, the subsequent erosion of the higher piece of land fills the grabens with alluvial sediments. The difference between the two is how the geological layers in the mountains will be oriented. In graben and horst faulting, mountain rocks will lie in flat layers. In tilted extensional faulting (half graben), the mountain rocks' layers will be tilted.

The faults along the Bull Run and Independence Mountains of the upper Owyhee subbasin are depicted in Figure 2.28. Faults mark the edges of the mountains where the grabens dropped down. Hot springs formed in north-south lines running along faults where groundwater could more easily flow down to the hot magma and back up to the

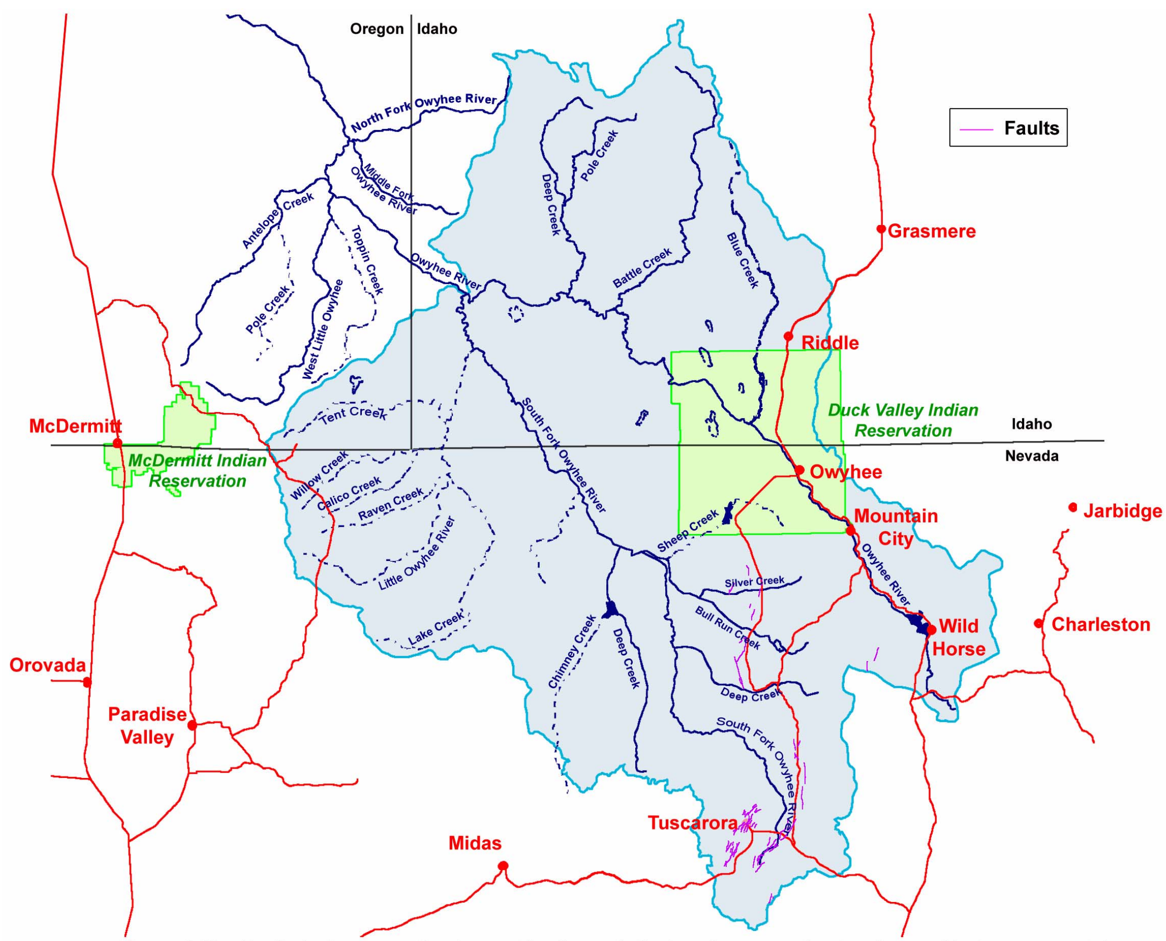


**Figure 2.28. Faults in the upper Owyhee subbasin mark the locations were basins dropped between mountain ranges and have not been covered by subsequent lava flows.[35]**

earth's surface. Adjacent basins filled with alluvial sediment eroded down out of the mountains.[35]

The land surface today within the basins of the upper Owyhee subbasin is a mix of sediments derived from the mountains on the sides and volcanic lava and tuffs. Active faulting has stopped in the area of the subbasin. Faulting is not consistent across the Basin and Range province as a whole. At present, the central 500 kilometers (of the 800 kilometer wide province) have almost no deformation.[105] Most faulting today occurs on the western edge of the province up against the Sierra Nevada and a smaller amount occurs in the east on the Wasatch front.[105]

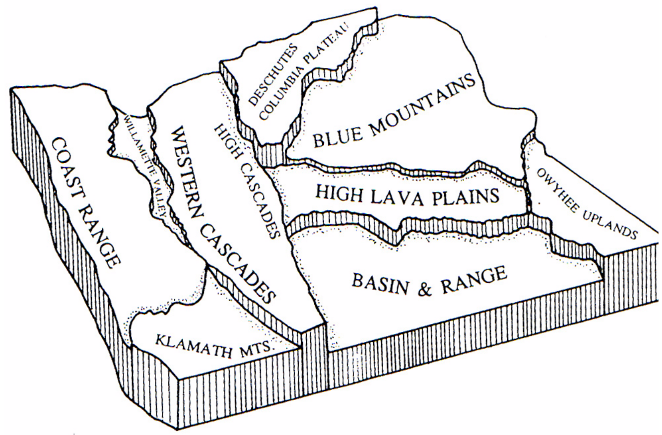


**Figure 2.29. Geological areas of Oregon**
**(Adapted from 86:1)**

In Oregon, the stretching and cracking of the crust also provided a way for lava to reach the surface. And it is from Oregon that we can see the events leading up to the building of the Owyhee plateau. Faulting was accompanied by volcanic eruptions on the Columbia River plateau, in the Steens Mountains, at Glass Mountain, and in the Strawberry Mountains.[16,86] This volcanism formed the High Lava Plains in central Oregon and the Columbia Plateau in northern Oregon (Figure 2.29).[118] In southeastern Oregon the Steens Mountain volcano sent basalt and ash into Idaho on the east, Lakeview County on the west, and up to

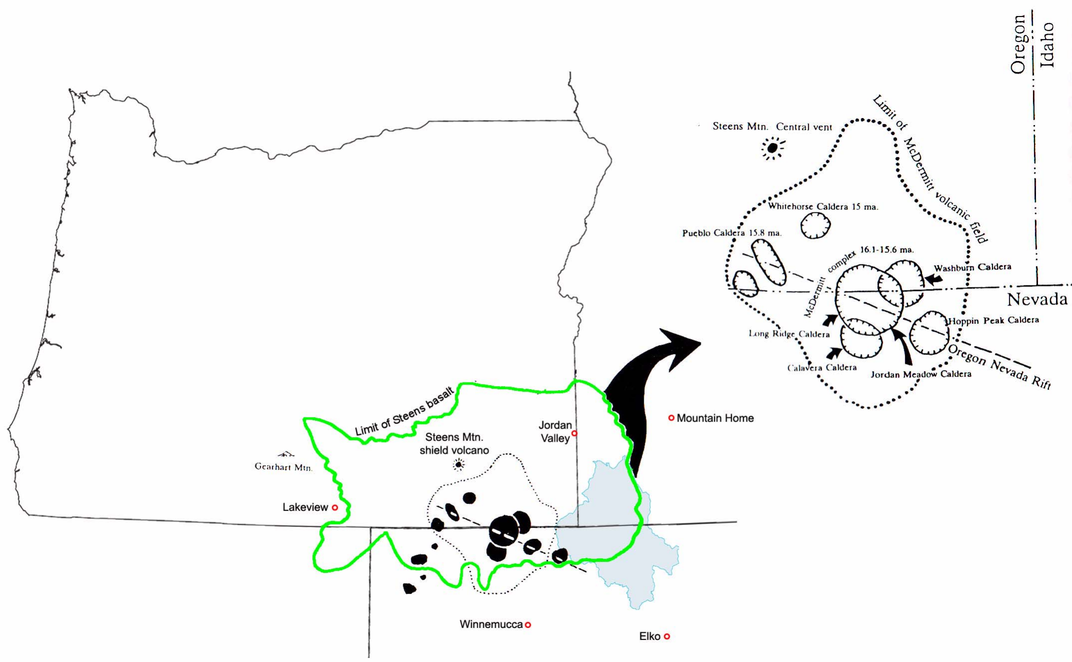


**Figure 2.30. The McDermitt volcanic field is located in the Owyhee uplands of southeastern Oregon and northwestern Nevada. Notice that Steens Mountain basalt flows covered much of the upper Owyhee subbasin.**

Saddle Butte in the North (Figure 2.30)[86] Basalt and tuff from the Steens contribute to a substantial portion of the basement rock in the upper Owyhee subbasin. In some areas of Idaho these rocks are 1000 meters thick.[38]

The volcanism with the greatest impact on the geology of the upper Owyhee subbasin is that of the Owyhee-Humboldt volcanic field. Welded rhyolitic tuff flows spread across an enormous area around 13.8 million years ago (Figure 2.31). The tuff of Swisher Mountain is a very large geological unit. It has been mapped over an area with a 100 kilometer diameter.[38] The Swisher Mountain tuff erupted from the Juniper Mountain volcanic center. Juniper Mountain is a gentle dome about 30 kilometers in diameter that lies directly in the progression of the Yellowstone hot spot.[12,38] The Swisher Mountain tuff is one of five different rhyolitic tuff sheets which make up the Owyhee-Humboldt volcanic field. The volcanic activity in this area did not create a noticeable crater, but over a 45 mile wide area of the valley to the south was filled with volcanic rocks to great depths.[38] These eruptions ceased with the eastward progression of the Yellowstone hot spot across southern Idaho and northern Nevada.[59]

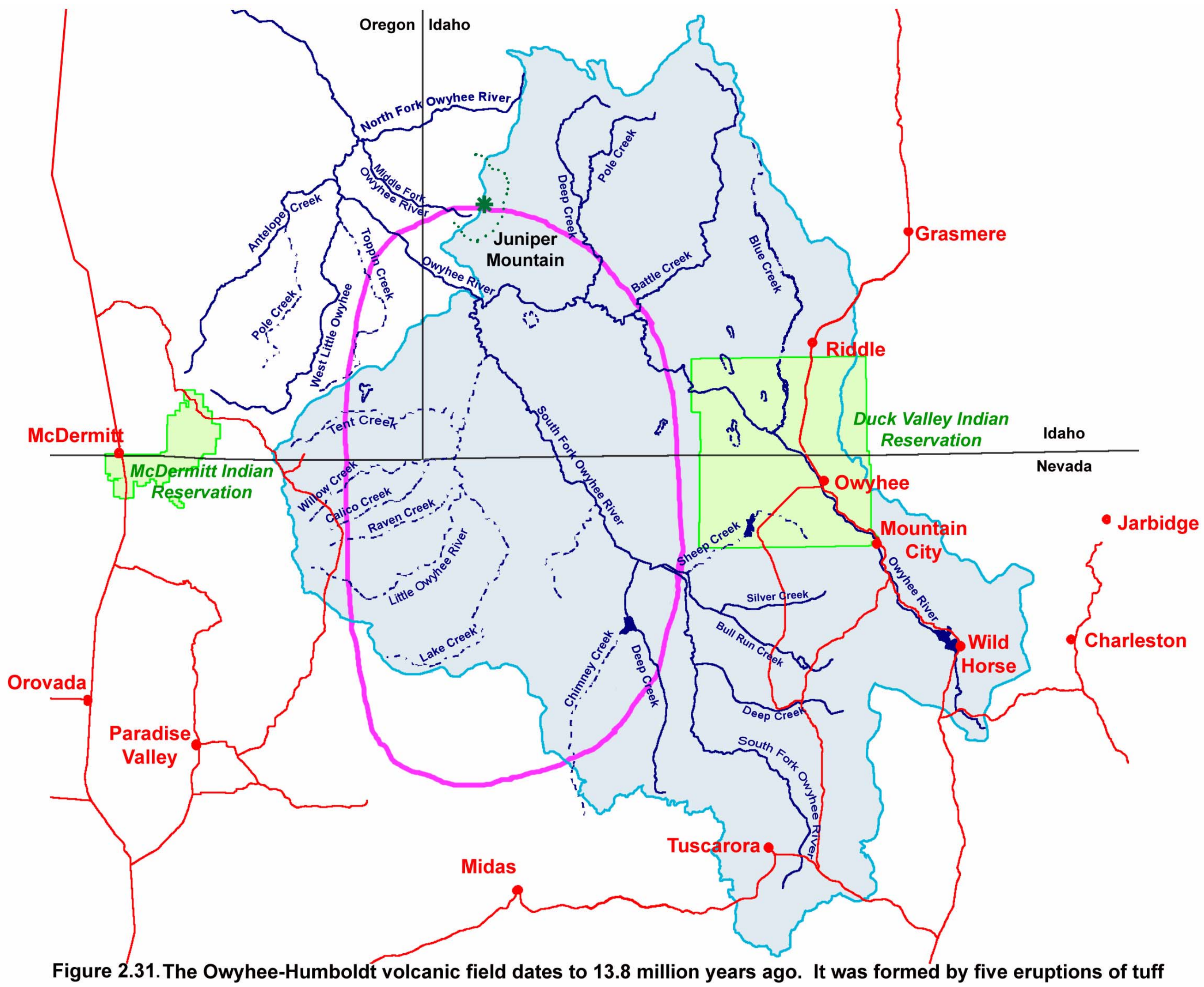

Figure 2.31. The Owyhee-Humboldt volcanic field dates to 13.8 million years ago. It was formed by five eruptions of tuff and lava from Juniper Mountain, including the "Swisher Mountain tuff". The hotspot that was responsible for this volcanism is now under Yellowstone National Park.[59,60,63]

The Little Jacks Creek eruptive center was the source of other rhyolitic tuffs of large proportions.[38] The point source of the Little Jacks Creek eruptive center is inferred to be to the east of Owyhee plateau.[38] In respect to the upper Owyhee subbasin, this tuff is found only to the northeast of the Owyhee River.[38] The cause of this volcanism could have been a continuation of the Yellowstone hot spot; however, the two available dates for the flows, from dating in the 1970s, do not corroborate this source.[38,60]

Basalt lava flows of a more recent origin cap (cover) the tuff and rhyolite of the Owyhee-Humboldt volcanic field in some areas.[54,73] Called the Banbury Basalt, the uppermost basalts come from many sources and have many dates.[12,39] Dates between 10 and 8 million years ago are suggested by Ekren.[12] Foord et al. suggest the dates may be more recent between 10 and 6 million years ago.[39] These basalt flows are probably related to Great Basin spreading as the flows are very thin and consist entirely of basalt.[66] Basalt flows of dark hues, with distinctive columnar jointing, cap portions of the upper Owyhee subbasin. Source locations have been suggested along faults for some of these basalt flows, but the origin of all is not known.[12]

Subsequent to the period of volcanism, large lakes formed in many of the basins in Nevada, Oregon and Idaho because warmer climatic conditions with higher rainfall prevailed. Alluvial sediments accumulated in the lake basins and along the stream courses feeding the lakes.[118] It is probable that a lake formed in the basin between modern day Tuscarora and the Independence Mountains. Other lakes may have formed in Idaho along Deep Creek and south of the Owyhee River just east of the Duck Valley Indian Reservation. In both locations the geological material closest to the surface is stream and lake sediments.[54] Fossil finds in Spring Creek Basin suggest that it also may have hosted a lake.[73] Eventually river downcutting connected the lake basins and drained the lakes.

Subsequent to the warm and humid periods that developed lakes, glaciation occurred on the north side of McAfee and Jack Peaks in the Independence Mountains. Remnants of the glaciation are evident today from u-shaped valleys and glacial moraines.

### *c. How did the Owyhee-Humboldt field volcanism begin?*

The Snake River plain is a huge, wide arc of sagebrush-steppe and present day croplands running from the Oregon-Idaho border to central Idaho where the valley continues to the Yellowstone National Park. It is commonly considered that the movement of the Yellowstone "hot spot" caused the creation of this wide valley. Hot spots are deep, hot locations on the earth that always produce volcanoes as the crust moves across them, like the Hawaiian islands. The Yellowstone hot spot was responsible for the valley created in central and eastern Idaho, but the hot spot missed the Treasure Valley northwest of Boise. The Yellowstone hot spot actually followed a straight course out of somewhere in southeastern Oregon or southwestern Idaho (Figure 2.32).[6,12,60,63]

Geologists debate how the Yellowstone hot spot began in southeastern Oregon or southwestern Idaho. Some credit the volcanism to a slab of the earth's crust that broke off as it was being pushed under the North American plate.[16,51,86] It has also been

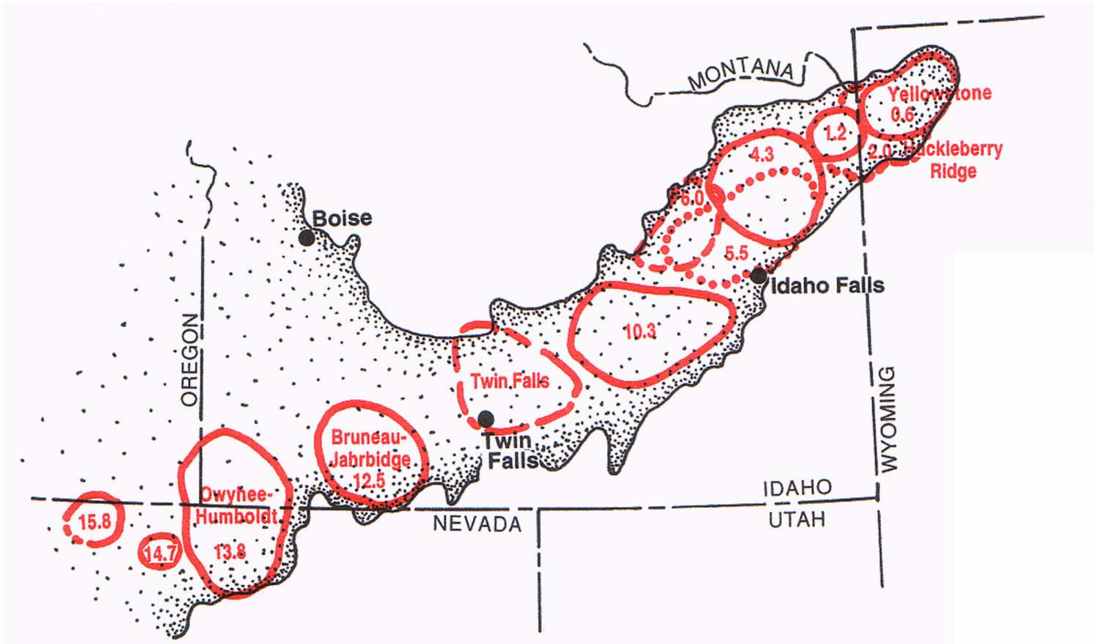


**Figure 2.32. Volcanic fields across Idaho mark the movement of the Yellowstone hot spot from its origin at the Idaho, Oregon, Nevada border to its current location in Wyoming.**
**(adapted from 6:270)**

suggested that faulting stretched the crustal sediments in southeastern Oregon thin, allowing for an outpouring of lava.[12,63] And yet others hypothesize the volcanism starting with a meteor impact.[4,5,6] Regardless of the origin of the Yellowstone hotspot, authors agree that volcanic activity began 17 to 18 million years ago and radiated from the Owyhee uplands both east and west. Volcanism, starting at the McDermitt caldera, just west of the upper Owyhee subbasin, followed the Yellowstone hot spot to the east (Figure 2.32).[6,63] And to the west, volcanic calderas spread from Malheur County west across the High Lava Plains to Newberry crater in central Oregon, the most recent caldera eruption (1.7 million years ago).[60,67]

## 3. Upper Owyhee subbasin geological features

### *a. Tuscarora volcanic field*

Dating to between 39.9 and 39.3 million years ago the Tuscarora volcanic field was contemporaneous to the subduction of the Farallon plate and early extension in the region (Figure 2.33).[49] There are many volcanic episodes and rocks that make up the Tuscarora volcanic field. These include a caldera and the hydrothermal systems that hosted gold and silver deposits.

#### *i. Big Cottonwood Canyon caldera*

Calderas form when volcanoes collapse after massive eruptions. Crater Lake in Oregon is a very visible volcanic caldera. A massive explosion of ash and lava left a large empty space inside the volcano and its exterior layer collapsed into a basin. At

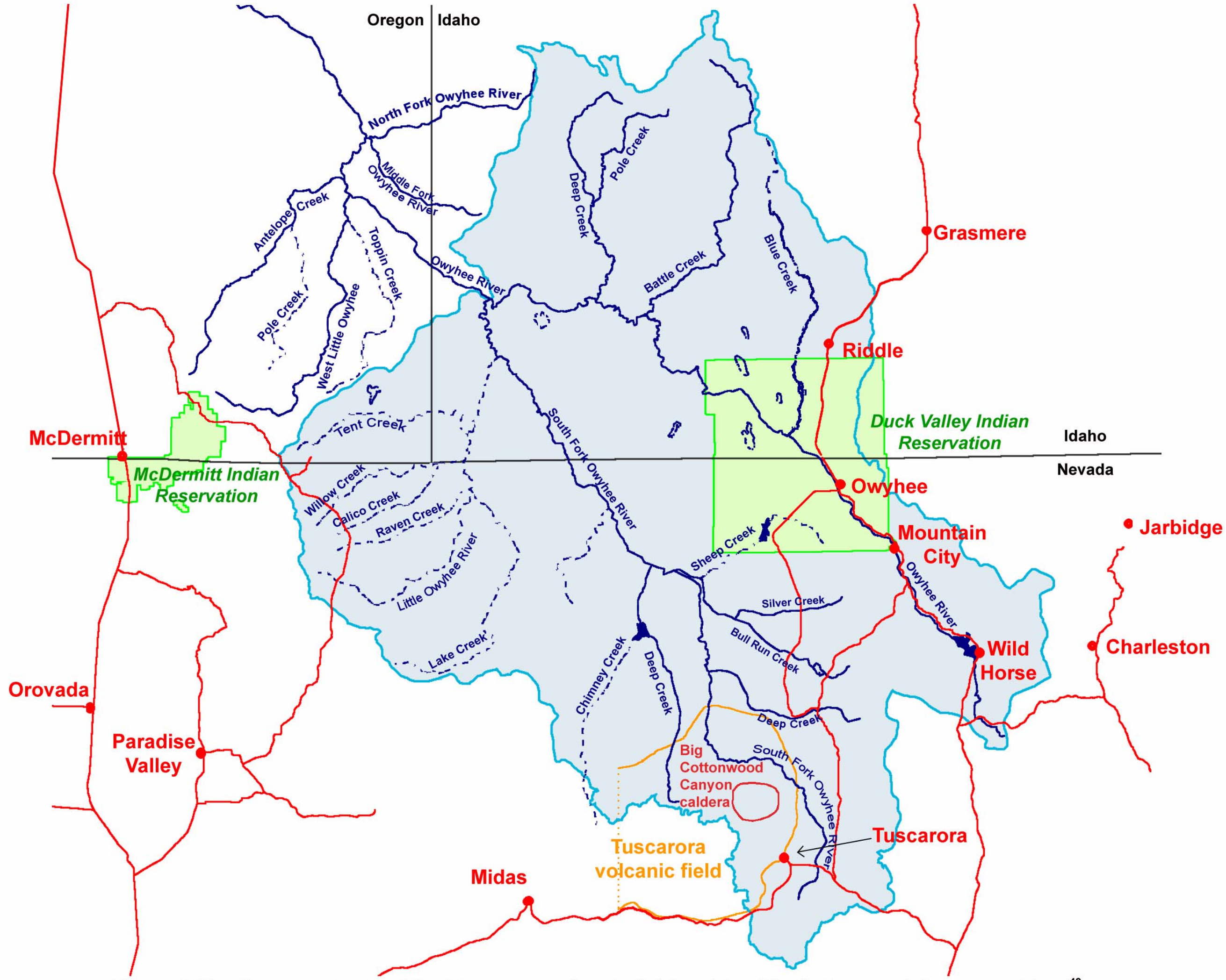


**Figure 2.33. Known extents of the Tuscarora volcanic field and the Big Cottonwood Canyon caldera.**[49]

Crater lake this basin has since been filled with water.[74] The key for geologists to find a caldera is to locate a rim where the surface material has fallen back into a basin. The Big Cottonwood Canyon caldera is not as obvious as the Crater Lake caldera because it didn't create as large of a basin and parts have since been covered by other material. The caldera is at least 15 kilometers (9 miles) east-west, but the other dimensions are unknown (Figure 2.33).[49] The Big Cottonwood Canyon caldera produced massive rhyolitic ash flow tuff, some of which escaped through failures in the caldera wall and some of which remained, filling the majority of the basin. Tuff flow is encountered 35 kilometers to the southwest of the caldera indicating that the flows were extensive, but the tuff is generally covered by more recent rock so there is no mapping of its extent.[49]

### *ii. Mount Blitzen volcanic center*

Slightly older than the adjacent Big Cottonwood Canyon caldera, the Mount Blitzen volcanic center also produced impressive amounts of tuff (Figure 2.34). The tuff at Mount Blitzen is at least one kilometer thick.[49] The exact nature of the volcanism (vents, volcano or caldera) is unknown. However, the volcanic center was bounded by

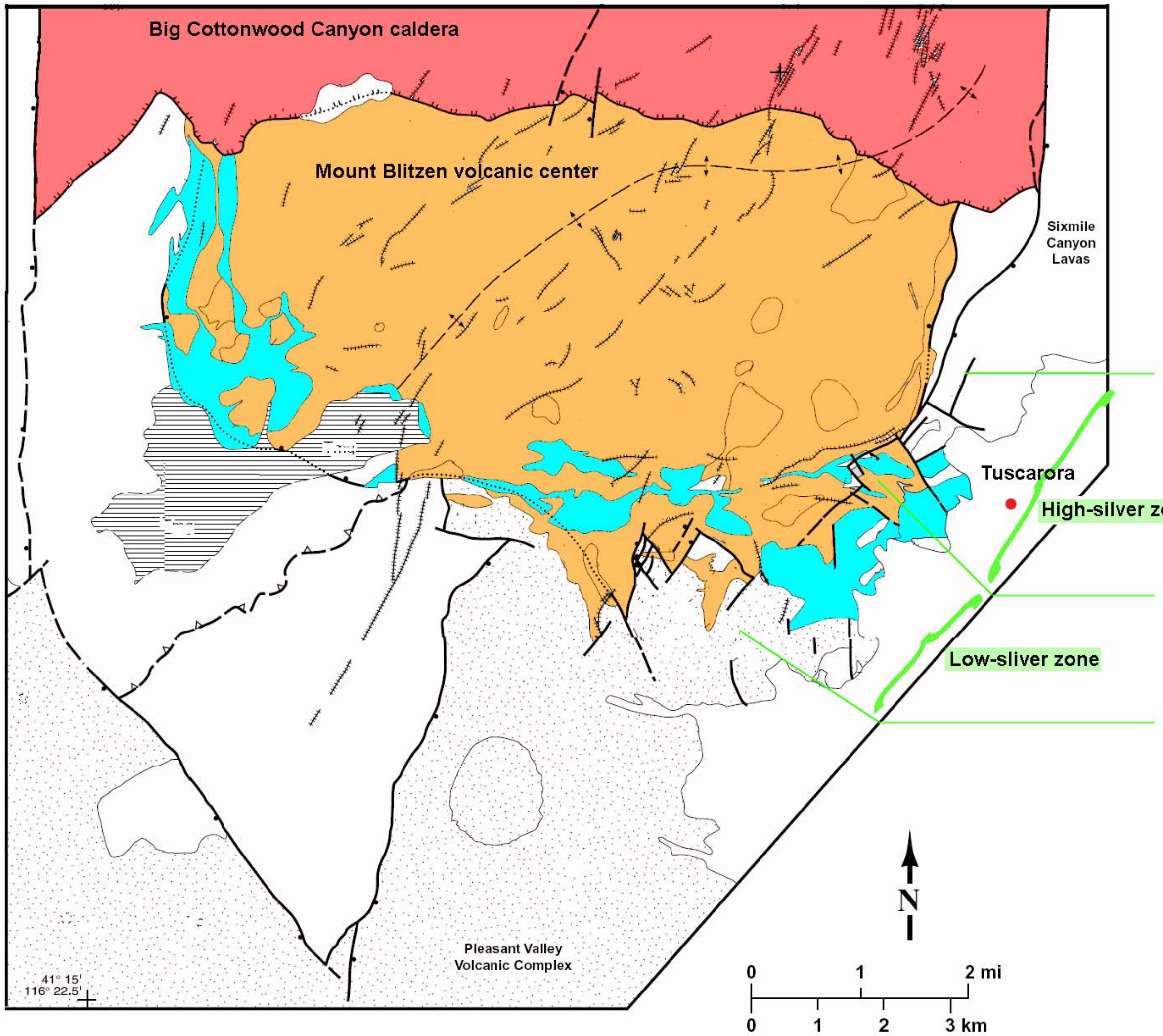


**Figure 2.34.** Major surface geological features around Tuscarora and approximate location of the two silver zones. Collapse of the Mount Blitzen volcanic center left many faults around its edges, now occupied by lavas (Mount Neva dactite) shown here in blue. Prior to filling with lava, the faults served as passageways for hot-spring fluids which deposited precious metals in the vicinity of Tuscarora. Ores are found in two zones, a high-silver and low silver zone. (Adapted from 49:Figure 2)

faults on the southeast. It was along these faults that hydrothermal activity and magma dikes intruded, leaving the vein deposits of precious metals in the Tuscarora district. The deposits which host the precious metals are Pleasant Valley complex tuff and Mount Neva dacite (Figure 2.34).[49]

### *b. Hot Sulphur Springs*

Hot Sulphur Springs is the hottest of the hot springs in the upper Owyhee subbasin. It is located at the northern end of Independence Valley. The spring temperature was reported to be 194°F and an estimate of 262°F was made for the hot springs reservoir water below the earth's surface.[41] The hot springs currently discharge 1000 gallons per minute of water into Hot Creek.[46]

Hot springs are a renewable energy source and can be used to generate electricity. In the 1970s, AMAX Exploration, Inc drilled holes prospecting for geothermal energy sources in the area of Hot Sulphur Springs. The shallow holes did not produce appropriate fluids. One deep, 5,400-foot, hole encountered suitable hot water under pressure but the well bore collapsed during drilling.[46] No electrical plant was built.

According to the State of Nevada, in March 2003 "Earth Power Resources was awarded a power purchase contract from Sierra Pacific for a 25 MW binary plant."[34] An area of approximately 12 square miles had been leased in Hot Sulphur Springs area for the production of geothermal power. Although Earth Power Resources had begun to explore the area and drill wells,[46] there seems to be no current activity. The plans for the plant called for the drilling of four production wells from which fluid at high temperatures (330°F) from 2500 foot depth would be pumped, fluid used to generate electricity, and the cooled fluid reintroduced into the geothermal system in other wells.[46] However, TG Power currently has permits issued in 2006, 2007, and 2008 for drilling at Hot Sulfur Springs.

### *c. Capitol Peak*

Situated on the western edge of the upper Owyhee subbasin, Capitol peak is part of the Calico Mountains. These mountains in turn form part of the Santa Rosa-Calico volcanic field.[21] This volcanic field lies principally outside of the subbasin to the west. It was active prior to the Owyhee-Humboldt volcanic field, from 16.5 to 14 million years ago. The Calico Mountains are covered with silica rich volcanic materials, predominately andesite, dacite, and tuff. Dacite is like andesite but with more iron. The amount of volcanic material in this area is impressive as can be seen from a geological section drawn from the central Calico Mountains just north of Capitol Peak (Figure 2.35).[21] At this location there are approximately 390 meters (1280 feet) of volcanic rocks from the eruptions at this volcanic field. In addition to the covering of volcanic rocks, at least one volcanic vent and two sets of dikes lie within the upper Owyhee subbasin near Capitol peak.[21] It is unknown how far the eruptive lavas and ash from the Capitol Peak area spread into the subbasin.

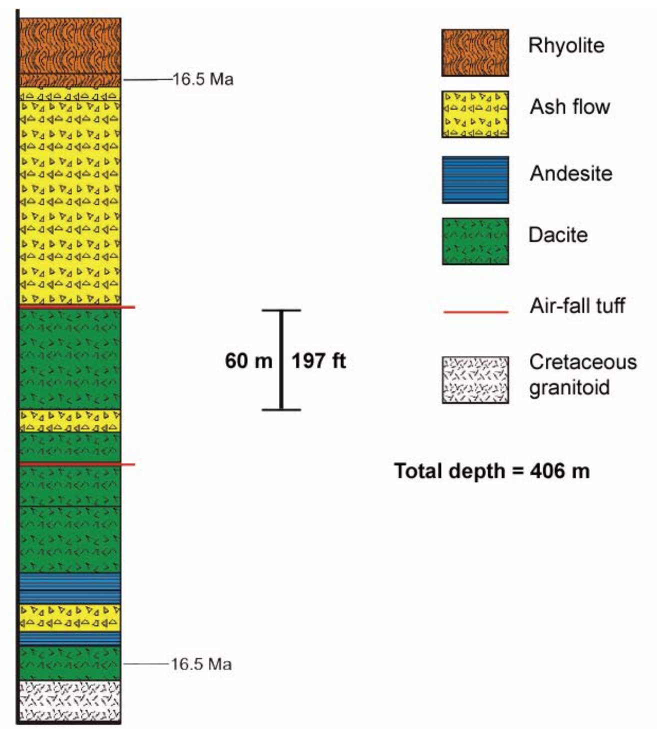


**Figure 2.35. Geological section depicting rocks from the Calico Mountains just north of Capitol Peak. The volcanic rocks are from the Santa Rosa-Calico volcanic field which dates to 16.5 million years ago.**
**(Adapted from 21:Figure 13)**

### *d. Canyon walls*

**Photo 2.6. Canyon walls of the east fork of the Owyhee River.**

The impressive volcanic geology of the upper Owyhee subbasin is on show in the various canyons created by the Owyhee River and its numerous tributaries. In discussing the 45 Ranch Allotment in Idaho, Murphy and Rust wrote that the "Tuff of Swisher Mountain is the most common rock exposed along the 50 to 200 m (160 to 650 feet) deep inner gorges of the South Fork, Main Fork, and Little Owyhee rivers (Ekren et al. 1981). It weathers characteristically into striking reddish-brown colored, vertical canyon walls and picturesque pinnacles, hoodoos, spires, and monoliths (Ekren et al. 1982). The walls drop straight into the rivers or may have a talus toe-slope composed of platy stones."[73:3] In some locations these abrupt canyon walls are offset by one or more shallow basalt flows in a striking almost black creating a second wall. As the basalt breaks apart more easily along its columnar joints it is often eroded farther back from the river with a talus slope separating the basalt cliffs from those of the tuff below.[73]

## 4. Geologic maps of the subbasin

**Photo 2.7. Copper ore debris from the Rio Tinto mine in the upper Owyhee subbasin. This photograph is not typical since almost all the copper ore mined was processed.**

Geological maps give a general picture of the type and age of rocks that can be found in an area. Geological maps are often used in environmental and hydrological planning and as guides to the general types of industrial materials that can be found in an area. Examples of industrial materials are rocks good for gravel and granite for making counter tops. General geological maps exist for all of the upper Owyhee subbasin.[32,66,69] The creation of local, specific geological maps is ongoing.

## 5. Minerals and mining

The distinct division of the upper Owyhee subbasin into the Basin and Range and Owyhee Plateau geological provinces is evident in the location of minerals. Valuable minerals have been found hosted in rocks of Basin and Range origin and the Tuscarora volcanic field. Economically significant mineral deposits are more rarely found in the volcanic rocks of the Owyhee Plateau.

The great geological diversity of rocks from the Basin and Range deposits is reflected in the diversity of mineral deposits. Metals, such as gold, silver, zinc and copper (Photo 2.7), are the most prominent of the minerals that have been mined in the area due to their great value. Other minerals have been mined but in lesser quantities and with less fanfare. These include antimony, arsenic, tungsten and uranium. The location of mineral deposits and the mining histories of some of these locations are discussed below.

The formation of mineral deposits within the upper Owyhee subbasin is poorly understood. Complicating the understanding of deposits is that in one mountain an ore may be found in a given rock and in another mountain it will occur within a different rock layer and possibly in a different format (vein vs. nodule for example). Some of the more studied mineral formations are discussed below.

### ***a. Mineral and rock deposits with economic or scientific value***

#### *i. Gold*

Gold has been found across the western US. Gold fever and boom-to-bust cities form part of the early history of Oregon, Idaho and Nevada, but there continue to be discoveries and new claims to this day.

**Photo 2.8. Quartz near Lime Mountain in the upper Owyhee subbasin.**

Gold occurs in many types of geological deposits.[9,45] Gold veins are generally in metamorphic rocks where the gold has accumulated in conjunction with quartz following the intense heating of the rock (Photo 2.8). Placer gold is found in alluvial sediments where gold has eroded out of the rock it was originally in and settled out of the running water along with other heavy metals. Thirdly, gold can be concentrated and deposited by chemical interactions at hot springs around volcanically active areas.[91] This gold may be concentrated in veins or disseminated through large quantities of rock.

#### *ii. Turquoise*

Turquoise is one of the preferred jewelry stones. Turquoise is found in various regions of the Basin and Range province. The area around Cortez, Nevada, known as the bullion district, was rich in turquoise. As turquoise from the surface had been collected by Native Americans, it took American prospectors longer to find some of the locations of this stone.[72] Turquoise is found in nodules, veinlets and seams. The stone can be pure, a solid blue, or spider web, with black impurities.

*iii. Fossils*

"Fossils are the mineralized or otherwise preserved remains or traces (such as footprints) of animals, plants, and other organisms."[40] "Fossilization is actually a rare occurrence because most components of formerly-living things tend to decompose relatively quickly following death. In order for an organism to be fossilized, the remains normally need to be covered by sediment as soon as possible."[40] Fossilized remains of plants and animals can tell us about the type of environments that existed in the past and the changes the environments have undergone.[16] Few fossils have been reported from the upper Owyhee subbasin.

*iv. Lapidary (jewelry) stones*

Jasper, thundereggs, and petrified wood are all used in the creation of non-precious jewelry due to their fine crystalline structure. This means that they can be polished as attractive surfaces. "A thunderegg is a type of rock similar to a geode but formed in a rhyolitic lava flow and found only in areas of volcanic activity. Thundereggs are rough spheres, most about as big as a baseball. They look uninteresting on the outside, but slicing them in half may reveal highly attractive patterns and colors valuable in jewelry."[107] The thunderegg starts as a cavity in the rock where over time the passage of water allows for the deposition of minerals as crystals.[43] "The size of the crystals, including their form and shade of color, vary – making each geode unique. Some are clear as quartz crystals, and others have rich purple amethyst crystals. Still others may contain agate, chalcedony, or jasper. There is no way of telling what the inside of a geode holds until it is cut open or broken apart."[43]

*v. Mercury*

Mercury is a commercially valuable metal that is used in batteries, paints and electrical devices.[123] Mercury deposits are formed at shallow depths and at temperatures of 50°C to 200°C (120°F to 400°F). Mercury generally fills in pores and fissures where it was carried by heated water. Mercury is often found in association with uranium and pyrite and nearby hot spring deposits of gold and silver.[98,123]

"Elevated concentrations of mercury in surface water can be derived from many sources, including natural processes and anthropogenic (related to humans) losses. Natural processes include volcanic and atmospheric deposition, degassing, and surface runoff and erosion of mercuric soils. Anthropogenic sources include mercury mining and processing, energy related activities, legacy pesticide application, chloro-alkali operations and small emissions from other industrial processes."[2:1] These other industrial processes include the mercury amalgamation methods used in gold and silver mining prior to the modern cyanide process. Geothermal activity can contribute to the concentration of mercury, so it is often found in regions of current activity or in rocks which developed under geothermal conditions.

*vi. Uranium*

The most frequently occurring minerals containing uranium are uraninite and coffinite. These minerals form in igneous rocks such as granite and in hydrothermal vents. Uranium is a naturally radioactive element. Radioactive elements are those which naturally break down over time into other elements. Uranium has three isotopic states, U238, U235, and U234, all of which are radioactive. Since U238 takes the longest to decay, it makes up 99.2 percent of all uranium naturally found.[42]

Uranium can be used in energy production, both within nuclear reactors and in nuclear bombs, when the element is artificially induced to break down. Uranium in the isotopic state of U235 can be broken apart to create energy; however, this isotope is rare making up only 0.71 percent of uranium.[42] Prospectors seek geologically recent uranium deposits that have higher concentrations of U235. The radioactivity of U238 can be used for energy production if the uranium is transformed into radioactive plutonium (Pu239). This is accomplished by bombarding the uranium with neutrons.[42]

***b. Mining districts in the upper Owyhee subbasin***

Mining districts are important to the discussion of geology because they are designated based on the location where a mineral was found. As such the location where a mineral has been found is likely coincident with geological formations containing that mineral. The Nevada mining districts outline some of the different geological areas of the Basin and Range. Most of the mining within the upper Owyhee subbasin is historic in nature. There is only one currently operating metal mine in the upper Owyhee subbasin. There are no operating industrial mineral mines.[29,36]

Mining districts were a California creation of miners to fill the power vacuum left by a lack of local government following the purchase of the territory from Mexico. Organized mining districts made rules for the establishment, marking and working of claims.[108] However, the districts also indicate the presence of the types of rocks within which the mineral was found.

In Nevada (then the Utah territory) mining districts spread out from the Comstock after 1859. While legislation by the federal government regarding mining lands was passed in 1866, Nevada left open the possibility for the establishment of new mining districts. Four of the eleven mining districts within the upper Owyhee subbasin were organized, meaning that the miners met and could set rules for activities within their area (Appendix B).[108] Originally mining districts were only established for areas where metals were extracted. The current usage of the term includes mining districts where industrial minerals (nonmetals) are found. Mining districts have changed names many times with newly prominent mines, the development of new claims, and the merging of adjoining districts. For example, "In the Independence Mountains of northern Elko County, the old Burns Basin district, surrounding some small antimony prospects, has been engulfed by the huge Independence Mountains district that includes extensive disseminated gold deposits developed there."[108:8]

There are eleven Nevada mining districts in the upper Owyhee subbasin (Figure 2.36). The best known mineral commodities are silver and gold; however, many other minerals have been found and are commercially important. The frequently and infrequently occurring mineral commodities are shown in Tables 2.10 and 2.11 by the districts from which they have been extracted.

Table 2.10. Frequently occurring mineral commodities found in the mining districts in the upper Owyhee subbasin.[64,108]

| Mining District | Gold | Silver | Copper | Lead | Zinc | Antimony | Arsenic |
|---|---|---|---|---|---|---|---|
| Aura | x | x | x | x | x | x | |
| Burner | | x | | x | x | | x |
| Cornucopia | x | x | x | x | | x | |
| Divide | x | x | | | | x | |
| Edgemont | x | x | x | x | x | | x |
| Good Hope | x | x | | | | x | x |
| Independence Mountains | x | x | | | | x | |
| Island Mountain | x | x | x | x | x | x | x |
| Lime Mountain | x | x | x | | | | |
| Mountain City | x | x | x | x | x | x | x |
| Tuscarora | x | x | x | x | | | x |

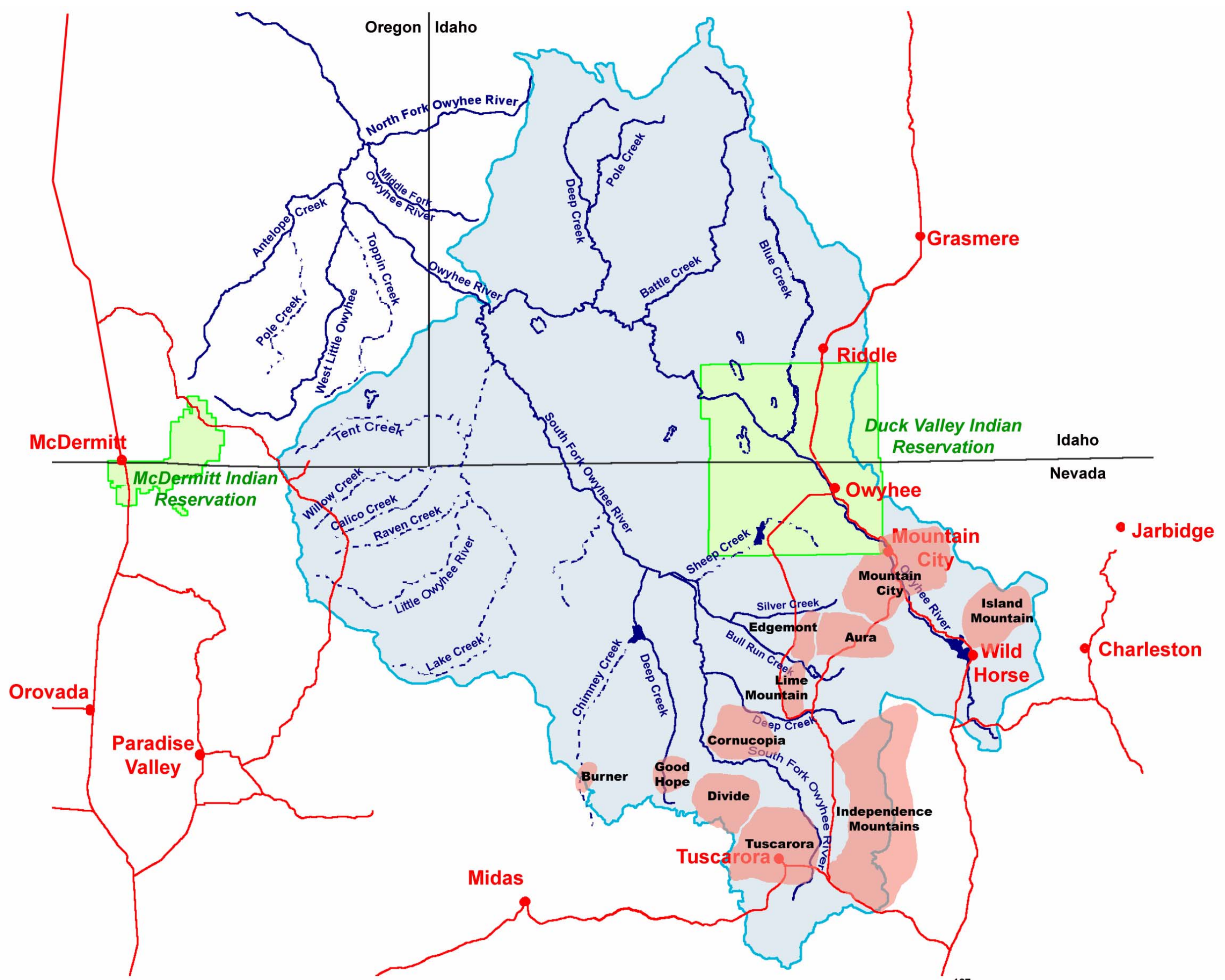


Figure 2.36. Current Nevada mining districts in the upper Owyhee subbasin.[127]

Table 2.11. Infrequently occurring mineral commodities found in the mining districts in the upper Owyhee subbasin.[64,108]

| Mining District | Tungsten | Uranium | Molybdenum | Mercury | Barite | Titanium |
|---|---|---|---|---|---|---|
| Aura | | | | | | |
| Burner | | | | | | |
| Cornucopia | | | | | | |
| Divide | | | | | | |
| Edgemont | x | x | x | | | |
| Good Hope | | | | | | |
| Independence Mountains | | | | x | x | x |
| Island Mountain | x | x | | | x | |
| Lime Mountain | | | | | | |
| Mountain City | x | x | x | | | |
| Tuscarora | | | | x | | |

### *i. Aura and Edgemont mining districts*

The Aura and Edgemont mining districts are located in an area where the rocks are old.[13,98] These are some of the rocks that were around in the Precambrian and as such are a mix of older rocks that have undergone various transformations. Since the area is a mix, it is difficult for geologists to interpret. The basic sequence of events began with sedimentary rocks, including limestone, sandstone, and dolomite that were partially metamorphized. In areas these sedimentary rocks were transformed into shale and siltstone, but in other areas they remain in their original form. Subsequent volcanism and principally the creation of granitic dikes at depth within the earth's crust formed veins of quartz and quartize that contain gold and silver deposits.[13] Called polymetallic veins, the veins include many other metals with lead, zinc and copper being the most common.[98] At some point these rocks were also deformed, crinkled into waves, and faulted. Deformation and faulting acted on the veins as well as the surrounding rock. As found by miners, the veins varied in size between one and seven feet in diameter but were hard to follow because deformation and faulting made them end and move abruptly.[13] The major distinction between the two districts is that veins of the Aura district were rich in silver while those of the Edgemont district were rich in gold and were discovered almost thirty years later.[13] Mines that exploited polymetallic veins included the California, Humboldt, and Columbia mines in the Aura district and Bull Run and Lucky Girl mines in the Edgemont district (Figure 2.37).[98]

### *ii. Tuscarora mining district*

The Tuscarora mining district is characterized by hydrothermal metal deposits. Specifically the deposits are epithermal, or hot spring, deposits. Epithermal deposits are those where deposition occurred at shallow depths, the pressures were low and the temperatures of deposition were between 150 and 300° Celsius (302 to 572° Fahrenheit).[53] The formation temperature for most gold and silver bearing epithermal deposits is 250° Celsius.[93]

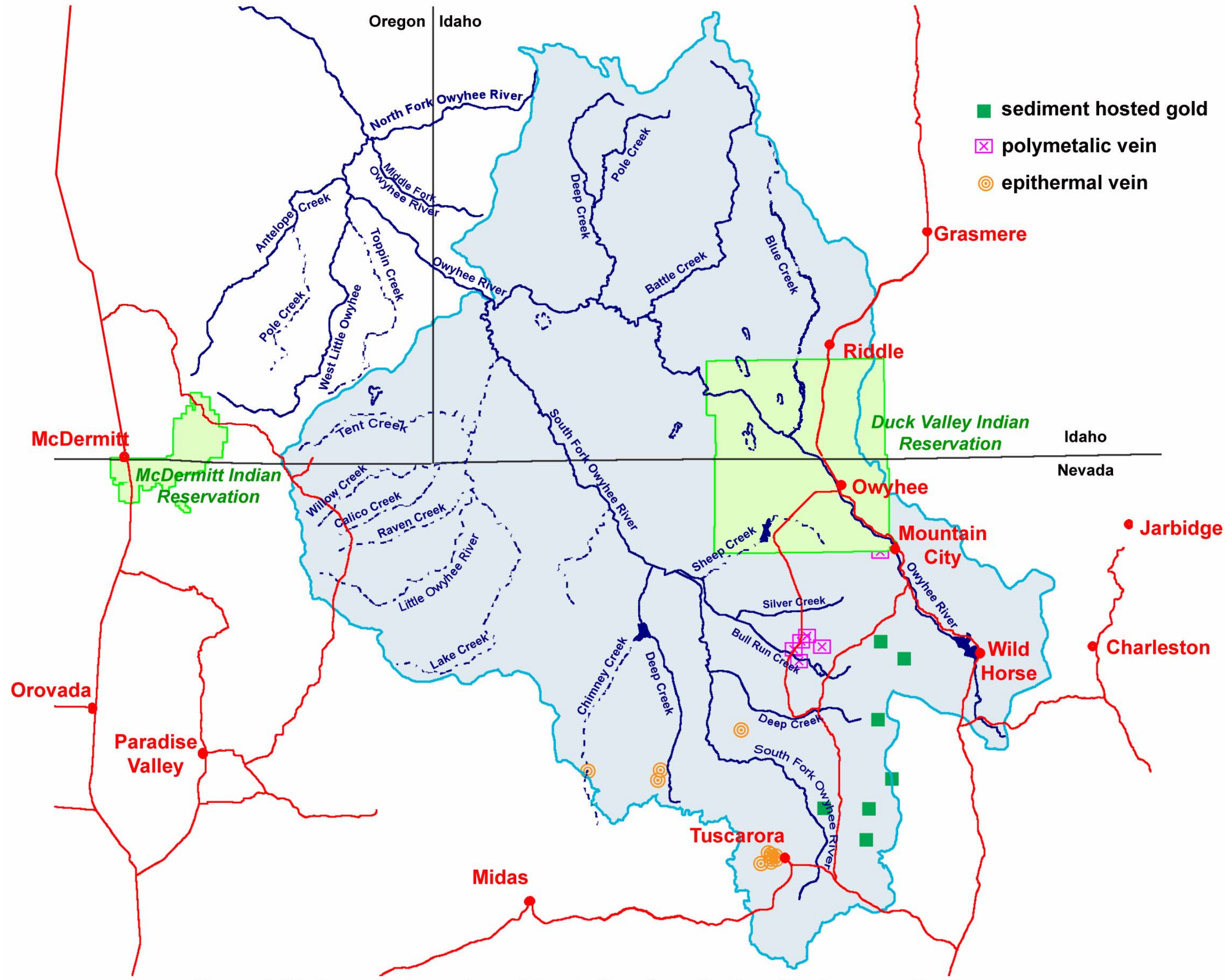


**Figure 2.37. Some of the major gold and silver deposits found in the upper Owyhee. Notice the different distribution for each type of deposit.**[69,98]

The Tuscarora mining district lies along and just outside the southeastern margin of the Mount Blitzen volcanic center . . . Veins in part occupy faults that make up the boundary of the Mount Blitzen center. Mineralization was contemporaneous with the Mount Neva intrusive episode; those intrusions were likely the heat source for hydrothermal circulation."[49:14-15] The district can be divided into two areas, a low-silver zone to the south and a high-silver zone to the north (Figure 2.34). The gold content of the two is very similar. "Median gold content in samples from the low-silver zone is 0.232 ppm versus 0.341 ppm in the high-silver zone."[49:15] The mineralization could be from one system with different types of deposition; however, some differences in composition suggest that the zones could have been separate hydrothermal alterations. Regardless, the age of mineralization in the two zones is not distinguishable.[49] Geochemical analysis also shows that the deposits in both areas are enriched in arsenic and antimony and slightly enriched in mercury and thallium.[49]

"The Tuscarora [high] silver zone is an area of about 1,200 by 1,500 m [3900 by 4900 ft] centered about 500 m [1640 ft] northwest of Tuscarora."[49:17] Here the median ratio of silver to gold is 110:1. Most of the mines in this zone are flooded and the surface accesses have caved in. Two of the major vein systems were the Navaho lode and the Grand Prize mine area. "The Grand Prize bonanza was discovered in 1876, and the Grand Prize mine operated until 1891, yielding about $2.6 million, the largest recorded production in the high-silver zone. On the basis of descriptions . . . the Grand Prize vein was about 2 m wide."[49:18]

"Mines and prospects in the low-silver zone are widely scattered over an area about 1,500 by 3,000 m that extends from the town of Tuscarora southwest to Battle Mountain and Beard Hill."[49:15] In the low-silver zone the median ratio of silver to gold is 14:1. "The Dexter Mine was the most productive property in the low-silver zone. Estimated historical production (1897-1935) was about 40,000 oz gold and 100,000 oz silver, and modern production (1987-1990) was about 34,000 oz gold and 185,000 oz silver."[49:16]

Aside from silver and gold, "very small amounts of mercury were produced from cinnabar-native mercury-pyrite veins in lavas of Sixmile Canyon at the Red Bird Mine about 1 km northwest of the high-silver zone."[49:19]

Future potential for mineral exploration in the district has been discussed. "Of the two styles of mineralization that took place in the district, the low-silver zone is considered to have the best potential for hosting unexploited mineralization. This conclusion is based on: 1) larger areas affected by this type of mineralization; 2) relatively low Ag/Au ratios and low base metal contents of productive vein and disseminated gold deposits elsewhere (e.g., Sleeper and Round Mountain, respectively); and 3) the presence of altered rocks and mineralized structures that project under pediment gravel along the southern and eastern borders of the district. By comparison, vein deposits in the high-silver zone, although of very high grade, are considerably smaller and more difficult to find."[49:19]

*iii. Independence Mountains*

The Independence Mountains mining district was known for antimony, but later gold was discovered. "Prospectors explored for antimony in the 1910s. Thirty to forty tons of stibnite as antimony ore were reportedly mined and shipped from the Burns Basin mine in the Jerritt Canyon district between 1918 and 1945. In the early 1970s there was a renewed interest in antimony exploration when its price reached historic highs of $40 per pound. Around 1971, FMC began exploring for antimony in the Independence Mountains. In 1972, FMC, later known as Meridian, discovered a disseminated gold deposit in the Jerritt Canyon area."[102:4-1]

The Independence Mountains have disseminated epithermal deposits. "The term 'disseminated' is now commonly applied to gold deposits in which very fine-grained gold is dispersed through a relatively large volume of rock. Deposits are amenable to bulk-mining methods, allowing profitable extraction from relatively low-grade ores."[9:11]

The Nevada 2007 report of mining showed one active mine in the upper Owyhee subbasin, the Jerritt Canyon mine with headquarters in Elko, NV. This mine operates within the Independence Mountain mining district. In 2007 the mine produced 121,708 ounces of gold and 17,560 ounces of silver and employed 357 people.[36] "The Jerritt Canyon deposits are typical of the Carlin-type deposit of micron to submicron-sized gold particles hosted primarily by . . . Paleozoic calcareous and sulfidic sedimentary rocks."[124] In other words, the gold is in particles so small that it can't be seen by the naked eye and it is found within the Precambrian rocks. The rocks must be crushed to a very find dust in order to extract the gold.[102,124] At Jerritt Canyon, "open pit mining occurred between 1981 and 1999. Portal-accessed, underground mining commenced in 1993 . . . Since mining began, Jerritt Canyon has produced over 8 million ounces of gold."[124]

The Jerritt Canyon mine was closed for parts of 2008 and 2009 by order of the Nevada Division of Environmental Protection (NDEP). The closure followed violations issued “for failure to properly maintain process equipment and air pollution control systems.”[130] The reopening of the mine followed a consent decree by NDEP that “requires extensive operational monitoring of process and emissions controls, including monthly mercury emissions testing to ensure the systems are operating as designed. The decree also requires continued improvements of fluids management systems, implementation of environmental audits and compliance plans for air quality, and the addition of emissions controls on supporting process equipment.”'[130] Jerritt Canyon operated for only 130 days in 2009 with a production of 9,700 oz of gold.[131,132] Employment was also affected by the partial closure as in 2009 there were 120 employees.[131] As of publication of this assessment, these are the most current economic statistics for the mine.

While the gold in the Independence Mountains is found within Precambrian rocks, the gold is not that old. Gold was transported into the rocks. "The origin of Carlin-type deposits, especially in the Carlin Trend and Independence mountains is controversial, but recent work shows that many formed in the Eocene, contemporaneously with extensive Eocene igneous activity."[49:1] These deposits date to between 42 and 36 million years ago (remember that the activity at the Tuscarora volcanic center occurred during the same time, dating to 39 million years ago).[9,24,49] Hydrothermal activity, in this case hot fluids carrying gold, entered into the existing sedimentary rocks through the pores in the rocks. This hydrothermal activity altered these underground sedimentary rocks by replacing calcium carbonate or other soluble minerals with quartz and by filling pore space in the rocks with quartz.[9,24] This quartz is host to pyrite and small amounts of gold. Locations of other disseminated gold deposits are poorly known, and may bear many metals besides gold.[9,24]

### ***c. Mineral data on the upper Owyhee subbasin***

#### *i. Gold and silver*

Three major types of deposits host the gold and silver found within the upper Owyhee subbasin: polymetallic veins, epithermal veins, and disseminated epithermal. Polymetallic veins are found in the Aura and Edgemont districts, epithermal vein deposits are found in the Tuscarora mining district and disseminated epithermal metal deposits are found in the Independence Mountain district. Each of these districts is discussed in more detail above.

The upper Owyhee subbasin produced substantial amounts of gold and silver. A conservative estimate for gold production prior to 1976 in the Tuscarora mining district was over 100,000 ounces of gold. Other mining districts within the upper Owyhee subbasin that produced between 10,000 and 100,000 ounces of gold prior to 1976, were Mountain City, Aura, Edgemont, and Cornucopia.[20] At that time the largest area in terms of production was the Tuscarora district.

Historical mining activities took greatest advantage of gold and silver occurring in vein deposits, in part because of the ease of mining vein ores. The only current production of gold and silver is within disseminated deposits of the Independence Mountains.[36] The potential for future gold and silver mining is greatest in disseminated deposits such as those of the Independence Mountains or in smaller, dispersed vein deposits such as the low-silver area of the Tuscarora mining district. In either case the mining efforts would require large-scale processing of rock to extract metals which occur in small quantities per ton of rock.

*ii. Oil and Gas*

Much of Nevada has been explored for oil and gas. The rock formations that generally contain oil and gas deposits are old Precambrian sedimentary or metamorphic rocks. The upper Owyhee subbasin has not produced any commercial wells.

Oil and gas drilling records for Elko County between 1906 and 1953 show that one well hole was drilled in the upper Owyhee subbasin. George Gilmore of Tuscarora drilled a hole on the western front of the Bull Run Mountains in 1922. The well reached a depth of 800 ft. and had a show of gas from one layer of sedimentary rock.[13,65] No oil or gas prospecting is recorded for the Idaho portion of the upper Owyhee subbasin; however, records are spotty for drilling prior to 1963.[125]

Since 1953 three additional wells have been drilled within the upper Owyhee subbasin.[50] A 1957 well explored the Precambrian formation near the 1922 drilling. The hole had some oil show, but is considered dry.[13,50] The Ellison No. 1 hole was drilled in the center of Independence Valley in 1977, reaching a depth of 4,460 feet. It also had a show of oil but is dry. The Ellison No. 1 drill hole is now used as a water well.[50] The third hole, Four Mile Butte Federal No. 1 hole, drilled by the Exxon Corp. in 1985 was drilled to over two miles of depth, 14,464 feet, on the mesa lands near Deep Creek but the hole was dry.[50]

*iii. Turquoise*

Turquoise found within the subbasin comes from Nevada. There is one reported mine within the subbasin, the Stampede mine.[23,72] "The mine workings are limited to an open pit about 70 feet long and 40 feet wide near the crest of a southerly trending ridge."[72:8] The turquoise from this mine southeast of Tuscarora is of extreme hardness and includes solid blue, matrix-marked and spider-web varieties. Much of the turquoise found in the region has actually been collected in the gullies where it washed down and was found by placer miners during the Tuscarora gold boom.[72]

### *iv. Fossils*

Fossils have been found at the north end of the Spring Creek Basin.[73] The fossils are found within a mix of stream, ash, and lake sediments. Fossils are of equids (horse family), camelids, proboscideans (elephant family) and rhinoceros that date to the Miocene or Pliocene.[73]

### *v. Rockhound material*

Rockhounds are interested in rocks for collections. Many rockhounds are looking for crystals. Just like a clear quartz crystal, many other minerals can arrange themselves into beautiful shapes, such as the cubes of pyrite (fool’s gold), if deposited under just the right conditions. The Basin and Range of Nevada had some of these ideal conditions in geothermal vents. Often, where vein gold and copper were deposited in the same veins, conditions allowed for the accumulation of other minerals. While rockhounds must respect existing mining claims and cannot collect on private land without permission, many find treasures out in the desert. The commercial value of most rocks sought by rockhounds is low.

On the 2001 Nevada rockhound map, the following locations in the upper Owyhee subbasin are listed: Zun claims, Taylor canyon, Murray Mine, Rio Tinto Mine, and the Autinik group. Undoubtedly there are many additional locations known to local residents. The rocks that are sought in these areas include pyrite, copper, quartz, barite, zunyite, rutile, stibnite, stibiconite, chalcopyrite, malachite, autunite, torbernite and metatorbernite.[23]

### *vi. Lapidary stones*

There are many areas within the upper Owyhee subbasin where petrified wood, thundereggs and jasper can be found. In addition to the rock in which they were formed, many pieces wash down the rivers and can be found as pebbles. For example, petrified wood can be found dispersed in the Rock Creek area northwest of Tuscarora.[23]

Opal, chalcedony, and thunder eggs have all been found at the north end of the South Fork Owyhee River. There is an active claim just outside of the South Fork Owyhee River WSA, and there are two abandoned claims within the WSA.[39] "The minerals at all the prospects are similar. The chalcedony is generally translucent to dull gray, milky white, or tan. The common opal is generally light tan and opaque. The lack of bright and interesting colors and patterns in the minerals limits their value and marketability. Any better-quality material that might occur would need to be selectively mined by hand. The material would probably be mined only for recreation by hobbyists."[39:F6]

### *vii. Tin*

Anomalous, high quantities of tin have been found in stream sediment samples from almost all of the WSA's within Idaho.[1,39,44,71,95] It is unknown where the tin comes from although guesses abound.

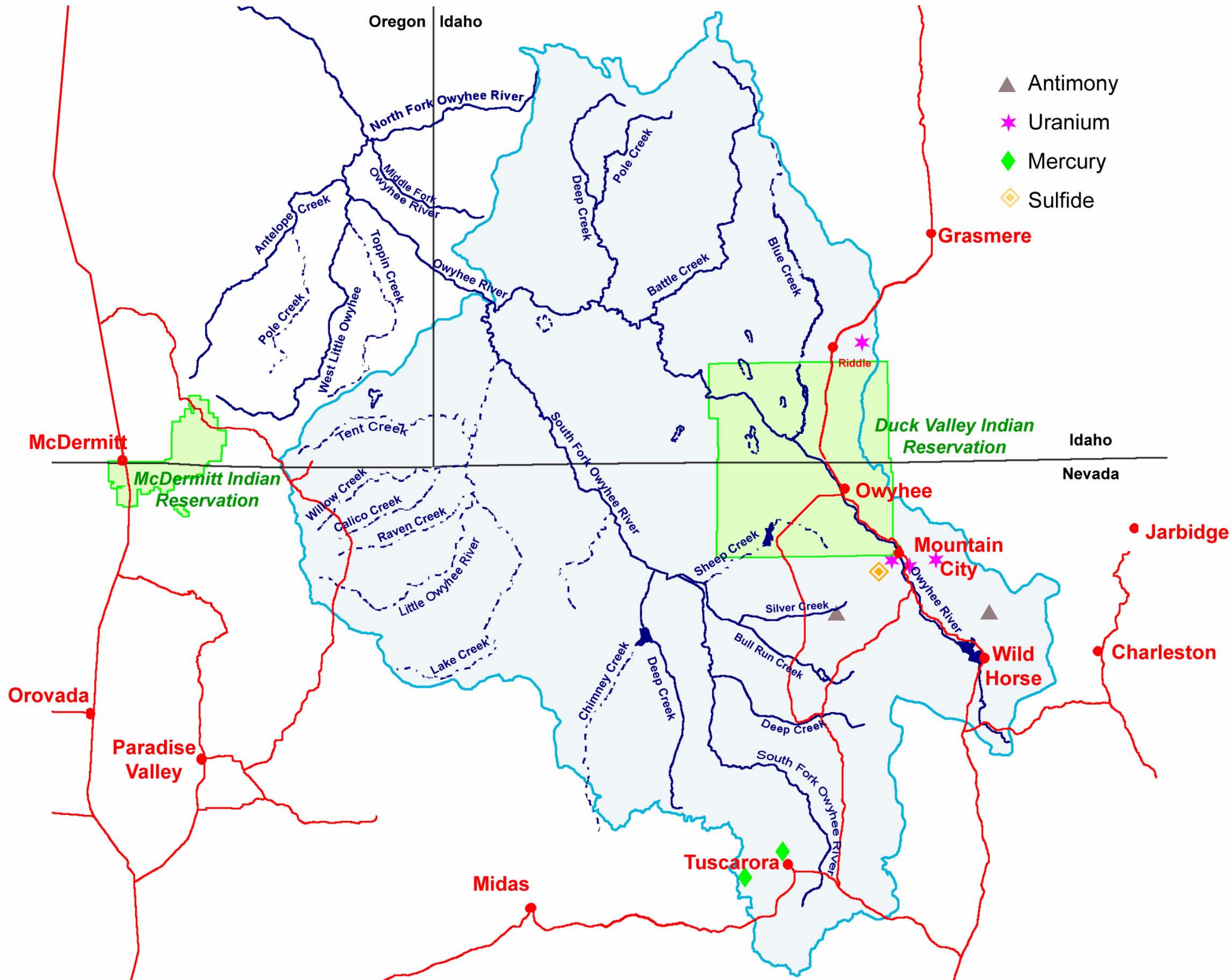


Figure 2.38. Large mineral deposits of antimony, uranium and mercury associated with hotspring systems in the upper Owyhee subbasin. The sulfide deposit is in old marine rocks.[98,128]

## *viii. Mercury*

Mercury occurs in hot spring deposits in the upper Owyhee subbasin. It has been mined within the Tuscarora district at the Red Bird Group and Berry Creek Group mines (Figure 2.38).[98] The quantity of mercury in no way compares to that found and continuing to be mined at the McDermitt volcanic field.[62]

## *ix. Antimony*

Antimony is a metal with numerous commercial uses; for instance, it is used in alloys which expand on solidification, in solders, in some medicines, in the manufacture of enamels, and in the electronics industry in the manufacture of semiconductors. Antimony has been mined at the Foss, Blue Ribbon and Eagle prospect mines within the upper Owyhee subbasin (Figure 2.38).[8,98] The Blue Ribbon mine produced seven tons, a significant quantity.[13] All of these locations have simple antimony that was deposited by hot springs. However, the locations are within the oldest rock formations in the subbasin so the age of the deposits is unknown.

*x. Uranium*

Uranium has been mined in the Mountain City district and is found in other areas of the upper Owyhee subbasin (Figure 2.38). Eighteen claims and prospects are located in the area.[42] Prospecting for uranium peaked in the 1950s. The amount of uranium produced from the Mountain City area is unknown; however, it pales in comparison to ongoing production at the McDermitt volcanic field.[42,97,98]

The uranium deposits in the Mountain City area occur at the boundary between a granite and a higher unit of ash. The uraninite was probably secondary in nature, meaning that the uranium was transported to these locations.[42] Hydrothermal processes may have been responsible for the uranium deposition and alteration of the host ash tuff where it is found.

Radon is one of the radioactive decay products of uranium 238. Radon and its immediate decay product polonium pose a health risk. Inhaling radon can increase the risk of lung cancer.[92] The Nevada radon pollution hazard map suggests that the Mountain City area is the only one within the upper Owyhee subbasin with a high hazard. A high hazard is based on the soils or surface geological layers exceeding 4 ppm of uranium or radon measurements within houses being high.[92] No specific household measurements were taken in Mountain City, but the uranium deposits in the Mountain City mining district account for the rating,[92] since radon concentration could naturally be high.

## 6. Erosion of geological deposits within the subbasin

As the rocks within the subbasin erode to form the soils, some of the minerals within the rocks and soils are carried in the water flowing off of the hills for great distances. Rocks and minerals being carried by the Owyhee River when it exits the upper Owyhee subbasin come from geological deposits upstream. Eroding sediments and rocks can carry both materials that are beneficial and harmful. Placer gold, silver, and turquoise all exist in river sands or gravels because they have been eroded from their original geological location. Likewise a pollutant which naturally occurs in a rock or was introduced to soils from antique mining practices can be eroded and carried downstream in river waters.

Many of the geological deposits in the upper Owyhee subbasin are enriched by minerals. The elevated naturally occurring quantities of these minerals means that the background concentration of these minerals that will be found in soil and water is higher than in regions with a different geological history.

The enriched geological deposits allowed for mining to be economically practicable. Antique mining practices have added to the pollutants that now move through the soils and waters by natural erosion. There are two components to mining's impact. First the increased fragmentation of rocks naturally bearing minerals places them at greater risks for erosion. Secondly, some antique mining practices depended upon the addition of cyanide or mercury for the extraction of precious metals.

### *a.* Cyanide

Successful mining of disseminated gold and silver deposits only became economic after 1890 when the cyanide leaching process was introduced commercially in South Africa.[9] Cyanide was used for mining in the Tuscarora and Edgemont mining districts.[64] Cyanide probably escaped from these operations and is an anthropogenic addition to the soils in the areas of the Lucky Girl and McKenzie mines. Other mines may have used the process and would likewise have contaminated soils. The cyanide concentrations in the soil can lead to cyanide entering groundwater and surface water.

### *b.* Mercury

Mercury has two origins in the upper Owyhee subbasin, as naturally occurring deposits and as a human addition to the environment. The natural mercury sources near Tuscarora have undoubtedly contributed mercury to the soils and waters. In addition, mercury was used in the legacy extraction of silver and gold. This is an anthropogenic addition of mercury to the environment. Once mercury or any other heavy mineral pollution is within the sediments, it will behave as if it were derived from a natural deposit and be moved by water flow, both groundwater and runoff.

**Photo 2.9. Alluvium deposited below a canyon on Hurry Back Creek**

## 7. Summary

The upper Owyhee subbasin has a long and diverse geological history. Within the geological history we learn how the mountains and basins came to be. Volcanic features of the landscape present striking vistas. Old rocks of the Independence and Bull Run Mountains provide deep rich soils for forests. Rivers are carrying out active erosion that adds mineral-rich soil to their banks and continues the process of canyon creation. The diversity and number of precious metal and heavy metal deposits briefly brought great prosperity to the region at the turn of the 20th century. Naturally occurring and legacy human-introduced heavy metals present a challenge for the environmentally conscious residents and users of the subbasin in the 21st century

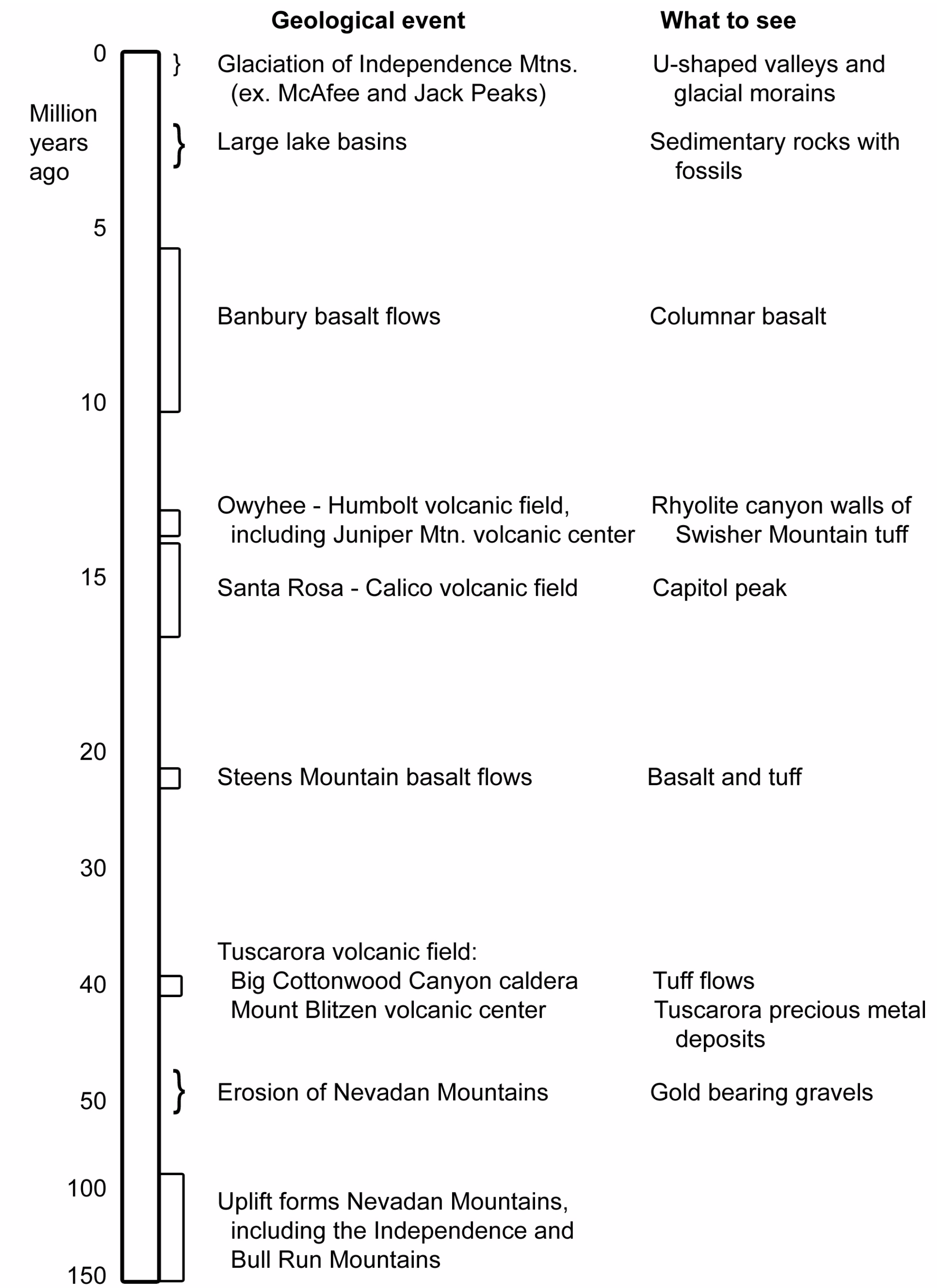


**Figure 2.39. Timeline of geologic events in the upper Owyhee subbasin.**

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# Upper Owyhee Watershed Assessment

## III. Issues



### Contents



## III. Issues

### A. Owyhee Watershed Council

To help focus the assessment, the Owyhee Watershed Council developed a list of local concerns which they wished to see addressed in the upper Owyhee watershed assessment. The primary concern was that the assessment be scientifically based, objective, and historically correct. In order to be useful as a tool by the watershed council they wanted the completed document to be written so that it could be read by an average person. The document would compile available data on the watershed, identify data gaps, and review existing watershed conditions. The assessment findings could be utilized locally as an educational tool about the watershed and as the basis for applying for grants that could be used for real improvements to real problems. The document should focus on real issues.

Ranchers and growers understand that watersheds are complicated and include interaction between humans, other species, and the environment. A major concern for ranchers is that the complexity between species interactions, nutrient cycles, and climate can obscure the real relationships between the various elements in the watershed. The assessment of the upper Owyhee subbasin should identify what is known about the subbasin and the gaps in our knowledge about the subbasin.

When assessing the different aspects of the upper Owyhee subbasin, the evaluations of either current or historical conditions need to be made taking into consideration naturally occurring factors such as the climate, the soils, and the geology of the region. Not only should conditions be compared with those that existed at Euro-American contact with Native Americans, but an effort should be made to document recent changes, both improvements and problems.

## B. Development of issues and concerns to address

One meeting of the Owyhee Watershed Council was used to develop a set of specific issues and concerns of the members of the watershed council. Other issues emerged from publicly advertised meetings. These meetings were held in Owyhee County, Idaho and Malheur County, Oregon. The meetings were primarily attended by ranchers. The stakeholders who provided input included ranchers with both private land and public grazing allotments in the upper Owyhee subbasin. A list of issues was developed from the discussions at these meetings. Interested individuals also expressed their concerns in informal conversations with the authors.

Many agency concerns are a matter of public record. In addition, the Owyhee Irrigation District provided specific information.

## C. Specific issues arising from public input

### 1. Land Ownership

Almost all of the upper Owyhee subbasin in Idaho and Oregon is BLM land. Allotment holders are constrained in the improvements which they can make.

### 2. Identification of phenomena not open to remediation

#### *a. Water temperature and quality*

The Idaho Department of Environmental Quality (DEQ) has completed an assessment and an identification of the total maximum daily load (TMDL) of the Upper Owyhee Watershed in Owyhee County. Stakeholders expressed concern that given the high naturally occurring summer temperatures that the temperatures established in the Idaho document were unrealistic. They feel that an effort needs to be made to identify the conditions which really exist in the streams under natural conditions. What water temperatures can be expected due to natural thermal heating?

Stakeholders are concerned that the targets for temperature and other elements need to be made attainable and realistic.

#### *b. Topography*

Concern was expressed that some of the implicit expectations for the upper Owyhee subbasin are based on generalizations that are not applicable. One of these expectations is that streams will be curvy, meandering through the landscape. Curvy streams are typical in relatively flat, geologically old, highly developed landscapes; most of the upper Owyhee subbasin is in geologically young formations.

Another problem is that streams like Blue Creek are impacted by heavy runoff. Since Blue Creek is sandy and about 20 feet below the surrounding landscape through some reaches, with heavy runoff it washes out.

### 3. Water supply

Water supply is critical to land owners. Wildlife, agriculture, livestock, and vegetation all rely in different ways on the availability of water.

In many areas water wouldn't make it to the Owyhee River except in springtime without the dams. In some tributaries water only runs with snow melt, and without dams and stock ponds there would be no water for livestock or wild animals during the rest of the year. In flatter sections of the landscape, spring runoff would spread out across the landscape and dissipate.

In the Idaho section of the upper Owyhee subbasin, most "live" water is on deeded ground.

### 4. Stock pond documentation

The stock ponds in the subbasin provide valuable riparian areas. At the time that many of the stock ponds were constructed, no documentation was needed. The only documentation is their presence on old maps. If the stock ponds wash out ranchers want to ensure that they could be reconstructed. If they aren't reconstructed, the riparian area is lost.

Stakeholders also are concerned that stock ponds are in danger of being fenced off, thus limiting access by both stock and larger game.

### 5. Weeds

Invasive weeds are of fundamental ecological importance. A number of very aggressive weed species have the potential to replace almost all native plant species at many sites. Invasive weeds can alter or destroy the entire natural web of life including grasses, wildflowers, insects, rodents, birds, grazing animals, and predators. Pollinators can depend on a series of wildflower species, and the pollinators can be lost or greatly weakened from the landscape with the advance of weeds.

Noxious weeds and invasive species are spreading into areas that have largely been free of them. The principal invasive specie of concern in the Idaho section of the subbasin is white top as it seems to be spreading rapidly.

Following the Shoofly fire, nonnative thistles began appearing in the Idaho section of the upper Owyhee subbasin north of Duck Valley Indian Reservation.

On the western side of the Idaho part of the subbasin, there is considerable juniper encroachment. Studies have shown that juniper utilizes more water than the vegetation it replaces. The amount of water in creeks, where juniper has spread into the drainage area, is greatly diminished or the surface flow is completely eliminated. The effect of juniper upon the vegetation and hydrology is further discussed in the range section.

Stakeholders are concerned about the spread or danger of spread of medusahead rye, halogeton, tamarisk, leafy spurge, and other noxious weeds.

### 6. Fire danger

A large build up of fuel in the uplands leads to a greater danger of fire and subsequent erosion following hot fire events.

### 7. Fish

Many nonnative fish species have been introduced into the reservoirs and streams of the upper Owyhee subbasin. Nonnative fish compete with native fish for habitat and sometimes replace the native fish. When fish species are closely related, there has been concern that there could be hybridization of the nonnative and native species.

Although a native fish may exist in streams in the upper Owyhee subbasin, not all streams will support that specie of fish. Some streams are intermittent with no water in them at some times of the year. Other streams will have temperatures which are outside the range that a specific specie tolerates.

### 8. Endangered species

There is concern that a casual attitude toward amphibians among the general populace results in the collection and use of these species as pets. When the pets are released to new environments, they compete with the species native to that environment and spread amphibian diseases.

Stakeholders are concerned that movement of water, boats, or fish will introduce zebra or quagga mussels into the watershed, jeopardizing native species and human water systems.

### 9. Recreation

Although less heavily used for recreation than some BLM land, the upper Owyhee subbasin provides opportunities for hunting, fishing, camping, and rafting. Access is either through private land or across multiple grazing allotments.

Since most access in the Idaho section of the subbasin is through private land, ranchers have found that people who have requested permission are usually more responsible. Access to several of the BLM reservoirs used for fishing is across private land.

Recreationists have the potential to impact areas beyond the maintained roads.

There is rafting down Deep Creek from Mudflat Road and rafts put in at Crutcher Crossing go downstream toward Three Forks. This route has a very limited season.

### 10. Legacy mining

Mining for gold, silver, copper, and mercury have disturbed the landscape. Residual effects remain with few monetary resources for remediation. Mercury is known to be detrimental to the fauna of an area.

# Upper Owyhee Watershed Assessment

## IV. Historical Conditions



### Contents



### IV. Historical conditions

Forward: This account relies on many sources. For the ease of reading, please note that ellipses, . . . , indicate a word, phrase, or short section has been omitted from a quote. Clarifying additions by the editor have been added in brackets, [ ]. Where trappers' or settlers' words are quoted verbatim, some of the spelling and punctuation may have been changed but the words and word order are the original. To avoid confusion, the place names used are the current names for locations, except within verbatim quotations.

## A. Pre-contact

Historical characterization of the landscape and conditions at the time of contact is an attempt to understand the 'pre-European' state of a river drainage and region that was influenced by Native American inhabitants for at least 10,000 years prior to European settlement. Archaeological research allows for an understanding of the prehistory which cannot be derived from historic documents. The Great Basin area of eastern Oregon, Nevada, and southern Idaho has been inhabited for more than 12,000 years.[2] The upper Owyhee subbasin lies within this area. In Idaho, Clovis projectile points have been found near the Bruneau and Snake Rivers.[51] These projectile points date to between 11,500 and 11,000 BP (before the present). Projectile points archaeologists find on the surface of the ground suggest people were living in the area. However, the only sure way to document habitation is by dating charcoal left in fire pits where people lived and this requires excavation by archaeologists. There have been very few excavations of archaeological sites in the Owyhee uplands so the available record is sparse (Figure 4.1). Around 9,500 years ago, people inhabited the Dirty Shame rock shelter in the Owyhee uplands.[51] This rock shelter is a few miles downstream from the upper Owyhee watershed. The earliest dated habitation within the upper Owyhee watershed comes from around 6000 BP at Nahas Cave.[51,70,71]

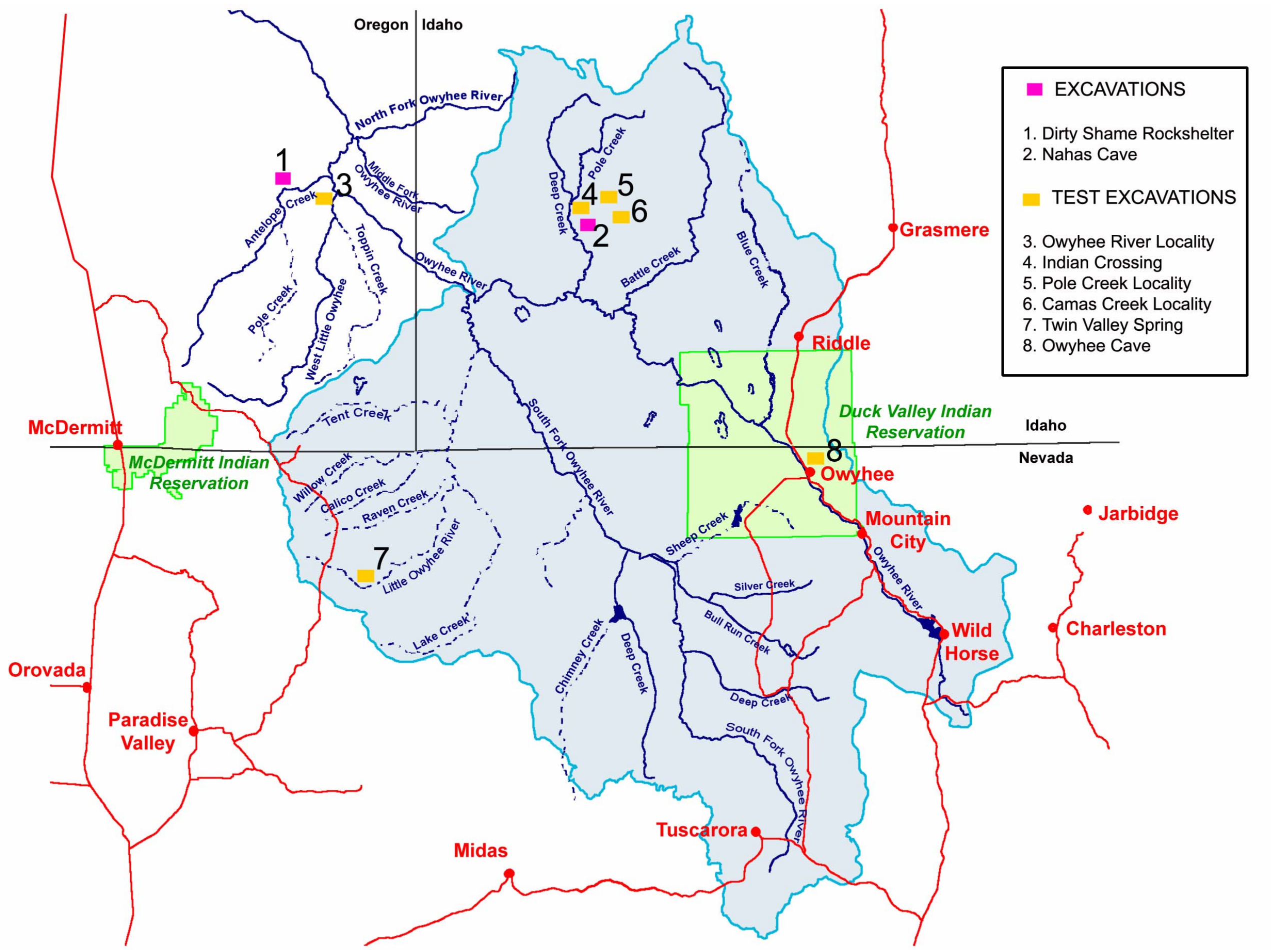


Figure 4.1. Location of archaeological excavations and test excavations in the upper Owyhee subbasin

Since the Owyhee uplands are currently semiarid and of recent geological formation, there is little soil formation. Most archaeological sites are on the surface of the land and the artifacts left by Native Americans are visible to hikers. These artifacts include flaked stone, ground stone, projectile points, petroglyphs, rock alignments, and some pottery. Plew surveyed along Pole and Battle Creeks in the subbasin and documented 700 archaeological sites.[71] The survey included the creek valleys to 100 meters beyond the rimrock and a few walked transects across the open desert (Figure 4.2). “Most [archaeological] sites are located along alluvial fans and terraces in canyon bottoms, on bench terraces and talus areas and along and near rim rock.”[71:57] In fact only scatters of flaked stone were common in the open areas between the creek drainages. This suggests an importance of the watercourses, possibly for water, to prehistoric inhabitants. On the basis of 700 sites in this portion of the upper Owyhee subbasin and the variety of projectile point types found it is clear that the region was inhabited by Native Americans for a long duration.[71]

Archaeological sites within caves provide more detailed records of prehistoric habitation. Nahas Cave in Idaho provides such a record. Excavated in 1979 and 1980, Nahas cave is a lava bubble that measures three meters across and 12 meters deep.

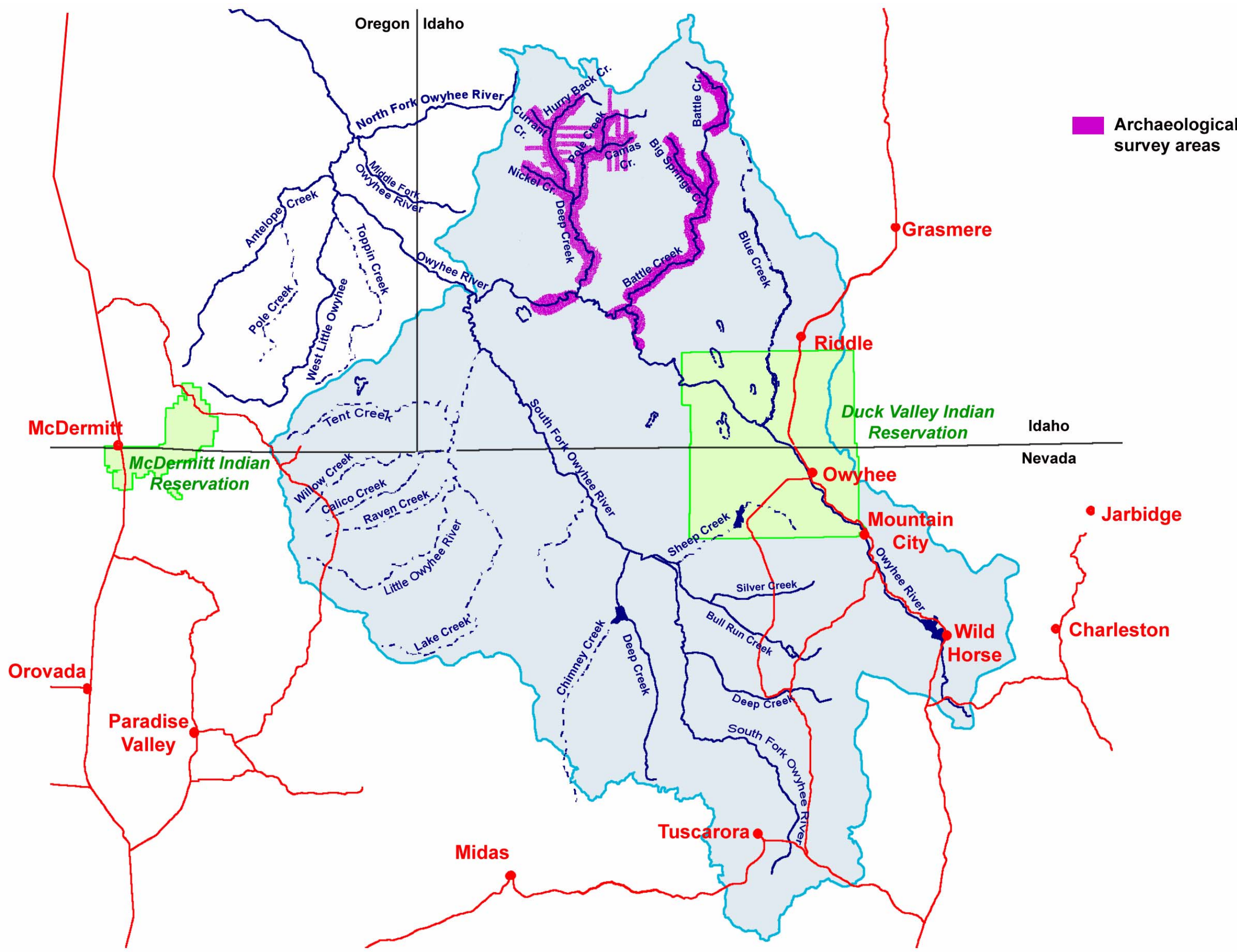

**Figure 4.2 Location of archaeological surveys conducted by Mark Plew in the upper Owyhee subbasin.**

The sediments fill was created by human garbage and windblown dust. Nahas cave was probably occupied as a hunting camp. The most recent Native American occupants left a few fragments of pottery in addition to the flaked stone projectile points and household garbage. Each successive layer of soil that was excavated showed older habitations and the changing styles of projectile points. The layers were also dated with eight radiocarbon dates.[70] “The earliest date of 5990 ± 170 BP . . . is associated with a fire hearth and mortar and pestal.”[70:98] In addition to hunting, “a limited groundstone assemblage suggests that some edible seeds and berries were consumed.”[70:98] The remains from Nahas Cave include seeds of chokecherry and hackberry.[70,71] The animal remains are of antelope, deer, ground squirrel, muskrat, jack rabbit, woodchuck, cottontail, badger, porcupine, and unidentified birds.[70] For fish there are, “the remains of six individuals of the sucker family, Catostomidae, possibly *Catostomus comlumbianus*, Bridgelip Sucker, and one individual of the Cotidae, possibly *Cottus bairdii*, Mottled Sculpin . . . [and] the remains of three individuals of *Salmo gairdnerii*, the Steelhead Trout. A fourth individual tentatively identified as *Salmo gairdnerii* may be *Salmo clarkii*, the Cutthroat Trout.”[72:129-130]

How much anadromous fish, like steelhead and salmon, were part of the Native American diet has been a highly debated topic. The importance of these fish runs varied by region. Native American populations along the Snake River in the Boise area were reported at contact as exploiting the yearly runs of anadromous fish.[92,87] The ethnographic records for the Owyhee uplands are less detailed, so research has turned to archaeology. Nahas Cave yielded three (or possibly four) bones of steelhead trout from layers dating between 3000 and 500 BP.[70] The find was considered important because of how far the fish would have had to travel to make it to Pole Creek (Figure 4.1). However these three bones should be taken in context: 8,230 bone fragments were excavated at Nahas cave, of which six hundred were identifiable. The importance of these fish in the diet of Native Americans in the Owyhee uplands is unknown.[70,71,72] In addition, the findings are qualified by the probability that only in early springtime would there have been enough water in Pole Creek for steelhead trout runs.[71] Another archaeologist has cautioned that the fish runs would be unreliable as “the Western Snake River Basin represents the upstream limits of the Columbia River anadromous fishery in the southern Plateau.”[51:67]

The Native American inhabitants of the region were people who adapted to the environmental situation in which they lived. Like all resourceful people, they attempted to modify the environment for their advantage. While we do not have a clear picture at present of the degree to which Native American inhabitants were altering the Owyhee environment, archaeological research in the Owyhee uplands indicates that they were doing so.[83] These 'pre-European' land use practices could have been either beneficial or harmful to mammal populations, fish populations, and vegetation communities. "That prehistoric and early historic humans occupying Montana, Idaho, Washington, and Oregon influenced the abundance of game animals by their hunting practices is indisputable."[46] Great Basin Native Americans are known to have taken massive rabbit populations, employed fish traps, nets, weirs and dams, and burnt range lands.[45,88,89] One of the Native American practices was promotion by propagation of economically important plant species, which would in turn affect the composition of vegetative communities, whether they were those of upland soil, wetlands, or riparian zones. "Wild seeds were sown broadcast in central Nevada but neither irrigated nor cultivated. ... All groups burned brush to facilitate growth of wild tobacco and sometimes of other wild-seed plants."[87] Plants that may have been propagated include, but are not limited to, great basin wild rye, sunflower, wild tobacco, currant, biscuit root, bitter root, wild onion, sego lily, chokecherry, and wild rose. These plants currently grow in the upper Owyhee subbasin.

## B. Native Americans at contact

When Europeans moved across the western US, they found the lands occupied by various Native American groups. The upper Owyhee subbasin crosses the divide between traditional Northern Paiute, Western Shoshone, and Northern Shoshone territories (Figure 4.3).[54,89,89,92] While Paiute and Shoshone peoples had different languages, they were not culturally isolated from one another. Anthropologists have

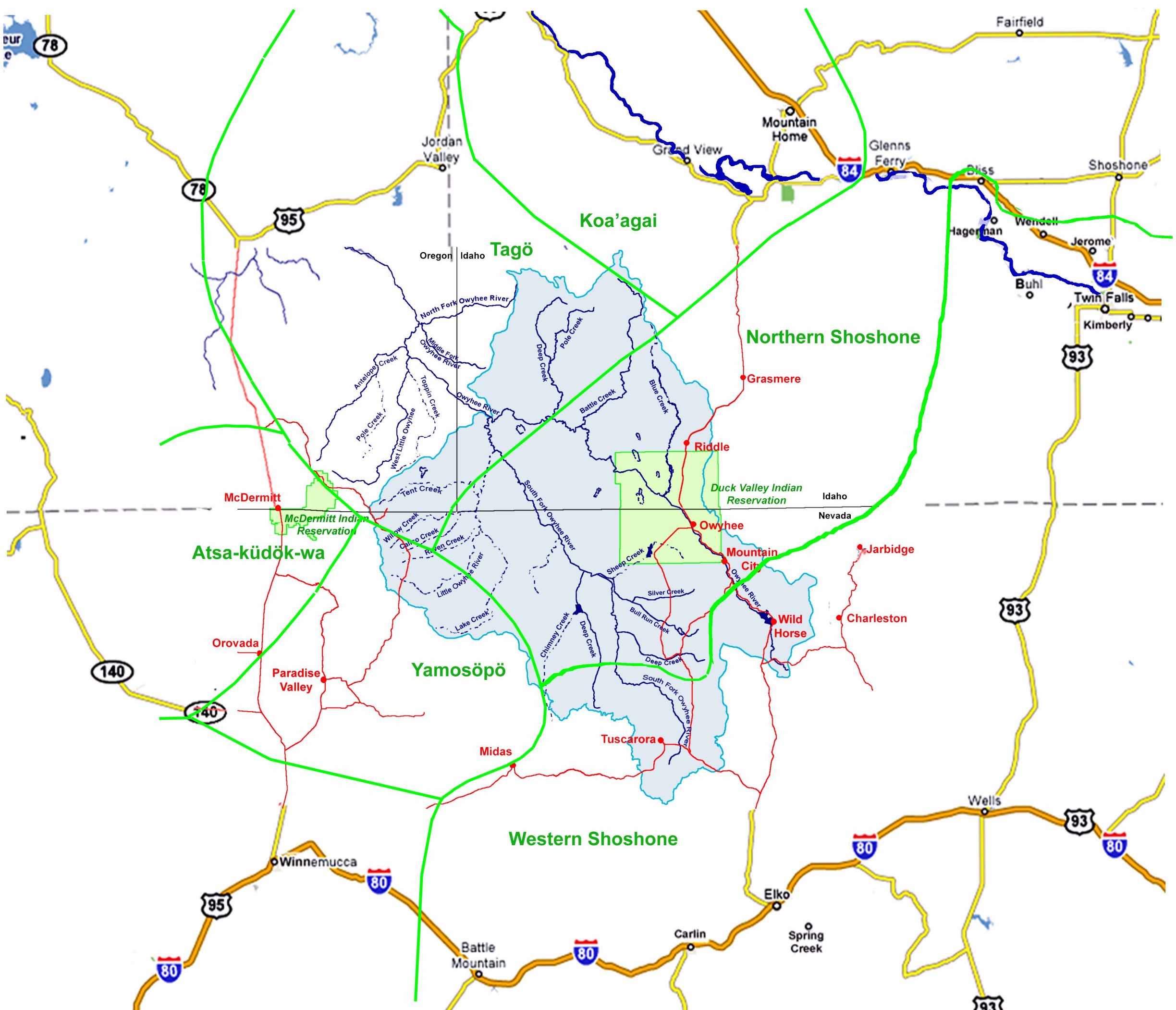


Figure 4.3. Traditional Northern Paiute, Western Shoshone, and Northern Shoshone territories at the time of Euro American contact.

noted that there was a zone of bilingualism and intermarriage between the Shoshone and Northern Paiute, in some places as much as 100 miles wide.[52] Both Northern Paiute and Shoshone who used resources in the upper Owyhee subbasin at contact with European settlers shared cultural practices and diet since the region was marginal, with few available resources.

During the 1920s and 1930s the oldest surviving members of these groups were interviewed by anthropologists. The information these individuals provided from their own experiences as well as their grandparents' stories helps us understand who was living in which areas in the past as well as the ways of life between approximately 1800 and 1850.

In the west, the Northern Paiute bands of the Tagö-Töka and Yamosöpö tuviwarai inhabited the upper Owyhee subbasin. Tagö-Töka means "eaters of *Lomatium* sp. roots"[19:468] which are more commonly known as biscuit root. Omer Stewart interviewed Tagö-Töka who were residing at the Duck Valley Indian Reservation.[89] He did not interview any of the Yamosöpö tuviwarai band whose name means "dwellers of Paradise Valley."[19] While Great Basin bands were often named for foods that they were known to eat, there were many regions without dietary specialization. The upper Owyhee subbasin would have been one of these areas, as it lacks any single extremely influential food resource. "In these areas, subsistence pursuits were about equally divided among the taking of small game and large game, numerous seeds, berries, and some roots, upland game birds and occasional waterfowl, insects, and sometimes fish. The details of the regimes varied by area, but little resource specialization was apparent." [19:438-439]

Julian Steward interviewed one Shoshone living near Elko and one from the Snake River, but no one in the area in-between.[89,92]. Neither of these informants was native to the upper Owyhee subbasin. One Nevada Western Shoshone band is discussed as inhabiting the North Fork of the Humboldt River, a location closer to the subbasin, but no information is given on their way of life as they followed the general pattern for inhabitants of the broader region.[92] By contrast the Northern Shoshone of the Snake River plain were in greater contact with white immigrants and had changed culturally during the 1700s and 1800s. They had adopted horses for travel and engaged in long distance yearly moves between salmon, camas and bison resources. However, these strategies did not work in areas with dispersed and low density resources like the Owyhees. "A ... dispersed Shoshone population was found south of the Snake River, between the watershed separating the Owyhee and Bruneau rivers and the area of Bannock Creek. This area was also roamed over by mounted Shoshone and Bannock from the east, but the resident population was mostly unmounted until after 1850. The people subsisted on salmon, small game, occasional deer, roots, and berries."[54:289] This unmounted, resident population was studied in greater depth by Harris.

Jack Harris and his wife Martha spent time on the Western Shoshoni Reservation at Owyhee, Nevada speaking with the *Tosawi* or White Knife Shoshoni.[29] The European name derives from the camps in the vicinity of Tuscarora and Battle Mountain where the white colored flint is found. "The White Knives practiced no agriculture; their rivers yielded no vast quantities of fish; buffalo were too far east to be hunted. In fact, they lacked any dependable or regularly recurring source of food, and were forced to utilize for sustenance every aspect of an unfavorable habitat."[29:40] "The chief but scanty sources of animal food were the rabbit, antelope, deer and mountain sheep. . . . Insects such as crickets and ants formed a substantial item of diet, but the bulk of food consisted of numerous roots, seeds, plants and berries."[29:40] Food shortages forced the White Knives to cover a much wider range of territory than their northern neighbors along the Snake River who had salmon.[29] "The summer months found the White Knives' camp groups ranging over an area which extended from southern Idaho to east central Nevada, roughly 25,000 square miles. Of course, not every camp covered this area but each group followed a more or less well-defined orbit, ranging from twenty-five to one hundred miles from its winter base."[29:44] The preferred area for winter camps was along the banks of the Humboldt River where a larger population could gather. Based upon the summer range, the population density of these Shoshone is estimated to be between one person per ten square miles and one person per fifteen square miles.[29,71]

**Photo 4.1. Mormon crickets swarming near Mountain City in the upper Owyhee subbasin**

### 1. Native Americans following contact

Following contact with European settlers, the Native Americans living within the Owyhee uplands made major changes to their ways of life. Some of these changes were voluntary while others were forced upon them by circumstance. Harris chronicles these events for the White Knife Shoshone.[29] While most of the following events were centralized along the Humboldt River, the White Knife population affected were native to the upper Owyhee subbasin.

Northern Nevada and southwestern Idaho were not heavily traveled by European Americans until gold was discovered in California in 1848 and Nevada in 1849. The California migrations wrought a great ecological disturbance in northern Nevada. The decade of 1850-60 was eventful for the White Knives. "Even during this late period of 1850, it seems that the White Knives did not yet have horses. Mules and horses were stolen, it was true, but they were not used for transportation, but to supplement the meager food supply which had already been diminished by the activity of the fur-trappers . . . and intensified by the passing of the emigrant trains."[29:75] It wasn't until

1854 that horse were noted being used as a pack animal by the White Knives, but soon after, in 1859, the horse had changed the tribe's dynamics as they transported food and camped in larger groups. "As early as 1855 and again in 1859, some Indians, with government aid, attempted to do some farming. However, these first farms were unsuccessful and abandoned."[29:81]

The 1860s brought another set of changes to the White Knives. From the establishment of large groups, they started raiding European wagon trains and settlers. These hostilities ended in 1863 with a treaty that promised them money as well as the hope of a reservation.[29] However no reservation was established until 1877 and the fourteen intervening years were hard for the White Knife population. "When some of the Indians were successful in raising crops, the Whites [Euro-Americans] dispossessed them from the fertile land. This was done by due legal process. . . . In 1875, Farmer Gheen reported: 'Some of the Indians who are engaged in farming, are compelled to rent land from the whites, nearly all of the tillable land being claimed by the white settlers . . . The whites are rapidly settling this country, and in many cases the Indians are compelled to give up their little farms. In other cases, the necessary water used by the Indians in irrigating their small patches was diverted from the streams above the Indian farms by White ranchers, thereby rendering the land valueless."[29:81-82] Between their failure as farmers, the loss of native food supplies, and delays to receiving a reservation, "the White Knives could no longer forage as self-sufficient camp units and so resume their former mode of life. Thoroughly discouraged by their failure to compete with the Whites as farmers, disheartened by the exploitation and their distrust of Whites, many Indians completely gave up the fight to gain their livelihood from the land. . . . Their solution was to attach themselves . . . to mining towns, ranches and railroad towns. Their new attempt at adjustment was to eke out what existence they could by doing wood-cutting, herding, washing clothes, [and] odd jobs."[29:82]

In 1877 a reservation was established at Duck Valley for the Western Shoshonean groups.

## C. At contact

Characterization of the landscape and conditions at the time of contact must rely on the observations of the few individuals who kept records, primarily diaries, of their journeys. From these observations of small sections of the landscape, we can extrapolate to conditions in the upper Owyhee watershed.

### 1. The fur trade

We do not know whether the fur trade that existed on the coast had already affected the area by encouraging the taking of animals for fur by the Native Americans. In the last decade of the 1700s, "a healthy 'ship based' fur trade flourished."[36] The editor of Robert Stuart's narratives notes that "Seafaring folk who, hailing principally from Boston and Salem, Mass., had for years been accustomed to triangular voyages in which they laded their ships with trading goods beloved by Indians, exchanged these goods for furs among the . . . [people] on the Pacific coast, bartered these furs for tea, nankeens, and silk in China, and then with their precious oriental cargo returned to their home port."[90]

It didn't take long after the journey of the Corps of Discovery across the US before the exploitation of the western region of the continent expanded. One member of the Lewis and Clark expedition, John Colter, remained in the West as a fur trader. The fur trade spurred the initial exploration of the region by nonnative peoples. By 1809 there were 25 Russian colonies along the Pacific coast of North America, extending as far south as California.[69]

Groups of trappers were some of the first people to make written records of the conditions in southeastern Oregon, southwestern Idaho, and northeastern Nevada at the time of contact. Two principal trapping companies exploited the region.

One company exploiting the region had been granted a Royal Charter in 1670. The Governor and Company of Adventurers of England Trading into Hudson Bay was better known as The Hudson's Bay Company.[49] A group of trappers had formed another company, the North West Company or Nor'Westers, in the late 1770s. Their competition with the Hudson's Bay Company for control of the northern fur trade motivated exploration into the North American interior. Twelve years ahead of American explorers Lewis and Clark, Alexander Mackenzie, a Scotsman, had crossed Canada and reached the Pacific.[48] The fierce rivalry which developed between the Nor'Westers and the Hudson's Bay Company led to the expansion of trade into new territories, particularly by the North West Company.

New competition for the British companies came from Americans. John Jacob Astor, one of the world's richest men, saw dollar signs. He formed the Pacific Fur Company in 1810 intending to establish a fur-trading base of operation at the mouth of the Columbia River. Fort Astoria was established In 1811.[69] Wilson Price Hunt, sent by Astor to find a convenient overland route to the Oregon coast, kept sketchy notes on his journey westwards to Astoria in 1811 to 1812. Robert Stuart, sent back to the east to gain help from Astor, kept more complete notes on his eastward journey from Astoria in 1812. Both these men, like other early travelers, found routes which followed the Snake River from what is today Wyoming to Farewell Bend, Oregon (Figure 4.4).

During the war of 1812 between Great Britain and America, the British controlled the seas and could arrive at any time and seize Astoria and its properties by force. Therefore the Pacific Fur Company sold its interest in its forts in the northwest to the North West Company. When the war ended in 1814, the treaty provided for the return of all captured property. However, Astor did not get Fort Spokane or his other posts back because they had not been captured but sold.[15,66]

The North West Company was overextended and unable to sustain its network. In 1820 they merged with the Hudson's Bay Company. Now the Hudson's Bay Company controlled almost three million square miles.[48]

By the mid-1820s, independent American traders were trapping along the Snake River. George Simpson, the Hudson's Bay Company governor felt this was an invasion of the western fur country. He decided on a scorched earth policy. Oregon and the West would be trapped clean. Not a single beaver would be left alive. He stated that "strong trapping expeditions should be sent south of the Columbia. These may be called the 'Snake River Expeditions.' While we have access we should reap all the advantage we can for ourselves, and leave it in as bad a state as possible for our successors."[47]

## 2. The journals

There are virtually no early records specifically of the Owyhee Watershed. The records which exist are journals of the trappers and later of early travelers and settlers. They recorded what was of concern to them. The trappers kept track of the number of beaver harvested, of the condition of their horses, of encounters with Native Americans, and of hunger and hardship. The records of the emigrants traveling along the Snake River or the Humboldt River dealt with sickness and death in their trains, disputes among members of the parties, and lists of places where they stopped. Neither set of chroniclers set out to describe the countryside. From information gleaned from different writers, we can get an idea of the conditions in the upper Owyhee watershed at the time of contact.

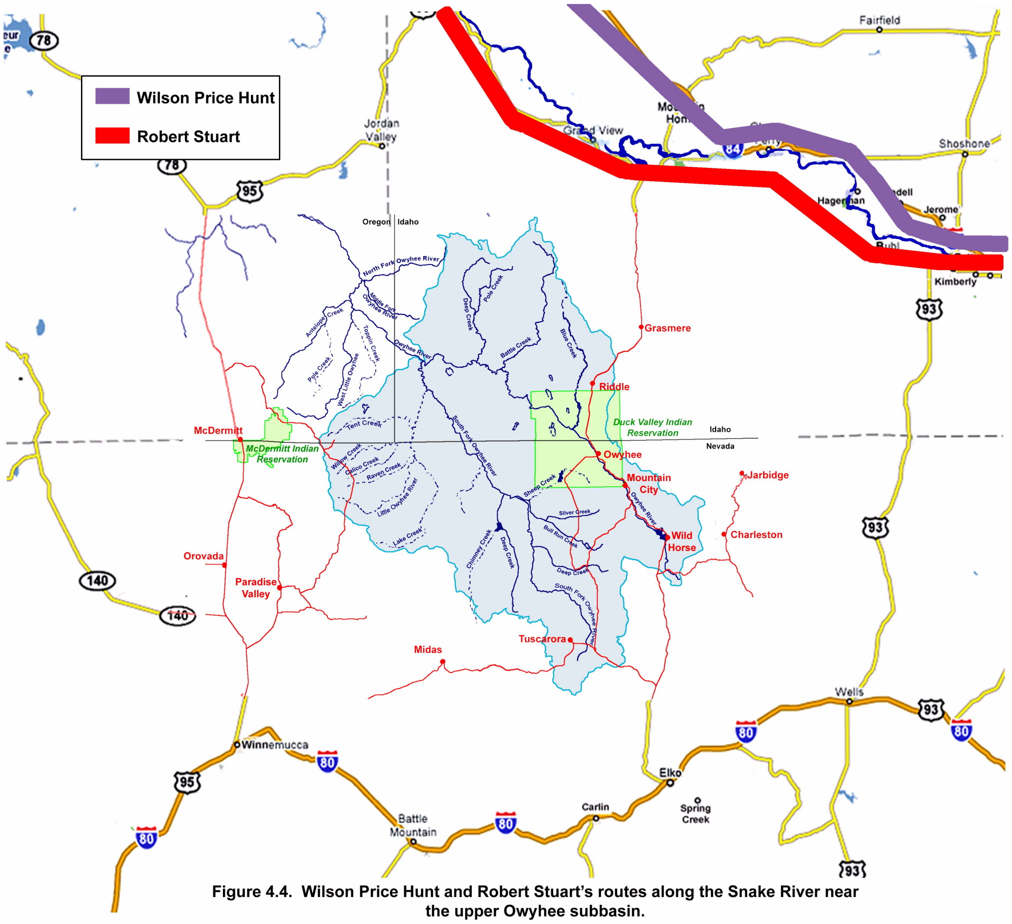


Figure 4.4. Wilson Price Hunt and Robert Stuart's routes along the Snake River near the upper Owyhee subbasin.

### *a. The brigades.*

The Hudson's Bay Company sent out brigades of trappers in the 1820s that included anywhere from 50 to 200 men, women, and children. Besides trappers, there were hunters, spouses, and families.[57] John Work's brigade consisted of 115 people. The 21 men and one slave were probably armed. Most of the 29 women were probably Native American wives of the trappers. They cooked, packed and unpacked the equipment, skinned beaver, and cleaned and stretched the hides. The 22 boys and 23 girls shared the work. They gathered wood, built fires, and helped keep track of the horse herd which consisted of 272 head at the beginning of the trip. Work's brigade started with 337 beaver traps.[33] The Snake River Brigade under Peter Skene Ogden used 200 horses for riding and carrying supplies, traps, and furs.[104]

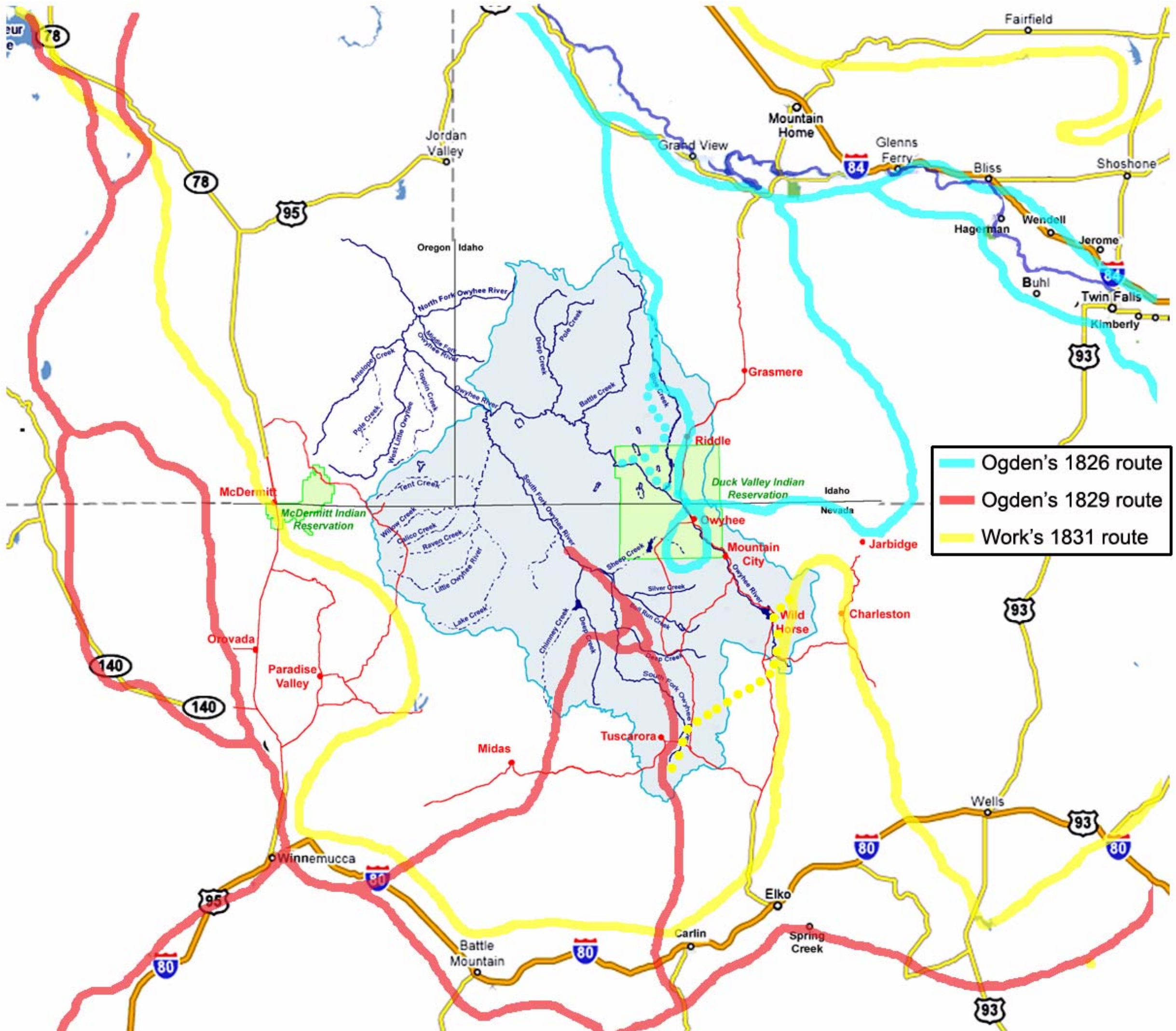


Figure 4.5. The routes of trappers Peter Skene Ogden and John Work. The dotted lines are the author's determination based on the original journals.

Two of Ogden's trapping expeditions took him into the upper Owyhee subbasin. John Work's first Snake Country expedition on behalf of the Hudson's Bay Company, after taking over that region's trapping operations from Peter Skene Ogden, also took him into a small section of the upper Owyhee subbasin (Figure 4.5).

### *b. The effect of trapping on conditions*

Peter Skene Ogden kept diaries of trapping trips from 1825 to 1829 while leading the Snake River Brigade of the British Hudson's Bay Company.

Already by 1826, Ogden was noticing a change in the condition of the countryside. There weren't as many beaver. In February of 1826 he noted changes on two rivers. After sending trappers up the Malheur River he wrote "Trappers who have been some distance up this river . . . report there are but few beaver. . . . It is rather strange for in 1819 this stream was well stocked in beaver and from its not having been trapped since, I had hopes of finding some more."[63] He found a similar situation on the Payette River, "it was then [1819] rich in beaver but now destitute."

Later in the journey when he was within the upper Owyhee watershed, he laid the blame first on "American traders [who were]. . . exerting themselves to ruin the country as fast as they can and this they will soon effect,"[63] and on the Native Americans "The fork we left this morning from was not many years since well stocked in beaver but the Snakes have destroy'd all not leaving one."[63]

Ironically a short while after blaming the Americans for a lack of beaver, his diary written near the northwest corner of Duck Valley Indian Reservation reads "This day 11 beaver 1 otter. We have now ruined this quarter. We may prepare to start [leave]."[63]

In 1829, Ogden recognized that the Hudson's Bay Company trappers were largely responsible for the elimination of beaver. Soon after Ogden had entered the upper Owyhee subbasin from the south, he wrote, "It is scarcely credible what a destruction of beaver by trapping this season, within the last few days upwards of fifty females have been taken and on an average each with four young ready to litter. Did not we hold this country by so slight a tenure it would be most to our interest to trap only in the fall, and by this mode it would take many years to ruin it."[64]

### *c. General description of the upper Owyhee subbasin*

The topography of the upper Owyhee subbasin has not changed since Euro-American entry into the area. Therefore, we can expect that at the time of contact, there were similar differences caused by elevation. The higher areas of the Bull Run and Independence Mountains would be cooler and experience more rainfall. Like today, the climate would be highly variable.

One member of Wyeth's 1832 party, John Ball, kept notes which he later edited. He had been traveling with a group of trappers on the Humboldt. When some of them went westward, Ball, with 12 others, turned north and traveled down the Owyhee River to the Snake River.

> "Our aim was to get back on to the Lewis [Snake] river and follow that to its junction with the Columbia. And I now presume we were on the headwaters of the Owyhee, the east boundary of Oregon. And the next day and for days we kept on the same or near. We pursued it till so shut in that we had to leave it by a side cut and get onto an extended plain above, a plain with little soil on the basaltic rock, and streams in the clefts or canyons. One day we traveled 30 miles and found water but once, and in the dry atmosphere our thirst became extreme. On approaching the canyon we could see the stream meandering along the narrow gorge 1,000 feet down, and on and on we traveled not knowing that we should survive even to reach it to quench our thirst. Finally before night we observed horse tracks and that they seemed to thicken at a certain point and lead down the precipitous bluff where it was partially broken down. So by a most difficult descent we reached the creek, dismounted and [went] down its banks to quench our thirst. And our horses did not wait for an invitation, but followed in quick time. The bluffs were of the burnt rock, some places looking like an oven burned brick kiln, and others porous."[4]

Since the beaver that the trappers sought lived along waterways, the trappers tended to travel in river and stream valleys.[104] The main camp was usually established along the river with trapping up subsidiary tributaries. Both Ogden and Work used "road" to mean the route which they chose for moving the whole camp. This was seldom right next to the river, but on the land to the side or above the river.

**Photo 4.2. The canyon of the east fork of the Owyhee River.**

Ball's description of expanses of nearly barren basaltic rock was echoed by numerous entries written by John Work in his journal. "The road very hilly and rugged . . . The country has a bare appearance." "The road is very hilly, rugged and stony." "The road hilly and uneven and in places stony," or "stony and generally gravelly and hard, which much wears down the horses' hoofs and renders their feet sore."[101]

Ogden expressed similar sentiments when he wrote that "we had a level road but a stoney one," and on a different day that they "had no cause to be pleased with our road still less our poor horses for it was one continued stone from the time we started to our encampment." One day they didn't move the camp since "the horses that were on discovery yesterday from the effects of the stones can scarcely crawl this day." He also commented on the lack of stones when the route was "very hilly but fortunatly not stoney."[47]

In addition to stony land, both Ogden and Work also found deep gullies or canyons which impeded their passage. Although Work had described part of his travel as being on a road which was "very hilly and rugged, being over a number of deep gullies," his expedition did not attempt to continue to follow "one stream which runs to the N. W. through a narrow channel bordered by steep, impassable rocks [Wild Horse]."[101]

Ogden encountered the same problem along the Owyhee. On June 12th, 1826, his scouts found that "the river is closed in by high cut rocks simalar to those we saw on Riviere au Bruneau and no doubt equal in length[.] they ascended a high hill and as far as the eye could reach it was one continued rock." The next day some Indians "gave our men to understand that . . . it was impossible for us to follow the river." After checking in another direction, on June 16th he wrote "I am at a loss what course to take to extricate ourselves . . . I sent Mr. Dears but he returned late in the evening and gives us no hopes from the quarter he has been in as far as the eye could reach one continued rock and stone[.] We must before we start tomorrow examine another quarter."[63]

Three years later, following the South Fork of the Owyhee, Ogden's camp "were obliged from both sides of the river being so rocky to leave it and ascend some high hills. We had not proceeded far when again our progress was stopped by steep gullies of cut rocks, and by winding up and down until near sunset we advanced not more than eight miles, and had some difficulty in reaching the river." The next day he wrote, "So far as they [trappers] have been are one continued rocks . . . I sent three men on discovery late in the evening. They returned having reached the main branch seen by me in 1826, they also saw the mountains on the south side of the South Branch. They followed the two streams to their junction and as far as the eye could reach one continued rock, and from the time they started to their return could not reach the river. . . . . . .I must now retrace back my steps.[64]

*i. Plains*

Although Ogden and Work both described much of the countryside through which they are passing as rock or stony, they also encounter more hospitable areas. John Work wrote that, "this little valley is about 20 miles long and 15 wide."[101]

Peter Ogden wrote "after so long traveling over stones and gravel we were rather surprised to find the banks of this river composed of good rich soil." However, some playas on what is today the Duck Valley Indian Reservation had filled with water and he recorded that "we cannot proceed far on this side there being a lake and swampy country which will take us a day to go round."[63]

Leaving the Humboldt watershed and entering the Owyhee watershed, Ogden wrote that they had "Crossed the mountains and encamped at 12 a.m. at the commencement of a large plain." Farther north he recorded that is was "nearly two miles [of] one continued hill and rock, still the river fine, we then reached a fine level plain about six miles in length."[64]

**Photo 4.3. Snow covered peak in the Bull Run Mountains on June 1**

*ii. Mountains*

Both Ogden and Work comment briefly on the Independence and Bull Run Mountains, impressed by the amount of snow still on them. In

June 1826, Ogden wrote that “we are surrounded by lofty mountains on all sides well covered with snow as in the middle of winter.”[63] Work wrote that there “is still a good deal of snow in large banks in the mountains” and “to the westward there is a high rugged mountain covered with snow.”[101]

#### *iii. Climate*

John Ball noted that "in the dry atmosphere our thirst became extreme"[4] Although neither Ogden nor Work comment on the lack of humidity, Wilson Price Hunt's party, being the first Euro-Americans to utilize a path along the Snake River was not prepared for the arid nature of the region and the resulting need for water away from streams so "several Canadians had begun to drink their urine."[34] In the surrounding regions of Idaho and Nevada, the lack of water was also mentioned by trappers and others when they were cutting across country.[82]

Both Hudson's Bay brigade leaders into the upper Owyhee subbasin noted variations in temperature in the Nevada section of the subbasin within the space of a few days. In April of 1829 near Tuscarora, Nevada, Ogden complained that it was “very sultry equal to the heat in June.” Ten days later somewhere on Bull Run Creek, possibly at a higher elevation, “it commenced snowing and continued all day. Nearly a foot has fallen.”[64]

South of Wild Horse Reservoir, Work wrote that “These nights past we have had sharp frost, but here the weather is sultry” and later that it was “cloudy, sultry weather in the morning, which was succeeded by thunder and heavy rain and hail, raw, cold weather afternoon.”[101]

Ogden also noticed differences in temperature between years. In June of 1826 near present day Owyhee, Ogden’s party “found nearly three feet of snow but this only for a short distance[.] here it was plainly visible to all the vegetation is very backward [season wise] . . . the summer heat has not been great this season and indeed this day we experience no inconvenience from our winter dress nor have we since the spring commenced”.[63] A few days later he wrote, “It froze a quarter of an inch in thickness”.[63]

## 3. Vegetation

What was the vegetation in the upper Owyhee subbasin prior to the advent of Euro-American settlers into the area? The trappers' sketchy descriptions are probably the best records we have. Most of the trappers’ observations were terse and mentions of vegetation were usually only an aside.

Except for Ogden and Work, the other trappers skirted the upper Owyhee subbasin, but their writings paint similar pictures of the area. The principal routes utilized between trapping areas were along the Humboldt River to the south of the upper Owyhee subbasin and along the Snake River to the north of the subbasin.

### ***a. Few Trees***

#### *i. Snake River Plain*

Within the Snake River plain, there were few trees. Slightly to the east of Boise, Wilson Price Hunt recorded in his diary that "The country was devoid of wood".[34] Both

Captain Nathaniel Wyeth and Ogden mentioned the lack of trees as a deterrent to building rafts or canoes for river travel. Wyeth "took a ride up the river to find a camp where timber, fit for a raft which we propose to build to carry some of the loose baggage and some men who are on foot can be found, [but] found none."[103]

Ogden stated "If this was a country of wood we might soon make a canoe . . . but we cannot even find willow to make a raft still less scarcely a sufficiency to cook our victuals."[63] He reiterated this in another entry. "The country [is] level, soil sandy, no wood to be seen excepting a few willow on the banks of the river and not even in abundance."[63] The next day they "encamped on a small river destitute of wood" and the following day "In hopes of finding grass we continued on till near night, but in vain, and encamped without wood, food for ourselves, and no grass."[63]

By contrast to the other rivers, the Boise River had timber along it and this was frequently noted. Wyeth,[103] Hunt,[34] Stuart,[90] and Col. Fremont[105] all note the atypical vegetation along the Boise River.[82]

*ii. Humboldt River Plain*

Peter Skene Ogden's expedition of 1829 was the first known exploration by a non Native-American along the Humboldt River. He also noticed the lack of trees and wrote "the river is scarce in wood." In another entry he stated “Wood very scarce, only a few willows on the banks of the river." Elsewhere he also found “willows in abundance."[64]

John Work traveled a similar path to Ogden’s along the section of the Humboldt River directly south of the subbasin. He also noted the willows and wrote "The river here has a good deal of willows on its bank."[101]

The other record we have of early trappers along the Humboldt is an account of an expedition of American trappers led by Joseph R. Walker in 1833.[79] Walker roughly followed Ogden’s route from Elko west. Zenas Leonard kept a journal on the trip and later published a chronicle of the trip. He wrote that they followed “a large stream [Humboldt River]; and to which we gave the name of Barren River — a name which we thought would be quite appropriate, as the country, natives and every thing belonging to it, justly deserves the name. — You may travel for many days on the banks of this river, without finding a stick large enough to make a walking cane. — While we were on its margin, we were compelled to do without fire, unless we chanced to come across some drift that had collected together on the beach.[44]

*iii. Within the upper Owyhee subbasin*

The total number of entries into their journals made by the trappers within the upper Owyhee subbasin is quite limited. In 1826 Ogden’s brigade were trapping within the subbasin for only 12 days. In 1829 they were there for 19 days. John Work was only in the subbasin for 13 days.

Ogden wrote in 1826 that they “saw yesterday . . . a fork of Owyhee River but from all appearances destitute of . . . wood, there being but a few willows and thinly scattered.”[63] And willows are again mentioned when he wrote “this stream certainly looks well, well lined with willows."[63] Work also commented on the presence of willows along stream banks. "The different forks in the valley have some willows on the banks."[101]

**Photo 4.4. Willows and a beaver dam on Trent Creek in the upper Owyhee subbasin.**

No other entries specifically mention a lack of wood. However, some of the observations on the general appearance of the countryside might be assumed to support this. In 1829 Ogden stated that "we had this day a level country, but a most barren one, covered with worm wood [sage brush] as is generally the case, travel in any direction you please."[64] Likewise Work wrote "The country has a bare appearance."[101]

Probably even more indicative of the lack of trees along the waterways is the fact that their presence is noted along specific streams. Where Burns Creek enters the South Fork of the Owyhee from the mountains to the east, Ogden wrote that they had "crossed over the plain and reached the junction of the different forks which forms a fine stream, well wooded."[64] As they are leaving the subbasin he has scouted ahead and found Chimney Creek. The next day he wrote "We reached the creek seen by me yesterday . . . its being well wooded and deep."[64]

South of Wild Horse, John Work noted "a branch [tributary] of Ogden's river where it issues from a steep, snow covered mountain. This stream is well wooded with poplar and willows." Then when Work ""Crossed the mountains . . . The road was in places nearly barred with burnt fallen wood. The little fork, where we are encamped is well wooded with poplar and willows."[101]

As brigade leaders, neither Work nor Ogden followed the smaller streams up into the mountains as that was the job for their trappers. Therefore, where they were noting some trees along streams flowing out of the mountains, it might not be too much of a stretch to infer that other streams in the mountains might have trees along their banks. Just before leaving the subbasin John Work wrote that "some of the men visited the head of the river to the mountain, and two forks that fall in from the eastward to near the same, and though they are well-wooded and apparently well adapted for beaver, yet scarcely a mark of them is to be seen."[101]

### *b. Willows*

In the previous section several citations mention willows. Similarly, John Work noted that "The part of the river we passed today is well-wooded with willows"[101] Aren't willows trees? The willow which the trappers mention is generally not a tree. It is an upright, deciduous shrub which may grow to 23 feet but is generally about 12 feet tall and about 15 feet wide. It grows in sagebrush country along creek bottoms, both on the shoreline and sometimes in the water. Willows form dense thickets of pure, even-aged shrubs. Short-lived, they are one of the most shade-intolerant native species and are threatened by both fire and drought. They can not survive long if the water table becomes too low.[13,14]

Willows were important to trappers because they provided building materials for the beaver dams and houses. Willows are often the most available species in much of the beaver's range and favored by the beaver. In addition to willows, beaver might use sagebrush, driftwood, aquatic plants, or other debris in construction of a dam. Bark, leaves, and growing tips of willow also make up a large portion of beaver diet in many areas.[3,7] Willows also provided a building material for Native Americans[82] and John Work. Near McDermitt, John Work "Proceeded up the river three miles . . . and succeeded in crossing it by means of a bridge of willows."[101]

### *c. Other vegetation*

The records remaining are only accounts of trapping expeditions on the eastern side of the upper Owyhee subbasin. There are no journals of any observations on the western side. There may have been few streams with willows or other conditions which beckoned trappers into the area.

Both Ogden and Work passed to the west of the subbasin (Figure 4.5). Near McDermitt, two of the men in John Work's party spotted "a small Indian camp, but [they] fled on our appearance and concealed themselves among the wormwood [sagebrush]."[101] A couple of days later, Work also noted lots of sagebrush, "The road good but in places stony and embarrassed with wormwood."[101] Further to the west of McDermitt, Ogden said they were traveling "over a plain covered with worm wood."[64]

**Photo 4.5. A large "plain . . . covered with worm wood" near the Idaho - Nevada border in the upper Owyhee subbasin**

South of the subbasin near Elko, Ogden also wrote that the large plain was "covered with worm wood."[64]

Since the trappers' horses required grass, the condition of the grass in an area was important. In the subbasin Ogden had written in 1826 that "our horses being greatly fatigued and having been nearly two days without grass we encamped early on a small brook."[64] The presence of grass could affect plans. As Ogden left the subbasin and recognized the terrain, he wrote "We encamped an hour earlier than usual knowing well if we advanced farther our horses would be without grass."[63]

South of the upper Owyhee subbasin a number of entries in Ogden's 1828 journal concern the need for grass. "Grass very scarce and our horses so weak." "For the preservation of our horse . . . from want of grass . . . are in a low state." One time he moved camp "with the hopes of finding grass for our horses". In the next camp he wrote "although grass scarce here . . . I did not raise camp."

As contrasted to the relatively bleak impression of the subbasin given by mentions of sagebrush plains and lack of grass, Ogden also wrote that he had seen "in this country certainly a fine variety of flowers, many known and many unknown to me. A strange sight to see red clover in abundance but not more than an inch in length. In this days journey a botanist would have had full employment and probably would have many additions to his stock."[63] Also, the many references to the Native Americans digging roots would indicate that the plants producing these roots were abundant around Duck Valley. Ogden also referred to one area as "fine pasture".[63]

At the time of Euro-American entry into the region, much of the landscape of the upper Owyhee subbasin probably had vegetation similar to that described in these fragments gleaned from the trappers' journals. Sagebrush plains, areas with little grass, and expanses of rocky ground predominated. Some streams' banks had willows along them and parts of the swampy areas of Duck Valley had more verdant vegetation.

### 4. Game

Both Peter Skene Ogden and John Work mentioned times of starvation. This shortage of food is particularly amazing since the trapping parties did eat the beaver which they trapped. Also, the large groups were accompanied by hunters whose sole function was to provide the rest of the party with meat. Joe Meek explained this aspect of trapping.

> "It was the custom of a camp on the move to depend chiefly on the men employed as hunters to supply them with game, the sole support of the mountaineers. When this failed, the stock on hand was soon exhausted, and the men reduced to famine. This was what happened to Sublette's company in the country where they now found themselves, between the Owyhee and Humboldt Rivers. Owing to the arid and barren nature of these plains, the largest game to be found was the beaver, whose flesh proved to be poisonous, from the creature having eaten of the wild parsnip in the absence of its favorite food. The men were made ill by eating of beaver flesh, and the horses were greatly reduced from the scarcity of grass and the entire absence of the cotton-wood."[38]

### *a. Scarcity of animals*

Within the upper Owyhee subbasin, John Work noted that “There are some cranes in the valley” following his statement that "Several of the people were out hunting, but with little success, which I regret as provisions are getting pretty scarce in the camp." Still on the east side of the Independence Mountains, he wrote "Not an animal except a chance antelope to be seen." However, after crossing the mountains to the west side and still within the subbasin, he recorded that “This seems to be a miserably poor country, not even an antelope to be seen on the plains."

**Photo 4.6. Sandhill cranes in the Mountain City valley.**

After leaving the basin Work wrote that "The best hunters are out, but as usual did not see a single animal of any sort.”[101] Likewise, Ogden stated that there was "not a trace of an animal to be seen in any direction . . . makes our situation the reverse of being pleasant."[63]

Joe Walker’s expedition experienced a similar lack of game. Zenas Leonard wrote that “having traveled through a poor, sandy country extending from the buffaloe country of the Rocky Mountains, to our present encampment, a distance of about 1200 miles,. . . and so poor and bare that nothing can subsist on it with the exception of rabbits — these being the only game we had met with since we had left the buffaloe country, with the exception of one or two antelopes. Notwithstanding these plains forbids the support of animals of every description.”[44]

### *b. Substitution of roots*

Ogden also mentions the lack of game when commenting on the Native-Americans' use of wild plants. In the upper Owyhee subbasin he wrote "This appears to be the season of roots in this quarter for all we see are busily employed in collecting them . . . if providence had not given them roots to subsist on 6 months in the year they would soon perish for want in such a barren country. They have no other resource to prevent them from dying."[63]

Five days later he commented that “all along our [route] this day the plains were covered with women digging roots [.] at least ten bushels were traded by our party.”[63] His own party took advantage of the fact that “the Camass root was to be seen in abundance and a considerable quantity was collected by the women of the camp.”

**Photo 4.7. Flowering camas in the upper Owyhee subbasin. Camas bulbs were one of the staple roots harvested from the upper Owyhee subbasin.**

Earlier he had complained that “we must as we have done content ourselves with a dish of roots in lieu of buffalo or beaver.” A group of Indians which they encountered further along the route “were busily employed collecting roots [.] a considerable quantity were traded from them[.] indeed two thirds of the camp subsist entirely on them, they far from being unpleasant in taste of flavour, but to me as well as others cause severe pain in the bowels with other unpleasant effects I shall not here mention.” Obviously unhappy with the diet since “almost any thing would be preferable to the roots we now subsist on”, he must also have rejoiced when “All our trappers came in and our success this day amounts to 44 beavers[.] This enables all once more to feast."[63]

John Work also traded with Indians within the subbasin. "Some Indians visited us with a few roots to trade . . . The small quantity of roots they bring . . . provides several people with a meal occasionally which is very acceptable to them as provisions . . . scarce among us.”[101]

As Ogden was leaving the subbasin he observed that "We well know that neither summer or winter are they any [deer] to be seen from River Malade (Sickly River) to Burnt River and this certainly, I am convinced, is the principal and only cause which obliges the Natives to go to buffalo [west of Yellowstone] otherwise many would perish from want . . . those who unfortunately for them who have no horses pass their lives without ever tasting meat."[63]

### *c. Sacrifice of horses*

The extent to which Ogden and Work’s brigades sometimes lacked game is shown by the sacrifice at times of their own animals although loath to do so. As Ogden left the basin in 1826, he recorded his worries. "I trust we will preserve them [horses] with the exception of those [which] should we not procure salmon will inevitably fall for the kettle . . . a more wretched country was never seen and which I cannot prevent."[63] His worry was warranted as a little later he wrote "when we last passed here a horse was then killed for food and the same [h]as again been acted here this day."[63]

Just after leaving the subbasin, John Work wrote "I much regret finding the river so high that it cannot be hunted as the people's last reliance was upon the few beaver which they expected to take in it in order to make up the hunt, but, more particularly, for food. The most of them are becoming very scarce of provisions, and they have now no other recourse but to kill horses."[101] A couple of days later, "Two of the men, J. Troupe and G. Rocque, killed a horse having nothing to eat, the provisions being all gone." And, "One of the men, P. O'Brien, was under the necessity of killing one of his horses to eat. Thus are the people in this miserable country obliged to kill and feed upon these useful animals, the companions of their labors."[101]

Near Paradise Valley, Ogden also was worried and wrote "we are now nearly destitute of food, the three horses found have been killed for food, and should we not soon find beaver, many more will soon fall."[64]

### *d. Antelope (pronghorn)*

However, the countryside was not entirely devoid of game. Antelope were occasionally mentioned by both Ogden and Work. Although trained hunters accompanied the party, they weren't always successful.

In 1826, two days before entering the upper Owyhee subbasin Ogden commented that "an antilope was seen also near our encampment." Antelope were mentioned again only the day before the brigade left the subbasin, "Our hunters seeing tracks of antelopes lost no time following them. They saw six, fired but without effect. A fresh meat would be very acceptable to all and to none more so than myself." The next day Ogden wrote "Our hunters joined us as we reach'd the encampment. Only one antilope was seen by them and fortunatly killed and still more so as it so happen by my hunter."[63]

Twice in the few days before the brigade entered the upper Owyhee subbasin, Work discussed the results of hunting expeditions. "Some of the people were out hunting. F. Payette and L. Kanotti killed each an antelope. These are the only animals to be seen here, and they are so shy that it is difficult to kill any of them. Several of the people are getting short of provisions." "Some of the people were hunting antelopes, which are the only animals to be seen here, but only one was killed." On the day they entered the subbasin, he wrote "Not an animal to be seen but antelopes and but few of them, and even these are so shy that it is difficult to approach them."[101]

The day they left the subbasin, Work wrote, "Some of the people are out hunting but without success. A chance antelope is the only animal to be seen." Once they were traveling along the Humboldt River, "They saw a small herd of antelopes in the plain, but they could not be approached." "This is really a miserable, poor country, not even an antelope to be seen." After they had traveled clear across to the base of the Steens mountains, Work wrote, "Two antelopes were seen yesterday, which was a novelty."[101]

### *e. Bison*

Throughout the region west of the Rockies, the records of various trappers record little game.[82] Although there is no doubt that there were some deer and pronghorn, in none of the journals is there any mention of bison. Ogden wondered "why buffalo should be confined to certain tract of country"[63] since some of Duck Valley was an equally appropriate habitat. Daniel Montgomery wrote later, "So far as I know, there has never been a trace of buffaloes found west of the main range of the Rockies, except one report that I got thirty or forty years ago from a pioneer named Jonathan Keeney. In 1843-4 he wintered near the sink of Lost River, in central Idaho, near where . . . Mackay now stands. He told me a bunch of thirty or forty head perished there that winter."[21] Examining reasons for the lack of bison west of the Rockies, Daubenmire[107] says that the phenomena was first remarked by Zenas Leonard. In 1832 Leonard "wrote in his diary that the failure of bison there seemed 'somewhat singular, as the country is just the same, if not better as to grass.'"[44] Lyman and Wolverton[46] review a number of different hypotheses for the "paucity of bison in southern Idaho (and areas west and north) throughout the last 10,000 years."[46]

### *f. Native consumption of game*

The variety of game eaten by the different tribes who roamed into the upper Owyhee subbasin is consistent with a general scarcity of game. The Tagötöka interviewed by Omer Stewart were willing to both hunt and consume small animals such as mice and chipmunks. In addition to eating deer, antelope, elk, buffalo (from trips east of the Rockies), and mountain sheep, the Tagötöka ate porcupine, jack rabbit, white rabbit, cottontail rabbit, pocket gopher, kangaroo rat, field mice, muskrat, wood rat, woodchuck, squirrel, ground squirrel, chipmunk, raccoon, bobcat, badger, and beaver.[89] In addition a number of bird species were taken as food. Jack Harris's White Knife informants said that in addition to an occasional pronghorn, deer or mountain sheep that "Insects such as crickets and ants formed a substantial item of diet, but the bulk of food consisted of numerous roots, seeds, plants and berries."[29:40]

## 5. Seasonal water flow

There are a few mentions in Work and Ogden's journals that could be interpreted as indicating fluctuations in water flow due either to season or to upstream storm events. Ogden recorded two instances of a creek or river rising or falling in a very short period of time. On June 8th, the trappers "found many of their traps high and dry the water having fallen nearly 1 foot perpendicular."[63] Another time he commented that "Horse thieves had certainly a favourable night for stealing but did not think proper to make the attempt, the water having risen nearly one foot perpendicular."[63]

Seasonal variations were indicated by Work when he was traveling near Wild Horse; "The water has been lately very high and all the plain overflowed, . . . but is now subsiding."[101] Another day he stated "The river here has been lately very high, and overflowed its banks, but the waters are subsiding, and river about 10 yards wide. Have fallen a good deal."[101] As Ogden was leaving the subbasin to the south, he wrote "we reached a fine large stream [probably Rock Creek] . . . but in the fall little or no water remains in it".[64]

### 6. Conclusions

What sort of picture emerges from the writings of the trappers while traveling in and skirting around the upper Owyhee subbasin? Predictably, the observed climate was very similar to what we would note today. The summer days were hot with almost no rain. Away from the mountains, there were expanses of sagebrush, stretches of rocky ground, areas with little grass, and verdant valleys.

Except for the main rivers and the streams of the Bull Run and Independence Mountains, there were few easily accessible water sources in the summer. Some water courses in the area were also noted as varying in flow at different seasons. There were even observations of overnight fluctuations both up and down.

The vegetation along the rivers in the area was generally willows similar to the coyote willow and other shrubby willows present along the river banks today. Even the willows were not always abundant along river banks. There were trees along mountain streams.

Perhaps the most amazing observation is the generalized severe scarcity of big game, game birds, and rabbits.

## D. California and Oregon Trail travelers

The California Trail passed south of the upper Owyhee subbasin while the Oregon Trail passed to the north (Figure 4.6). In 1836, Narcissa and Marcus Whitman traveled along the Snake returning to their mission in Walla Walla.[99] However, the first wagon train is considered to be the Peoria Party in 1839.[25] The first travelers along the California Trail were the Bartleson-Bidwell party of 1841.[5,78] They roughly followed the later route of the trail. Other small parties of emigrants used the trail until the discovery of gold in California in 1848 when suddenly there were massive parties of emigrants traveling the route along the Humboldt.[11] At the same time, the Oregon Trail along the Snake River also became a heavily used route.[67]

Because both trails were somewhat remote from the upper Owyhee subbasin, no attempt has been made to utilize the diaries kept by emigrants along either trail to describe conditions in the upper Owyhee subbasin.

## E. Early settlement

### 1. Discovery of gold

Rich deposits of placer gold were found along Jordan Creek in Idaho in 1863 followed by the discovery of quartz ledges where hardrock mines could be developed.[98] Miners and gold seekers moved to the area from Idaho and elsewhere. With both placer and hard rock mining, there were "two hundred fifty mines recorded from 1863 to 1865."[27] The towns which grew up to supply the mines, Booneville, Ruby City, and Silver City, were the first permanent settlements in the Owyhee watershed. These towns were located just to the north of the upper Owyhee subbasin in the middle Owyhee subbasin. However, the development of thriving communities in the middle Owyhee did not lead to settlement in the adjacent areas of the upper Owyhee.

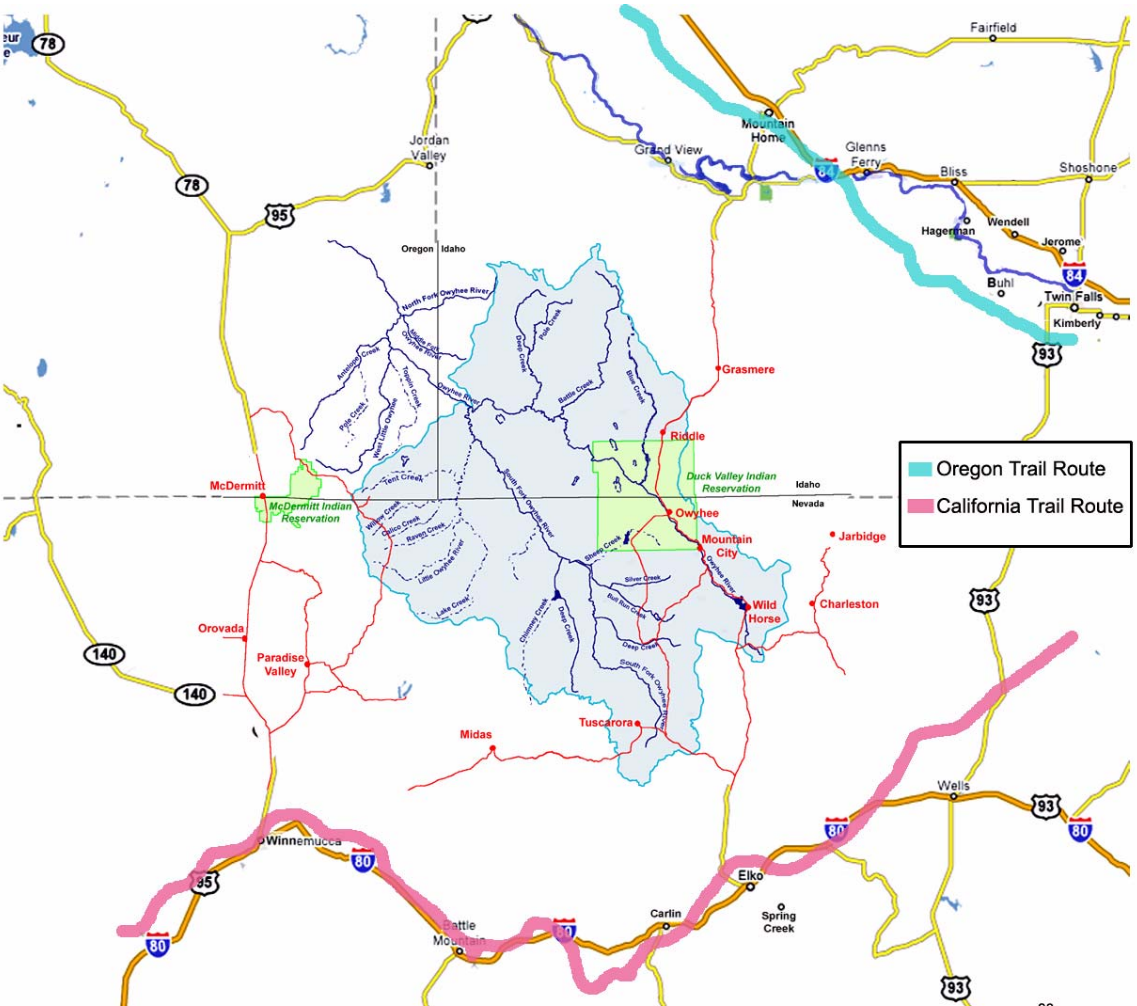


Figure 4.6. The routes of the California and Oregon trails around the upper Owyhee subbasin[68]

Placer gold was discovered in the upper Owyhee subbasin along McCann Creek in Nevada in 1867.[24] The area was called Tuscarora and the discovery of gold led to an influx of prospectors into the subbasin. Gold discoveries were made in other areas of the subbasin and by 1868 there were the beginnings of mining towns at Mountain City and Columbia. The original homestead on Jack Creek also was established at that time.[26] Throughout the 19th century other towns were started near new gold or silver mining (Figures 4.7 and 4.8).

## 2. Development of towns

After the discovery of gold at Tuscarora, gold was found in nearby districts. Following the initial strike in any district, there was an influx of miners. Rich mine fields like that around Tuscarora attracted not only the prospectors and hard rock miners but also the gamblers, the promoters, and the adventurers. The first discoveries were rapidly followed by the development of a sizable camp of men and women.[97] Even small towns such as Blythe City (Blue Jacket mine) might have a justice of peace or constable. [26]

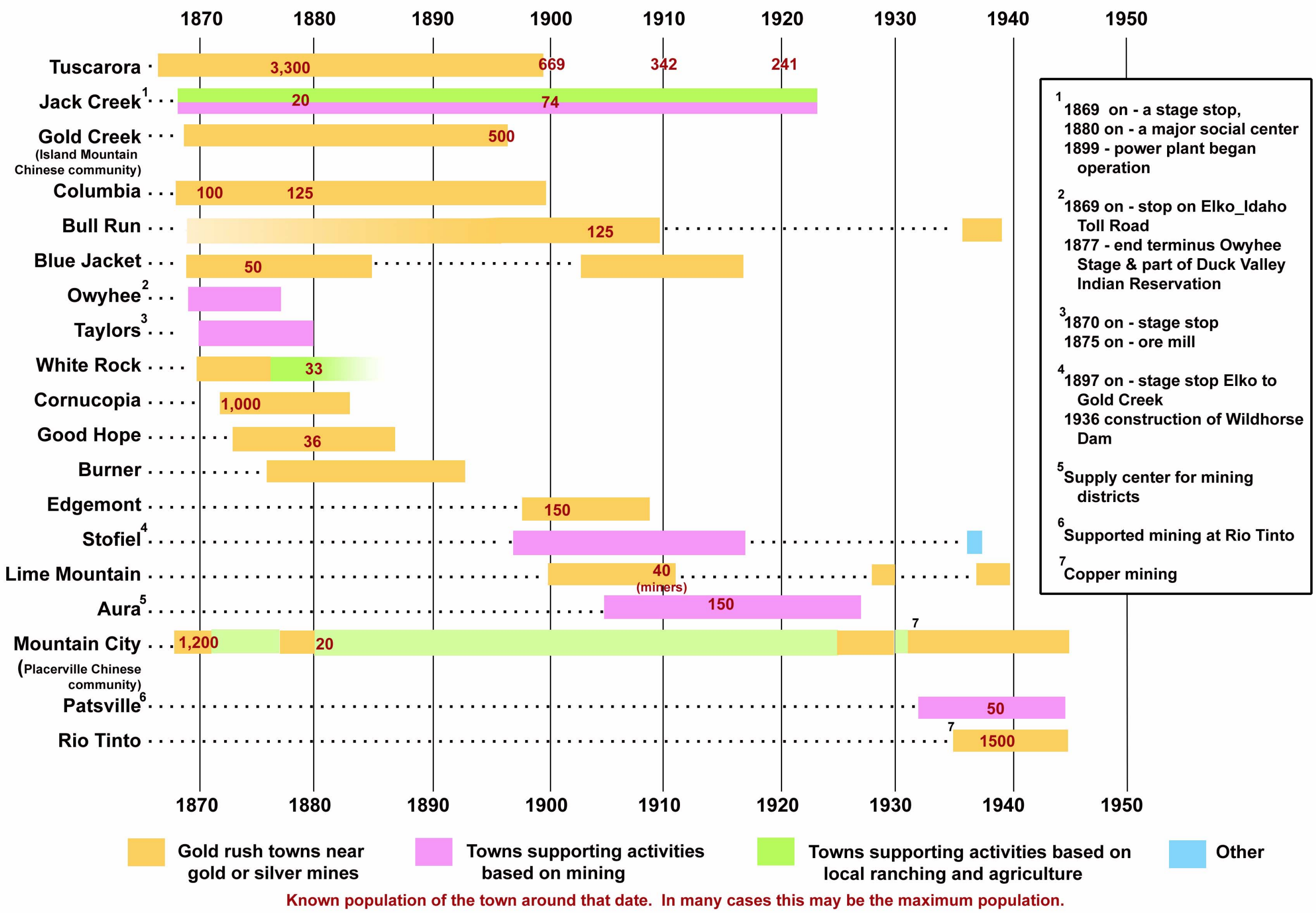


**Figure 4.7. Periods of activity of towns in the Nevada section of the upper Owyhee subbasin.**

Cornucopia demonstrates the rapid development of an area following the discovery of gold. Placer gold was located near Cornucopia in 1872, and by August 1873, 1,000 people lived in town. In addition to the hotel, boarding house, and dry goods store, town included three saloons, two restaurants, two butcher shops, a bakery, a blacksmith shop, and a small school. For entertainment there were horse races and dances. In 1875 one of the saloons was issued the first gaming license in Elko County.[26] Although the original gold found was placer gold, later gold discoveries were lode deposits and hardrock mines were developed.[26]

Tuscarora grew to be the largest town in the upper Owyhee. The initial placer operations were labor intensive, and Euro-American miners hoping to get-rich-quickly became discouraged.[26] In 1869 the Central Pacific Railroad had been completed; Chinese laborers dismissed from the railroad were drawn to Tuscarora.[26,59] When disgruntled whites sold claims to the Chinese, the Chinese organized into companies for high-volume placer operations. By 1870 only fifteen white prospectors were left and 104 Chinese. The discovery of rich silver lodes located close to town caused another rush of both white and Chinese prospectors.

**Photo 4.8. Gold veins occurred in the quartz deposits near Cornucopia**

At one point Tuscarora had the largest Chinatown outside of San Francisco. There were two tongs, immigrant societies organized for mutual business and social support, in Tuscarora. Each year the "election" of the "president" of Chinatown provided spectator sport for most of the silver camp's population. A rocket shot into the air carried a bomb. Whichever tong could retrieve the bomb and place it on the steps of their house could keep it. The only rule in the free-for-all was no pigtail pulling. Inside one of the 20 bombs stuffed with presents, candy, and cookies was a gold ring. The candidate from the tong that found the ring was Chinatown's president for the next year.[32] However with the influx of people, the Chinese eventually became not only a segregated, but frequently a despised, minority.[26]

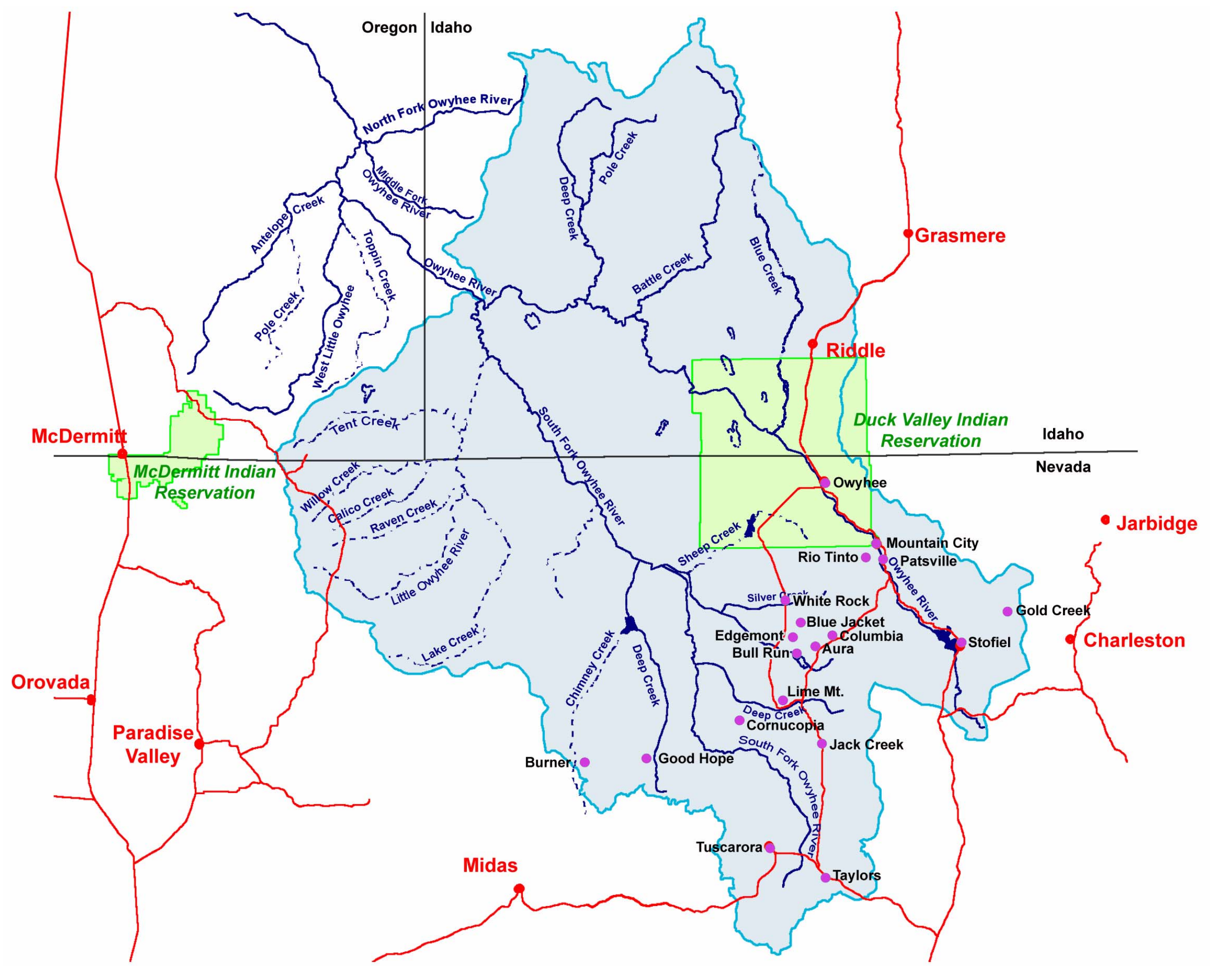


**Figure 4.8. Mining era towns (●) in the upper Owyhee subbasin**

During Tuscarora's heydey there were around 3,300 residents. David MacLain lived in Tuscarora about 1880. In 1938, he recalled that "there were two large boarding houses in the place, two good-sized hotels, several general stores, saloons, a drug store, a jewelry store, a gun shop, and enough houses to comfortably care for the population.[97] There were also two breweries, several attorneys, two newspapers, service clubs, bands, the Tuscarora baths, a racetrack, and a baseball team. Educational institutions included not only the Tuscarora Polytechnic Institute but also ballet and ballroom dancing academies, and an elocution school. [26,59]

**Photo 4.9. One of the remaining houses in Tuscarora.**

A new ore discovery not only led to people rushing into an area, but a stage line was quickly established. Passengers, freight, and mail were carried on the stage lines. Nearly all these stages carried mail which was eagerly awaited by prospectors and pioneers. Stage lines were scheduled runs. A few ran daily, some weekly, and others twice or three times a week. Tuscarora, Cornucopia, and Mountain City within the subbasin all had stage lines connecting them in various directions.[17,26,102] Many of the roads on which the stages ran were toll roads, constructed by individuals who ran them for profit. Cornucopia's residents' only roads out of town were toll roads.[26]

In addition to towns that developed close to mining, other towns in the upper Owyhee subbasin were primarily stops on stage routes. A stage stop might be slightly more than a ranch house or develop into more of a town around a hotel. Jack Creek, Taylors, White Rock, Stofiel, and Owyhee Meadows all served largely as stage stops (Figure 4.8).[26, 41,65]

In 1877, Rutherford B. Hayes established the Duck Valley Indian Reservation. Recognizing that the Duck Valley Tribal Council operates as a sovereign entity, the history of the lands and towns of the reservation presented in this assessment terminates in 1877.

### 3. Mining

Mining was not limited to solitary miners. Development of the larger lodes necessitated more labor. Miners and mill operators were hired and most of the larger mines were owned by a company rather than an individual.[26]

### *a. Mining Districts*

When the discovery of gold brought an influx of miners into an area, it was frequently beyond the reach of effective government. Miners began to organize a local mining district to provide some form of government for the mines.[96] In 1931 Ricketts defined a mining district as

> ". . . a section of country usually designated by name, having described or understood boundaries within which mineral is found and which is worked under rules and regulations prescribed by the miners therein. There is no limit to its territorial extent and its boundaries may be changed. . . . The organization of mining districts is entirely optional with the miners, as there is no law requiring such organization."[76]

When the miners began pouring into the upper Owyhee subbasin, the General Mining Act of 1866, and later the Mining Act of 1872, stated that local rules should be recognized and confirmed. Even with effective government in an area, miners continued to organize mining districts.[96] Reuben Riddle, whose family later were some of the first settlers in Duck Valley, had a background in both surveying and mining. After he moved to Mountain City in 1870, he was asked to help formulate new laws for each of the mining districts.[62]

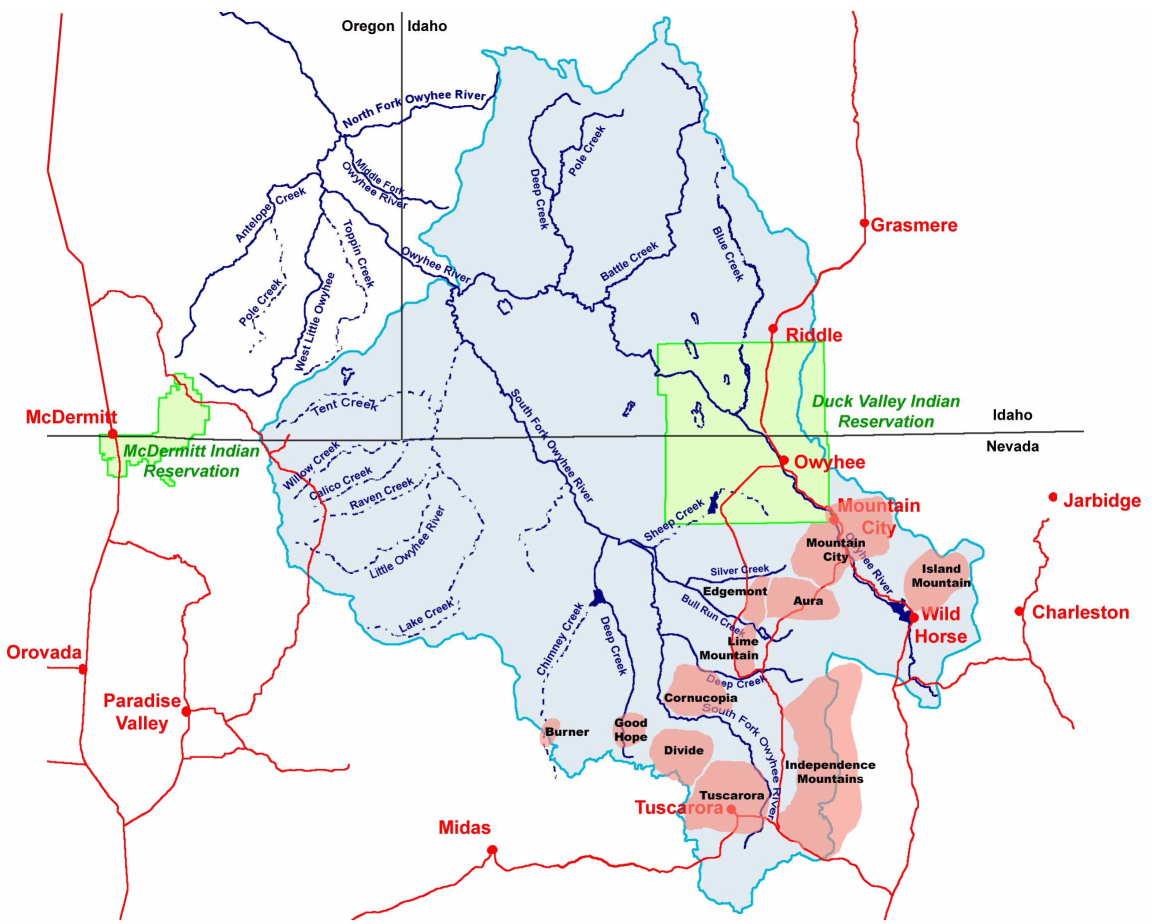


Figure 4.9. Current Nevada mining districts in the upper Owyhee subbasin.[106]

District boundaries were fluid, and both the names of districts and the boundaries varied over time. The names currently used may have been applied to a different district in the past.[Appendix B] Figure 4.9 shows the current Nevada mining districts.

### *b. Mining techniques[53,80,94]*

In the Tuscarora District, by 1871 placer ores were being mined extensively in a square-mile area, principally by companies of Chinese miners who ran dirt, sand, gravel, and water through sluices.

The water which was needed for mining operations had to be diverted. Usually a rock dam was built across the stream at the point of diversion. Frequently the first spring flood would wash out the dam and it would need to be rebuilt.[104] Both Tuscarora and Gold Creek miners built several-mile long ditches to bring water from more distant sources.[26]

High grade lode ore is relatively uncomplicated to mine, whereas processing gold and silver placers require special techniques. The best, and earliest known solution to this problem was the use of mercury. When gold and silver particulates (and those of any other metal but platinum or iron) are brought into contact with mercury, they amalgamate or clump. Amalgamation was used by placer miners to recover fine particles. Mercury was placed behind the riffles of their sluices, and the amalgam that was heavier than regular gravel and sand particles was collected at intervals.

Sluices were effective methods for collecting ore occurring in small particles, however the mercury they used was not all recaptured. In California, where placers were mined extensively, sluice losses of mercury have been estimated at a minimum of 10% per year, and more typically 25% of the total used. An individual sluice would have an operating requirement of at least 0.1 pound of mercury per square foot.

Amalgamation was also used extensively in the processing of lower-grade hard-rock ores. Stamp mills would crush the ore to a sand-like particle size. Using the Washoe process developed in Nevada's Comstock Lode, the crushed ore was placed in shallow iron tanks, combined with mercury and salts of sodium chloride and copper sulfate, heated and agitated. In the late 1800s and early 1900s, gold and silver miners in the upper Owyhee subbasin used mercury to process much of the ore.

Once amalgamated, gold, silver, and other metals would be separated from the mercury by retorting (heating to distill mercury vapors). Precious metal separation by boiling off mercury works because the boiling point of mercury is 357°C but the boiling point of gold is 2808°C and silver is 2210°C. The volatilized (gaseous) mercury would be captured, condensed and reused. This was an important step, since mercury itself was an expensive metal. Regardless, mercury losses on the Comstock Lode using these methods were approximately 1:1, with an ounce of mercury lost for each ounce of silver or gold produced. A similar loss could be expected in the processing of ore in the upper Owyhee subbasin.

Mercury amalgamation was the only known way to process low-grade ore until the arrival of cyanide. Nevada's first cyaniding plant was built in Tuscarora District in 1892 with additional plants built to rework tailings in 1898 (at the Independence Mine)

**Photo 4.10. An abandoned structure in the canyon below Blue Jacket mine.**

and 1911. Cyanide was also used in the Bull Run District beginning in 1899. It is unclear to what extent the cyanide process supplanted amalgamation or if it merely supplemented the mercury process by allowing the processing of tailings from earlier operations.

### *c. Boom-bust cycles*

Sometimes ore reserves played out quickly and a town lasted only a short period of time (Figure 4.7). A national depression or drop in ore prices might lead to the closure of nearby mines. In some cases a small number of prospectors remained, processing placer gold or working small veins. A new discovery or reopening of a mine would result in another influx of miners, sometimes reviving the town.

Until the 20th century, Tuscarora's mining never completely stopped and it repeatedly picked up following a downturn.[31] Bull Run exemplifies the more precipitous ups and downs of some of the other towns. Although gold was discovered in 1869, little was produced before new discoveries were made in 1896. All activity ceased in 1910 and the residents left. The mine was reactivated in 1936 with a 25 ton mill. Although a 100 ton mill was built in 1939, all work ceased in 1940.[26]

### *d. Natural resource consumption*

Prior to 1903, there were no complete records of precious metal production. The upper Owyhee subbasin probably produced in excess of $10,000,000 of gold and silver.[56,84] The lode gold came primarily from Tuscarora and Edgemont. Gold prices varied little, $18.94 per ounce,[56] so around 53,700 ounces of lode gold were mined before 1900.[42] Placer gold was produced primarily at Island Mountain and Tuscarora. Placer gold production prior to 1899 has been estimated at 77,800 ounces.[39] Silver varied considerably in price, from $.59 to $1.75,[23] averaging $1.08 an ounce so based of the profits about 6,950,000 ounces on silver were also produced.

Wood was needed both for mine timber and as an energy source. During the 1870s and 1880s woodlands were severely depleted as energy sources for the mining industry.[104] The development of lode deposits at Cornucopia was slowed by a lack of wood for mine timber. Wood timbers from abandoned mines might be salvaged for reuse. The mine timbers at Lime Mountain came from old mines at Kennedy.[26]

A huge demand for fuel was created by the mills. By 1877 in Tuscarora "the lack of wood necessitated the use of sagebrush."[26] During the fall and winter, Chinese made up a large portion of crews hired to cut sagebrush to fuel the steam boilers in the silver mills and mines of Tuscarora. Sagebrush was harvested up to 25 miles from town.[31] The mills at both Cornucopia and Good Hope also ran on sagebrush.[26] Obtaining fuel for all uses was a problem. The Tuscarora Times-Review "called attention to a message from telegraph company headquarters in San Francisco. The message warned that the telegraph lines to Tuscarora would be taken away if Tuscarora-Elko teamsters didn't quit chopping down the poles to use as fuel."[74]

**Photo 4.11. Ruins of the mill at Tuscarora**

### 4. Timber industry

Jack Creek was a major source of the wood used in Tuscarora. Both mine timbers and firewood were brought from there. An 1881 description identifies both the general scarcity of trees and the forested hills around Jack Creek. "Wood is found in the gulches in limited quantities, but in the Jack Creek range, on the east, there is plenty of timber, and a sawmill is established on the creek by that name, whence come the mining timbers for the Tuscarora silver mines. About forty men are constantly employed in the lumbering business at this mill."[93] Between 1877 and 1892, 200,000 linear feet of mine timber and 12,000 cords of firewood were harvested around Jack Creek.[26]

On the other side of the mountains, Reuben Riddle started a lumber and saw mill in Mountain City in 1870.[62]

## 5. Livestock industry

Miners and the other people in the developing towns required food. Cattle were introduced to the region to feed the miners. Sheepmen also realized that "gold-seekers would pay high prices for mutton, especially when beef was scarce."[27] Jack Harrington was possibly the first rancher near the Nevada mines. He homesteaded on Jack Creek in 1868 and was a rancher all of his life.[26] Other entrepreneurs had already recognized the grazing potential of the land just north of the subbasin. In 1867 Con Shea brought in a herd of long horns from Texas for the start of the cattle business in the Owyhee region.[6] Pick Anderson, who settled at Golconda in Nevada sometime before 1874, utilized the range on Juniper Mountain in the upper Owyhee watershed (Figure 4.10) Cattlemen frequently also ran sheep. At one time Pick was grazing twenty thousand head of cattle and fifteen to twenty bands of sheep.[27]

Near Tuscarora, the South Fork Owyhee River flows through Independence Valley.[58] This crescent shaped valley is about twenty five miles long and eight miles wide. By 1871 there were five ranches in the valley and the number continued to increase over the years. [65] One of these original ranches as owned by two Basque brothers, the Altubes. They drove 3,000 cattle from "Old Mexico" to Independence Valley. Their ranch, near Tuscarora was roughly 20 miles long by 10 miles wide and they also ranged their cattle on thousands of acres of public land.[43] In 1881 Independence Valley was described as having "an abundance of water, many small creeks rising in the mountains and swelling the main stream. . . . Along the river are

**Photo 4.12. Looking out over Tuscarora towards the upper end of Independence Valley**

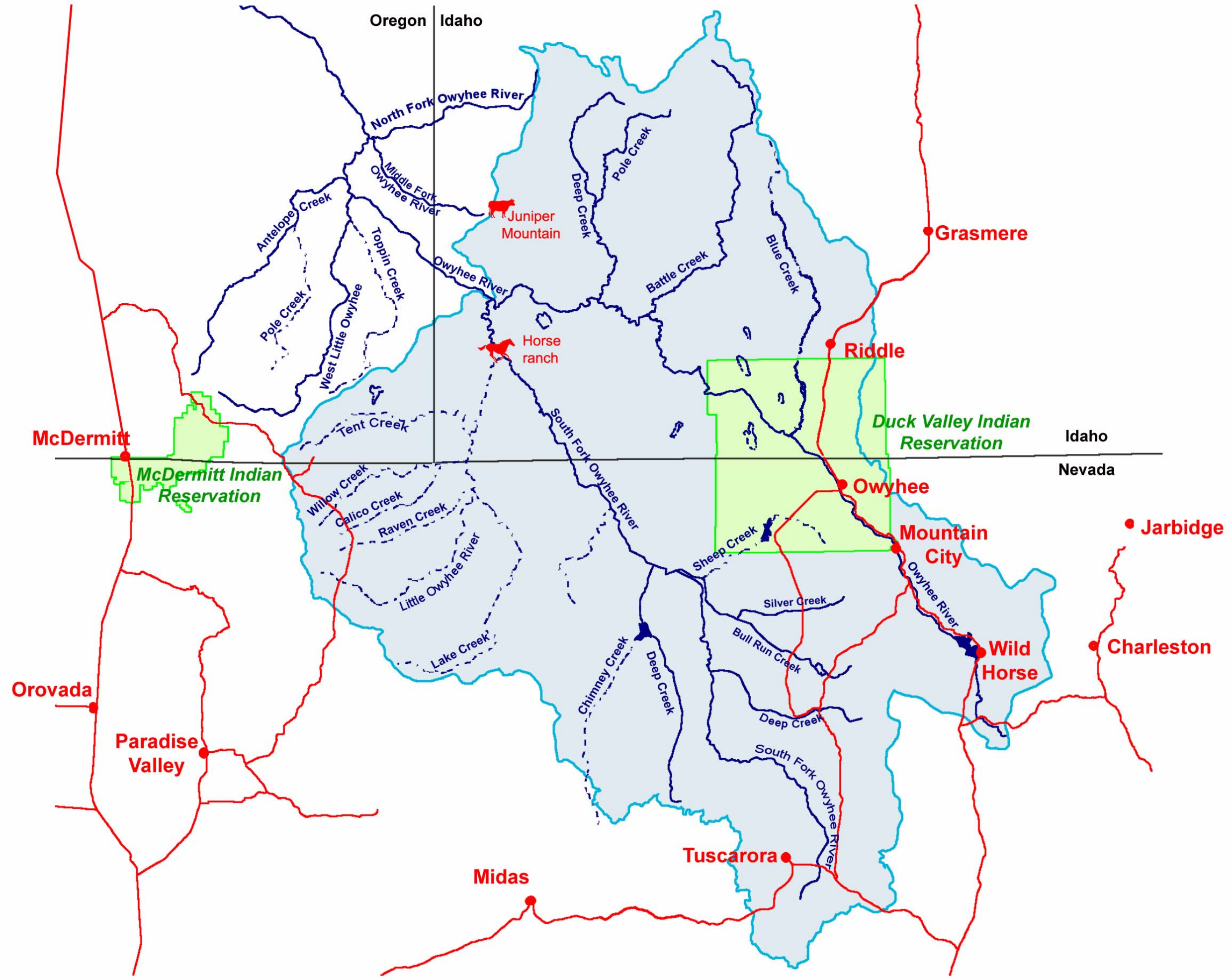


**Figure 4.10. Early use of the Idaho section of the upper Owyhee subbasin.**

beautiful meadows that widen out in some places to three miles, which produce thousands of tons of hay. Lying at an altitude of 7,000 feet above the level of the sea, grain does not grow as well as could be wished, though it is raised to some extent. . . The land is used principally for grazing purposes, only about 300 acres being devoted to agriculture, most of which lies in the eastern portion of the valley."[93]

Grazing on the range followed the Spanish system of open-range livestock.[104] However, the large operations tacitly utilized different areas. Cattle were generally moved with the seasons. Sagebrush ranges were used in the spring and fall while mountain ranges were summer pastures. During the winter, cattle were moved to areas where they wintered on bunch grass and winterfat (white sage), frequently at the margins of playas (salt deserts).[104] In 1870, David Shirk, who was supplying cattle to the mining towns just north of the subbasin, drove cattle up from their winter range to Duck Valley. He identified it as an ideal summer range, with miles and miles of waving bunch grass covering the hills and mountain slopes.[81] Few ranchers thought about putting up hay for cattle although from the earliest days most ranches put up some hay for stock horses.[104] Homesteaders with just a few cattle supplemented their income by making and selling butter and cheese. As their herds grew, they also turned their animals out on the Owyhee desert.[62]

With the completion of the transcontinental railroad, shipping cattle by rail cars changed the economics of ranching. Some ranchers expanded their operations and ranchers with bases outside the upper Owyhee subbasin used the upper Owyhee subbasin as part of their range. Humboldt Valley ranchers used the Owyhee Desert to winter cattle.[104] One outfit, Jarvis and Brass purchased steers to winter them on the Owyhee desert and canyons. Other cattlemen like David Shirk only used the upper Owyhee subbasin for summer range.[81] In the Idaho section of the subbasin, cattle of the Horn outfit had ranged into the lower country, including Duck Valley, starting around 1880.[77]

Horse ranching was also profitable in the sagebrush/grasslands. "Southeastern Oregon and northern Nevada were well known by 1880 for producing fine cow horses"[104] In 1880 a horse ranch was established just downstream of the confluence of the South Fork Owyhee River and Little Owyhee River in the upper Owyhee subbasin (Figure 4.10).[8]

During the 1879-80 winter, there was little snow on the ground in the Owyhee Desert. Many intermittent and ephemeral streams lacked water. Since the cattle stayed close to existing water supplies, the forage, mainly winterfat and Indian ricegrass, was entirely consumed near water sources. Cattle starved, but few ranchers started putting up hay. Sheep, which could obtain water from skiffs of snow and were less selective browsers, were less impacted.[104]

From 1886 to 1889, precipitation throughout the region was reported to be below normal. There was a terrible drought in the spring and summer of 1889. Waterholes dried up and feed was scarce. Streams that had been perennial for as long as the oldest settlers could remember shrank to interrupted pools, then dried up completely. Cattle were already in poor condition when an early December snowstorm brought seven consecutive days of blizzard conditions. Snow storm followed snow storm and temperatures through February reached record lows. Elko newspapers estimated that 95% of livestock was lost.[102,104]

"The transplanted Spanish system of open-range livestock was dead."[104] One immediate effect of the harsh winter was an increase in the sheep on the range. Previously the range sheep industry had competition from established cattle ranches. However, there were fewer sheep losses over the extreme winter; the sheep industry was smaller and sheep were better adapted to the environment and forages of the desert ranges.[104]

## F. End of the nineteenth century, early twentieth century

By the end of the 1800s, changes in the upper Owyhee subbasin included the introduction of cattle, sheep, and horses on the range. Towns had appeared and disappeared.

The changes in the subbasin during the 19th century following Euro-American settlement set the stage for activities in the succeeding decades. The routes of principal roads evolved near where they are today. By 1927, the highways on the Rand McNalley road map are shown in their current locations.[75]

The principal enterprises in the subbasin during the 1800s were engaged in mining or ranching. Mining and the associated towns relied on the geology of the region and the location of gold and silver deposits. Ranching relied on utilization of public lands for grazing on the extensive, unpopulated Owyhee uplands. The amount of land which could be homesteaded was quite restricted so some control over use of the rangelands was exerted by ownership of the lands with water.

Many of the records consulted for the following section of the history do not have exact dating, especially those recollections written long after the fact. There has been an attempt here to develop an accurate sequence for the changes recorded below, however many of the topics cover several decades and there may be some unintentional errors.

## 1. Effects of the white winter, 1889-1890

### *a. On vegetation*

Two decades of unlimited livestock grazing had severely reduced the pristine plant communities of the sagebrush grasslands. Cattle and sheep had selectively eaten the perennial grasses. The perennial grasses were largely bunchgrasses which reproduce by seed. The two decades of excessive grazing had virtually eliminated seed production in many areas. Low reserves of grass seed in the soil meant that perennial bunchgrasses couldn't respond to improved growing conditions like shrubs and juniper.[104]

The water provided by the snows of the white winter promoted excellent plant growth. In the spring of 1890, the ranges had virtually no cattle on them. Shrubs took advantage of the lack of perennial grasses to expand their dominance. Shrub establishment included stands of the desirable browse species bitterbrush, but also included an abundance of toxic big sagebrush. There was a basic change in forage resources of sagebrush grasslands. The juniper woodlands also greatly expanded.[104]

### *b. On ranching*

#### *i. Expansion of sheep*

The first Basques in the upper Owyhee subbasin had arrived in the Nevada portion in the early 1870s.[16] These original settlers like the Altube brothers on Spanish Ranch and the Garats on the YP Ranch were cattlemen. Sheep and cattle were frequently run on the same ranch, although the range sheep industry didn't really take off until the beginning of the 1900s. Young men from the Basque Country were willing to take the lonesome job of sheep herder even though the job was different from what they had done in the old country.[43] Their dependability and hard work led sheep owners and ranchers to hire workers from this immigrant group. By the late 1880s, Basques were also working in eastern Oregon and southwestern Idaho.[16]

The diet of sheep and cattle overlaps. However, sheep are browsers, eating forbs and brush. Cattle are grazers, preferring grass. Following the white winter, the

Altube brothers on the Spanish ranch greatly increased the numbers of sheep they were raising. To herd them they hired Basques. At one time the Spanish Ranch ran about 18,000 cattle and 12,000 sheep on the same ranch.[43]

As the sheep industry expanded, more labor was required. Some Basque sheepherders took sheep instead of wages. As these new outfits grew, they tended to hire newly arrived Basques, frequently family members.[43,12] Many of these sheep bands were grazed on public lands. When a sheep herder had no home base, his herd was considered a tramp sheep outfit.[43]

*ii. Cattle outfits*

Some small outfits like the Horn outfit were forced out by the winter of 1889-1890.[77] Surviving ranchers realized the need to put up hay for the winter to feed cattle that grazed on the sagebrush ranges.[104] The Riddle brothers had built up a cow herd with a home base at Whiterock. Following the winter of 1889-1890 when the need for winter feeding became apparent, they felt the Duck Valley wild hay meadows could provide a good source of hay. Owyhee County, Idaho could be homesteaded since surveys to establish townships had been completed. The Riddle brothers were among the earliest Euro-Americans who settled in that part of the Idaho section of the subbasin.[30,62,77,85,104]

**Photo 4.13. Irrigated hay fields in the upper Owyhee subbasin being used for fall pasture after harvest.**

The number of settlers who followed the Riddle brothers and their families into the Duck Valley region was limited.[77] In 1898, the Wickahony directory, which included not only Duck Valley but families living in other nearby drainages listed, 18 ranchers.[1] The 1919 Idaho Farm directory listed people by their home town and then the township and range of land which they owned. It listed 22 land owners as living in Riddle. Of these 22, only 16 owned land in the Idaho section of the upper Owyhee subbasin. Eight of these were Riddles, three were Yates and two were Stones.[22]

## 2. Water

The need for a reliable source of winter feed led to an increase in the need for water. Hay required water. Existing natural hay meadows could be enlarged by flooding adjacent areas. However, irrigation was necessary to economically grow larger amounts of forage in the semiarid environment.[104]

In the Nevada section of the upper Owyhee subbasin, the mining companies were already utilizing water, the twelve-mile-long ditch at Gold Creek being the greatest redirection of water by miners.[26] The ranchers on the western side of the Bull Run and Independence Mountains were utilizing the water from the creeks flowing out of the mountains. Water was a finite resource and increased demands on this resource highlighted the need for laws governing water rights. In general, water laws in the West evolved from mining laws. Western semiarid states were granted authority to regulate waters for irrigation whereas the federal government controlled stock water.[104]

As state laws evolved, the upper Owyhee subbasin occupied areas where the appropriation doctrine for water rights was used. Water rights were based upon the beneficial use of the water rather than upon the ownership of land. The priority for the rights was based upon when the user first began to utilize the water for the stated purpose or when the construction of diversion works began. The owners of the earliest water rights could use the water even if it meant that the owners of later rights were deprived of water.[104] Ranchers were frequently the first settlers to make beneficial use of the water, so their water rights were established under the “prior appropriation” doctrine. Idaho, Oregon, and Nevada all recognized and protected such rights.[86]

Although Reuben Riddle had filed a number of water right claims in the upper Owyhee subbasin by 1874,[62] many early water users did not file claims until a much later date. Then people encountered problems in remembering the dates, locations, and amounts of water utilized as long as fifty years previously.[104]

Where placer miners wanted to divert water from a stream, they had been piling rocks across the stream to create a primitive rock dam. The first spring flood would wash out the dam. When ranchers began irrigating with diverted water, they built similar rock dams. In the spring, before they could start irrigating, they needed to repair the dam.[104]

Irrigation greatly increased the available forage base in the subbasin. This forage could be converted to hay for winter feeding and irrigated farming became integrated into range livestock operations.[104] To provide enough water and irrigable land to grow hay to feed their herd through the winter, ranchers acquired tracts of private property. During the summer the herds drank from streams and springs on the public lands where they were grazing, but established water rights were crucial for the success of a ranch. When land was sold, it was understood that the water rights on both the land and on the public portion of the ranch’s grazing allotment were included.[86]

## 3. Settlement in Idaho

### *a. Land ownership*

The number of land patents issued is some indication of the number of ranchers or farmers in an area. A land patent documents the transfer of land ownership from the federal government to an individual.[9] Most of these transfers were based on one of the homesteading acts. Sometimes each member of a family filed a claim but the claims were managed as a single ranch. A rancher might file claims for different sections of land at different times. There was a steady increase in the number of patents issued in the Idaho section of the upper Owyhee subbasin. Prior to 1900 there had been only three patents issued. Other than land deeded to the state of Idaho or to railways, between 1900 and 1909, 17 patents were issued. Between 1910 and 1919, 88 were issued. And, 165 patents were issued between 1920 and 1929(Table 4.1).[9]

Figure 4.11 is a generalization of the pattern of settlement in the basin based on the land patents.[Note A] By 1909 individuals had settled in the Riddle area and along the headwaters of Pole Creek and along Battle Creek. The following decade patents were also issued along Deep Creek and Blue Creek. A common element of all these lands was their placement along water courses, underscoring the integration of water for irrigating hay with ranching. Both the Riddle and Stone families constructed reservoirs to hold water from melting snow.[30,85] Henry Rhubelt built a reservoir on Shoefly Creek.[77] Many of the later claims were adjacent to land directly north of the upper Owyhee subbasin and may have been parts of larger operations.

Table 4.1. Number of patents issued in the Idaho section of the upper Owyhee subbasin through 1929. Townships listed are only those where patents were issued.[9]

| Township | Range | Before 1900 | 1900-1909 | 1910-1919 | 1920-1929 |
|---|---|---|---|---|---|
| 14S | 2E | 3 | | 5 | 10 |
| 14S | 3E | | 11 | 17 | 14 |
| 13S | 3E | | 1 | 14 | 13 |
| 13S | 2E | | 2 | 2 | 7 |
| 10S | 1E | | 1 | 4 | 7 |
| 10S | 1W | | 2 | 13 | 8 |
| 16S | 5W | | | 1 | |
| 15S | 1W | | | 2 | 2 |
| 14S | 5W | | | 1 | 1 |
| 14S | 2W | | | 2 | 1 |
| 13S | 4E | | | 1 | |
| 12S | 3W | | | 4 | 6 |
| 12S | 1E | | | 1 | 5 |
| 12S | 2E | | | 1 | 5 |
| 11S | 1E | | | 1 | 1 |
| 11S | 2E | | | 1 | 2 |
| 10S | 3W | | | 2 | 9 |
| 9S | 3W | | | 2 | 8 |
| 9S | 1W | | | 2 | 2 |
| 9S | 1E | | | 9 | 5 |
| 8S | 1W | | | 1 | |
| 8S | 1E | | | 2 | 3 |
| 16S | 1W | | | | 1 |
| 15S | 4W | | | | 1 |
| 14S | 1W | | | | 1 |
| 14S | 1E | | | | 2 |
| 13S | 1E | | | | 3 |
| 12S | 5W | | | | 1 |
| 12S | 1W | | | | 2 |
| 11S | 4W | | | | 8 |
| 11S | 3W | | | | 6 |
| 10S | 4W | | | | 10 |
| 10S | 2W | | | | 6 |
| 9S | 2W | | | | 14 |
| 8S | 3W | | | | 1 |
| | **Total** | 3 | 17 | 88 | 165 |

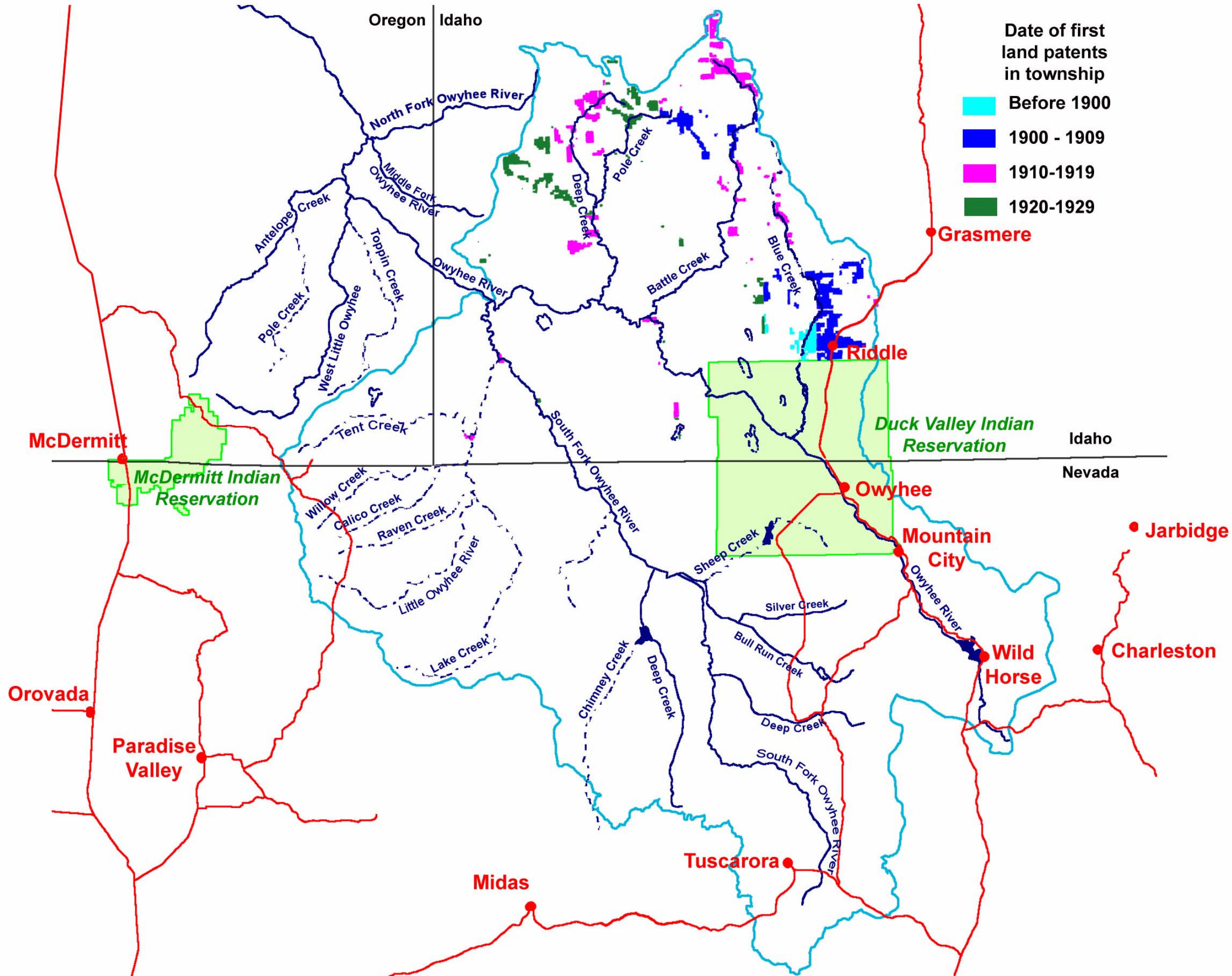


**Figure 4.11. Progressive land settlement in the Idaho section of the upper Owyhee subbasin by date of entry in the township. Cumulative land ownership over the decades.**

Not all of the settlers were successful. Even the Riddle's small apple orchard across from a stream flowing out of a spring never produced. However, the Riddle families successfully grew wild varieties of hay for winter feed. Horse drawn sleighs crossed the snow covered fields of winter to deliver loads of hay to the cattle.[30]

Three German emigrants who settled on Harris Creek and at Dad Springs "couldn't develop sufficient water for farming so they only stayed a few years, selling out to Mr. Sewell."[77] Joseph Sewell, the owner of a general store and trading post in Owyhee, waited, and "when all the available land with water was located and proved upon he bought each settler out, finally owning all the land on Blue and Little Blue Creeks all the way to the head of each creek."[77] He built reservoirs on both creeks. He ran both cattle and sheep.

Since homesteaded land could be sold once it was "proved up", the number of original patents might not represent people living on the land. The 1919 Idaho Farm directory not only lists thirteen upper Owyhee subbasin land owners living outside the subbasin, but also includes one livestock company based in Grandview.[22]

There were no claims made on a huge section of the upper Owyhee subbasin. These areas might have enough water for cattle to graze on them, but there was not adequate water for producing hay to winter the cattle (Figure 4.11).

### *b. Snippets of life*

The density of settlers in the Idaho section of the upper Owyhee subbasin during the first two decades of the 1900s was low. Marjorie Hawes remembers that they considered people living 45 to 50 miles away as neighbors. Before the advent of motorized travel, families would make about two trips per year to get supplies.[10,30] The ranchers would cure hams and bacon when fat hogs were killed in the fall, but they had to purchase flour, sugar, bayo [sic] beans, dried fruits, coffee beans, coal oil, and Chinese block matches.[30]

Marjorie had her first automobile ride in Mountain City about 1906.[30] By 1915, her family had a car. The roads were dusty and full of both ruts and chuck holes. Since tires blew out frequently and had to be fixed on the road, they could make Bruneau in a day or all the way to Mountain Home if they had few blow-outs.[30]

Many of the original homes were rock houses.[10] The earthquake of October 3, 1915, in Pleasant Valley, Nevada resulted in considerable damage in southwest Idaho a hundred miles from epicenter.[108,109] After the earthquake, the Hawes wood frame house listed and had to come down. Marjorie wrote, “Everyone was building rock houses around the area so we joined the club” and built a new two story house of stone.[30] A scarcity of local wood meant that sagebrush was used as fuel both in the kitchen stove and the fireplace.[10] A huge sagebrush was even turned into a Christmas tree.[30] There were flocks of ducks and geese which fed on the wild meadows. These not only made good eating, but their feathers were made into feather beds and pillows.[10,77]

In 1926, thirteen year Oliver Tremewan’s jobs on the ranch outside Mountain City included irrigating, haying, building fence, gathering cattle, fixing machinery and breaking horses. In the winter he also sawed blocks of ice from the frozen pond and stored them in a hole.[50]

Some areas retained more of their pioneer aspect for longer. Nancy Fretwell’s parents purchased the 45 Ranch at the confluence of the Little Owyhee River and South Fork Owyhee River in 1937. Nancy remembers a one room main house built into the hillside. There was no ceiling but a sheet tacked across the room. When the Mormon crickets were bad, they would build up on the sheeting until it wouldn’t hold, then they dumped out. In addition to the main house, there was a sod roofed bunkhouse, a rock and willow barn, a rock chicken house, and a rock ice house to store blocks of ice. During World War II, they would make one trip per year out to Mountain Home to purchase a year’s supply of goods.[21]

## 4. Grazing Pressure

When livestock were first introduced, the grass on public lands was "free" and lured livestock growers to turn out herds of sheep, cattle, and, sometimes, horses to roam freely. There was a "winner take all" attitude that encouraged grazing.[40,28] To protect their interests to the free grazing range, livestock owners acquired lands with water resources. "Owning the sources of water was a means of controlling the surrounding grazing lands."[40]

The established sheep and cattle operators had a base property. Many of these were developed to raise hay for wintering the stock.[55] "Several large local cattle operations branched into the sheep business with scarcely a comment from their neighbors."[104] "It was the tramp cowman and tramp sheepman who caused the friction. They had no base property, so mooched off those who had put together an outfit. Cattlemen and sheepmen alike fought these itinerant individuals,"[27] frequently completely migratory Basque herders who owned no base property at all.[104]

There is evidence that during the late 1880s Sparks and Tinnin, large ranchers in the Nevada section, recognized that the rangelands were nearing grazing capacity.[104] However, in 1914 Owyhee County was being touted as having grazing lands which "were almost limitless in extent."[20] As the number of cattle in Owyhee County declined from a high of 100,000 head before the white winter, the sheep industry increased to 200,000 sheep in 1914. Sheepmen had holdings ranging from 3,000 to 50,000 head which grazed in bands of from one to three thousand. Owyhee County was described as providing " the most ideal conditions for stockmen that are to be found within the state [Idaho]."[20]

## G. End of an era

### 1. Taylor Grazing Act

Years of unbridled use of western range lands eventually resulted in the passage of the Taylor Grazing Act of 1934. To undo the over-grazing of the open range by sheepmen herding sheep wherever there was grass and water and by cattlemen and horse owners who turned their herds out onto the public domain, the Taylor Grazing Act required livestock owners to show proof of a base of operations. This requirement would eliminate "tramp" operators. The BLM began to adjudicate the range based on the productive capability of the base properties, prior use of the federal land, and a system of seniority that gave old time operators preference over late comers.[27]

The Taylor Grazing Act also ended the policy of the previous 150 years of transferring public lands into private ownership. It withdrew public lands from homesteading. Now to file a desert claim, a man had to prove that his quarter section was more valuable for agriculture than for grazing. "The only way he [could] prove that [was] to get water enough to irrigate it."[37]

### 2. Dam construction

Downstream from the upper Owyhee subbasin, near the mouth of the Owyhee River, the Owyhee Dam was constructed during the 1930s. A dam was also constructed in the subbasin on the Owyhee River upstream of the Duck Valley Indian Reservation. Wild Horse Dam was authorized by congress in 1931 to provide water storage for the reservation. Construction was begun in 1934 and completed in 1938. Wild Horse Dam is owned by the US Department of the Interior Bureau of Indian Affairs.[18,60,73,91]

On the South Fork Owyhee drainage the Willow Creek Dam was constructed in 1931. It was a WPA project for flood control and irrigation.[100] This dam is currently owned by the Petan Company. There are another five dams on their holdings, including the Bull Run Dam on the Bull Run Creek. (At the time of writing this assessment the author did not have information on when the other five dams were constructed.)

Although small dams had previously been built, the larger dams had a much greater impact on the hydrology of the subbasin.

## 3. Mining

Mining in the upper Owyhee subbasin has never completely stopped. There was a resurgence around Mountain City in the 1930s with the opening of the Rio Tinto copper mine. The buildings constructed at the mine and in the supporting town of Patsville have become ghostly structures since the mine closed in the 1940s.

**Photo 4.13. An abandoned store in Patsville south of Mountain City**

## 4. Conclusion

As the geography and natural resources of the upper Owyhee subbasin are complex, so its history varies. The passage of the Taylor Grazing Act and the increased water available for irrigation behind dams introduced a new era. Technology in mining and ranching was evolving along with a greater awareness of how to protect natural resources. Along with the rest of the nation, the upper Owyhee subbasin slowly slipped into the modern age.

Note A. The Idaho land records database viewer was used to identify the current boundaries of private land in Owyhee County Idaho.[35] A land patent search was conducted for every township and range in the Idaho section of the upper Owyhee subbasin. All Idaho private land within the subbasin was identified by the first patent issued within the township.[9] This gives a rough idea of the settlement pattern of the area, but individual properties settled later than the initial patent are not identified separately.

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# Upper Owyhee Watershed Assessment

## V. Hydrology



### Contents



The Oregon governor's strategic initiative for ensuring sustainable water resources for Oregon's future, Headwaters 2 Ocean, considers all water resources from the hilltops to the Pacific Ocean. The completion of the assessment of the upper Owyhee subbasin is consistent with the governor's initiative. The upper Owyhee subbasin contains the headwaters of the Owyhee River and two of its principal tributaries, the South Fork Owyhee River, and the Little Owyhee River.

## V. Hydrology

Hydrology is the study of how water moves within a system. Hydrology incorporates factors other than just precipitation, runoff into streams, and flows to the ocean. In addition to describing how water travels across the landscape, hydrology takes into account the source of the water and the fate of the water. The processes involved are described as the water cycle.

### A. The water cycle

#### 1. Description of parts of the water cycle

**Precipitation** is the water that falls out of the atmosphere and reaches the ground. The water can arrive at the earth's surface as rain, snow, hail, or a mixture of these. There are several things that can happen to precipitation.[25,45]

**Interception** occurs whenever anything interrupts the flow of precipitation into the soil or runoff to streams. This can happen when water flows into puddles or lands on vegetation or organic material. During freezing conditions, the precipitation may be "intercepted" on the surface of the ground; most of it doesn't go anywhere until it melts.[25,46]

**Infiltration** is the movement of water from the surface of the ground into the soil. The infiltration rate (how much water is absorbed into the soil) depends both on the composition, structure, and compaction of the soil and on the amount of moisture already in the soil.[25,45] Wet, frozen soil conditions greatly interfere with infiltration.

**Percolation** is the movement of water through the soil. Once underground, gravity is the primary force moving water. Impermeable layers of rock and the water table are the locations where the groundwater stops moving downward. If there are large natural underground reservoirs which can store the water, they are called aquifers.[25]

**Runoff** is the water that travels downslope on the soil surface towards streams. Runoff is made up of water that has fallen on the ground and has flowed across the surface and of water that has infiltrated or percolated into the soil and has moved horizontally to reappear on the surface. All the sources of water flowing in a stream channel form the total runoff which is called the streamflow.[25,45,50]

**Transpiration** is a plant's "sweating". Plants remove water from the soil. Water inside the plants exits the plants through pores in the leaves called "stomata". How much water is transpired depends on the species of plant, water in the soil, temperature, relative humidity, wind, and the amount of light it receives.[25,39,45]

**Evaporation** is a change in the physical state of water from a liquid to a gas. The gaseous water in the air is called water vapor. The amount of evaporation from the soil depends on soil moisture, wind, relative humidity, temperature, atmospheric pressure, and the amount of direct light (solar radiation).[25,46]

**Condensation** is the change in the physical state of water from a gaseous state to a liquid state. Condensation forms liquid water droplets on plant leaves and in the air when the air cools or the amount of vapor in the air increases to saturation point.[25,46]

Water is stored in three basic locations: in the atmosphere, on the surface of the earth, and in the ground. Storage on the surface is in lakes, reservoirs, glaciers, and the oceans. Underground storage is in the soil, in aquifers, and in small cracks in rock formations.[25,45]

### 2. Discussion

In general, the water cycle is described as evaporation off oceans, off other water bodies, and off soil and plants, adding moisture to the atmosphere. Atmospheric conditions cause the moisture to condense and fall as precipitation. Some of that precipitation is returned to the atmosphere by evaporation from water on vegetation, soil, rocks, roads, and buildings. Some of the precipitation is intercepted by plants, some is absorbed into the soil, and some of it flows into streams and rivers. The water in the soil can be returned to the atmosphere by evaporation, transpiration of plants, or it can percolate down to the groundwater. Also, some of the water in the streams and rivers can infiltrate into the soil and recharge the groundwater. In turn, the groundwater can resurface (springs) and contribute to the streamflow.[25,45]

There is no real beginning or end to the water cycle and no definite path that water follows. Water in the water cycle moves between the atmosphere, surface bodies of water, and the soil and rock underground.[25,46]

The different aspects of the water "cycle" affect the fate of water differently in different environments.

## B. The water cycle in the upper Owyhee subbasin

The upper Owyhee subbasin is part of a semiarid desert created by the rainshadow of mountain ranges. To the west, the Cascade Mountains and the Sierra Nevada both receive much more rain and snow on their western sides. The prevailing wind direction moves air from the west to the east. Air cools as it rises to cross the mountains. As air cools, the water vapor in it condenses and falls as precipitation on the western side of the mountains. The water has been "wrung out" so little rain falls to the east.[25,26,45,49] Other mountains can also capture moisture if the air flow across them still contains sufficient moisture. The Calico, the Owyhee, the Independence, and the Bull Run Mountains around the boundaries of the basin all collect precipitation as the air crosses them. Some of the water captured by these surrounding mountains supplies flow into the rivers and streams of the upper Owyhee subbasin.

The majority of the upper Owyhee subbasin to the west of the Bull Run and Independence mountains can be classified as semiarid desert, specifically cold winter desert (background section). The winter temperatures in this semiarid desert section drop significantly so that most of the winter precipitation falls as snow.

### 1. Sources of primary precipitation data.

There are two primary sources of precipitation data for the upper Owyhee subbasin: weather stations and snow surveys. Traditional meteorological stations have measured temperature and precipitation. Snow surveys have been used to forecast annual streamflow volume. Beginning in the 1930s, snow surveys were conducted manually.

In the upper Owyhee subbasin, automated SNOpack TELemetry (SNOTEL) stations which record both temperature and precipitation were installed at seven sites and have continual records since 1980: Mud Flat, Fawn Creek, Laurel Draw, Jack Creek Upper, Jacks Peak, Big Bend, and Taylor Canyon (Figure 5.1).[20,21] The SNOTEL stations measure precipitation year-round, not only during the period of winter snow. Since these records cover the same years, they are comparable. The standard measurements at the SNOTEL stations are the snow depth, the snow water equivalent, air temperature, and precipitation from rain.

There are four meteorological stations within the upper Owyhee subbasin with more than 25 years of data: Tuscarora, Tuscarora Andrae Ranch, Mountain City, and Wild Horse Reservoir (Table 2.7). ***These stations have recorded data over different years and are not directly comparable either to each other or to the SNOTEL***

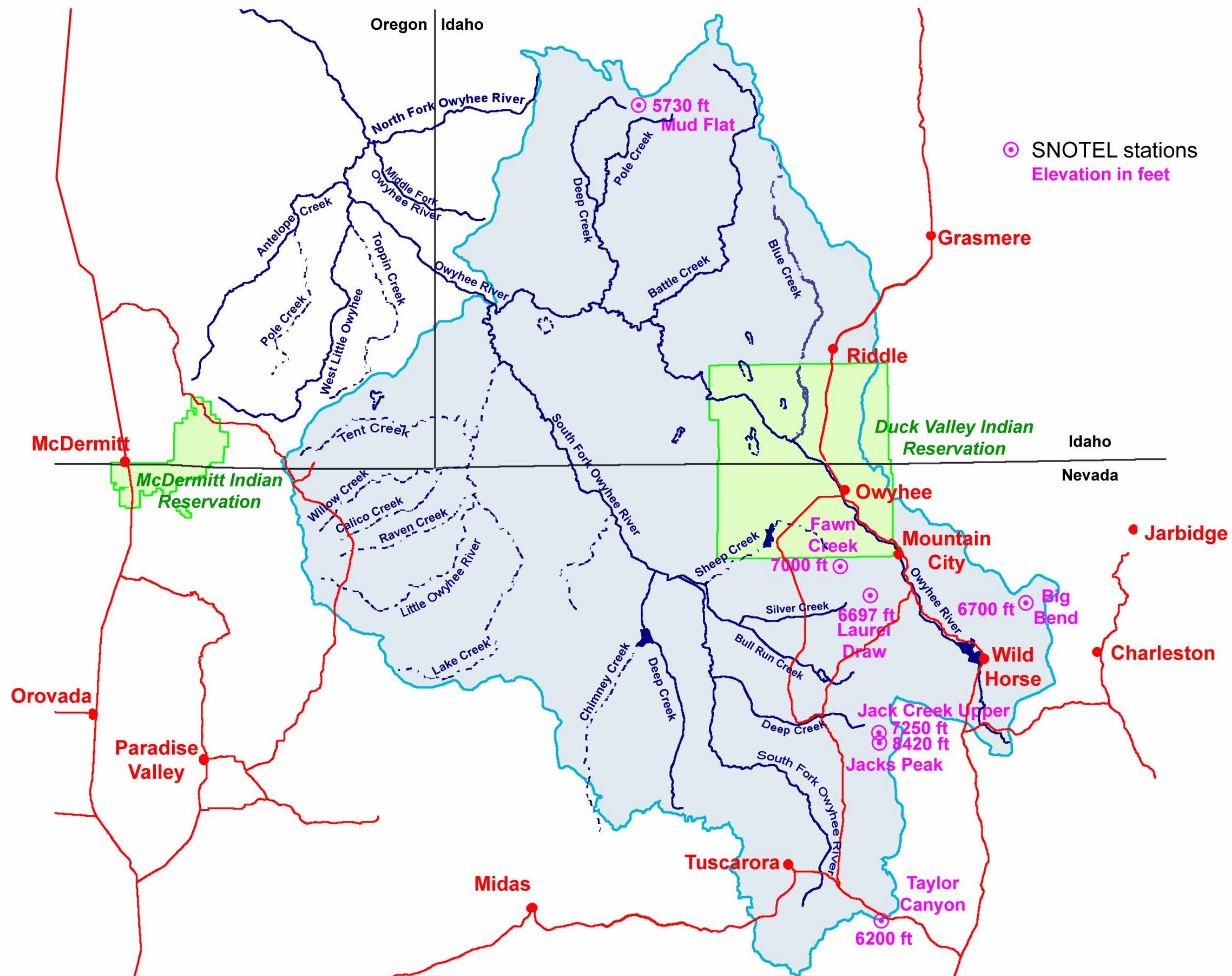


**Figure 5.1. SNOTEL stations in the upper Owyhee subbasin.**

***records***. However, the data from these stations give ideas of general conditions. In addition, the Owyhee station was included in some of the analyses of precipitation since it is within the geographical boundaries of the subbasin although it is located within the Duck Valley Indian Reservation (Figure 5.2). The temperatures recorded at these stations are discussed in the background section of this assessment.

## 2. Water cycle interactions

How does the water cycle operate within the upper Owyhee subbasin? The subbasin is at the headwaters of the Owyhee River, so the primary source of water in the subbasin is precipitation. Precipitation includes both the rainfall and the amount of water in snow.

### *a. Precipitation*

To calculate the mean monthly precipitation, the daily precipitation readings are totaled for each month. Totals for a given month of the year (e.g. March) are averaged across the multiple years of readings to obtain the mean monthly precipitation for that month. This is done for each weather station and SNOTEL station. The water year is considered to start October 1 and end September 30.

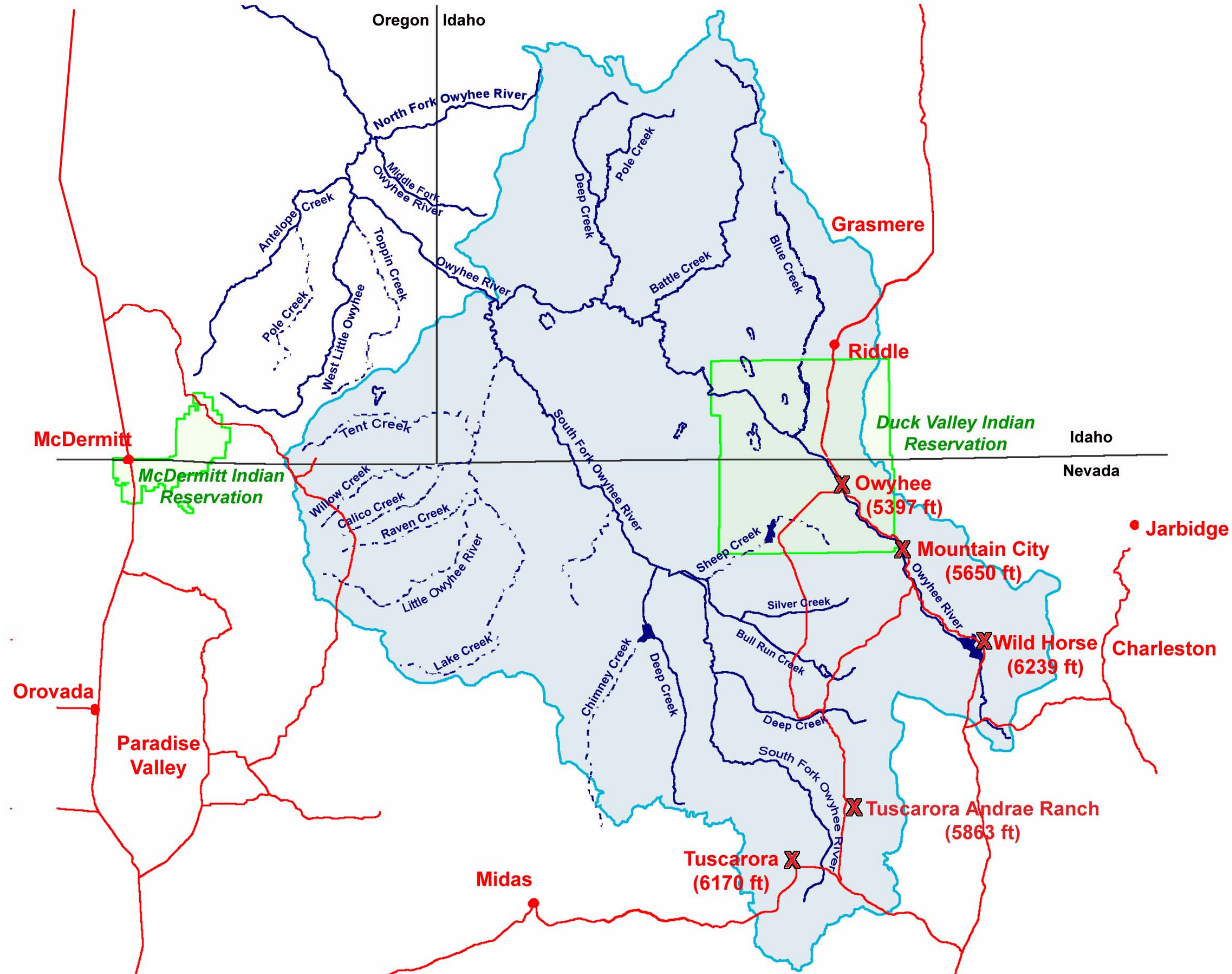

**Figure 5.2. Locations and elevations of meteorological stations within the upper Owyhee subbasin.**

The pattern of precipitation over the year has been similar between the five meteorological stations (Figure 5.3). July and August were the driest months, rainfall increased through December, dropped some in February (fewer days in the month) and peaked again in May. A similar pattern of precipitation is observed at the SNOTEL stations (Figure 5.4). However, these higher elevation stations receive greater precipitation. At the Jacks Peak station, the month with the greatest mean precipitation, January, averages close to five inches. Only the Taylor Canyon station has a mean precipitation in January less than two inches. The meteorological stations are at lower elevations. In no month did any meteorological station have a mean precipitation that reached two inches.

The total amount of precipitation which falls in a year varies significantly from year to year. These totals are based on the calendar year and span water years. On Figure 5.5, the total precipitation for a year is represented by a cross. The greatest yearly precipitation recorded and the least annual precipitation recorded are the highest and lowest marks for each station. Both the amount of precipitation and the year in which it fell are shown for the greatest and least precipitation at each station. Across all the SNOTEL stations, 1984 was the wettest year. The mean annual precipitation for each station is shown in the red box. This mean may not coincide with the amount of

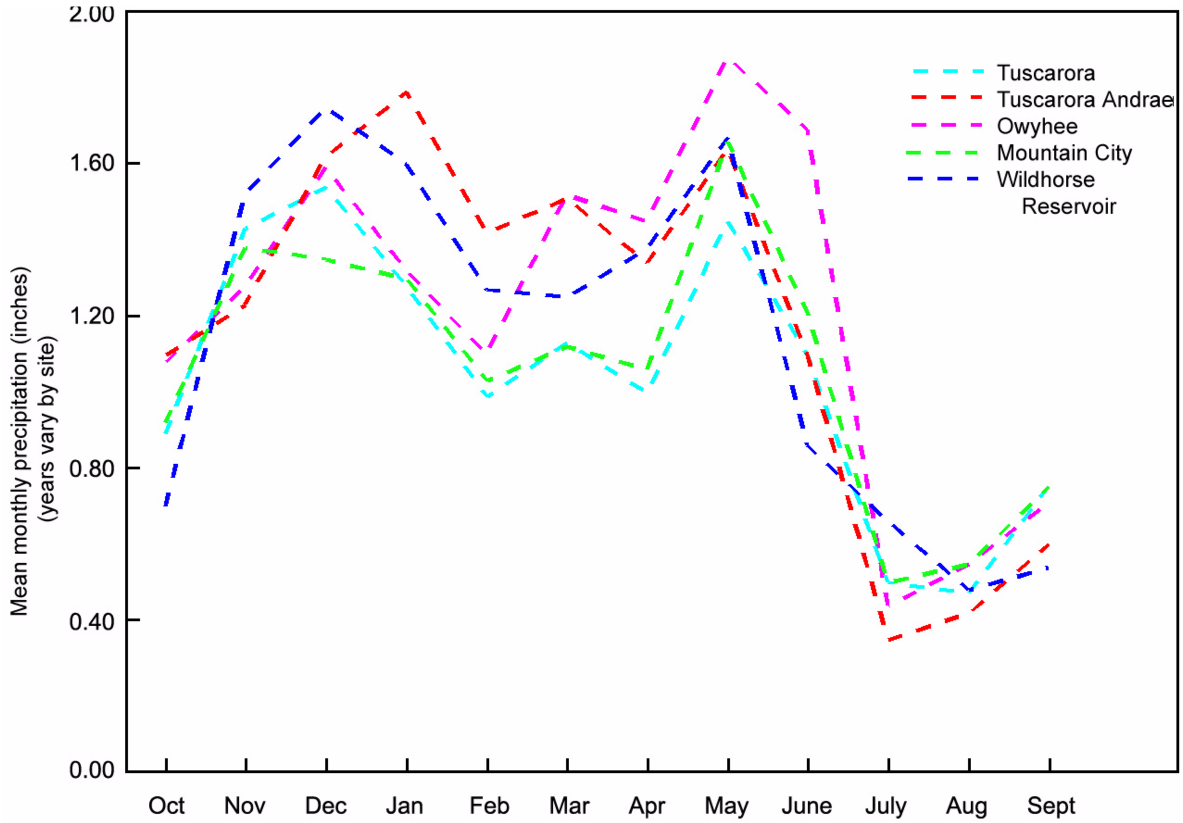


**Figure 5.3. Mean monthly precipitation at five meteorological stations in the upper Owyhee subbasin.**

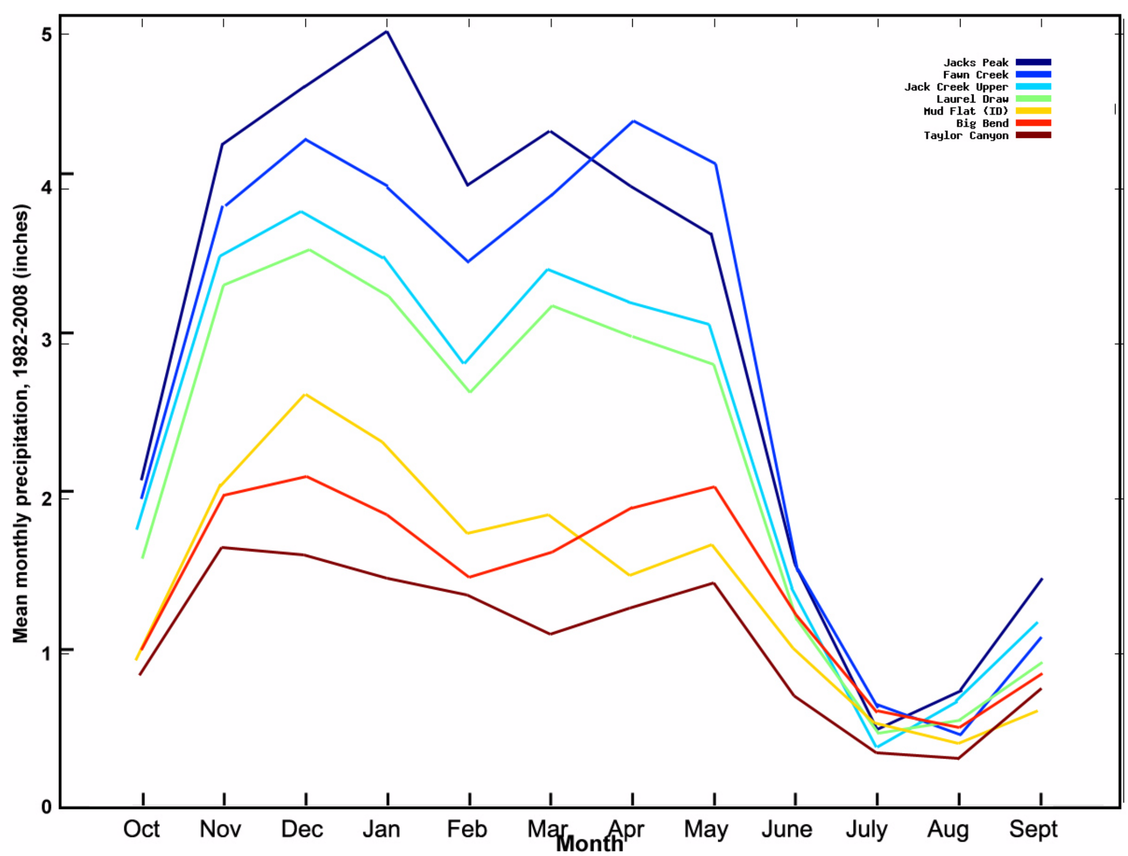


**Figure 5.4. Mean monthly precipitation at 7 SNOTEL stations in the upper Owyhee subbasin.**

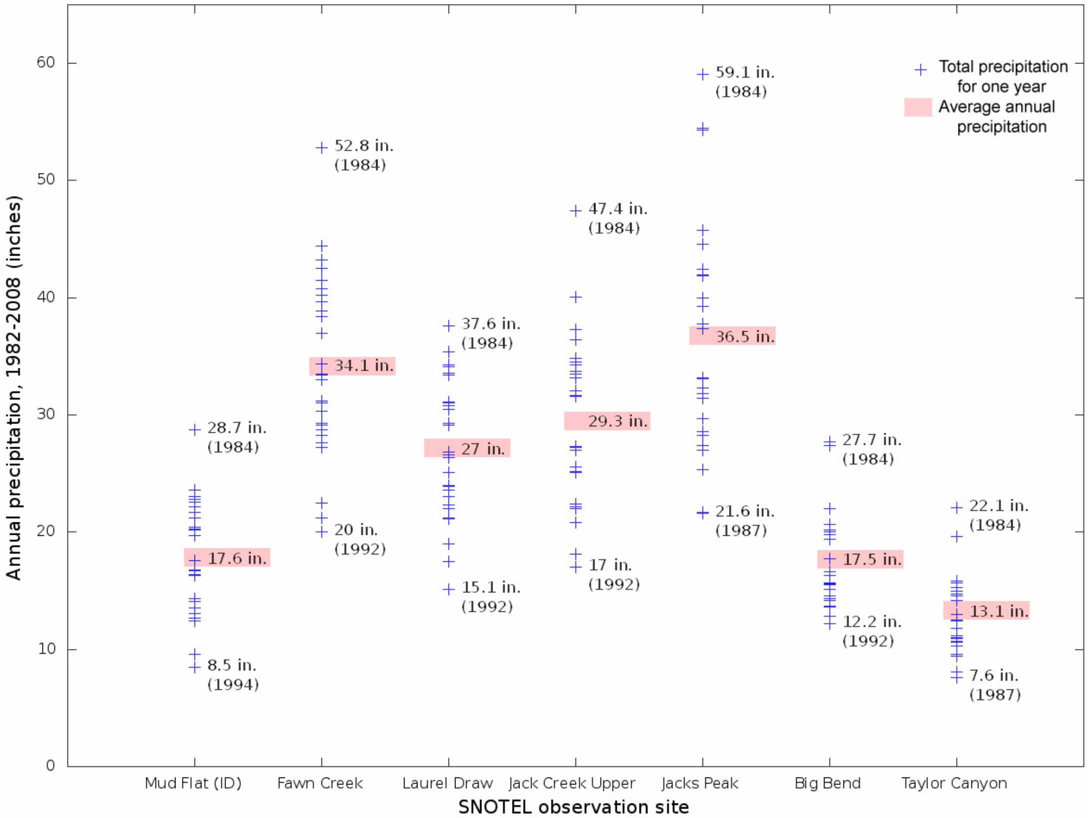


**Figure 5.5. Total annual precipitation at 7 SNOTEL sites in the upper Owyhee subbasin**

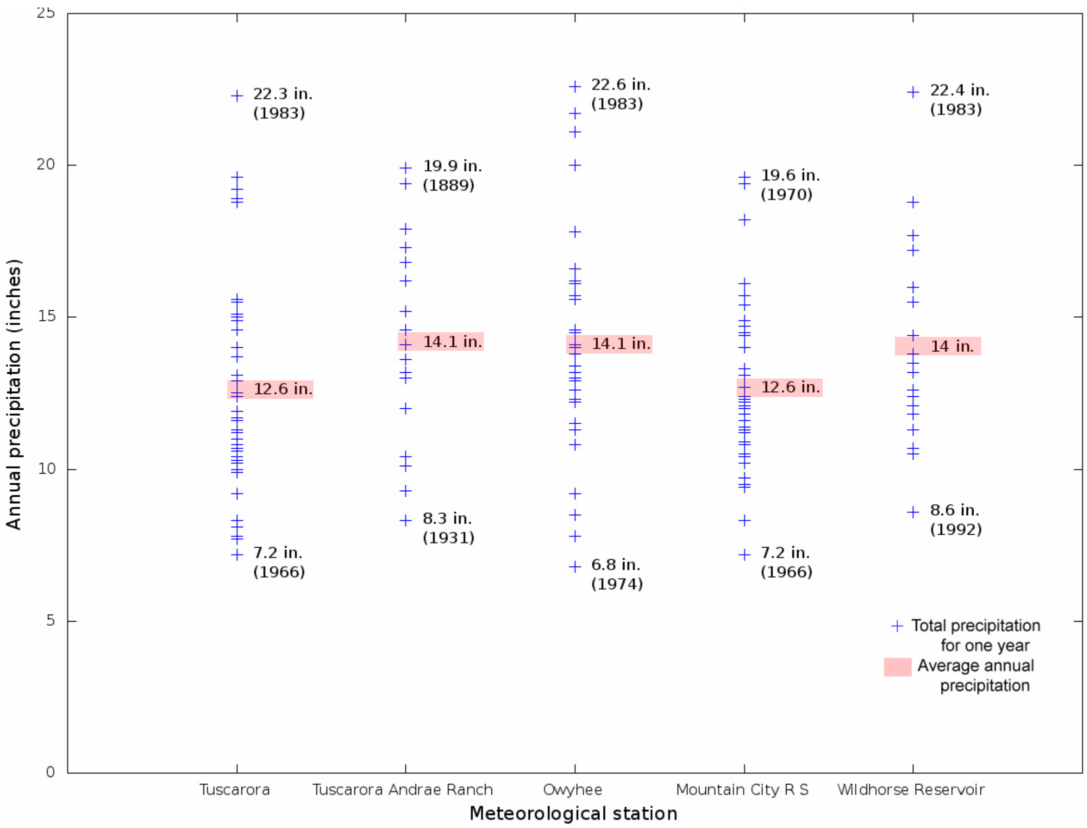


**Figure 5.6. Total annual precipitation at 5 meteorological sites in the upper Owyhee subbasin.**

precipitation in any one specific year, as is obvious for the Jack Creek Upper station. A similar graph for the five meteorological stations indicates that the mean annual precipitation was not directly related to elevation since the Owyhee station, at the lowest elevation, received the most precipitation (Figure 5.6). This information can only be taken as an indication since the five stations have data from different years.

The amount and the timing of precipitation affect what happens to the precipitation. As mentioned above, the rainfall at the stations within the upper Owyhee subbasin is not evenly distributed over the year (Figures 5.3 and 5.4). Although just two months apart, average precipitation in May is significantly more than in July, varying from 2.5 times as much at Wild Horse Reservoir to 7.7 times as much at Jack Creek Upper station (Figure 5.7).

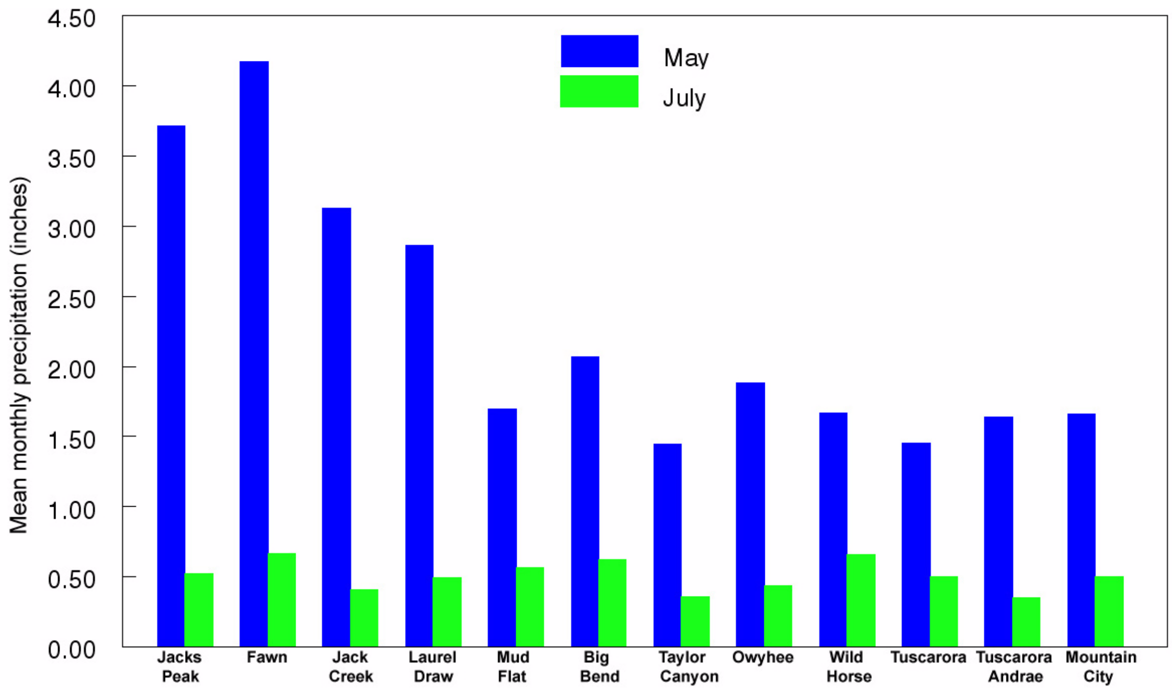


Figure 5.7. Rapid decline of precipitation from May, a wet month, to July, a dry month, at seven SNOTEL and five meteorological stations in the upper Owyhee subbasin.

### *b. Water budget*

What happens to precipitation after it arrives on the land surface? After falling, precipitation is partitioned into four principal components: evapotranspiration, runoff, groundwater recharge, and the change in soil water. This "water budget" can be expressed as an equation where P = precipitation, ET = evapotranspiration, R = runoff, G = groundwater recharge, and $\Delta S$ = change in soil water.[50] Some rainfall is directly intercepted by plants and not included in the water budget.

$$P = ET + R + G + \Delta S$$

The specific figures for the percentages that each of these components contribute to the fate of precipitation in the upper Owyhee subbasin are not available, but there are some general principles for arid rangelands which apply to the unirrigated section of the upper Owyhee subbasin.

### *c. Runoff*

Runoff is the water that flows toward stream channels. Some of the runoff may be evaporated en route or soak into the soils, but the runoff that reaches channels becomes the streamflow.[50] Although worldwide about a third of precipitation which falls on land runs off into streams and rivers,[44] runoff from rangelands is much lower. Rangeland "runoff generally accounts for less than 10%, and most often below 5%, of the annual water budget, and most of this occurs as flood flow."[50] Flood flow can result from snowmelt in the spring or large rain events at other times. Small runoff amounts are alsoimportant as they redistribute and concentrate the limited water resource.

There are a number of factors that help determine the proportion of a rainfall event that is lost to runoff. Some of the physical characteristics that affect runoff include soil permeability, soil moisture resulting from prior precipitation, soil cover, and topography. Some of the meteorological factors affecting runoff are the intensity, duration and amount of rainfall, and climatic conditions that affect evapotranspiration including temperature, wind, and relative humidity.[44] Possibly the intensity of the rainfall and the soil permeability and cover are the most important factors in determining runoff from a specific event. If soil is wet and frozen it has low permeability.

There are no data for the upper Owyhee subbasin on how much runoff will occur with rain events of different intensities on the different soil types.

In the upper Owyhee subbasin, a large percentage of the runoff that does occur comes from snowmelt. Snow fields “act as natural reservoirs for many western United States water-supply systems, storing precipitation from the cool season, when most precipitation falls and forms snowpacks, until the warm season when most or all snowpacks melt and release water into rivers. . . water supplies in the western states are [largely] derived from snowmelt.”[42]

### *d. Evapotranspiration*

Evapotranspiration is the sum of all the different processes by which water is changed from a liquid state to a gas. These include evaporation from the soil, evaporation of water that lands on plant or littered organic material surfaces (called interception loss), transpiration from plants, and sublimation.[39,50] Each of these processes is discussed separately below. Sublimation is the direct change of the state of matter from a solid to a gas (e.g. snow to water vapor) with no intermediate liquid stage.[43,46] Almost all the water from small, infrequent precipitation may be evaporated back into the atmosphere. With wind or heat, greater amounts of precipitation evaporate.[25,44]

#### *i. Evaporation*

Evaporation is a process by which liquid water is transformed back into water vapor. Evaporation can be from the soil surface or from precipitation that was intercepted. The rate of evaporation depends on a number of factors. Warmer water evaporates more quickly. Higher air temperatures increase the rate of evaporation. Drier air (lower relative humidity) above the soil surface has a greater "thirst" for water and more water evaporates into it. Wind across the soil surface increases the rate of evaporation. Sunlight directly hitting a surface increases the rate of evaporation.[5,8,11,25,48] A shaded stock trough may have 36% less evaporation than an unshaded trough.[48]

The amount of water evaporated depends on the amount of water present and on the rate of evaporation. In the upper Owyhee subbasin there are no measurements of the rate of evaporation. The closest evaporation pan is at a weather station in Elko Nevada. There is also an evaporation pan at the NOAA and AgriMet station at the Malheur Experiment station in Ontario, Oregon.[52,55] Evaporation pans measure how much evaporation occurs from a standing body of water and is indicative of the rate of evaporation. The total amount of water that can evaporate from the soil also depends on the amount of available moisture in the top layers of the soil.

Based on the climatic data from the two meteorological stations in the drier section of the upper Owyhee subbasin on the west side of the Independence Mountains, the temperatures for part of the year are relatively high. From May through September the average maximum temperatures at Tuscarora Andrae are, respectively, 63, 75, 86, 84, and 73 degrees Fahrenheit. At Tuscarora the average maximum temperatures for the same months are 63, 74, 85, 83, and 73 degrees Fahrenheit. By comparison, the maximum temperatures at the Elko airport are 70, 80, 91, 89, and 79, respectively from May through September. The five- to six-degree difference between Elko and the meteorological stations in the subbasin indicates that there would be some difference between the amount of evaporation expected due to the heat.

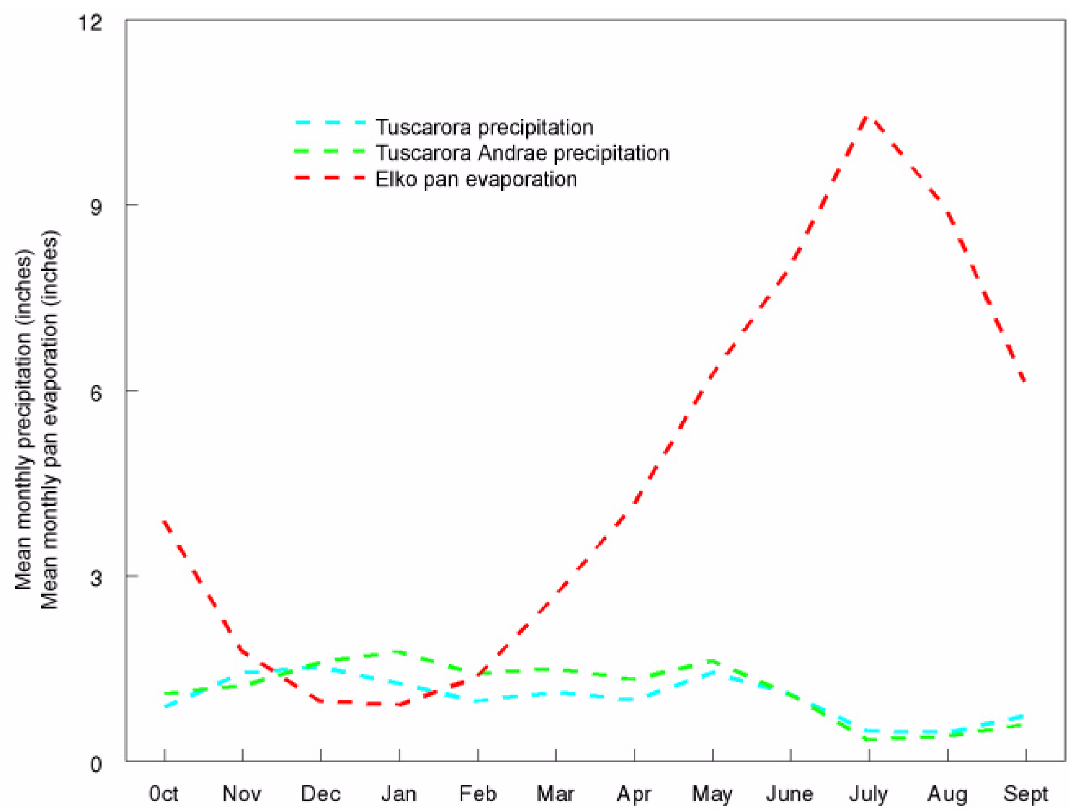


**Figure 5.8. Mean monthly precipitation at Tuscarora and Tuscarora Andrae meteorological stations in the upper Owyhee subbasin compared to pan evaporation at Elko Nevada.**

When the average monthly rainfall at Tuscarora over a 52-year period and at Tuscarora Andrae over a 68-year period are compared to the average amount of water which evaporated from a flat evaporation pan at Elko over a 108-year period, the rainfall is only a small portion of the water which could evaporate (Figure 5.8). Even assuming that the evaporation at Tuscarora and Tuscarora Andrae were less than at Elko, it would appear that the evaporative potential from April through October would be great enough to return most of the rainfall to the atmosphere. A larger rainfall event during these months might lead to some water infiltrating into the soil or running off, but a large portion of precipitation during these months could be expected to evaporate. These patterns are similar to the rainfall and evaporation patterns in the lower Owyhee subbasin.[56]

In rangelands, soil water evaporation generally accounts for 30 to 80 percent of the water budget. Soil water evaporation is often limited to the uppermost layers of the soil.[50] General estimates of soil water evaporation from mountainous areas of the western United States vary significantly. A seven year study in a semiarid region of New Mexico showed that evaporation from unvegetated ground ranged from 88 to 95%. The greater the slope of the ground, the higher the percentage of evaporation.[22]

*ii. Interception loss*

Precipitation which has been intercepted by leaves or other organic matter has a larger exposure to environmental conditions that might cause it to evaporate. Interception loss results when precipitation landing on organic matter evaporates and thus never reaches the soil surface. Drylands lose considerably more water, on a percentage basis, via interception than do more humid environments. Interception loss on rangelands may be substantial.[25,50]

The vegetative cover affects interception. In general arid shrublands have a smaller interception than a similar area with juniper cover. Juniper leaves and stems intercept a higher percentage of precipitation since they have a large leaf area all year long. They also create an organic carpet that intercepts considerable water. Measured interception, expressed as a percentage of precipitation, may be as high as 46% for juniper. For sagebrush the value ranges from 4 to 30%. The vegetative canopy in each area can only intercept so much water. For any specific storm, the percentage of precipitation intercepted varies greatly. Larger storm events have a smaller percentage of the water from that storm intercepted.[50]

Although figures for the percentage of precipitation intercepted by different types of canopy covers are available for other areas, interception data has not been collected in the upper Owyhee subbasin.

Not all precipitation that is intercepted is evaporated back into the atmosphere. Water on plants can be absorbed by plant tissues and can also drip off onto the surface beneath the plant or it can run down the leaf to the stem and from the stem to the ground.[28] The amount of precipitation that reaches the soil surface often depends on the total precipitation of a storm event as a strong rain will provide more opportunity for water to drip onto the soil surface than a light shower.

*iii. Transpiration*

In a desert environment transpiration contributes a smaller percentage to the total evapotranspiration than in less arid environments. Many arid region plants have developed adaptations that conserve water, allowing them to transpire at a slow rate when there is little available soil moisture.[25,39] Transpiration rates also vary depending on the temperature, humidity, and wind as mentioned above. The transpiration rate both goes up as the temperature increases and as the relative humidity falls. Both of these conditions are met during the upper Owyhee subbasin summer. However, as plants start to senesce (die), they transpire less.[39]

Vegetation not only transpires, it also shades the soil and reduces the wind speed. Both shade and lower wind speed slow down the evaporation from the soil surface. However, the water absorbed from the soil by the plant roots offsets any effects that the vegetation has in slowing evaporation from the soil. Transpiration not only contributes to the loss of soil moisture in the upper soil layers, but also from substantially greater depths if water is available since moisture from uptake by plant roots can reach the leaves and be transpired.[25,39,50]

*iv. Sublimation*

Since much of the precipitation in the upper Owyhee subbasin falls during the colder winter months, it may fall as snow. Even with freezing temperatures, the snow cover on the ground will gradually be reduced over time. This is sublimation. Ice (or snow) will go straight from a solid state to a vapor. Low relative humidity, dry winds, lower air pressure, and a higher sun angle increase the rate of sublimation. Sublimation is greater at higher altitudes since the air pressure is lower. The effect of the sun angle is only relevant on sunny days. At the start of winter, the sun angle is a minimum (the sun is lowest in the sky) and the angle is much higher in late winter so the rate of sublimation is apt to be much higher in late winter than in early winter.[9,43,46]

Many winter days in the upper Owyhee subbasin have low relative humidity and dry winds, favoring sublimation. The effect of sublimation may not be obvious if additional snow accumulates on the ground.

A common way for snow to disappear in the arid west is a "Chinook wind." If a warm wind (60-70$^0$F) with relative humidity less than 10% hits the snowpack, ice evaporates directly to vapor.[43] David Shirk recalls a Chinook wind in the region in about 1868. "When we retired the previous evening, there was fully twenty-four inches of snow covering the ground. At about eight o'clock, the Chinook wind began blowing, and in eight hours, not a particle of snow remained anywhere in the valley."[29]

Since the upper Owyhee subbasin snowpack supplies part of the spring runoff needed to fill Lake Owyhee, a Chinook wind could decrease the supply of water to the reservoir.

***e. Infiltration***

There are a number of factors that can affect water infiltration into the soil including precipitation, soil characteristics, soil saturation, land cover, slope of the land and evapotranspiration. The amount, intensity, duration, and form (rain, snow, etc.) of precipitation varies between precipitation events. There is variability across the landscape. More water will run off of sloped land, and more water infiltrates if the land is flat. No water infiltrates where there are impervious surfaces such as rocks or bentonite clay. Vegetation slows the movements of runoff and allows more time for water to seep into the soil.[15,28,41]

Soils with different soil textures and structures have differing infiltration rates and absorb more or less water. Some soils have greater degrees of water repellency. Fractures in the soil surface also affect the amount of water infiltrated. Infiltration slows as soil becomes wet; fully saturated soils can hold no more water.[15 ,28,41]

### *f. Groundwater recharge*

The high evaporative demand in an arid climate means that eventually most water that has infiltrated and is stored in the soil will evaporate or be transpired. If there is further precipitation, it can cause the water to percolate down. Percolation also occurs due to the pull of gravity over time if the soil moisture is not lost to evapotranspiration. Groundwater recharge in rangelands is generally only a fraction of an inch per year. Soils with high permeability because they are sandy or fractured will have higher percolation and higher groundwater recharge.[25,50]

The movement of groundwater is controlled by gravity and geologic formations below the surface soil. Not only is groundwater replenished slowly, it tends to move very slowly. The water tables are generally formed above impermeable layers of rock or salt accumulations within the soil. Like all water, if it moves, it moves downhill. Water returns to the surface at a lower elevation than where it infiltrated. Some of the infiltrated water may travel close to the surface and soon emerge as discharge into streambeds. This water tends to move over duripans, layers of soil cemented by silica, iron oxides or calcium carbonate. Most of the discharges of groundwater into a stream occur where the water table intersects the ground surface. There may be a spring or slow seepage of the water into the stream. Seepage of groundwater into a stream forms the base flow for perennial streams.[25 ,27,40,45,46]

There has been no mapping of groundwater reserves or calculation of groundwater recharge for the upper Owyhee subbasin.[37,38]

The type and stability of water flow from a spring or seep is dependent upon the size and nature of the groundwater reservoir that feeds the spring. A spring fed by a deep aquifer will be more reliable and uniform. The water being produced by the spring can be from precipitation which fell hundreds or thousands of years ago. However, a spring which is dependent upon a local shallow water

**Photo 5.1. Wilson Reservoir dam, Nevada**

table for its recharge will have a more variable flow based upon precipitation, infiltration, and water use within the last few years. The predominance of water use by deep-rooted vegetation, such as big sage or juniper, will reduce flows to riparian areas and streams from shallow aquifers.[2,13,32]

### *g. Storage in dams*

There are a number of impoundments in both Owyhee County, Idaho and Elko County, Nevada (Figure 5.9). In Idaho there are six larger reservoirs: Big Blue Reservoir on Blue Creek, Little Blue Reservoir on Little Blue Creek, Paine Creek Reservoir on Paine Creek, Juniper Basin Reservoir on Juniper Creek, Squaw Creek Reservoir on Squaw Creek, and Bybee Reservoir on Shoo-fly Creek.[24] In Nevada there are seven larger reservoirs: Wild Horse Reservoir on Owyhee River, Wilson Reservoir on Wilson Creek, Bull Run Reservoir and Rawhide Reservoir on Bull Run Creek, Desert Ranch Reservoir on Chimney Creek, Deep Creek Reservoir on Deep Creek, and Dry Creek Reservoir on Dry Creek (Appendix D).

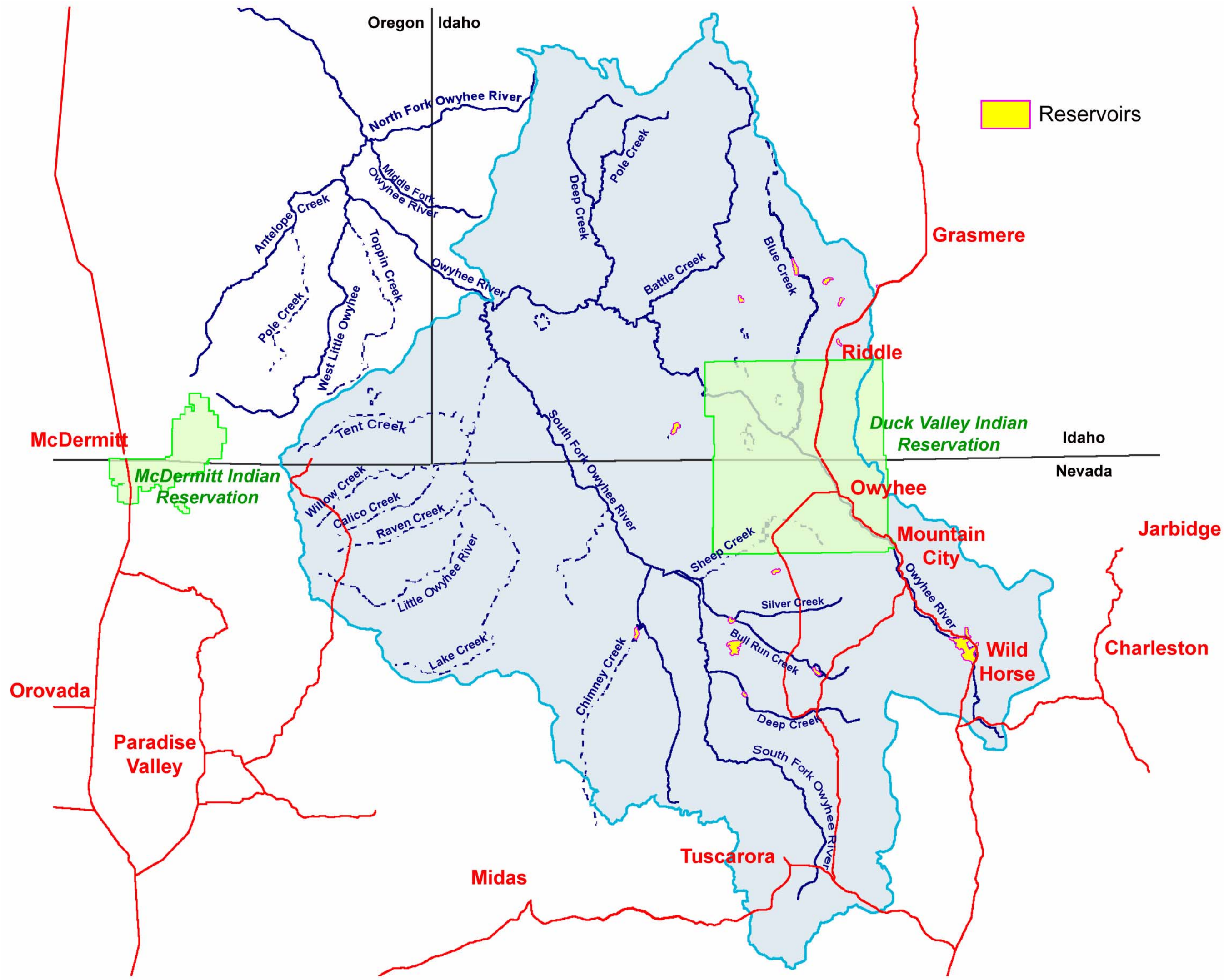


Figure 5.9. Reservoirs in the upper Owyhee subbasin.

**Photo 5.2. Wild Horse (above) and Wilson (left) Reservoirs are the reservoirs that cover the largest surface areas in the upper Owyhee subbasin in Nevada.**

There are several small dams as well as those mentioned above that have been built in the upper Owyhee subbasin to impound stream flows in small reservoirs or stock ponds. Dams create a different distribution of surface storage.[25] Dams on intermittent streams will increase the infiltration of water into the ground and reduce or eliminate the flow of water in the streambed. However, these ponds do not have the potential to impound much water. The guide for estimating the acres of drainage area required to average an acre-foot of pond storage shows that away from the base of the mountains, more than 80 acres are required on the plateau in the upper Owyhee subbasin.[33]

Beaver are also building dams on some of the small streams, generally streams less than 10 feet wide. Like dams created by people, beaver dams can provide a more stable water supply for wildlife. Water retention behind the dam can also increase infiltration into local water tables stabilizing the water supply for vegetation. By reducing the flow velocity following heavy rainfall, dams mitigate flow fluctuations in the stream bed below the dam. This reduces channel scouring, stream bank erosion, and

**Photo 5.3. Beaver dams on Trail Creek in the Bull Run Mountains, Nevada**.

downstream flooding. Dams also can form considerable sediment traps, reducing sediment loads in downstream water.[57,58,59]

#### *h. Subbasin water balance*

Within the relatively arid upper Owyhee subbasin, the water balance is determined by the fact that potential evapotranspiration is much greater than precipitation, creating a large soil water deficit. As a rule, evapotranspiration is the largest component of the loss side of the water balance equation, in comparison other components are generally quite small.[50]

## C. Data for flow estimates

One of the primary concerns of the assessment of the hydrology of an area is identifying potential peak flows and low flows. Using data from the past, we can try to anticipate what might happen in the future.

### 1. Precipitation

The precipitation that provides stream flow in the upper Owyhee subbasin comes from two principal sources. Snowfall, particularly in the higher elevations of the upper Owyhee subbasin, melts in the late winter and in the spring. This is supplemented by runoff from the rainfall events in winter and spring.

**Photo 5.4. Beaver dam on Current Creek along Mud Flat Road, Idaho**

There is a very great variation in both the amount of precipitation and when it occurs. In one day, more rain can fall than would be expected for total rainfall for the whole month. Figure 5.10 compares the average total monthly rainfall to the recorded maximum one day rainfall at Tuscarora. Almost every station has had at least one single event where in one day more precipitation has fallen than the average amount for the month. A single large event, if the precipitation falls as rain, will result in runoff. Smaller back-to-back significant events will also result in runoff.

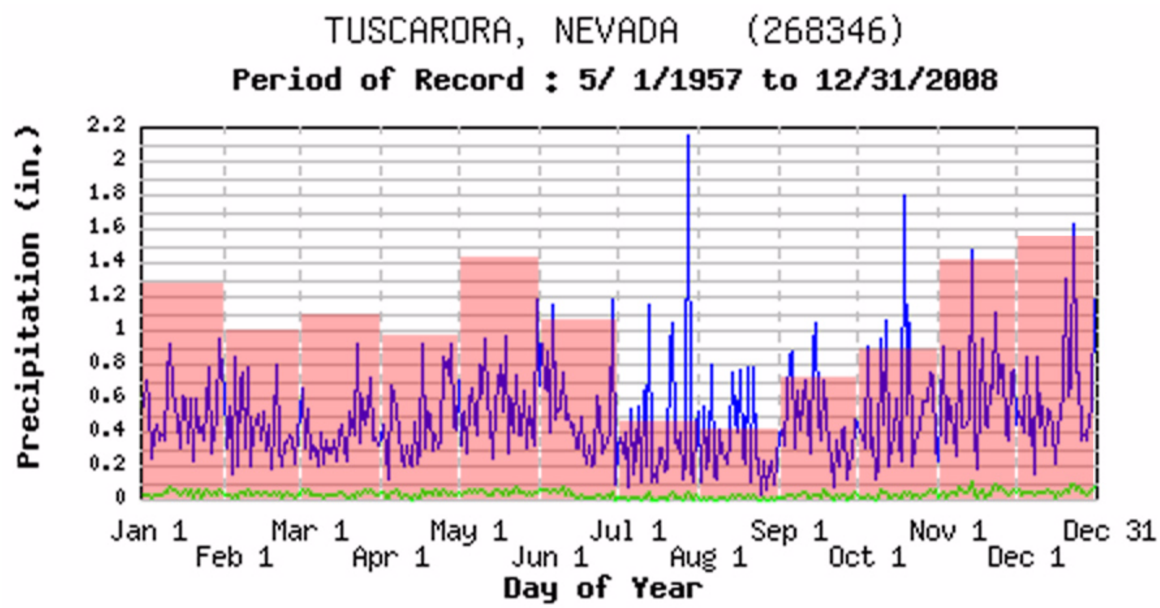


**Figure 5.10. A comparison of the extreme precipitation on one day of the year (blue line) with the average for that date (green line) with the mean monthly precipitation (background shading).**

When television weather forecasters predict rain for the following week, they give a probability of rain each day. "We can only make probabilistic statements because even if we have perfect knowledge of weather variables at some point in time, we cannot predict their values for some future time with certainty."[51] Figure 5.11 shows that there is a small probability of half an inch of rain (green line) falling at Tuscarora around

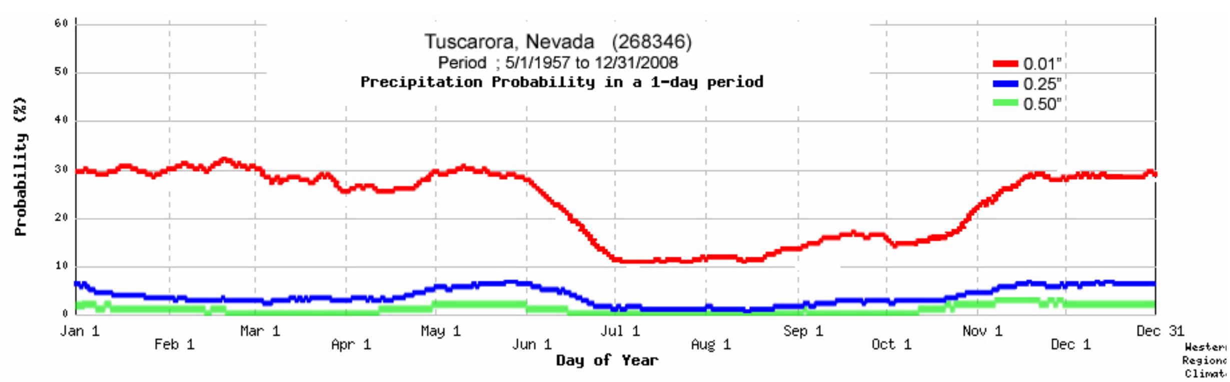


**Figure 5.11. The probability of specific amounts of precipitation on a specific day of the year.**

the first of June. However, there is the same small probability of half and inch of rain the next day and then the next day. The probability of it raining half an inch three days in a row is VERY small, but the possibility exists.

## 2. Streams with water

Although only a small percentage of the precipitation becomes runoff, the less probable large events are the ones which account for most of the runoff. During a large precipitation event or snow melt, there are many drainages in the upper Owyhee subbasin which can carry water (Figure 5.12). These drainage flow lines are ***not*** streams but the courses along which water would flow if there were water to flow in that region.

The previous condition of a stream can also affect the rate of runoff from that stream. The flatter the land, the more slowly water moves across it. Broad, flat valleys often have curving, sinuous stream channels in them. Over time the meandering

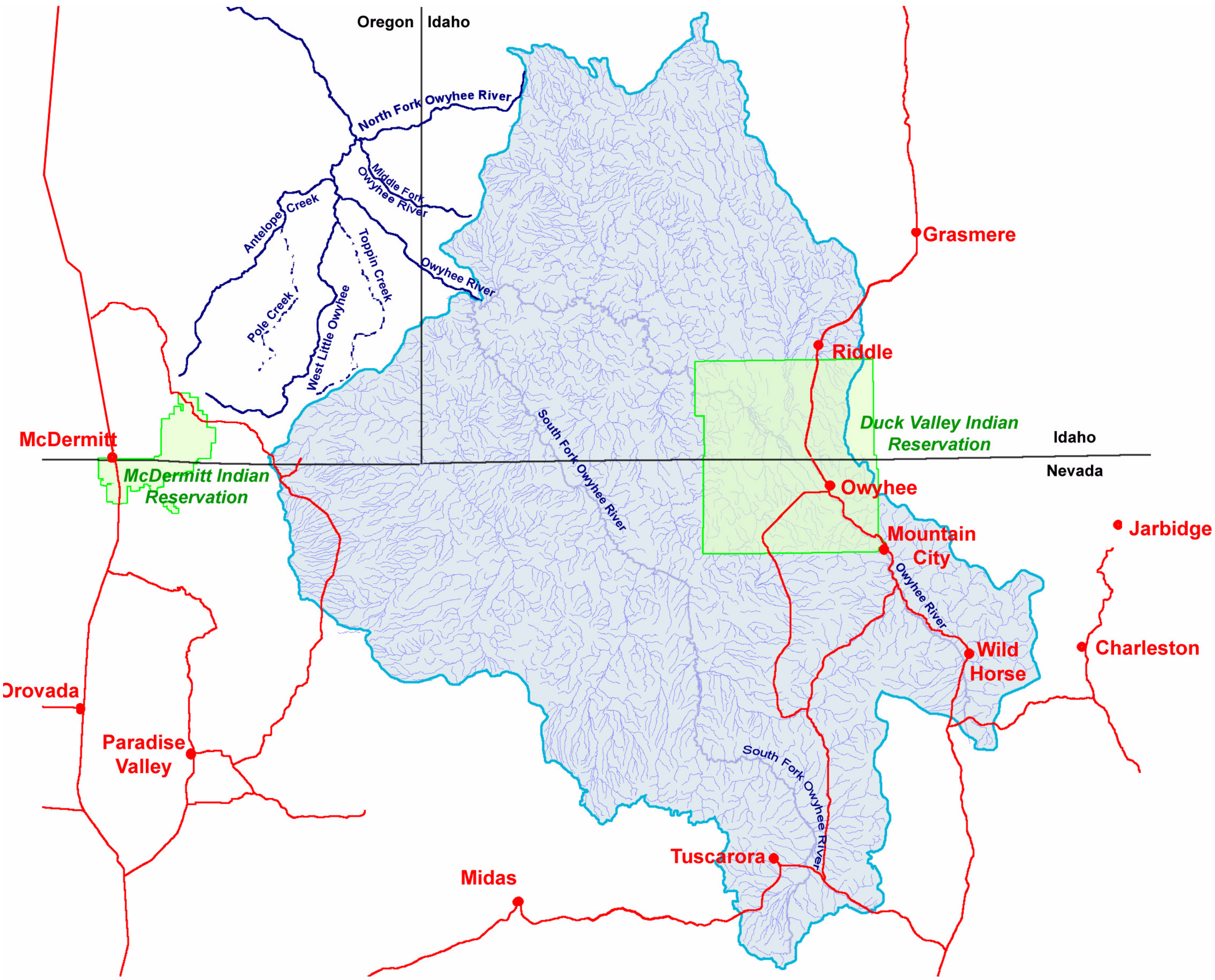


**Figure 5.12. Water flow lines in the upper Owyhee subbasin.**

stream reworks the entire valley floor. Sediment dropped by the stream continues to build a large flat valley. Large amounts of water entering a stretch of stream like this will spread out across the land and lose velocity. By contrast, once a stream has eroded down into the surrounding landscape, large flows will largely be contained within the stream course. Not losing velocity, they will continue to scour the channel and deliver more water downstream.[60]

**Photo 5.5. Penrod Creek, a meandering stream east of Wild Horse Reservoir, Nevada**

### *a. Perennial streams*

In an arid region, there are very few streams that carry water all year, every year. USGS topographic maps distinguish between perennial streams, those that essentially flow year-round, and intermittent or ephemeral streams which flow for only part of the year.[23] These designations are not changed in map revisions unless the information has been verified on the ground.[35]

**Photo 5.6. A stream which has started to cut down into the landscape, Nevada**

The stream reaches in the upper Owyhee subbasin identified as perennial in the National Hydrography Dataset GIS coverage of the area are not numerous (Figure 5.13). A careful comparison with a selection of the USGS topographic maps that cover the upper Owyhee subbasin indicates only minor differences between the GIS coverage and the stretches which are identified as perennial on the USGS maps.[AppendixA]

Both the South Fork Owyhee River and the Owyhee River are perennial throughout their reaches in the upper Owyhee subbasin except near their upper reaches where they become intermittent (authors' observations). A number of the creeks draining into the South Fork Owyhee River from the Independence and Bull Run Mountains, such as Bull Run Creek, Deep Creek, and Jack Creek, are also perennial throughout their reaches. Blue Creek, Deep Creek, and Battle Creek draining into the Owyhee River from the north are also perennial.

The short distances of perennial tributaries which do not continue as perennial are typical of desert landscapes where runoff decreases over distance because of transmission losses in the alluvial stream channels.[50] There are no tributaries of the Little Owyhee River that are perennial for more than a short distance. The huge expanse of the upper Owyhee subbasin south of the South Fork Owyhee River and between the Owyhee River and the South Fork contains no perennial streams.

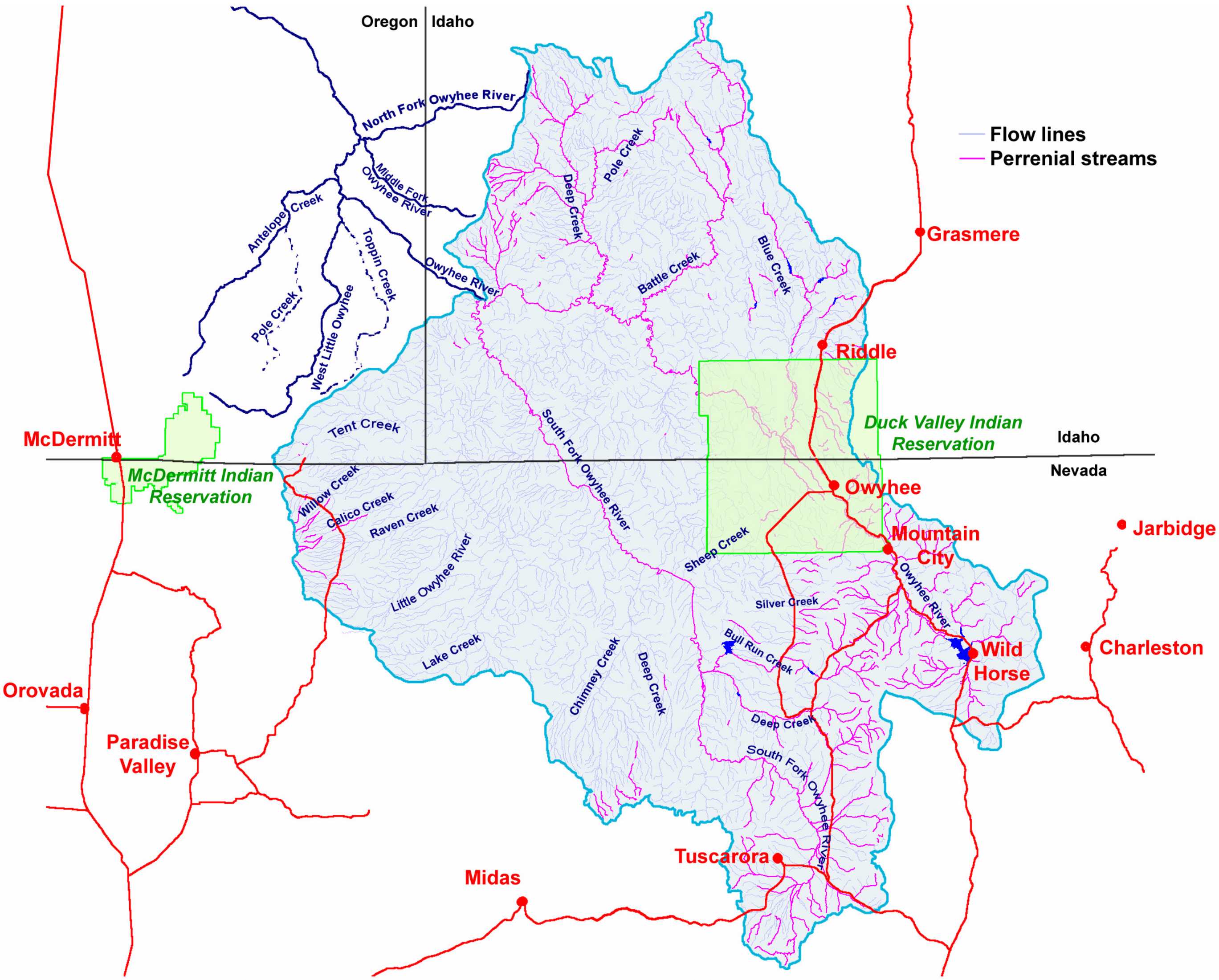


Figure 5.13. Perrenial streams only occur along a small proportion of the water flow lines in the upper Owyhee subbasin.

**Photo 5.7. Near the upper end of the Owyhee River, Nevada**

### *b. Intermittent and ephemeral streams*

In the USGS guidelines for creating their topographic maps, intermittent streams were not distinguished from ephemeral streams. The guidelines say "Do not distinguish between Streams that contain water for only part of the year and Streams that contain water just after rainstorms and at snowmelt in arid or semiarid regions."[36] They further define a drainage as a stream if it flows out of a lake or pond, if it is 2,500 ft in length, or if it "contains water throughout the year, except for infrequent periods of severe drought and is in an arid region."[36]

For purposes of a watershed assessment it is very important to know which streams are intermittent and which streams are ephemeral. "Intermittent streams are those which flow for only certain times of the year, when they receive water from springs or runoff. . . . During dry years they may cease to flow entirely or they may be reduced to a series of separate pools."[7] Ephemeral streams have channels which are always above the water table. They only carry water during and immediately after rain, particularly storm events.[7,31] "Most of the streams in desert regions are intermittent or ephemeral"[7] as we observe in the upper Owyhee subbasin.

### *c. Classification of streams as ephemeral*

Since the USGS maps do not distinguish between intermittent and ephemeral streams, ground survey is necessary to make a determination. This information is not available for most drainages in the upper Owyhee subbasin. How could the determination be made in the future? There are at least several lines of reasoning that could be used to classify streams as ephemeral.

Observation of streams for several years may show some streams to have water in them for many weeks each year independent of snow melt and runoff; they are probably connected to the groundwater and are intermittent. If streambeds are dry most years, they have no connection with groundwater and are ephemeral by definition. If water runs in streams only briefly in response to snow melt and very large precipitation events they are ephemeral.

Sagebrush dies when flooded. Stream channels that have sagebrush growing directly in the bottom of the wash are most likely ephemeral (Photo 5.9). Sagebrush does not tolerate saturated soil, and if the soil stays saturated for two weeks, sagebrush dies. Spreading water for two weeks on sagebrush land is a well known method of sagebrush control, since the root systems die from lack of aeration, but the method is little utilized in arid lands due to scarcity of water.[23]

Photo 5.8. Water course of an intermittent stream draining west from the Independence Mountains, Nevada.

Sampling of stream bed soils can show whether the soils have been subject to persistent water logging during at least part of the year. Soils subjected to water logging should develop some of the chemical and physical characteristics of hydric soils. Such a soil would indicate an intermittent stream.

## 3. Runoff

Because the other parts of the water balance equation account for the destination of much of the precipitation, it isn't possible to use the average amounts of precipitation to determine flood risk.

In streams, increased flows can be associated with winter rainstorms, winter rain-on-snow, snowmelt, spring rain-on-snow, and spring or summer cloudbursts or thunderstorms.[47] Snowmelt, the runoff produced by melting snow[14], will generally be more gradual if it isn't accompanied by rain-on-snow. When the ground is frozen, rain can cause snow to melt and run off without soaking into the ground. Rain hitting saturated ground will also flow overland.[44]

Each of the factors associated with increased flows can also increase the danger of "flash flooding" or other huge runoff events in intermittent streams. Ephemeral drainages which don't normally have flow are more apt to have runoff associated with unusual precipitation in a short amount of time. There has been no distinction made in the upper Owyhee subbasin between intermittent streams and ephemeral streams on maps or by ground truth.

During heavy rain events, water will tend to run in the established stream courses. As a liquid, water runs downhill. The path of least resistance is also the steepest gradient.[45] The steepest gradient funnels water into the established water courses of intermittent and ephemeral streams. In the beds of intermittent streams and

**Photo 5.9. Sagebrush growing in the bottom of an ephemeral stream**

in dry washes where the streambed flows only after significant rainfall, the sudden torrent of water from rains upstream may cause a flash flood.[31]

The typical condition for this ecoregion is that the maximum peak flow in each drainage is vastly greater than the average flows and average flows are much larger than the minimum flows, although data to support this fact have not been collected.

### *a. Snowmelt*

#### *i. Models*

Models that predict water runoff from snow melt on a daily time scale are important in water resource management and flood hazard assessment. Different models such as HBV and Snowmelt Runoff Model (SRM) handle meltwater modeling differently. Decisions in the modeling include problems of complexity or simplicity, the inclusion of different types of measurements, and the way spatial variability of snow cover is incorporated.[1,6,18]

Forecasting the future of any system relying on weather is difficult. The SRM model is used for areas such as the upper Owyhee subbasin where snow melt makes a significant contribution to runoff into streams. The model requires both the daily mean air temperature and the extent of the snow. The daily mean air temperature is extrapolated for each elevation zone from one or more meteorological stations so the fewer the meteorological stations the less accurate the forecast. The extent of the snow depends on the area covered, the depth of the snow, and the water content of the snow. These data for the upper Owyhee subbasin are taken from the SNOTEL stations.[18] In evaluating the SRM model in one basin, Thomas et al[101] found that the main source of error of the runoff forecasts was the limited quality of the meteorological forecasts.

#### *ii. Contribution of snowpack melt to spring runoff*

A good way to visualize the contribution of snowmelt to streamflow in rivers is to look at the hydrograph (Figure 5.14), which shows daily mean streamflow (average streamflow for each day) for nine years for the South Fork Owyhee River at Spanish Ranch near Tuscarora, Nevada (USGS real-time streamflow data). The light pink bars highlight the readings in April, May, and June of each year. The large peaks in the chart are mainly the result of melting snow, although storms can contribute runoff also.

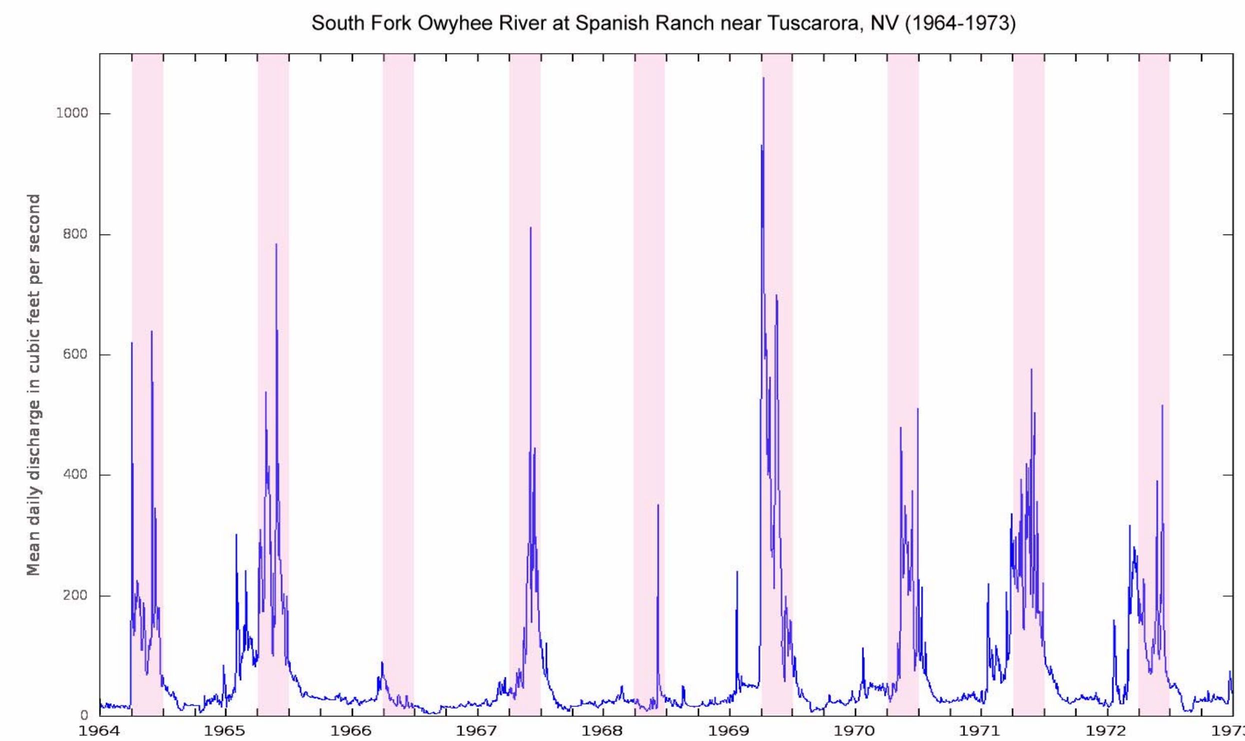


**Figure 5.14. Daily mean streamflow from 1964 to 1973 at gage 13177200 on the South Fork in the upper Owyhee subbasin. The pink blocks are the months of April, May and June each year.**

Note that runoff from snowmelt varies not only by season but also by year. Compare the high peaks of streamflows for the year 1969 with the much smaller streamflows for 1966. The lack of water stored as snowpack in the winter can affect the availability of water for the rest of the year. This can have an effect on the amount of water in reservoirs located downstream, which in turn can affect water available for irrigation or other downstream uses.[42]

Table 5.1. Sites of historic and current stream flow gages in the upper Owyhee subbasin.

| Site Number | USGS Site Name | Years of data | |
|---|---|---|---|
| | South Fork Owyhee | | |
| 13176600 | TAYLOR CYN TRIB NR TUSCARORA, NV | 1967-1979 | Peak flow only |
| 13176900 | JACK CK BLW SCHOONOVER CK NR TUSCARORA, NV | 1962 -1969 | Peak flow to 1978 |
| 13177000 | JACK CK NR TUSCARORA, NV | 1913 -1925 | |
| 13177200 | S FK OWYHEE RV AT SPANISH RANCH NR TUSCARORA, NV | 1959 -1975 | |
| 13177800 | S FK OWYHEE RV NR WHITEROCK, NV | 1955 -1981 | |
| | Upper Owyhee | | |
| 13174500 | OWYHEE RV NR GOLD CK, NV | 1916 - 2009 | |
| 13174900 | OWYHEE RV AT PATSVILLE, NV | 1971 - 1975 | |
| 13175000 | OWYHEE RV AT MOUNTAIN CITY, NV | 1913 -1948 | |

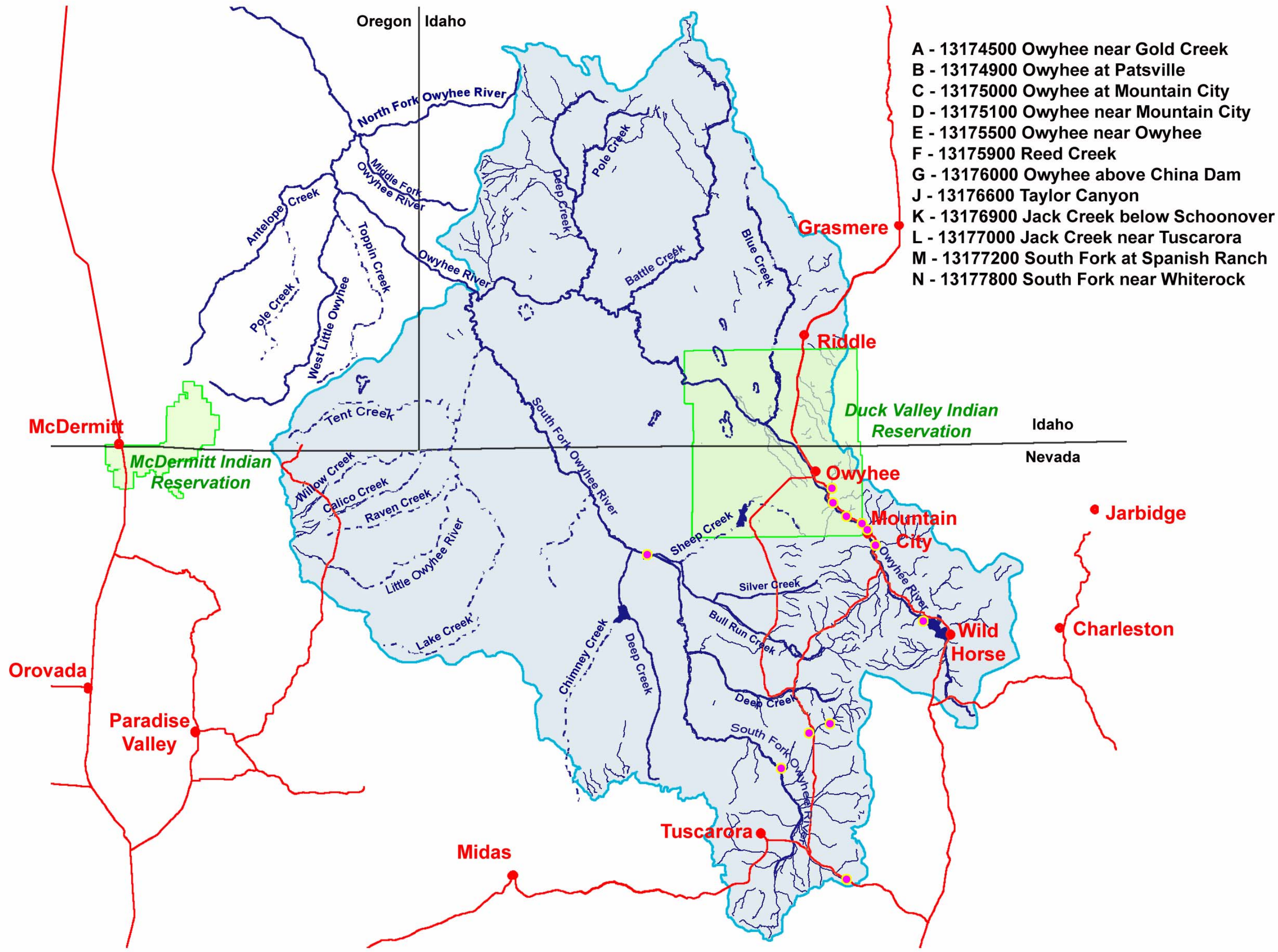


Figure 5.15. Location of historic and current stream gages in the upper Owyhee subbasin.

## 4. River flows

Due to the erratic nature of storm events, it is difficult to make any estimation of the flood danger in a particular intermittent or ephemeral stream bed. However, past records of flows in the Owyhee River can help estimate the probability of flood events along the river.

### *a. Sources of river flow data*

Within the upper Owyhee subbasin the number of locations with stream gages is extremely limited. Information from seven USGS gages in the Upper Owyhee HUC and from five gages in the South Fork Owyhee HUC is accessible. Three of the gages in the South Fork Owyhee HUC and five of the gages in the Upper Owyhee HUC have at least ten years of data (Table 5.1, Figure 5.15).

The South Fork Owyhee River and the Owyhee River remain separate rivers until close to the Idaho-Oregon border, so flow in the two systems can be considered separately. The earliest of the gages in the South Fork Owyhee drainage began recording in 1913 on Jack Creek near Tuscarora. However, after it was abandoned in

1925 no other gages were installed until 1955. Currently there is no gage on the South Fork Owyhee. On the Owyhee River, gages began recording data in 1913 near Mountain City and Owyhee. The Mountain City gage continued recording until 1948 and overlapped with gages installed later at other points along the river.

In considering stream flows, a word of caution is needed. The data for each river is very limited both in the number of years data has been collected and the number of locations. There have never been gages downstream from the one abandoned in 1981 on the South Fork Owyhee near Whiterock. There are no gages in the upper Owyhee subbasin on the Owyhee River beyond the Duck Valley Indian Reservation. The first gage on the Owyhee River after it leaves the upper Owyhee subbasin is at Rome, Oregon, after the confluences with Middle Fork Owyhee River, North Fork Owyhee River, and Jordan Creek.

An assertion made in the *Digital Atlas of Idaho* that "the Owyhee River has an annual average discharge of 661,500 acre-feet of water at the Oregon/Idaho border"[12] has no source given and can not be substantiated from any of the USGS gage data. What can be substantiated is that the mean daily flow from 1950 to 2008 at Rome, Oregon, much farther downstream, is 932 cubic feet/second or 675,000 acre-feet per year. The flow at Rome includes substantial contributions from Jordan Creek, the Middle Fork Owyhee River and the North Fork Owyhee River.

It is possible, however, to look at probable general trends in the data.

### *b. Data*

Figure 5.16 shows information from the gage at Jack Creek near Tuscarora. The central double line between the yellow and green colors shows the median daily discharge in cubic feet per second ($ft^3$/sec). Each day of the year the total flow for the day in cubic feet is averaged by the number of seconds in a day (86,400). This gives the mean daily flow (or discharge) per second. The median shows the daily discharge rate at which the mean daily discharge rate is exceeded for half of the years graphed and not exceeded for the other half. It indicates what the flow rate is on a given day in an "average" year.

The information is graphed on a logarithmic scale so that the information about the low flows is not lost due to a few extreme high flows. On a logarithmic scale the distance on the y axis from 0.1 to 1 is the same as from 1 to 10, which in turn is the same as from 10 to 100 and from 100 to 1000. Figure 5.17 shows a logarithmic scale with the multiples of 10 below. Each of these is split into the nine major intervening intervals with some of the interpretations of these intervals labeled above.

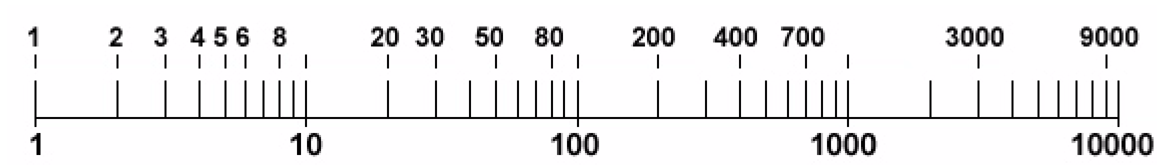


**Figure 5.17. A logarithmic scale**

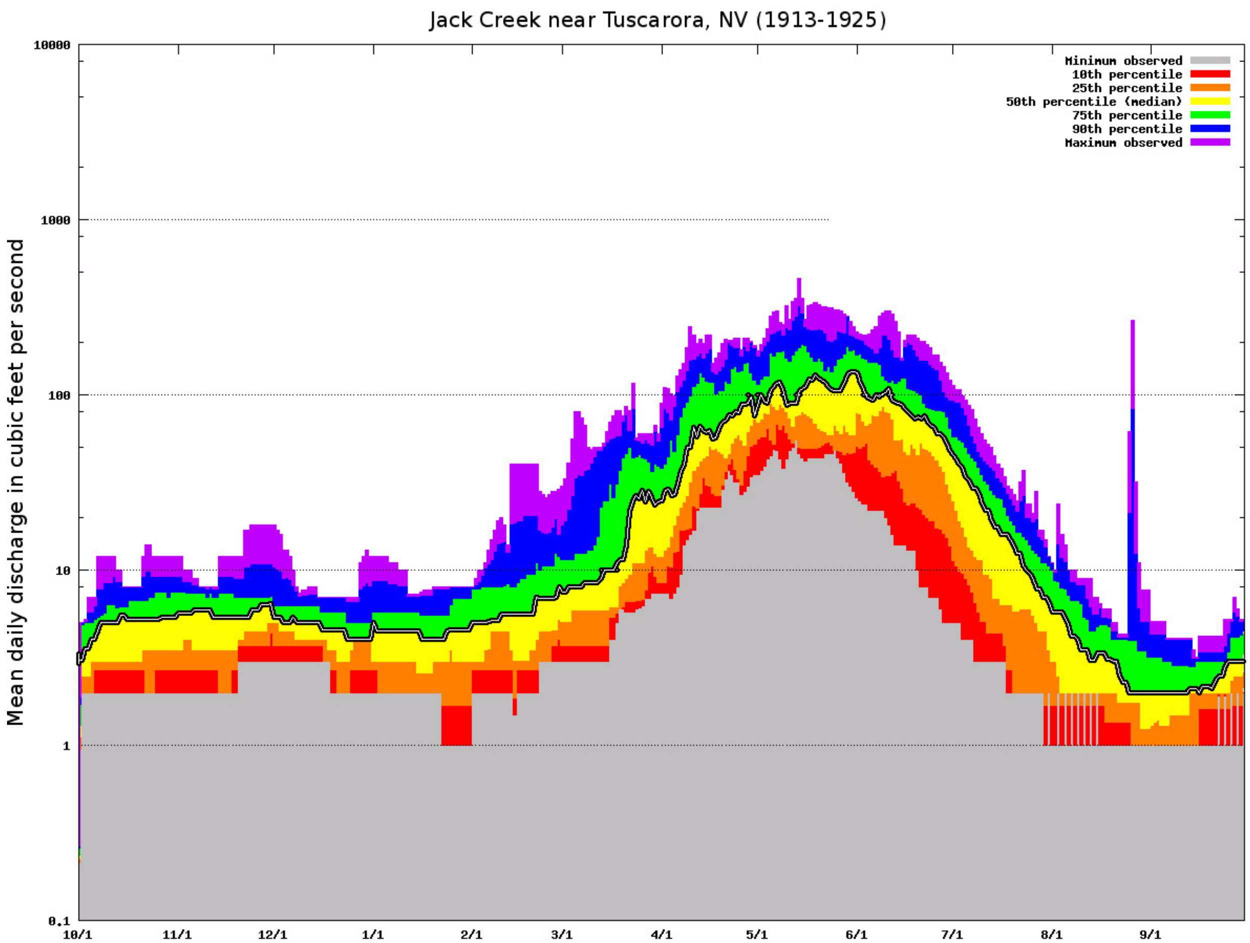


**Figure 5.16. Observed distribution of the mean daily stream flow at USGS gage 13177000 in the upper Owyhee subbasin.**

In addition to the median daily discharge shown by the border between the yellow and green sections, the distribution of daily means over the different years is shown by the differently colored sections. The top of the gray section is the minimum daily discharge on that date. At Jack Creek near Tuscarora (Figure 5.16), there were no years in which the flow was less than 1 ft$^3$/sec. The top of the purple section is the maximum daily discharge for that date. The median flows between the first of October and the first of March varied between 3 and 8 ft$^3$/sec. During March the median flows rose to 30 ft$^3$/sec. The greatest median flows, about 100 to 125 ft$^3$/sec occurred between the first of May and the middle of June. The flows dropped steadily so at the beginning of September the mean flow was close to 2 ft$^3$/sec. The unpredictability of flows is evidenced by one maximum flow near the end of August that is greater than the maximum mean flows for the year.

*i. South Fork drainage*

Gages shown on Figure 5.15 as K, Jack Creek below Schoonover Creek; L, Jack Creek near Tuscarora; M, South Fork Owyhee River at Spanish Ranch; and N, South Fork Owyhee River near Whiterock, are downstream from each other. Although the dates of record are not comparable, the change in flows may be indicative of general trends. On Figure 5.18 the flows at the gage farthest up the mountain on Jack Creek

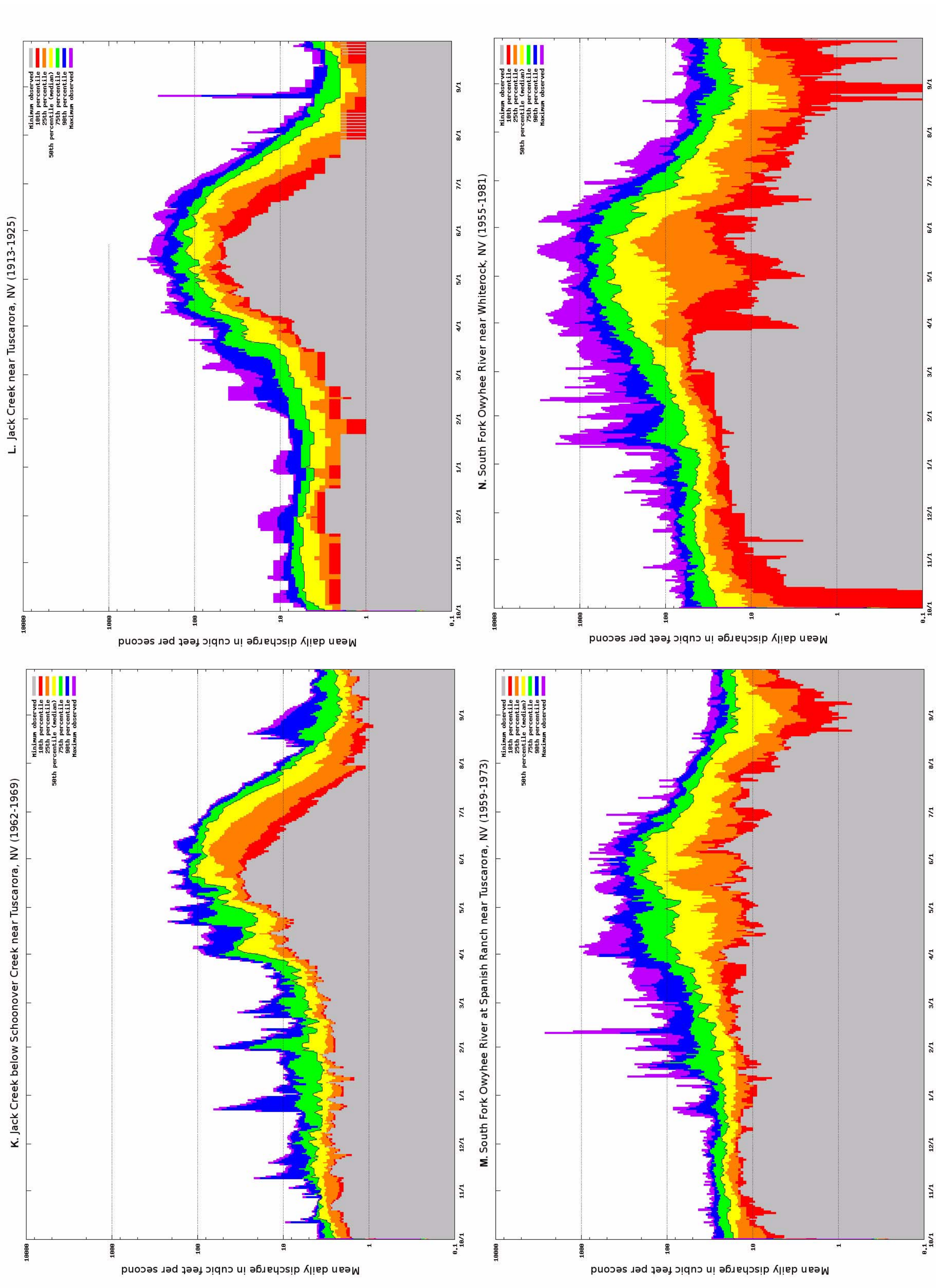


**Figure 5.18. Observed distribution of the mean daily stream flows at sequential downstream gages in the South Fork drainage in the upper Owyhee subbasin.**

tend to have the least fluctuation on any one date between the minimum flow observed and the maximum flow observed. The fluctuation between the minimum and maximum flows increases moving farther downstream. The median daily flow increases moving downstream past the gages, particularly during snowmelt during May and June from around 95 $ft^3$/sec at Jack Creek to close to 500 $ft^3$/sec near Whiterock.

The effect of the evaporative potential is shown by the gage near Whiterock. It is farther from the mountains out in the Owyhee uplands (on the Owyhee plateau). Where the bottom of the red band touches the x axis on the graph, the amount of flow in at least one year was less than 0.1 $ft^3$/sec. Since the next gage downstream is at Rome, there has been no data generated for the flows on the South Fork Owyhee River as it crosses the plateau. Between July and October, it is possible that there are years when even the South Fork Owyhee River has been at most a trickle.

### *ii. Owyhee River in Nevada*

The gages on the Owyhee River in Nevada are even less comparable than those on the South Fork Owyhee River. The original Wild Horse Dam was completed in 1937[10] and changed the flows in the river. Only gage 1317550 near Owyhee recorded exclusively prior to the construction of the dam. Gages 13174500 near Gold Creek and 1317500 at Mountain City also began recording before the construction of the dam, but also continued recording after the construction. Gages 13175100 near Mountain City and 13176000 above China Diversion Dam both began recording after the construction of the dam.

**Photo 5.10. Wild Horse Reservoir is impounded behind a double-curvature arch dam completed in 1969 to replace the original dam, Nevada**

The gage on the Owyhee River near Gold Creek is currently just beyond Wild Horse Dam. The data from this gage show the radical change in the hydrology just below the dam (Figure 5.19). Before the river was impounded, the flows in late July and August were the lowest, but never fell below 1 $ft^3$/sec. As flows out of the dam were controlled following the construction of the dam, the river below the dam frequently fell below 0.1 $ft^3$/sec, including more than half the time between early February and early

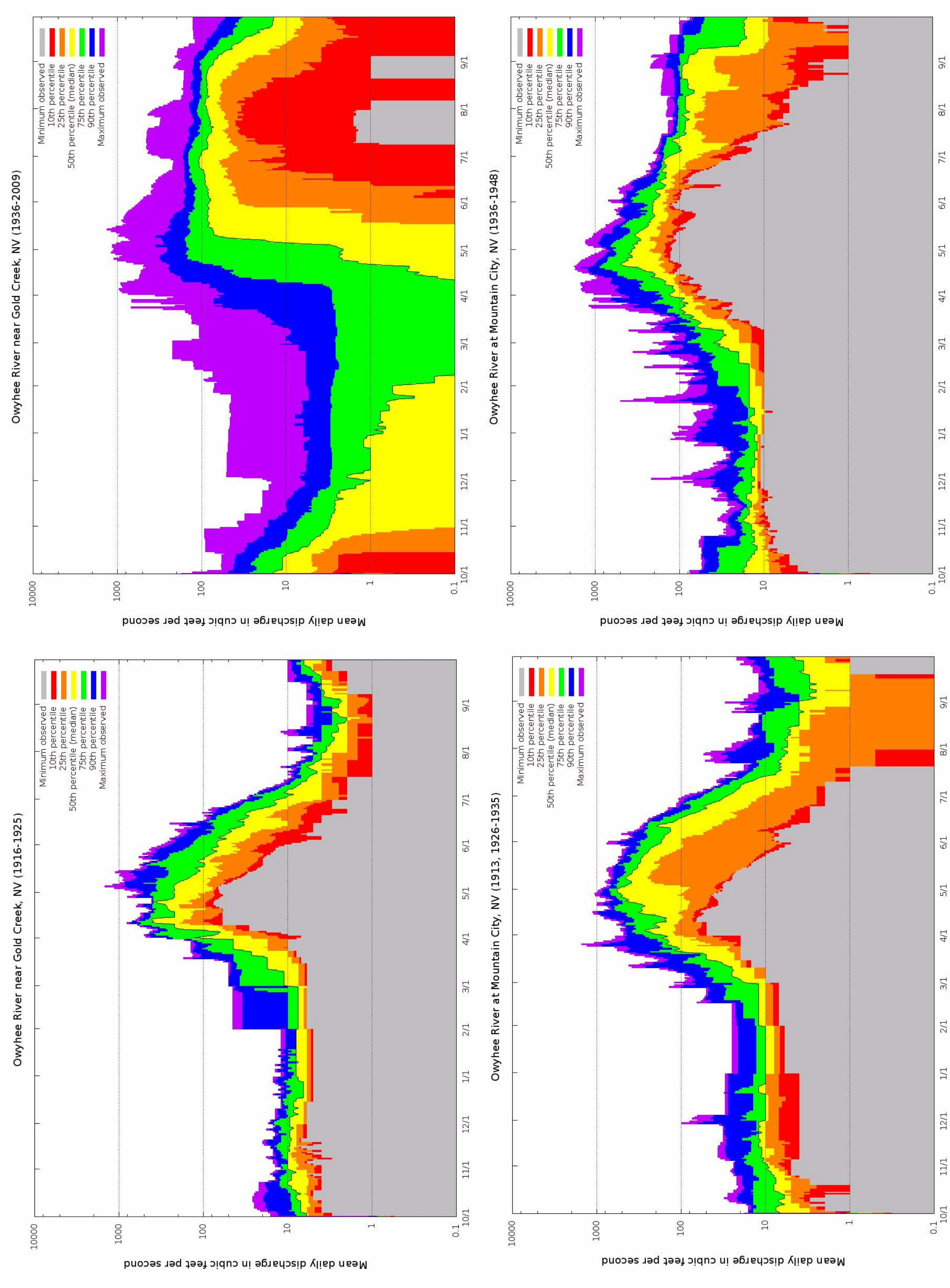


**Figure 5.19. Observed distribution of the mean daily stream flow at two stream gages on the Owyhee River before (on left) and after (on right) the construction of Wildhorse Reservoir.**

April. The fluctuations in the flow between years were also much greater than before the construction of the dam.

Farther downstream at Mountain City, the flows after the dam construction fluctuated less between years than before the construction. Following impoundment, the flows did not decrease as much between May and September as prior to impoundment. The supply of water from the dam during the growing season has been more constant, mostly in excess of 10 $ft^3$/sec.

*iii. Snowmelt*

Although the gages on the South Fork Owyhee River and Owyhee River have measured the flow generated by snowmelt in the Bull Run and Independence Mountains, Jay Chamberlin of the Owyhee Irrigation District estimates that the snow that accumulates on Mud Flat provides, on average, 35 to 40 percent of the water that eventually flows into the Owyhee Reservoir. Only one of the SNOTEL stations, Mud Flat, is in this area (Figure 5.1).

**Photo 5.11. Water being released from Wild Horse Reservoir into the Owyhee River, Nevada**

When the irrigation district flies the snow fields to look at their extent, the plane roughly circles from the Mud Flat SNOTEL station along Blue Creek to Riddle, back along the Owyhee River to the Idaho-Oregon border, and north along the western edge of the upper Owyhee subbasin.[54]

Semiarid mountain watersheds have both complex topography and vegetation that is not all of the same kind or nature. These cause the distribution and melting of seasonal snow cover to vary greatly in both space and time. The effect of topography, wind, and vegetative cover on climate conditions, snow deposition, and snow melt for these regions is not well understood.[16] Even though an estimate of the amount of snow and possible snow melt is made, the amount of water delivered to the river is also dependent on when and how quickly the snow melts. If the ground is frozen, melting snow will not soak into the ground but will flow into the Owyhee River. However, if the surface of the ground is no longer frozen when the snow melts, the soil usually absorbs a large portion of the water.

### *c. Flood risk*

The information needed to accurately assess flood risk in any year in the upper Owyhee subbasin is not being collected. Flooding in the upper Owyhee subbasin on the Nevada side has not been a priority in the state's hazard mitigation plan,[30,34] possibly due to the sparse population in the subbasin. However, the National Weather Service does keep track of the gage height and flood stage at Wild Horse Reservoir and at Mountain City.[19]

On the Idaho side, the state's hazard mitigation plan identifies the Owyhee River as one of those "presenting the most significant flood risks."[14]

> "Flooding has produced the worst disasters in Idaho . . . The three types of flooding experienced in Idaho are riverine flooding, flash floods, and ice/debris jam flooding. Riverine flooding is generally associated with winter storms and spring runoff and produces the largest scale events. Flash flooding is associated with extreme precipitation and runoff events, insufficient infrastructure, and dam failures. Although typically limited in extent, flash floods are considered the most dangerous to human lives. Ice jam floods are associated with extreme winter cold events while debris jams may result from landslides or human activities."[14]

Annually the potential for flash floods exists throughout the upper Owyhee subbasin. When the ground is saturated and cannot hold much more water, the conditions are ideal for flash floods with further rain.[4] In addition, thunderstorms that are "slow-moving and strong . . . can produce heavy rain conditions and possible flooding."[17] "Predicting where the flooding might occur is difficult" so a flash flood watch is issued. If the watch turns into a flood warning, flooding has already occurred.[4]

The potential contribution of the upper Owyhee subbasin to flooding downstream can be visualized by comparing the earlier graph of snowmelt contribution to river flows (Figure 5.14) to a graph which includes a few prior years (Figure 5.20). In 1962 the mean daily streamflow on February 10 was 2,680 ft$^3$/sec followed by a streamflow of 1,250 ft$^3$/sec on February 11. This was a rain event that caused historic flooding in southeastern Idaho when earthen impoundments broke. The peak flow was over two times as great as the maximum mean daily streamflow in 1969. These flows may eventually combine with other flows to present a greater flooding danger downstream. In the lower Owyhee subbasin the Owyhee Reservoir has 100,000 acre feet of capacity assigned to flood control, however flood control is informal and advisory only. A "minimum of 70,000 acre-feet of space is maintained in Owyhee Reservoir through February and more space is maintained beginning in January if the inflow forecast is large."[3]

Real-time data to reliably forecast the contribution of the upper Owyhee subbasin to the flow into Owyhee Reservoir does not exist.

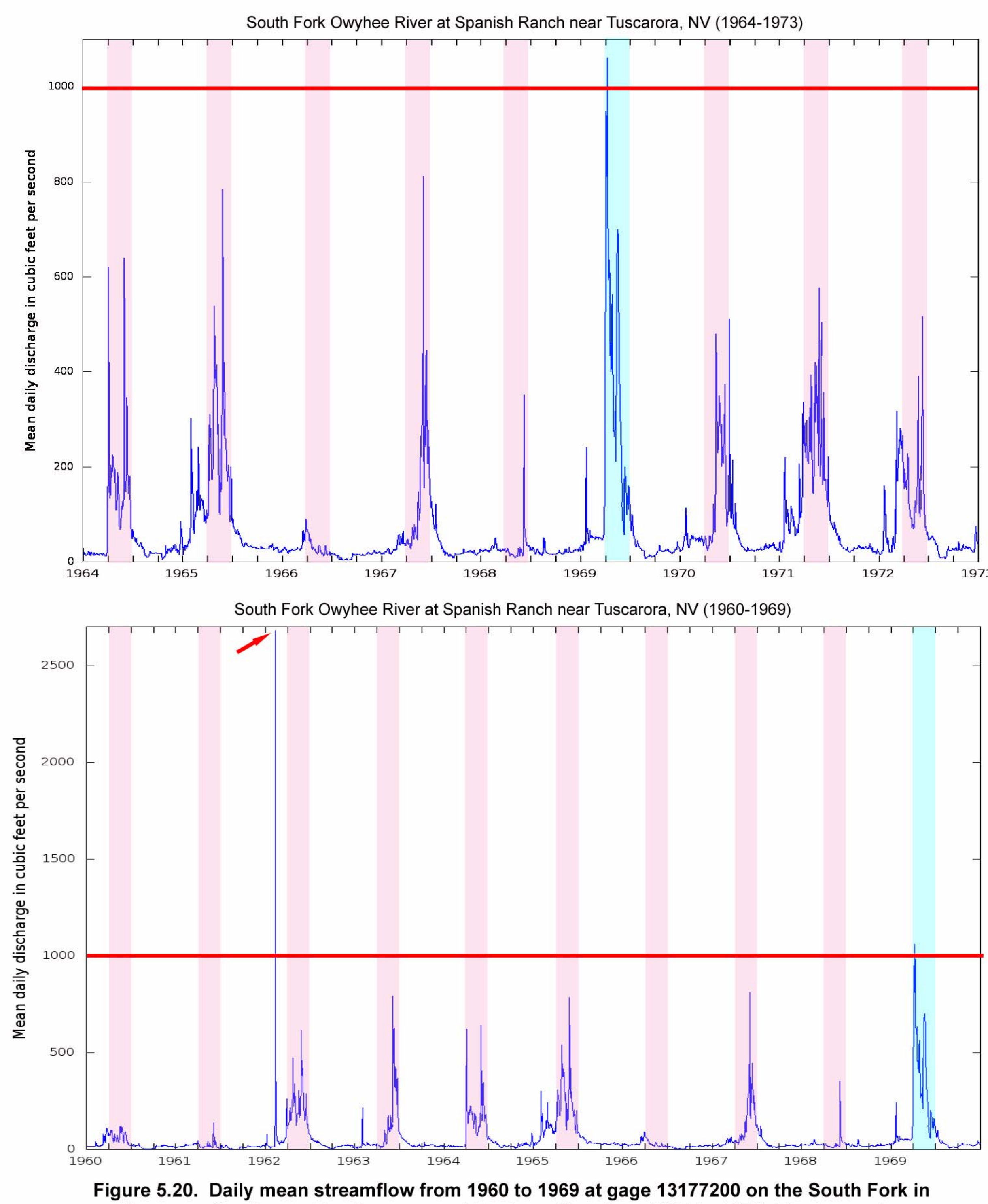


**Figure 5.20. Daily mean streamflow from 1960 to 1969 at gage 13177200 on the South Fork in the upper Owyhee subbasin compared to streamflow from 1964 to 1973. The turquoise block highlights the identical information in 1969.**

## D. Land use effect on flows

Since most of the upper Owyhee subbasin is in rangeland, the management of the rangeland could have a significant effect on the flows, particularly on the flows of intermittent and ephemeral streams. Part of the impetus behind the passage of the Taylor Grazing Act was the condition of the rangelands in the western states. Overgrazing up to 1934 had led to areas where there were few plants left to stem the flow of water across the ground surface or secure the soil; rainfall events resulted in small eroded rivulets leading to the drainage channels. The continued erosive flow in these rivulets led to deeper scars in the landscape. Controlled grazing has eliminated most of this problem, as further discussed in the rangeland section of this assessment.

Many roads across the landscape consist of only two tire tracks. These tracks tend to interrupt the normal flow of water across the landscape; water that is running across the landscape concentrates in the tracks and is delivered downstream. In general no features are planned or built to remove water at relatively short intervals from the two-track roads. Consequently these two-track roads concentrate water and provide the volume and acceleration of runoff that subjects the land to soil loss.

All terrain vehicles can denude and compact the soil, leaving many paths for accelerated water runoff.

In the upper Owyhee subbasin, human activities are not responsible for the peak flows and their potential destructive force. The construction and management of dams, stock ponds, and small reservoirs tend to mitigate peak flows.

## E. Data gaps

There are data missing for the upper Owyhee subbasin that are frequently available for other hydrologic basins. There are has been no mapping of groundwater aquifers, there are no data for water infiltration rates, and key variables for hydrology are generally unavailable. The mapping of vegetative coverage is basic.

There has been no ground verification of which streams are ephemeral, intermittent or perennial. The three types of streams can not be looked at in the same fashion when considering if any remediation is feasible. Rainfall estimates model rainfall between the sparse SNOTEL and meteorological stations in the subbasin and stations surrounding them. The sparsity of these stations means these precipitation models have limited accuracy and give little idea of any local conditions that differ. Models of snowmelt also rely on sketchy data.

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# Upper Owyhee Watershed Assessment

## VI. Irrigated Agriculture



### Contents



## VI. Irrigated Agriculture

### A. Importance of irrigation

The upper Owyhee subbasin is a semiarid cold desert (see background section) with agricultural production restricted to hay due to frost risks. Prior to the development of irrigation projects, agriculture was impossible due to arid conditions during the growing season. Early hay production was restricted to narrow strips of irrigated land along rivers.

### B. Sources of information

Data about irrigation and irrigated agriculture that applies specifically to the upper Owyhee subbasin is difficult to locate. Much of the information available is aggregated for either Elko County in Nevada or Owyhee County in Idaho. This information may be applicable to the upper Owyhee subbasin qualitatively, if not quantitatively. Since a large section of Owyhee County borders the Snake and Bruneau Rivers, data for irrigated acreage and crops in Owyhee County may be overshadowed by information from properties receiving water from irrigation districts along these rivers.

### C. History

#### 1. Before 1890

Prior to the winter of 1889-90, most of the ranches had put up some hay for stock horses. Some of this hay was harvested from natural wetland meadows. Bancroft and Victor observed that "on all the creeks of the northern part of the state [Nevada] are extensive patches of rye-grass, which grows often six feet high, and makes excellent hay".[1] Irrigated hayfields were confined to the small floodplains along streams where water could easily be diverted. Water diverted by rock dams near the upstream end of a claim could irrigate the lowlands along the streams. Flooding uncleared land killed the native desert shrubs. Although the land was not leveled, the irrigation created a wet meadow hayfield and native sedges and rushes invaded from the adjacent floodplain and established a native hayfield.[4,16]

## 2. Irrigated hayfields

The high mortality of cattle during the white winter of 1889-1890 was due to both a lack of available forage and the cold temperatures and "drove home the lesson that forage had to be conserved for wintering cattle on most of the sagebrush ranges."[16] Ditches were dug by ranchers to irrigate land farther from the immediate floodplain. Ranchers worked together "mucking" cooperative ditches in the spring. The sod in the bottom of the ditch was cut and lifted out. Generally the new native hay meadows were only flooded once each season in the spring. Low dams of earth or brush were used to keep the irrigation water on the land from one to four weeks. Until the rains of autumn, the native hay meadows didn't receive any more water.[5,16]

Ranchers were not choosy about what they cut as hay. During his 1901 examination of the forage conditions north of Winnemucca, among the species David Griffiths identified in hayfields were alkali bullrush, cattail tine, wire grass, squirrel tail, and spike rush. Although most hayfields were comprised of native species, where irrigation was practiced alfalfa fields were the most productive, possibly averaging 3 to 4 tons an acre where only two cuttings were made. In 1901, both redtop and timothy were being introduced in some areas. Griffiths considered creeping wildrye as one of the best and hence most important crops of the region.[5]

Early methods of harvesting a crop of hay were adapted to the handling of native hay which could withstand the rough treatment. These methods were hard on alfalfa which is a difficult hay crop to cure and handle properly. However, alfalfa produced with deliberate irrigation yielded three to four times as many tons per acre as wild hay irrigated by flooding. All of the hay raised was to support the ranching activities, not for sale to exterior markets.[1,5]

## 3. Expansion of hayfields

Today about 48 percent of the irrigated land in Elko County is in the upper Owyhee subbasin.[12] Assuming this percentage may have been similar over time, the figures given for Elko county are approximately double those applicable to the Nevada portion of the upper Owyhee subbasin section of Elko County.

In 1873 there were 15,000 acres of hayfields in Elko County.[11] By 1880 the irrigated land in Elko County had grown to 16,124 acres.[12] Not all of this irrigation was on hayfields as the county also produced small amounts of wheat, barley, oats, and potatoes. Combining irrigated and unirrigated hayfields, there were 16,000 acres of hay harvested in 1880.[11] After the winter of 1889-1890, the land under hay crops in Elko County increased to 239,000 acres and stayed about the same for the next fifty years.[11]

In addition to the hayfields in Elko County, some hay was produced in the Owyhee County section of the upper Owyhee subbasin. It is more difficult to estimate what percentage of the cultivated lands in Owyhee County were located in the upper Owyhee subbasin. An 1898 directory of the County stated that "Hay of all descriptions, mostly alfalfa, is produced in large quantities."[7] Early in the next century, Hiram French wrote "In the southern portion [of Owyhee County]. . . the waters of the streams have been diverted for irrigation and large crops, chiefly of alfalfa, are grown."[4] In the county as a whole, in 1912, there were 13,384 acres planted to alfalfa and 13,812 acres of other hay harvested.[4]

## D. Climate

The climatic conditions of the upper Owyhee subbasin have constrained the crops that can be grown on the irrigated land. High elevations and cold temperatures lead to a short growing season. The "average" last frost free date in the fall is the date when there is a 50% chance that frost will occur before that date. The "average" first frost free date in the spring is the date when there is a 50% chance that there will be no more frost after the given date. The frost-free season is considered to be the number of days in an "average" year when the minimum temperature is above freezing. This is defined as the period from the average date of the last frost in spring to the average date of the first frost in the fall.[2,3]

At Elko, south of the upper Owyhee subbasin, the average frost free period is from June 10 to September 9, or 91 days (Table 1, Figure 6.1). Longer frost free seasons are an advantage to the agricultural potential of an area.

Table 1. First and last frost dates at Elko, Nevada, elevation 5,050 feet.

| Last Frost | | | First Frost | | |
|---|---|---|---|---|---|
| 10% | 50% | 90% | 10% | 50% | 90% |
| May 16 | June 9 | July 2 | August 25 | September 10 | September 26 |

Alfalfa and other hays grow with shorter frost-free seasons than many other crops. They have continued to be the primary crops grown on irrigated land in the upper Owyhee subbasin.[9,13,14] The majority of the irrigated fields are on private land and are used by ranchers to grow supplemental feed for the winter season. The forage produced on farms from irrigated acreage, both hay fields and irrigated pasture, is critical to the support of livestock operations in the surrounding uplands. Without irrigation, forage production on these lands would probably drop about 90%. Some of the lower lands with some natural water might produce one cutting of hay.[12]

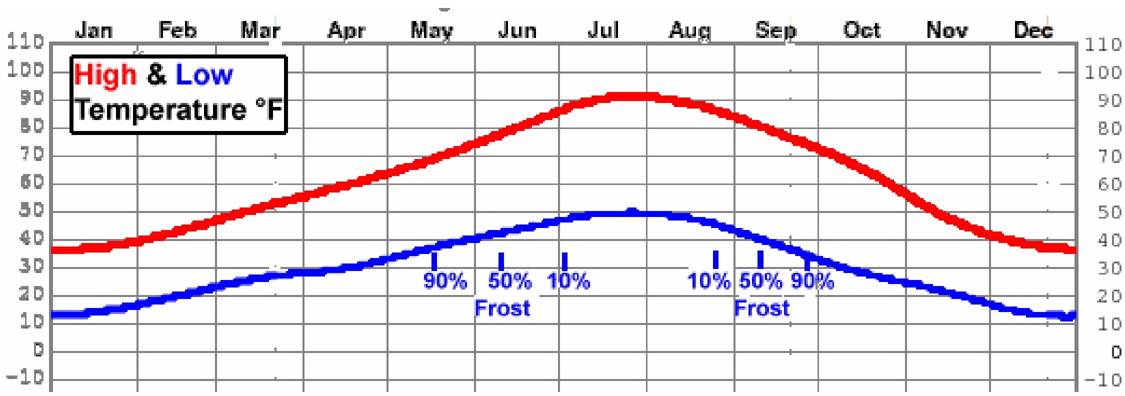


**Figure 6.1. Distribution of frost-free days at Elko, Nevada.**[3]

## E. Areas under irrigation

The Bureau of Reclamation considers the 43,000 acres that receive natural flow diversion from the South Fork Owyhee River and the Owyhee River as a “natural flow irrigation service area” and the rough boundaries of this area are shown in Figure 6.2. Natural flow irrigation water users either divert or pump their own irrigation water supply from the natural flows of these rivers. Even in these areas, some landowners may also irrigate with water pumped from the groundwater.[12]

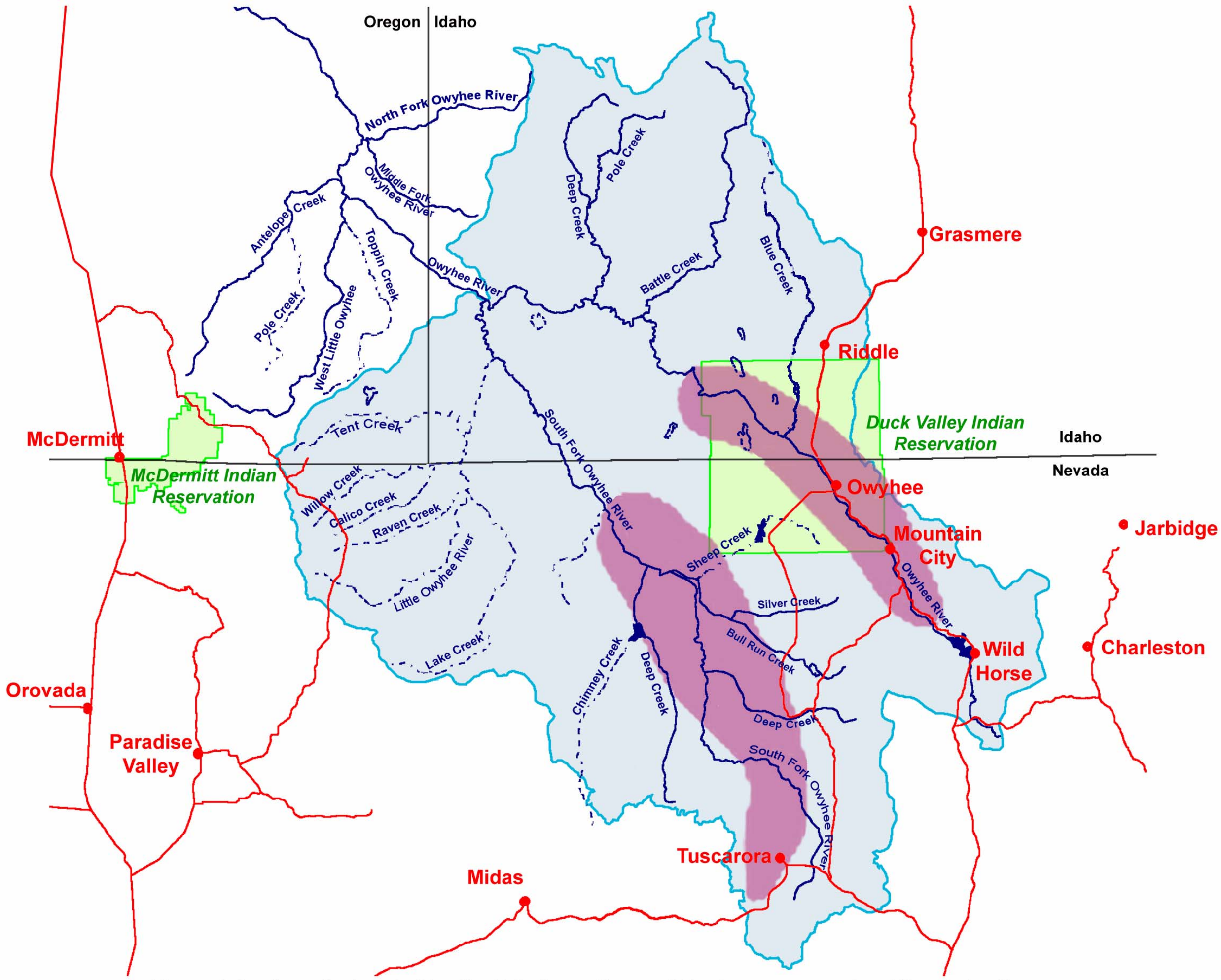


**Figure 6.2. Area designated by the U.S. Army Corps of Engineers as a natural flow irrigation service area in the upper Owyhee subbasin.[12]**

The irrigated areas in the upper Owyhee subbasin are usually located within the historic floodplains of stream corridors.[8] Since the irrigated land in the upper Owyhee subbasin comprises about 48 percent of the irrigated land in Elko County,[12] approximately 98,500 acres in Elko County in the upper Owyhee subbasin were irrigated in 2002.[9] Of this land, about 62,500 acres were used to grow alfalfa and other hay.[15] This acreage had diminished to around 57,400 in 2007. The irrigated acres not in hay crops are primarily pastures.

**Photo 6.1 Irrigated hayfields in Independence Valley at the base of the Independence Mountains**

**Photo 6.2 Irrigated pasture below Wild Horse Dam in the upper Owyhee subbasin.**

**Photo 6.3. Windrowed mown hay near Riddle, Owyhee County Idaho**

By contrast, in the Owyhee County section of the upper Owyhee subbasin, only 3,889 acres were under irrigation in 2003.[8] 1,493 acres were gravity irrigated and 2,396 acres were sprinkler irrigated.[8] Since most of the alfalfa and other hay grown in Owyhee County is on irrigated lands outside the subbasin, we do not know whether some of the irrigation within the subbasin was on pasture lands rather than hayfields.

**Photo 6.4. Stacked hay near Riddle, Owyhee County Idaho.**

The areas with irrigation in the upper Owyhee subbasin are shown in Figure 6.3. For the section of the subbasin in Owyhee County, the information was taken from the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load* study by the Idaho Department of Environmental Quality. The areas identified with irrigation in the Elko County section of the subbasin were taken from examination of the satellite images on Google Earth and in Google Maps.

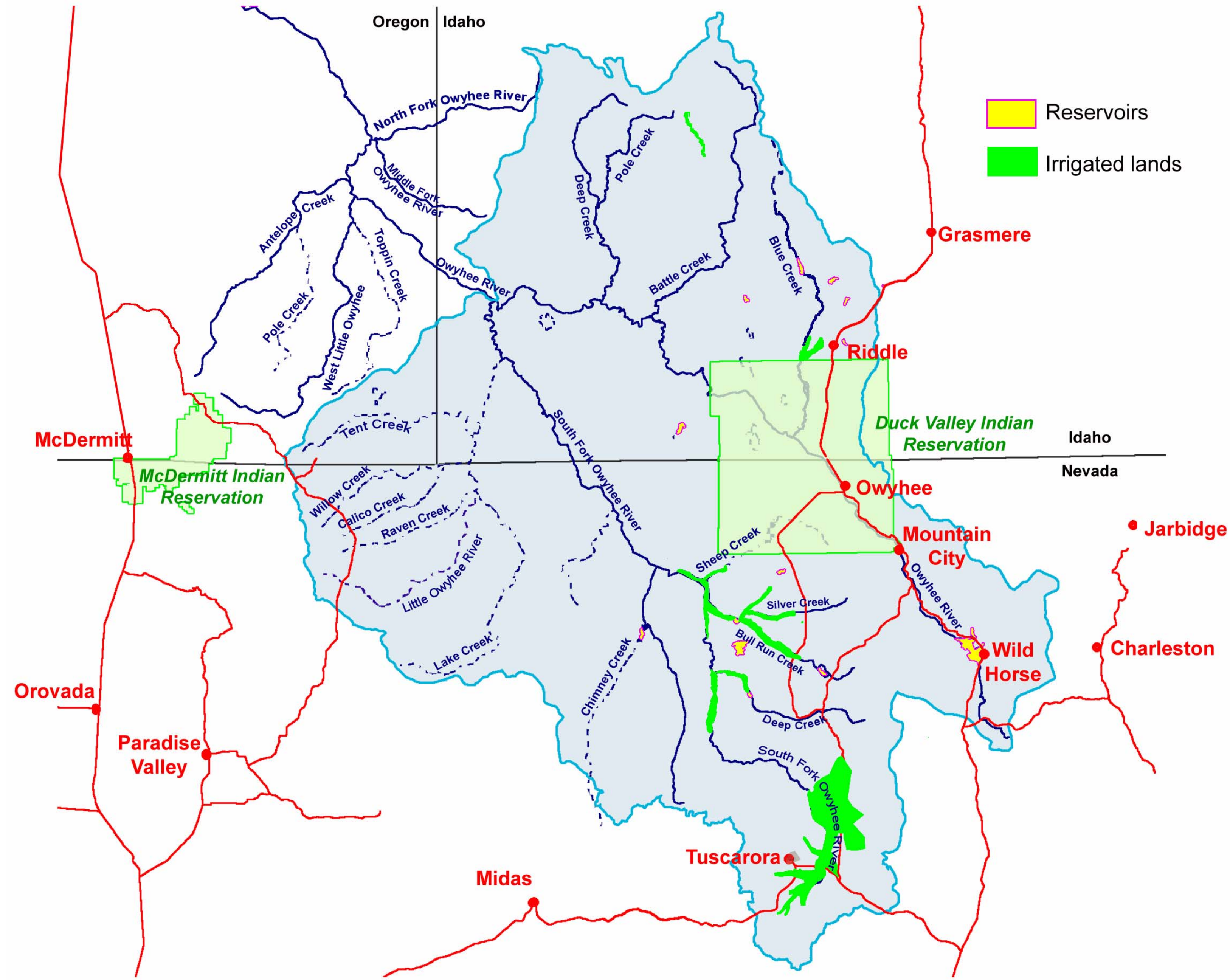


**Figure 6.3. Irrigated lands in the upper Owyhee subbasin.**

## F. Changes in irrigation

The original rock dams rebuilt each spring to divert water from streams and rivers onto floodplains to grow native hay gave way to more permanent structures and more elaborate ditch systems designed to deliver water to larger areas. The Petan Company of Nevada has some of the largest areas in the upper Owyhee subbasin under irrigation. Water stored in dams flows into ditches along both sides of Bull Run Creek and irrigates the land between the ditch and the natural course of the creek.

**Photo 6.5. Irrigated land along a canal on the Petan Company land**

One of the Petan Company's water rights from Bull Run Creek has a priority date of 1871. However, construction of the current dams dates to the 1940s. The company filed a water rights application for Rawhide Reservoir in 1940.[6] This application may be have been for a different dam than the dam proposed in 1941 for Bull Run Creek [possibly Bull Run Reservoir].[10]

Although the dams and irrigation ditches used to deliver surface irrigation improved with time, flood irrigation of meadows and pastures dominated. The application efficiency of an irrigation system is measured by the quantity of water delivered to the crop root zone to meet crop water needs in relation to the amount of water applied to the field. Only water reaching the crop's roots can meet the plants' water needs. From surface irrigation with graded furrows the efficiency ranges from 50 to 80 percent with an average of 65 percent. For center pivot irrigation, the efficiency ranges from 75 to 95 percent with an average of 75 percent efficiency.[17] In the upper Owyhee subbasin, irrigation efficiency has recently been improved in some areas by the conversion from flood irrigation to center pivot irrigation.

In 1994, aerial photos along a section of the South Fork Owyhee River in the Independence Valley show two areas with furrow flood irrigation. Five years later in 1999, the irrigation of a large part of one these areas had been converted to center pivot. In 2003 another region had been brought into cultivation under a center pivot. By 2006, a third center pivot had replaced some of the remaining furrow irrigation (Figure 6.4).

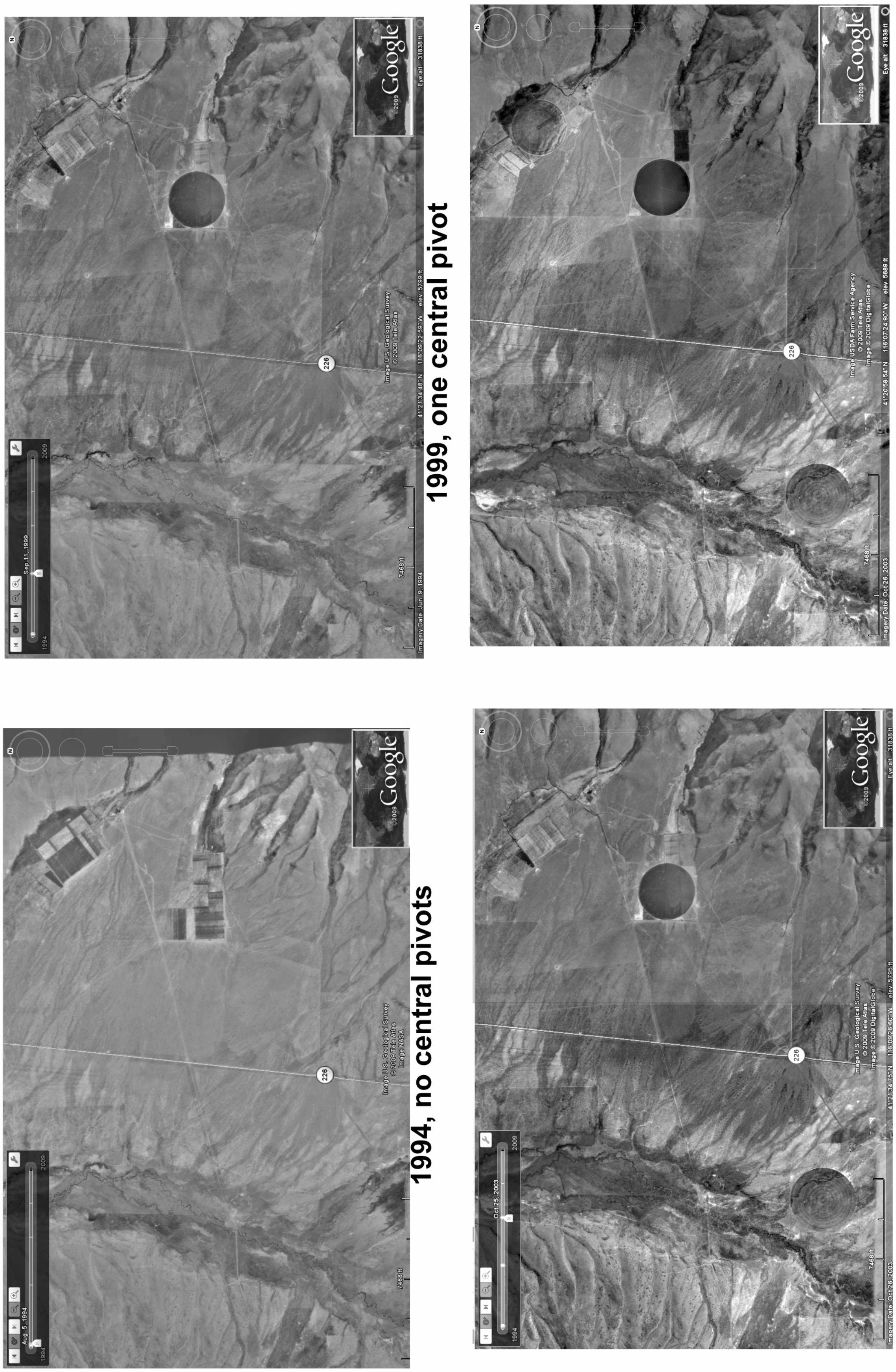


**Figure 6.4. Evolution of irrigation systems in Independence Valley in the upper Owyhee subbasin.**

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# Upper Owyhee Watershed Assessment

## VII. Rangeland



### Contents



### VII. Rangeland

The Oregon governor’s strategic initiative for ensuring sustainable water resources for Oregon’s future, Headwaters 2 Ocean, considers all water resources from the hilltops to the Pacific Ocean. The completion of the assessment of the upper Owyhee subbasin is consistent with the governor’s initiative. The upper Owyhee subbasin contains the headwaters of the Owyhee River and two of its principal tributaries.

## A. Introduction

### 1. What is rangeland?

Rangeland is extensive, uncultivated, mostly unforested land that is dominated by native plants. The term range was originally used to describe the wide open lands of the western half of the United States, probably because it was possible to "range" over large expanses.[59,139]

Land that is not towns or cities, farmland, dense forest, barren desert, "badlands", rock or glaciers is termed rangeland. Rangelands include open woodlands, grasslands, and shrublands. Since they exist worldwide, rangelands are known by many names: prairies, plains, grasslands, savannas, steppes, shrublands, deserts, semideserts, swards, tundra and alpines.[58,139,140]

Although rangelands occur on every continent and account for about 45 percent of the earth's land surface, they account for only 36 percent of the land surface of the United States. Most of these rangelands are in the western US where about 80 percent of the lands are rangelands.[59,138]

Rangelands are the dominant type of land in the arid and semiarid regions. In addition to having limited precipitation, they generally have sparse vegetation, sharp climatic extremes, and highly variable and frequent saline soils.[59,138,140] The dominant vegetation of western American rangelands is grasses, shrubs, and forbs (broadleaf plants like wildflowers).[58,138]

The terminology rangelands is generally not applied to lands managed by forestry principles.[139] However, in this assessment of the upper Owyhee subbasin rangelands, the land managed by the U.S Forest Service in the Bull Run and Independence Mountains is sometimes included in the discussion as the use of the land is frequently similar to the use of rangeland.

### 2. How is rangeland used?

Historically, the primary use of rangeland has been to provide forage for livestock and wildlife. Rangelands also provide wildlife habitat, habitat for a wide array of diverse native plant species, mineral resources, recreation, open space, and areas of natural beauty.[58,59,138,140]

Rangelands provide the varied habitats needed by a wide array of animal species including both game animals and non-game animals. Numerous species of mammals, birds, reptiles, amphibians, fish and insects live in the rangelands. Ruminants, animals such as deer, pronghorn antelope, and big horned sheep, can digest the cellulose in rangeland plants due to their specialized digestive systems. Small rangeland mammals have adapted to the arid environment and the forage provided by rangeland plants.[58,138]

Sheep, cattle, and goats are also ruminants and can utilize the cellulose in rangeland plants. Livestock production on rangeland supplies meat, leather, and wool. In the 19 western states, rangeland and associated pasturelands support 58% of all beef cattle in the United States, 79% of all stock sheep, and 88% of all goats.[58]

Outdoor recreational activities in rangelands include hiking, camping, river rafting, fishing, hunting, and photography.[138] The importance of rangeland for recreation and water production is growing.[58]

## B. Rangeland in the upper Owyhee subbasin

Most of the upper Owyhee subbasin is rangeland, however this rangeland is not homogeneous. The different ecoregions (see background section) will support different types of vegetation. The Bull Run and Independence Mountains with their increased elevations will not only have differing vegetation but will also present different problems for ranching.

## C. Historical condition of rangeland in the upper Owyhee subbasin

We have little written information on which to base an understanding of the condition of the rangeland before the introduction of livestock. The pioneers on the Oregon and California trails kept to limited routes which skirted the upper Owyhee subbasin. Most of the trappers and early explorers also kept to routes outside the subbasin.

**Photo 7.1. Rangeland in the upper Owyhee subbasin**

The journals of the trapping expeditions which entered the subbasin give a sketchy idea of the vegetation. These three trapping brigades spent a total of only 44 days within the upper Owyhee subbasin. From the meager entries in the journals of John Work and Peter Skeen Ogden, the vegetation of the Owyhee plateau at the time of Euro-American entry into the region was sagebrush plains and areas with little grass amid large expanses of more barren rocky ground. Some streams banks had willows along them and parts of the swampy areas of the Duck Valley Indian Reservation had more verdant vegetation. The brigade trappers ascended streams into the mountains, and the journals indicate some trees along these streams, but there are no descriptions of any vegetation away from the streams.[77,78,141] (See the at contact section of the history component of this assessment).

### 1. Prior to significant livestock introduction

The upper Owyhee subbasin was largely unused before miners had discovered gold in the Owyhee Mountains in 1863. Cattle and sheep were introduced on the rangelands of the upper Owyhee soon thereafter. In his memoirs, David Shirk describes the rangeland in 1867.

> "From the west slope of the Rocky mountains to the east slope of the Cascades . . . the valleys along the water courses are covered with a growth of browse, such as greasewood, thorny rabbit brush, salt brush

and white sage. This grows to a height of from fourteen inches to four feet, and is excellent forage for horses, cattle, and sheep. I have driven cattle off the range, where white sage was abundant, in the month of January, as fat as I ever saw in the corn fed stalls of Illinois. On the upland, or mountain ranges, there is little feed save the famous bunch grass, no browse growing worthy of mention. Horses will live indefinitely on the white sage, eating the snow for water. . . Cattle will perish after about six weeks. In the latter, after a period, the browse will become dry in the stomach and will not digest, and hence they will soon die."[110]

"Throughout the great valley of the Snake River, the first vegetation that appears in the spring is Larkspur, a rank poison. While the ground is yet soft, cattle in feeding will pull up some of the roots and if not attended to at once, will die. . . . Consequently, cattle have to be moved into the foothills of the mountains to feed upon bunch grass, and follow up the snow as it melts away."[110]

**Photo 7.2. White sage (winterfat)**

In 1877, W. J. Hoffman published an article which described in general terms the distribution of vegetation in the Bull Run Mountains.

“The level of the prairie at Bull Run is 5800 feet above the sea . . . At Bull Run the timber-line, at an altitude of 8300 feet, terminates with the upper line of the belt of *Coniferae*, while the lower line rests upon a belt (400 feet of the vertical section) of mountain mahogany (*Cerocarpus ledifolius*), which in turn gives place at 7000 feet to the belt of *Salicaceae*. This group terminates irregularly at the beginning of the foot-hills, at an elevation of about 6200 feet. The foot-hills are chiefly covered with *Phlox*, *Lupinus*, and *Rosaceae*, an the plain with “grease-wood” (*Sarcobatus vermiculatus*) and “sagebrush” (*Artemisia tridentata*), the former being greatly in excess, but is gradually replace by the latter going southward [sic]. The lines of demarcation are frequently indistinct, owing to the mingling of species of one belt with the adjoining ones.” [42]

“. . . Upon the foot-hills . . . different species of plants occupy distinct patches, but it is apparent that there are changes going on, and that in time some will be destroyed, giving place for hardier varieties.” [42]

## 2. Following livestock introduction

(Further discussion is available in the History component of this assessment dealing with the end of the nineteenth century, early twentieth century).

In the early 1870s, changes in the upper Owyhee subbasin included the introduction of livestock to the rangelands. By 1876 David Shirk says they "began to realize the necessity of preparing food for winter, as the native grasses, mostly bunch grass, were slowly giving way, and prudence required preparations for winter."[110]

When livestock were first introduced, the grass on public lands was "free" and lured livestock growers to turn out herds of sheep, cattle, and, sometimes, horses to roam freely. There was a "winner take all" attitude that encouraged grazing.[33,46] Cattle outfits tended to graze different sections of rangelands so as not to compete with each other. In winter cattle were moved to areas with bunch grass and white sage.[57] The Desert Land Act of 1877 encouraged settlers to settle on arid lands and cattle outfits now faced competition. Competition between cattlemen, sheepmen, and settlers led to overstocking of the range.[46] Prior to 1890 cattle were sold by the head as much for the hide as for the meat. It was more important that cattle survived than the quality of the livestock.[56] After the Desert Land Act, livestock operations acquired lands with water resources to enable them to control the surrounding grazing lands.[34,46]

In 1894 and 1896 the Division of Botany of the Department of Agriculture sent botanists to survey the vegetation of eastern Oregon. The rangeland had been grazed to a greater or lesser extent for 20 years. Frederick Coville, one of those botanists recorded his general impressions for a National Geographic article.

> "The vegetation of the country consists primarily of sage brush, the well-known *Artemisia tridentata* of botanists, a shrub three to six feet high, closely related to the wormwood of Europe, and having in common with that plant a light gray color and a strongly aromatic odor. Away from stream beds and sinks and the shores of lakes, sage brush covers the whole country like a gray mantle and constitutes probably nine-tenths of the total vegetation. It is a plant the herbage of which is eaten by but few animals and by those only in starvation times, one that will grow with little moisture and will stand the widest range of temperature. Sage brush gives to the country its character. A level stretch is known as a sage plain; the grouse which live there are known as sage hens; the fuel of the region is sage brush; the odor upon the atmosphere is that of sage brush."[21]

> "A few other shrubs form an inconsiderable part of the woody vegetation, but these and the sage brush make up by no means all the plant life of the country. As the snow melts away in the spring, the well moistened soil between the Artemisia bushes becomes covered with the seedling of innumerable annuals. For a few weeks the ground is carpeted with these plants, which flower in the greatest profusion, but after about two months they ripen their seeds, dry up, die, and disappear. Growing with these annuals is another type of plants, tuberous-rooted perennials which have stored up during the preceding year's growth a large amount of nourishment. They therefore bloom at the first break of spring, go through a brief period of rapid growth, lasting usually a little longer than that of the annuals, and then the newly formed bulbs, well protected by

impervious coats against the desiccating influences of a long, dry summer, carry over a full supply of plant food for the next spring's blooming."[21]

### 3. Overgrazing

Already, Coville sees that the rangelands will not support uncontrolled grazing.

> "There is one phase of wastefulness of the natural resources of the United States which a trip across the plains of Oregon particularly impresses upon the traveler, namely, the careless destruction of our great natural wealth of forage . . . Continued over-grazing year after year, if sufficiently excessive, unquestionably kills out the native forage plants, which are then replaced largely by introduced weeds. The original nutritious grasses never regain their former luxuriance and sometimes are almost exterminated. Under moderate grazing the native species produce yearly a good crop, or if even slightly over-grazed will after a few years of rest regain their former abundance."[21]

Probably the first effect of overgrazing was reduced perennial bunch grasses in the spaces between the shrubs. Annuals may have invaded the bare ground, but Russian thistle and cheatgrass had not yet been introduced. The increasing species were probably unpalatable and included big sagebrush and rabbitbrush. In some places the sagebrush thickened and became a monoculture, the predominant plant growing at the site.

In 1902, when Theodore Roosevelt was in the White House, David Griffiths traveled from Winnemucca, Nevada to Ontario, Oregon on horseback. He was invited by the cattle producers who provided him with guides and services. Griffiths, a USDA scientist, wrote that the "public ranges of the region are in many places badly depleted." He reported finding large areas of bare soil and traveling across deteriorated ranges which he says were "directly traceable to overstocking and it does not appear clear how matters will improve in the near future."[31]

As early as the 1860s the cattlemen had been trying to get grazing controls on the public lands. The railroads opposed the establishment of grazing rights that might compromise their plans for settlements. In the early 1900s, both cattlemen and sheepmen in the upper Owyhee subbasin and adjacent areas who had a base property wanted to control the cattle and sheep operators who just used the land with no base property. Local ranchers approached congress and even President Theodore Roosevelt claiming the range was being destroyed by indiscriminate use. Nothing was done by the federal government to manage the use of lower elevation rangelands until the passage of the Taylor Grazing Act in 1934.[34]

Numbers of cattle, sheep and horses increased through the early twentieth century. In addition to causing immediate changes in vegetation, overgrazing by livestock during this period also set in motion long term changes in plant community structure. The reduction of fine fuels in the system interrupted the natural fire cycle. Coupled with the continual consumption of native grass species, which reduced their competitive ability, a reduction in fires resulted in a rapid increase in sagebrush. More insidious, was the increase in juniper seedlings in the wetter sagebrush plant communities. This increase was only really apparent 40 years later when the juniper became large enough to dominate the landscape. Some members of the livestock industry in the West perceived the destruction going on and championed the Taylor Grazing Act.[121,132]

The number of animals on the range varied, but tended to increase until the Taylor Grazing Act of 1934.[46]

Exotic plant species that were often contaminants of crop seed, found excellent seed beds on the overgrazed ranges and spread rapidly. Russian thistle first began growing on rangeland about 1900, followed by mustard species. The cheatgrass which appeared about 1915 spread over large areas of rangeland during the 1920s. Cheatgrass tended to increase ground cover and although it provided scanty forage, it was more than had been produced by barren lands. Cheatgrass also provided a flash fuel and fires became common.[40]

By the end of the 1940s fire suppression on rangelands had begun to affect the plant communities of rangelands.

## D. Vegetation

### 1. Types of rangeland vegetation

The plants that grow on rangeland can be categorized into grasses, grass-like plants, forbs, shrubs, and trees.

**Grasses** have long narrow leaves and produce grain-like seeds. They do not have showy colored flowers. The leaves are on two sides of a hollow stem. Grasses are generally the most abundant kind of range plant.[58,61]

**Forbs** are herbaceous (non-woody), broad-leaved plants which usually have showy flowers. They have solid stems. The above ground growth dies back each year. A few forbs, like wild onion, have leaves with parallel veins. Most forbs have leaves with a network of veins. Most wildflowers are forbs.[58,,61,76,113]

**Grass-like plants** look like grass but aren't. They have solid stems which are often triangular. Sedges have leaves on three sides. Rushes have leaves on two sides.[61,76,113]

**Shrubs** and trees are plants with above-ground stems that do not die back from one year to the next. Shrubs grow from several main, solid woody stems that branch from near the base. Their leaves have a network of veins. Shrubs often produce berries.[58,61,76,113]

**Trees** have a definite main trunk which is woody. Usually trees are bigger than shrubs. Some species of shrubs can form either a tree or shrub depending upon the local conditions, but most shrubs never grow up to be trees.[58,76]

**Browse** is the part of a woody plant, usually a shrub, that is used for forage by wildlife and livestock. Browse usually includes leaves and young stems.[58,76]

## 2. Rangeland types

All rangeland is not the same. There are several broad types of rangeland that comprise most of the plateau rangeland in the upper Owyhee subbasin. The type of rangeland may be related to the eco-region (see the background component of this assessment) but a different way of looking at the landscape is by principally examining the vegetation which grows in the area. Like ecoregions, the descriptions of rangeland types can vary. The sagebrush-steppe is an ecosystem encompassing many diverse communities. Sagebrush-steppe is a dry habitat where the vegetation consists primarily of sagebrush and other shrubs and short grasses. Precipitation averages between six and fourteen inches a year and the winters are generally cold and the summers hot and dry. Large portions of the upper Owyhee subbasin can be termed sagebrush-steppe. The natural vegetation consists of a shrub overstory with an understory of perennial grasses and forbs. Great variation exists in soil resources and therefore in the kind, cover, and amount of vegetation present.[44,66,129,132]

### *a. University of Idaho[106]*

The University of Idaho's current descriptions of range regions in Idaho includes pacific bunchgrass, sagebrush grasslands, salt-desert shrub, juniper woodland and coniferous forest and mountain meadow. Like ecoregions these are extremely broad categories. Only three of these are shown as present in the upper Owyhee subbasin: sagebrush grasslands, salt-desert shrub, and juniper woodland.[106]

#### *i. Sagebrush-grasslands*

Sagebrush-grasslands are a mix of sagebrush and bunchgrasses.

> "The most wide-spread type of rangeland in Idaho . . . is dominated by sagebrush and bunchgrasses. These rangelands stretch across the plains, plateaus, and valleys . . . Precipitation generally ranges from 10 to 15 inches per year. Big sagebrush is the most common species of sagebrush, but there are actually about a dozen different species of sagebrush in Idaho. Sagegrouse, pronghorn antelope, and black-tailed jackrabbits call sagebrush grasslands home. The shrub-grass mix provides good spring and fall grazing for livestock and wildlife."[60]

#### *ii. Salt-desert shrub*

Salt-desert shrublands, also known as salt desert scrub, are located in areas where there is no drainage and therefore salts accumulate in the soil. The desolate looking plant community results from the soil salinity along with cold winter and hot summer temperatures. These shrublands receive very little precipitation each year. Shrubs generally grow better under these conditions than grasses or forbs.[63,130,137]

> "In Southern Idaho, a kind of dry deserts are created by salty soils and cold temperatures. Shrubs . . . are able to live in these salty soils that dominate this "cold desert" (covering 1.5 million acres). These shrublands get very little precipitation each year, usually 10 inches or less. Shrubs are generally more well suited for these harsh conditions than grasses or forbs. Because these shrubs have high nutritive value in winter, cold

> deserts are excellent winter range for pronghorn and are considered some of the world's best winter sheep range."[60]

*iii. Juniper woodland*

> "In Southern Idaho, two kinds of small evergreen trees, Western Juniper and Utah Juniper, create a kind of "pigmy forest." The juniper woodlands usually grow on the rougher terrain and can be dense or open depending on soils and topography. These woodlands usually occur in scattered patches rather than solid stands . . . Annual precipitation ranges from 12 to 30 inches per year. The reduced frequency of natural wildfires allows juniper to expand into the adjacent sagebrush-grasslands." [60]

### *b. Oregon State University Rangeland Department*

The Oregon State University Rangeland Department uses an alternative description of rangeland types that includes herbaceous range, shrub and brush rangeland, and mixed rangeland.[56]

*i. Herbaceous range*

The herbaceous rangeland category is land dominated by naturally occurring grasses and forbs as well as those areas of actual rangeland which have been modified to include grasses and forbs for rangeland purposes.[2]

*ii. Shrub and brush rangeland*

The brushlands found in arid and semiarid regions are characterized by xerophytic (adapted to life with a limited water supply) vegetation with woody stems such as big sagebrush, shadscale, greasewood, or creosotebush and also by the typical desert succulents such as cactus. Moister areas may have mountain mahogany.[2]

*iii. Mixed rangeland*

When more than one-third intermixture of either herbaceous or shrub and brush rangeland species occurs in a specific area, it is classified as mixed rangeland. [2]

### *c. National Vegetation Classification System.*

A classification system provides a set of criteria for examining plant communities.[32] Both the Natural Resources Conservation Service (NRCS) and the BLM use the ecological site description, correlated to soil surveys, from the NRCS land classification system to determine vegetation type. Although BLM and NRCS use a different classification system, a National Vegetation Classification System (NVCS) was adopted by the Environmental Protection Agency and the US Geological Survey (USGS) in 1997 [28] and was revised in 2008.[29] It is now used to classify rangeland sites based on plant associations.[57]

> "The national vegetation classification system focuses on existing vegetation rather than potential natural vegetation, climax vegetation, or physical habitats . . . The vegetation types covered in the classification range from the short-lived to relatively stable and persistent plant

communities. The classification includes natural, seminatural, modified, and cultural vegetation."[128]

In other words, this classification system is based on the plants that are really growing in an area. This differs from the ecoregion approach as it focuses on the current vegetation. The NVCS also includes different levels. One of the higher levels focuses on the way the area looks and for terrestrial vegetation is divided into forest woodland, sparse woodland, shrubland, sparse shrubland, dwarf shrubland, sparse dwarf shrubland, herbaceous, and sparse vascular/non-vascular. The lowest level is delineated by the association of two or more species.[128]

## 3. Vegetation in the upper Owyhee subbasin

The vegetation of the upper Owyhee subbasin is extremely varied, including plant species growing above the tree line in the Bull Run and Independence Mountains, evergreen and deciduous shrubs of the sagebrush steppe ecosystems, and riparian species along the streams. Not only does it include species native to the area, but it also includes both invasive and introduced species.

### *a. Surveys of vegetation*

There has been one exhaustive survey of vegetation within the upper Owyhee subbasin which focused on a small section of the subbasin. The Idaho Department of Fish and Game, Conservation Data Center (CDC) contracted the Nature Conservancy to conduct an ecological inventory and assessment of the 45 Ranch. The ranch is bordered by the Little Owyhee, South Fork Owyhee and Owyhee rivers on the west, east, and north respectively. Although exhaustive, the survey only recorded species encountered in the 100 square miles of the ranch. The project occurred in two phases. The inventory of riparian and wetland communities was completed in 1998. The phase focused on terrestrial vegetation was completed during the 1999 field season.[73] All of the species of both riparian and terrestrial vegetation which they encountered on the 45 Ranch are identified within the subbasin plant list, Appendix E.

David Charlet used personal observations and visited fifteen herbarium collections to document the distributions of all conifer species occurring in Nevada. Within the subbasin he identified eight species either currently or historically present in the Bull Run and Independence Mountains of the upper Owyhee subbasin.[18,AppendixE]

### *b. Plant communities*

Surveys of vegetation frequently identify broad rangeland types. However, the plants living in association with each other, the plant communities, are classified more narrowly.

The species in a plant community differ in kind or proportion from the species of a different plant community. Traditionally these communities, or associations, are named for two of the species in them. On rangelands this combination of names tends to be the dominant shrub followed by the most obvious grass. However, the community name may be that of two shrubs or include the name of a forb. The NVCS classification system may include the names of two equally present species or differentiate based on a third prominent species. Although there is a recognized superstructure for identifying plant communities, different researchers may identify them more broadly or more narrowly.

### *i. Plant communities on the 45 Ranch*

Using the NVCS classification system, the survey of the 45 Ranch described 37 terrestrial plant associations in the upland environments. Table 7.1 lists 25 of these plant communities. Within some of these plant communities, the Nature Conservancy split the community by the inclusion of a third species so that they have more than 37 associations.[73] Three of the plant communities included in the survey were observed by Moseley in the earlier survey of riparian vegetation.[72] They consist of riparian plant associations that occur in intermittent drainage and pool habitats of plateau environments.

**Photo 7.3. The 45 Ranch on the South Fork Owyhee River in the upper Owyhee subbasin**

Table 7.1. Terrestrial plant communities identified on the 45 Ranch in the upper Owyhee subbasin.

| | | |
|---|---|---|
| *Artemisia arbuscula/Agropyron spicatum* | | *Salvia dorri/Oryzopsis hymenoides* |
| *Artemisia arbuscula/Festuca idahoensis* | | *Juniperus occidentalis/Danthonia californica* |
| *Artemisia arbuscula/Poa secunda* | | *Juniperus occidentalis/Festuca idahoensis* |
| *Artemisia cana/Muhlenbergia richardsonis* | | *Juniperus occidentalis/Artemisia arbuscula* |
| *Artemisia tridentata tridentata* | | *Juniperus occidentalis/Artemisia tridentata vaseyana/* |
| *Artemisia tridentata tridentata/Elymus cinereus* | | *Juniperus occidentalis/Artemisia tridentata wyomingensis* |
| *Artemisia tridentata wyomingensis-Haplopappapus acaulis* | | *Acer glabrum-Holodiscus dumosus-Ribes* spp |
| *Artemisia tridentata wyomingensis/Agropyron spicatum* | | *Haplopappus nanus/Poa secunda*. |
| *Artemisia tridentata wyomingensis/Festuca idahoensis* | | *Sarcobatus vermiculatus* |
| *Artemisia tridentata wyomingensis/Poa secunda* | | Riparian Working Group |
| *Artemisia tridentata wyomingensis/Sitanion hystrix* | | Riparian graminoid |
| *Artemisia tridentata wyomingensis/Stipa thurberiana* | | Riparian Shrubland |
| *Poa secunda/Eriogonum* spp. | | |

On the 45 Ranch, the dominant shrubs tend to be *Artemisia tridentata tridentata (*basin big sagebrush), *Artemisia tridentata wyomingensis,* (Wyoming big sagebrush), and *Juniperus occidentalis* (western juniper). These are the plants that will be most obvious to an observer looking out over the landscape.

### *ii. Other plant communities*

In addition to the sagebrush/steppe terrestrial vegetation, the upper Owyhee subbasin includes rangeland in pinyon-juniper woodland, mountain shrub, subalpine forest, and alpine tundra.[135] No survey similar to that done on the 45 Ranch has been conducted in the more mountainous regions of the subbasin.

Juniper stands occur throughout the higher elevations of the subbasin, generally as part of the sagebrush steppe vegetation. Starting around the 5,500 foot elevation, juniper can be found with stands of aspen and mountain mahogany. Douglas fir and sub-alpine fir occur on the highest slopes.[10,118] Other high elevation vegetation includes juniper, quaking aspen, snowberry, sagebrush and willow (*Salix* spp.).[9,118] Whitebark pine grows in the highest elevation forest and at timberline. In the Bull Run Mountains whitebark pine is usually associated with limber pine.[3]

### *iii. Recent mapping of vegetation*

Recent improvements in the resolution of remotely sensed data and data analysis have produced new vegetation maps. The Landsat satellites take high resolution images of a small section of the earth. The smallest unit which maps to a single pixel within these images is about 30 meters by 30 meters. These images record wavelengths, levels of brightness, and number of gray scale levels. The Gap Analysis Program is designed to map vegetation using the spectral bands. The upper Owyhee subbasin lies within two of the completed projects: the Northwest Regional Gap project and the Southwest Regional Gap Analysis projects completed in 2004 and 2007.[148,149,150]

Figure 7.1 depicts the distribution of land cover within the upper Owyhee subbasin. The Northwest Regional Gap project and the Southwest Regional Gap project sometimes used slightly different classifications for the land cover, resulting in an artifact at the Nevada - Idaho border. Of the plant associations mapped by the Gap Projects in the upper Owyhee subbasin, 45 account for most the of vegetated land (Figure 7.2).

## 4. Invasive Species

Invasive species are species which have the potential to expand or invade all or part of their U.S. range and degrade the landscape. Invasive species are commonly called weeds. These weeds are invasive because they grow vigorously and are competitive. Since they out-compete other species for light, water, nutrients, and space, they many rapidly dominate a site. Problems caused by these species include crowding out desirable vegetation, causing crop and forage losses, ruining good wildlife habitat, causing degradation of streams and wetlands, and creating rangeland fire hazards. Although most of these species are nonnative species from outside North America, not all invasive species were introduced to the U.S. Some species are native but have managed to spread and invade habitats such as rangelands or agricultural fields. Other species are native in part of the country but are serious pests in other parts.[64,116,125,126]

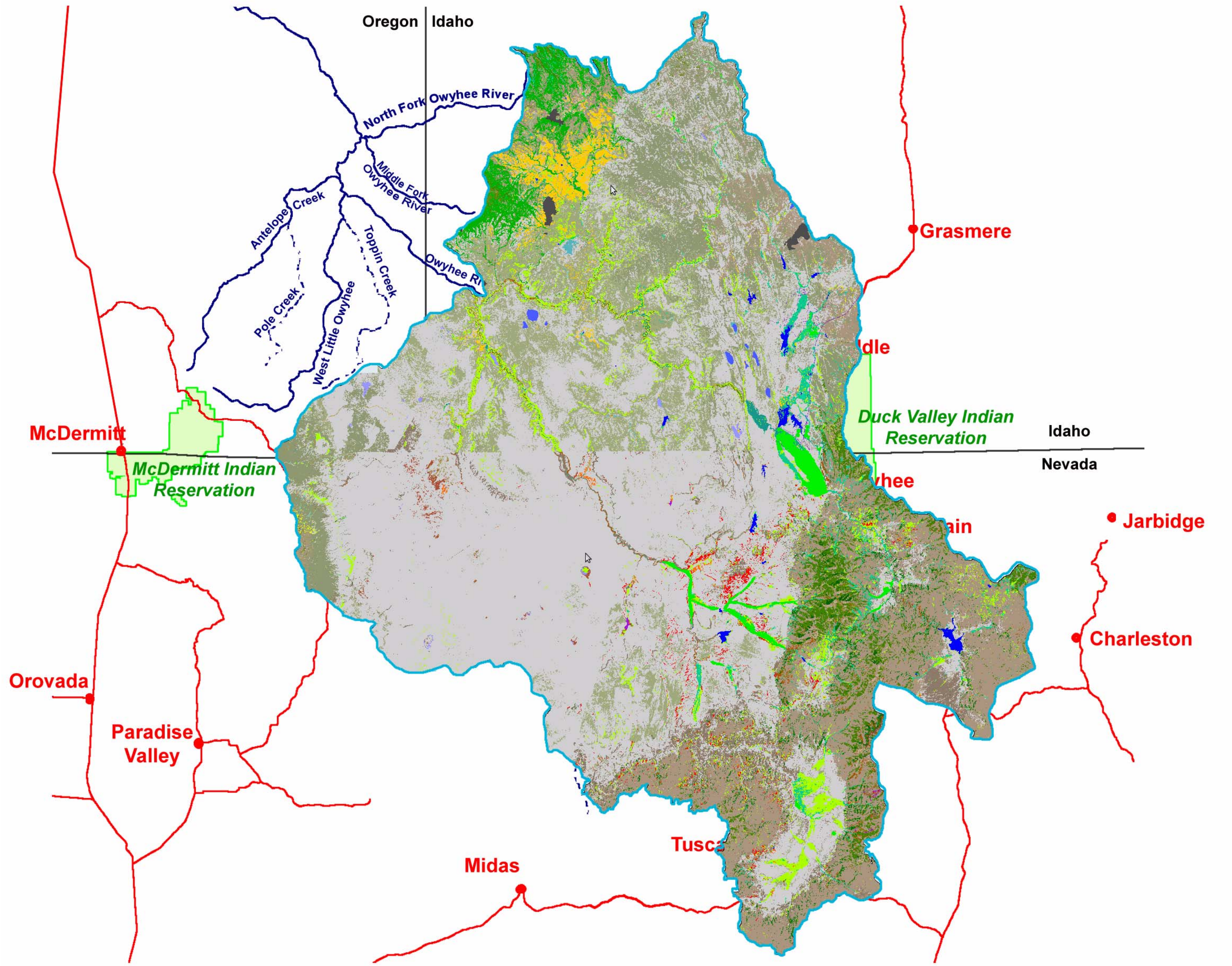


**Figure 7.1. Land cover in the upper Owyhee subbasin.**

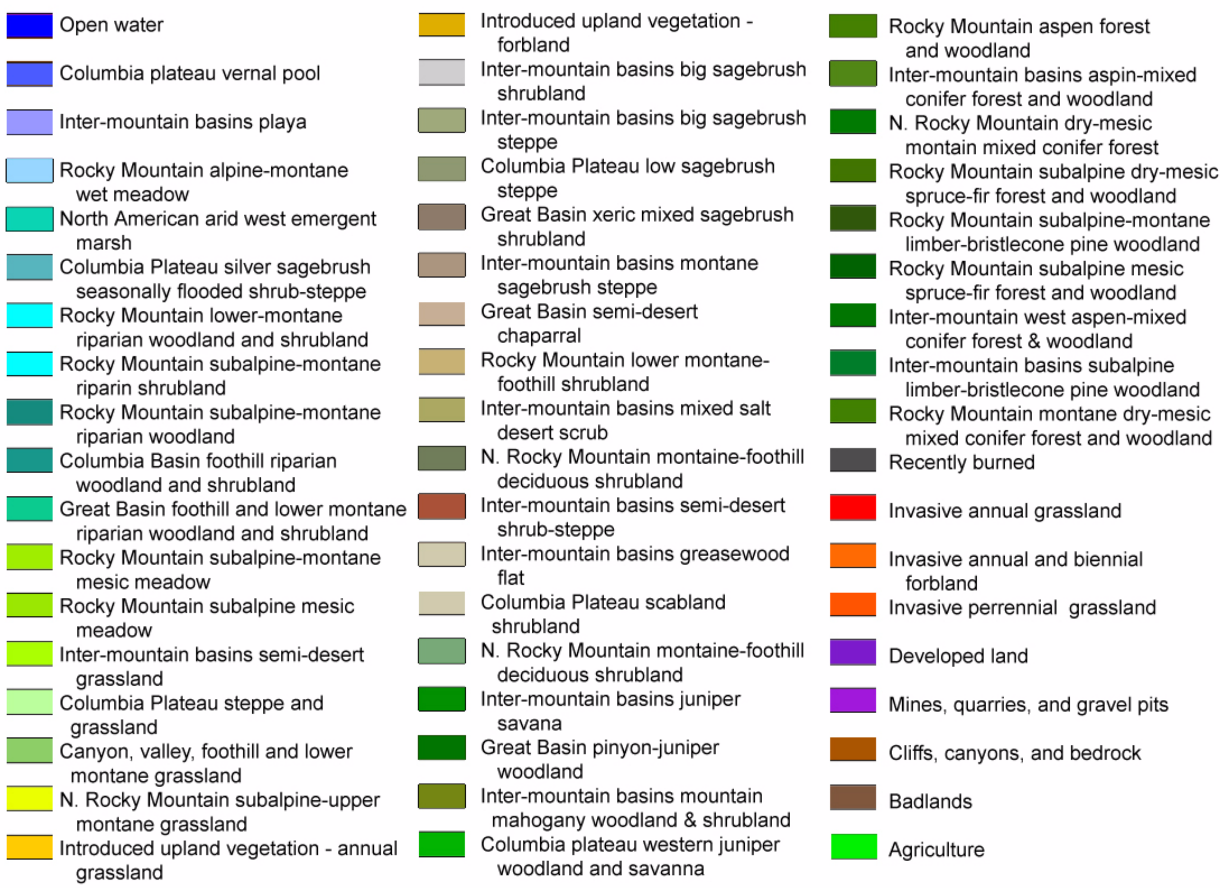


**Figure 7.2. Descriptions of the land cover on Figure 7.1.**

Species from other countries may have arrived either in the ballast of sailing ships or in shipments of desirable seeds. Some were introduced intentionally as garden plants. The introduction of invasive plants into the US has increased dramatically in the past couple of decades due to the increased ease and speed of national and world travel and the expansion of global commerce. Wind, water, and animals can naturally spread invasive weeds locally, but human activities such as, recreation, vehicle travel, and the movement of contaminated equipment, products, and livestock often greatly increase the distance and rate of dispersal.[83,116]

### a. *Noxious weeds*

A weed is designated noxious when it is considered by a governmental agency to be injurious to public health, agriculture, recreation, wildlife, or property. Noxious weeds are considered to be serious pests because they cause economic loss and harm the environment. Noxious weeds can choke out crops, destroy range and pasture lands, clog waterways, threaten native plant communities or affect human and animal health.[83,116]

Some general characteristics of noxious weeds are their ability to spread rapidly, reproduce in high numbers, and crowd out native plants. Noxious weeds also tend to be very difficult to control. There are many challenges to managing noxious weeds. They are often resistant to mechanical and cultural practices and existing herbicides.

Noxious weeds are generally non-native plants. Noxious weeds appeared and spread with European settlement and new weeds continue to arrive today. A large number of the least desirable weeds are of Mediterranean, European, or Asian origin. Not all weeds are noxious weeds.[116,451]

Invasive plants affect the plant community composition and have profound negative consequences for native biotic diversity. In rangeland, the most significant invasive species affecting the plant community composition are fire-adapted annual grasses, like cheatgrass and medusahead rye. The expansion of these grasses has resulted in annual grass-fire cycles that rapidly replace sagebrush-steppe and salt-desert shrubland systems.[7,17]

### *b. State designations of noxious weeds*

The states of Idaho, Nevada, and Oregon all maintain lists of weeds designated as noxious weeds in that state. Each of the states has a different way of categorizing noxious weeds. Laws governing control of weeds varies from state to state but generally outlines what should be done concerning the identification, reporting, and treatment of noxious weeds. The names of the classifications do not intuitively provide an indication of what the state expects the treatment to be.

Idaho classifies weeds into a statewide EDRR list, a statewide control list, and a statewide containment list.[115] Nevada separates the weeds into categories A, B, and C.[75] Oregon classifies weeds as A or B, either of which can also be classified as T, weeds that represent an economic threat to the state of Oregon.[134]

For Idaho the EDRR list is composed of weeds which must be reported within ten days after identification and "shall be eradicated during the same growing season as identified." Weeds on the control list are considered to already exist in Idaho, but in concentrations where control or eradication may be possible. The control methods should reduce known population within five years. Noxious weeds on the containment list are widespread enough that control efforts are "directed at reducing or eliminating new or expanding weed populations."[117]

Nevada's categories are also based to some extent on the weed distribution. Category A weeds are similar to Idaho's EDRR list in that the weeds are to be "actively eradicated wherever found," and control by the state is required in all infestations. Category B weeds have some established scattered populations and should be "actively excluded where possible." Poorly established populations and populations occurring in locations where they were previously unknown require control by the state. Category C weeds are currently established and generally widespread in many counties of the state and abatement is at the discretion of the state quarantine officer.[75]

In Oregon noxious weeds are "weeds of economic importance" and are classified as either A or B. In addition some weeds in each category are considered to "represent an economic **threat** to the state of Oregon" and should be reported "if you suspect you have found any of these weeds." All A classified weeds should also be reported if found since these weeds "occur in the state in small enough infestations to make eradication/containment possible." Noxious weeds with a B classification are regionally abundant but may have limited distribution in some counties.[98,134]

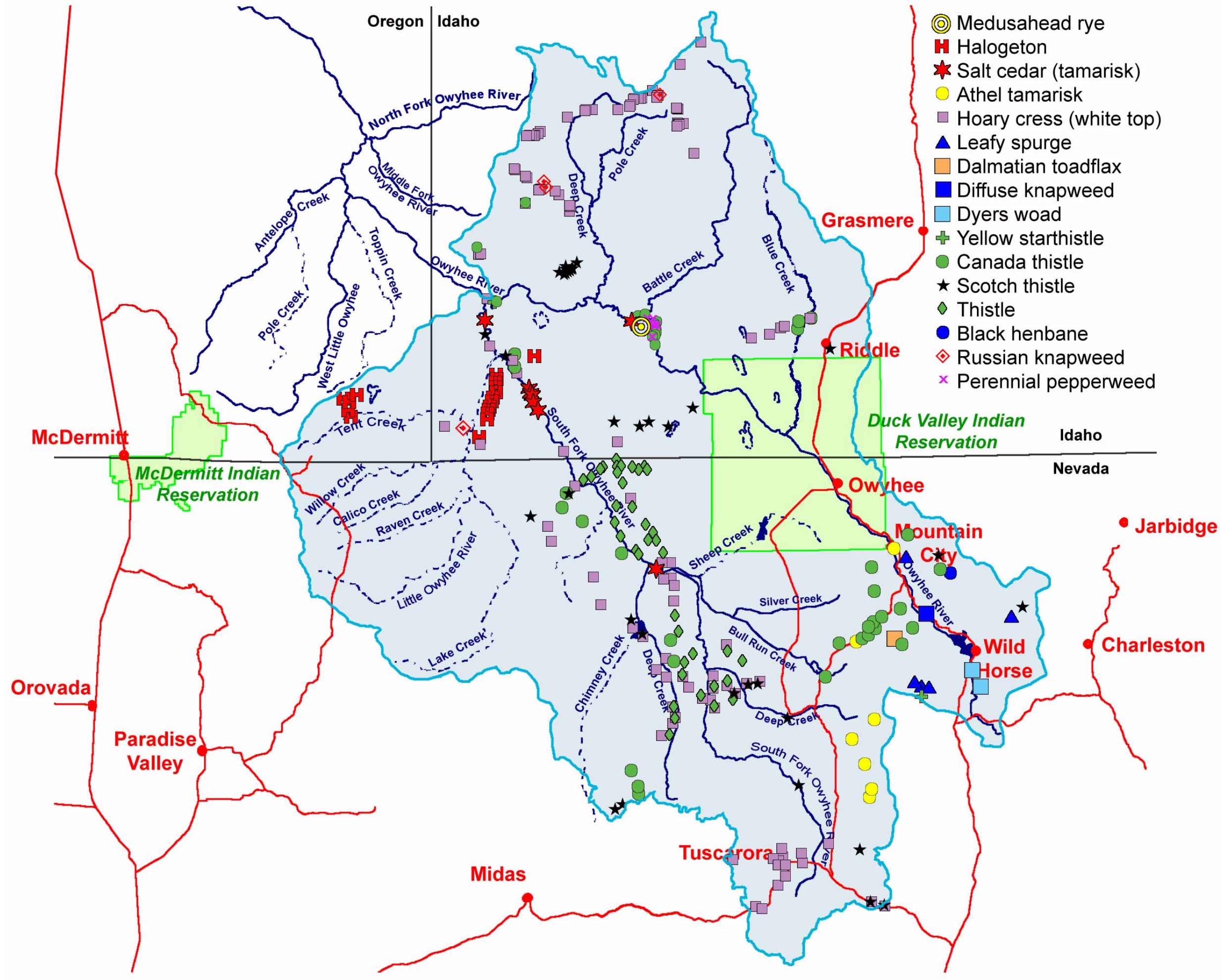


Figure 7.3. Known locations of weeds in the upper Owyhee subbasin.

### *c. Noxious weed species in the upper Owyhee subbasin*

The upper Owyhee subbasin is currently relatively free of noxious weeds compared to some of the surrounding areas. Most of the species identified as within the upper Owyhee subbasin have a very limited range. Individuals, including the authors, familiar with the region and with the species have provided information on the occurrence of a noxious weed species within the upper Owyhee subbasin. Within Elko county, the BLM has identified locations where a specific weed species has been found.[142] The Owyhee field office of the BLM provided a map of the known location of specific weed species. Other mapped occurrences of a species were taken from GPS readings of the locations where they were identified (Figure 7.3).

The potential for a noxious weed to be within the subbasin or to expand into the subbasin has been determined from a number of different sources. The state of Idaho identifies counties in which a noxious weed species occurs. Species identified as noxious weeds by the state of Idaho which are present in Owyhee County have been included in Table 7.2.[115] For species identified as noxious weeds by Nevada, their presence in Elko County as recorded by the USDA plants database has resulted in their inclusion. Within each Oregon county, the state maps where a species has been reported. Species occurring within the boundaries of the upper Owyhee subbasin in Oregon or very close to the boundary have been included in the list.[133] Table 7.2 includes noxious weeds whether they occur primarily on rangeland, in riparian areas, or in cropland or pastures.

Table 7.2. Noxious weeds known to occur in the upper Owyhee subbasin and candidate species for spread into the upper Owyhee subbasin from adjacent areas.

| Several sources were used to record the presence of a weed within the upper Owyhee subbasin | |
|---|---|
| 45 - Present on the 45 Ranch[72,73]<br>O - Presence in Owyhee County noted by mapping from the Idaho's noxious weeds list.[115]<br>N - Presence in Elko County from USDA plants database[85] | M - Presence in Malheur County from weedmapper[95]<br>P - Presence noted by individuals |

| | | Present | State classification | | |
|---|---|---|---|---|---|
| Common name | Scientific name | | OR | ID* | NV |
| Black Henbane | *Hyoscyamus niger* | O, N | | c | A |
| Buffalobur | *Solanum rostratum* | | B | c | |
| Bull thistle | *Cirsium vulgare* | 45, P | B | | |
| Canada thistle | *Cirsium arvense* | 45, O, N, P | B | d | C |
| Cheatgrass | *Bromus tectorum* | 45, P | | | |
| Dalmatian toadflax | *Linaria dalmatica* | O,N, P | B,T | d | A |
| Diffuse knapweed | *Centaurea diffusa* | O, M, P | B | d | B |
| Dyers Woad | *Isatis tinctoria* | O | B | c | A |
| Eurasian Watermilfoil | *Myriophyllum spicatum* | O | B | c | A |
| Field Bindweed | *Convolvulous arvensis* | O | B | d | |
| Field sow thistle | *Sonchus arvensis* | N | | c | A |
| Halogeton | *Halogeton glomeratus* | O, P | B | | |
| Houndstongue, gypsyflower | *Cynoglossum officinale* | N | B | d | A |
| Leafy spurge | *Euphorbia esula* | O, N, P | B,T | d | B |
| Mediterranean sage | *Salvia aethiopis* | | B | c | A |
| Medusahead rye | *Elymus caput-medusae* | M, P | B | | B |
| Musk thistle | *Carduus nutans* | O | B | c | B |
| Perennial pepperweed | *Lepidium latifolium* | O, N, P | B | d | C |
| Poison hemlock | *Conium maculatum* | O, N, P | B | d | C |
| Puncturevine | *Tribulus terrestris* | O, N | B | d | C |
| Purple loosestrife | *Lythrum salicaria* | O, M, P | B | d | A |
| Rush skeletonweed | *Chondrilla juncea* | O | B,T | d | A |
| Russian knapweed | *Acroptilon repens* | O, M, P | B | c | |
| Saltcedar, tamarisk | *Tamarix ramosissima* | O, N | B,T | d | C |
| Scotch thistle | *Onopordum acanthium* | 45, O, M, P | B | d | B |
| Spotted knapweed | *Centaurea stoebe* or *C. masculosa* | O, N, P | B,T | d | A |
| Spotted water hemlock | *Cicuta maculata* | N | | | C |
| White top, Hoary cress | *Cardaria draba* | O, N, M | B | d | C |
| Yellow starthistle | *Centaurea solstitialis* | N, P | B,T | d | A |
| Yellow toadflax | *Linaria vulgaris* | N | B | d | A |

* b. Idaho EDRR c. Idaho statewide control lists d. Idaho statewide containment list

### *d. Rangeland noxious weeds*

Although there may not be observations of specific occurrences in the upper Owyhee subbasin of the noxious weeds which are described below, all of these weeds have the potential to exist within the subbasin or to expand into the subbasin.

#### *i. Leafy spurge (Euphorbia esula)*

Leafy spurge is one of the west's worst weed species because it reduces cattle carrying capacity of infested rangelands by 50 to 75%. Once established, control of even modest-sized infestations is difficult. This weed is most common under dry conditions where competition from native plants is reduced. It is capable of invading disturbed sites, including abandoned cropland, pastures, rangeland, woodland, roadsides and waste areas.  A milky latex exists in all broken parts of the plant that can cause skin irritations in humans, cattle, and horses and may cause permanent blindness if rubbed into the eye.[53,86,111]

#### *ii. Medusahead rye (Taeniatherum caput-medusae)*

Medusahead rye has the ability to outcompete other annual grasses and generally crowd out perennial grass seedlings by extracting the majority of moisture well before perennial grasses have begun to grow.  Medusahead is almost worthless as forage for cattle, sheep or wildlife as it becomes unpalatable in late spring.  The stiff awns and hard florets can injure eyes and mouths of grazing animals.  Once land is invaded by medusahead, it becomes almost worthless, no longer supporting domestic livestock or native plants, animals, and birds.  Medusahead rye changes the temperature and moisture dynamics of the soil, greatly reducing seed germination of other species and creating fuel for wildfires  The propensity of medusahead to support frequent fire cycles makes range restoration even more difficult.[76,87,100]

Medusahead rye has invaded and completely dominated large tracts of land in the mid-Snake River region.  It can invade stands of bluebunch wheatgrass.  Expansion of medusahead rye places economically viable livestock production in peril with far reaching consequences.  Medusahead has already had a serious impact on sage grouse habitat.  It may also affect the movements of big game.[100,111]

#### *iii. Rush skeletonweed (Chondrilla juncea)*

Rush skeletonweed is an aggressive plant in both rangeland and cropland.  A deep-rooted, creeping perennial, it also reproduces by seed.  Rush skeletonweed has the capability to reduce or choke out native range species, decreasing range productivity and diversity. [51,92,111]

Rush skeletonweed has been found at sites contiguous to and intermingled with Malheur forget-me-not (*Hackelia cronquistii*), Mulford's milkvetch (*Astragalus mulfordae*), Owyhee clover (a*Trifolium owyheense*), and Malheur valley fiddleneck (*Amisinckia crinata*), all of which have been identified by the BLM as threatened or endangered.[100]  Despite efforts to eradicate or contain outbreaks, new sites are being found each year.[92]

Rush skeletonweed reaches new sites mainly by wind borne seed. However, increased occurrences at recreation sites indicate that those seeds also arrive with recreationists and their vehicles.[100] It is hard to control because of the deep taproots, and tilling it under can spread the rootstock. Rush skeletonweed does well on road sides, rangelands, grain fields, grasslands, open forest, and pastures.[111]

### *iv.* ***Halogeton (Halogeton glomeratus)***

Halogeton is poisonous to cattle and sheep. The toxic substance is found in both fresh and dry plants. Halogeton is not highly competitive in vigorous range conditions, but thrives in disturbed sites or sites limited by alkaline soils. It produces two types of seeds: one has wings to blow in the wind and can germinate within one year and the other type can lie dormant for several years. Late in its growth stage it can break off and tumble across the landscape, spreading seeds as it rolls.[84,111]

Halogeton has gained a foothold along some of the roads in the upper Owyhee subbasin. From these sites it is expanding into neighboring rangelands since much of the upper Owyhee subbasin has alkaline soils.

### *v.* ***Spotted knapweed (Centaurea maculosa)***

Spotted knapweed is one of the most dominant weed species in the western United States. It has seriously degraded millions of acres of prime range and native habitat throughout the northern Rocky Mountain states. It will form dense stands on any open ground, excluding more desirable forage species and native plants. On heavily infested range, the necessary control measures to recover the land are often more expensive than the income potential derived from grazing. It establishes on disturbed soil and is competitive for soil moisture and nutrients. A spotted knapweed plant can produce up to 1,000 seeds. Control success is hampered by seed longevity.[95,100,111]

### *vi.* ***Yellow starthistle (Centaurea solstitialis)***

Yellow starthistle is an aggressive, adaptable weed that inhibits the growth of desirable plants in pasture, rangeland, and wasteland. It will grow wherever cheatgrass grows as well as growing in canyon grasslands, rangelands, pastures, edges of cropland, roadsides, and disturbed areas. This plant may become a problem in ground where the grass stand is weak. Many large rangeland sites in the western US have become dominated by yellow starthistle. It will grow in any type of soil and intermountain environment. Yellow starthistle is toxic to horses causing “chewing disease”, equine spongiform encephalopathy, if they eat it.[97,111]

### *vii.* ***White top, hoary cress (Cardaria draba)***

Whitetop is a deep-rooted perennial that spreads by seed and vegetative root growth. It forms dense patches that can completely dominate sites, restricting the growth of other species and degrading pastures. The species is not toxic to livestock but is only grazed in the absence of more desirable species. White top had been mainly confined to riparian or seasonally wet areas for much of the time since its arrival in the area around 1930. However, white top has spread and is continuing to advance into many of the rangelands including the upper Owyhee subbasin. Whitetop spreads by seed and vegetatively under the soil and is very competitive with native vegetation on disturbed or alkaline sites. [49,96,100,111]

### *viii.* ***Dalmatian toadflax (Linaria dalmatica) and Yellow toadflax (Linaria vulgaris)***

Both Dalmatian toadflax and yellow toadflax can invade rangeland, overgrazed pastures, and roadsides. Both species are unpalatable, and although yellow toadflax may contain a poisonous glucoside, reports of livestock poisoning are rare. They reproduce by seed and horizontal rootsocks. A mature Dalmatian toadflax plant my produce as many as 500,000 seeds per year. The seeds can remain dormant in the soil for up to 10 years.[16]

### *ix.* ***Scotch thistle (Onopordum acanthium )***

Scotch thistle is a wasteland weed that generally inhabits moist sites or drainages in dry locations. Scotch thistle can be found along roadsides, waste land areas, and lower range slopes, where there is more moisture than in surrounding range. Scotch thistle also invades grasslands and sagebrush communities, especially where there is disturbed soil. If not controlled, it presses into farmland or forms dense canopies in any area overgrazed or not under intense cultivation. It is a major issue in rangeland management.[8 ,54,94,111]

### *x.* ***Diffuse knapweed (Centaurea diffusa)***

Diffuse knapweed will form dense stands on any open ground, excluding more desirable forage species. It is very competitive with native range plants, growing from taproots. It is very aggressive, and invades roadsides, waste lands, grass lands, and dry rangelands. It spreads rapidly and can quickly forms stands. Once established, the necessary extensive control measures are often more expensive than the income potential of the land. Diffuse knapweed grows under a wide range of conditions, such as those of riparian areas, sandy river shores, gravel banks, rock outcrops, rangelands, and roadsides.[82,111]

### *xi.* ***Musk thistle (Carduus nutans )***

Musk thistle is unpalatable to wildlife and livestock. Wildlife and livestock selective graze on native plants and leave musk thistle alone, giving musk thistle a competitive edge. The musk thistle spines can harm animals and hinder their movement through infested areas. Musk thistle may produce chemicals that handicap the growth of other plants. Musk thistle invades fields and pastures, especially under conditions of heavy grazing. It spreads by seeds, taking advantage of human disturbance and is also found on ditch banks, stream banks, roadsides, waste lands, and in grain fields.[88,111]

### *xii.* ***Houndstongue (Cynoglossum officinale)***

Houndstongue can be a serious problem in rangeland and pasture. The weed is highly invasive and can significantly reduce forage. The plant produces barbed seeds, or burrs, which allow the plant to readily adhere to hair, wool, and fur and can in turn reduce the value of sheep wool. In addition houndstongue contains large quantities of alkaloids which can cause liver problems in cattle and horses. Animals may survive six months or longer after they have consumed a lethal amount.[50,85,111] *xiii.* ***Russian knapweed (Acroptilon repens)***

Russian knapweed can grow aggressively, eliminating most native plants. After invading rangelands or fields, it forms dense stands, spreading by rhizomes, horizontal plant stems with shoots above and roots below the ground, or by seed. Once established, it can overrun native grasslands as well as irrigated crops. It is bitter and not palatable to livestock. Its aggressive and deep spreading root system make it very difficult to control and it is drought tolerant. [52,93,111]

*xiv.* ***Buffalobur (Solanum rostratum)***

Buffalobur is not very competitive and survives in disturbed, dry areas. A native of the Great Plains, buffalobur is drought tolerant and grows most frequently on disturbed, sandy soils. The burs may cause damage and considerable loss in wool and fiber value for sheep and goats.[79,111]

*xv.* ***Bull thistle (Cirsium vulgare)***

Bull thistle is a biennial found in waste lands, along road sides, in fields and pastures, and many other places where there is disturbed soil. It takes the place of forbs and grasses and if not controlled, presses into farmland. The seeds develop on top of the flowers, with fluffy white tops which can be picked up by the wind and spread all over, infesting more places with this noxious weed. Horses consider the flowers to be a delicacy because the heads are filled with sugary nectar.[80,111]

*xvi.* ***Canada thistle (Cirsium arvense)***

Canada thistle invades crop fields, pastures, rangeland, riparian areas, roadsides, and waste lands. Individual plants easily grow into dense, persistent thistle patches. A lack of control will result in dramatic reductions in crop production in heavily infested ground. This strong, aggressive perennial is difficult to control. New infestations can be spread from seeds, but are more often caused by redistribution of roots by tillage practices.[81,111]

***e. Riparian noxious weeds***

Although a number of the noxious weeds grow primarily in riparian areas, they can affect the health of the rangeland. A variety of range animals, both wild and domestic, may rely on the riparian area as part of their habitat.

*i.* ***Poison hemlock (Cicuta douglasii)***

Poison hemlock is a highly toxic plant and commonly infests riparian areas. It is considered to be one of the most poisonous plants in North America. It has accidentally poisoned many who have mistaken it for water-parsnip or other edible plants of the same family such as celery, parsley, and sweet anise. Several deaths of livestock and humans are attributed each year to poison hemlock. Poison hemlock can be found in marshes, wet meadows and pastures, along stream banks, and on roadsides.[90,100,111]

*ii.* ***Saltcedar, tamarisk (Tamarix ramosissima)***

Tamarisk or saltcedar is a strong perennial shrub to small tree species that is invading riparian areas in the mid Snake River region, and the upper Owyhee subbasin.

Tamarisk is known to use prolific amounts of water and dry out riparian areas. It has a habit of mining salts from the soil profile and exuding them on the surrounding soil, rendering those areas unable to support plant species that cannot tolerate saline conditions.[100,111]

Salt cedar is at or near the top of the list of noxious invasive weeds for all agencies. There is a high probability that established salt cedar will limit the ground flow of water to an extent that it may affect fish and wildlife. Tamarisk has very prolific seed production and can out compete native riparian trees and shrubs. [65,100,111]

#### *iii.* ***Perennial pepperweed (Lepidium latifolium)***

Perennial pepperweed establishes and colonizes rapidly. It degrades riparian areas and nesting habitat for wildlife. It can completely displace desirable species in natural riparian areas and hay meadows. It lowers the digestibility and protein content of hay and inhibits grazing. It can grow in a large variety of habitats but grows best along streams and in other wet areas such as ditches, roadsides, and marshes. Perennial pepperweed had been mainly confined to riparian or seasonally wet areas since its arrival about 1930. However, perennial pepperweed is appearing in some very remote seasonal streams and springs. Perennial pepperweed spreads through root fragmentation and seed.[89,100,111]

#### *iv.* ***Purple loosestrife (Lythrum salicaria)***

Purple loosestrife is a vigorous noxious weed that crowds out marsh vegetation required by wildlife for food and shelter. It can eventually destroy marshes and choke waterways. Decreased waterfowl and songbird production has been well documented in heavily infested marshes. Purple loosestrife is an escaped former ornamental species and can be found along wetlands, stream banks, or farm ponds. One plant can produce 300,000 seeds a year, as well as being able to reproduce by offshoots and cuttings.[91,111]

### ***f. Other invasive range weeds***

There are other weeds which have not been classified as noxious by the state of Oregon, Nevada, or Idaho, but which may affect the rangeland of the upper Owyhee subbasin.

#### *i.* ***Bur buttercup (Ranunculus testiculatus)***

Bur buttercup has rapidly colonized broad expanses of rangeland. Since bur buttercup begins growing early in the spring and has a short growing season, it can use most of the available moisture before many of the annual native species have emerged. It spreads into bare, denuded sites subject to erosion. Because it is comparatively shallow rooted, produces scant biomass, and has a relatively short life span, the potential for soil erosion in areas where it is dominant continues to be very high. It is toxic to sheep and can be competitive with small grain crops. Bur buttercup seed heads are irritating to hands, knees, or bare feet. The seed and seed heads also have the annoying habit of sticking to shoe laces, pants cuffs, etc. with tiny Velcro-like spines. [48,100,111]

### *ii. Moth mullein (Verbasum blattaria)*

Moth mullein is a sun-loving plant usually found on bare hillsides, in worn out fields, in closely grazed pastures, along fence rows that are not overgrown, and in other waste places. Livestock will not eat the hairy, felt-covered leaves. It cannot stand much competition, even by grass, but prospers on dry poor upland soils. Moth mullein can be invasive in pastures and rangelands affecting forage quality and quantity. It has the potential to displace native species.[19,30,111]

## 5. Cheatgrass, downy brome (*Bromus tectorum*)

Cheatgrass is considered as a desirable forage grass in many places and a valuable forage resource. It provides a substantial amount of forage for many livestock operations and some of the earliest green feed available to deer on some winter ranges.[101,122] Other rangeland scientists and ranchers consider it an undesirable exotic or noxious weed.[17,26,67]

Cheatgrass is vigorous, short lived, and widely distributed. Cheatgrass does provide forage but can form dominate stands following repeated fire events. It grows rapidly and competes with and replaces native grasses. It is a widely adapted plant and has spread throughout the upper Owyhee subbasin.[100,111]

### *a. Why it spread*

As early as 1900 uncontrolled livestock grazing had depleted and permanently altered vegetative composition of rangelands. Although an exotic species, cheatgrass was well adapted to the climate and soils in much of Idaho, Nevada, and Oregon. Cheatgrass filled the void left vacant by the reduction of native herbaceous vegetation by legacy livestock grazing.[67,101,120]

### *b. Competitive advantage*

Cheatgrass competes strongly with native grasses and planted crested wheatgrass. It not only is a prolific seed producer, but the seed is highly viable. The seed is capable of germinating in either the spring or autumn, giving it a competitive advantage over native plants. Viable cheatgrass

**Photo 7.4. Rangeland dominated by cheatgrass above Red Basin in the upper Owyhee subbasin**

seeds can survive in the soil for up to five years, enabling cheatgrass to survive periodic drought.[67,101]

Cheatgrass germinates early in the season or in the fall and overwinters. It grows rapidly following emergence. It has rapid and extensive root penetration into the soil and extensive root development. Cheatgrass has been shown to reduce the growth of seedlings of bluebunch wheatgrass and crested wheatgrass. By extending its roots during the winter, it gains control of a site before bluebunch wheatgrass seedlings become established. Cheatgrass is capable of producing twice as many roots as bluebunch wheatgrass seedlings during the first 45 days of growth. Its roots also move down into the soil faster than those of bluebunch wheatgrass.[35,36,37,67,101]

Cheatgrass has a short growth period relative to native plants. It can out compete native plants for water and nutrients in the early spring since it is actively growing when many natives are initiating growth. It matures four to six weeks earlier than bluebunch wheatgrass and utilizes the limited moisture supply prior to use by bluebunch. Cheatgrass is tolerant of grazing and increases with frequent fire.[67,101]

### *c. Fire danger*

Cheatgrass ranges burn frequently. Wildfire return intervals are now less than five years on some rangelands heavily infested with cheatgrass. The short growth period of cheatgrass relative to native plants increases the likelihood that wildfires will start and spread. Cheatgrass becomes flammable four to six weeks earlier and remains highly flammable for one to two months later than native perennials. Cheatgrass is usually dry by mid-July when perennial plants may contain 65% moisture. Standing dead cheatgrass and litter are extremely flammable resulting in shorter wildfire return intervals. As cheatgrass ranges burn frequently, the population of native plants is limited so that natural reseeding of the site doesn't occur.[17,67,101]

As fire cycles increase, cheatgrass abundance increases until the rangeland is essentially a cheatgrass range. Some federal land managers call this a "locked in" range. The name "locked in" refers to the never ending cycle of fire with more cheatgrass filling in the interspaces until perennial plants such as Wyoming sagebrush and bluebunch wheatgrass become replaced.[67] In these rangelands, each fire further reduces the native plant population with the accompanying loss of native plant seed production.

### *d. Removal of livestock*

Some cheatgrass communities have maintained a steady state that would not return to native vegetation after livestock removal. Some researchers have speculated that the removal of livestock from rangeland could increase the rate of conversion of the range to cheatgrass because of the increased fuel accumulations which would result in more frequent wildfires.[101] Livestock will eat cheatgrass, limiting fuel accumulation.

### *e. Other considerations*

Cheatgrass normally provides adequate soil cover for watershed protection. Cheatgrass litter effectively reduces raindrop energy and promotes infiltration. However in drought years and after a wildfire, this protection is reduced and the potential for erosion is increased.[101]

Forage quality and digestibility also affect cheatgrass use by livestock. The period that cheatgrass is palatable and nutritious for herbivore consumption is considerably shorter than for most native herbaceous plants. Forage quality declines as cheatgrass matures, therefore early spring to early summer grazing provides the greatest nutritional benefits to livestock.[101]

### *f. Research, solutions, and unknowns*

#### *i. Greenstrips to reduce fire danger*

Strips of fire resistant vegetation, greenstrips, can be used to manage the fuels on rangeland. These strips are designed to slow or stop wildfires. As early as 1946, Platt and Jackman proposed planting fire resistant species in strips in cheatgrass areas.[102,104]

Wildland fires burn differently depending on the type of vegetation, the amount of fuel, the proximity of fuel sources to each other, the water content, and the fuel volatility. Greenstrips slow fires by separating volatile fuels and disrupting fuel continuity, reducing the amount of accumulated burnable material, and increasing the proportion of plants with a higher moisture content. Fine fuels that readily ignite and carry fire are replaced with perennial, less flammable vegetation.[39,102]

Reports suggest that forage kochia (*Bassia prostrata*) is a very effective greenstrip species to decrease fire frequency by successfully competing with and decreasing cheatgrass density. Forage kochia has four times the moisture content of crested wheatgrass and ten times the moisture content of cheatgrass. Fires have burned up to a forage kochia greenstrip and stopped because of the green biomass and sparsity of contiguous fine fuels. When fires burn in forage kochia the flame length and intensity are both reduced, aiding fire fighting.[39,102]

There have only been a few burning trials of forage kochia and there is a lack of published data on its fire suppressant qualities. The most efficient greenstrip width, best establishment practices, and potential combinations with other greenstrip species are unknown.[39]

#### *ii. Competitive native vegetation*

There have been promising initial studies that show that squirreltail can invade both cheatgrass and medusahead stands. Is it a more promising native plant to seed in cheatgrass infested areas?[67]

#### *iii. Management to increase native vegetation*

A five-year research project is being conducted that will explore ways to improve the health of sagebrush rangelands across the Great Basin in the western United States. The purpose of the SageSTEP project is to conduct research to be able to provide land managers with improved information about sustaining and restoring sagebrush rangelands. The project is a collaboration among the USGS, Oregon State University, University of Idaho, University of Reno-Nevada, Brigham Young University,

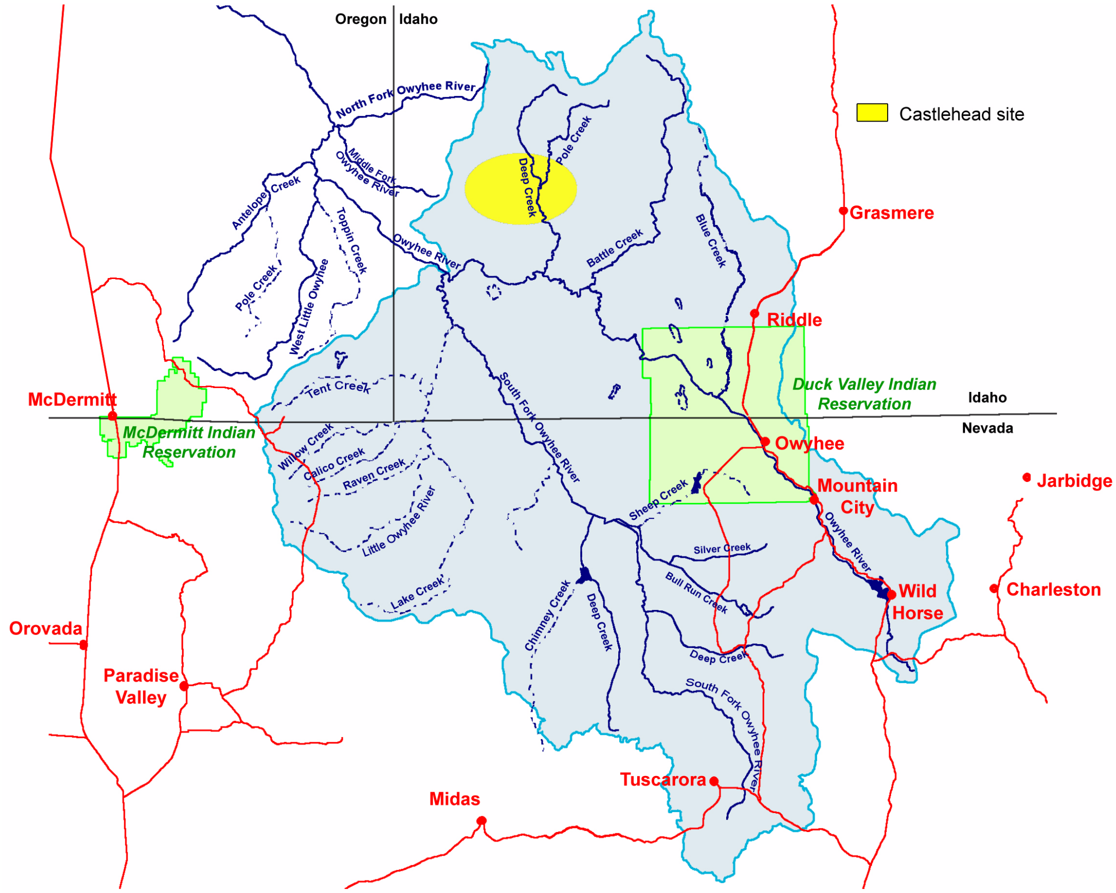


**Figure 7.4. Location of the Castlehead site of the SageSTEP project in the upper Owyhee subbasin.**[107]

US Department of Agriculture (USDA) Forest Service, USDA Agriculture Research Service, and BLM.[1,114,127]

One of the two experiments of this project is focused on sagebrush communities threatened by cheatgrass invasion. Four primary land-management treatment options will be studied including prescribed fire, mechanical thinning of shrubs and trees by mowing, herbicide applications, and a control with no management action. Some sections within the treated areas will have an additional herbicide application applied to control cheatgrass. One objective is to discover how much native perennial bunchgrass needs to be present to create a community that will be more resistant and resilient to fire and weed invasion without having to conduct expensive restoration.[1,127] One of the cooperating sites, the Castlehead Site, is within the upper Owyhee subbasin. Three 35 to 60-acre core plots will include a control and be treated mechanically and by burning. Burning will also be done on a 3200 acre plot with a 2545 acre control plot (Figure 7.4).[107]

In cheatgrass infested rangelands, could livestock grazing management practices be used strategically to improve the vigor and quantity of native perennial vegetation by reducing the competition from cheatgrass?[101]

*iv. Understanding conditions favoring and retarding cheatgrass dominance*

Dominance by cheatgrass varies depending on the elevation. At higher elevations cheatgrass performance is closely related to temperature. At lower elevations it is related to soil water.[123] Can we use these relationships to anticipate which areas are most subject to cheatgrass dominance?

The USGS has begun an investigation of factors related to cheatgrass performance including climate, sources and forms of soil nutrients, soil characteristics, underlying geology, and topologic location.[7]

## 6. Western juniper (*Juniperus occidentalis*)

### *a. Juniper expansion*

Since the settlement of Euro-Americans, juniper has been spreading throughout the Great Basin including the Owyhee uplands and the upper Owyhee subbasin (Figure 7.5). Although the data on expansion are not specific to the upper Owyhee subbasin, anecdotal information indicates that the trends documented in adjacent areas apply to the subbasin. In southwestern Owyhee County of Idaho, the area occupied by western juniper has more than doubled from what was occupied in 1860.[69] "Analysts estimate the annual encroachment rate in Owyhee County to be as high as 2500 acres/year."[145]

The invasion of juniper into sagebrush steppe communities over the last 120 years has been documented by various methods including determining the age of trees, studies of juniper pollen increases, and comparisons of aerial photographs. The expansion of juniper in southeastern Oregon began in the late 1860s and accelerated in the 1880s. In the state of Oregon the estimated area of juniper forest and savanna is over four times the acreage of 1930.[5,38,68,69,123,136]

### *b. Problems of juniper expansion*

Juniper expansion into sagebrush communities results in many negative consequences. These changes result primarily from the fact that juniper hogs water.

*i. Changes in plant community*

Juniper invasion results in major changes in the plant community composition. Increasingly abundant juniper outcompetes other native vegetation for water. Biomass production is significantly affected and there can be a serious loss of forage. The diversity of plants in the community is reduced and desirable understory vegetation can disappear. The amount of ground covered by herbaceous (non-woody) plants is diminished. The grass clumps are smaller and more widely spaced so there is an increase in bare ground. As juniper utilizes more of the water and nutrients at a site, other plants lose vigor and die.[5,69,70,136]

*ii. Wildlife*

A change in the plants growing in an area alters the wildlife habitat and impacts the wildlife species. Increasing dominance by juniper results in a decline in wildlife abundance and diversity. Much of the food for large herbivores like mule deer, pronghorn antelope, and elk disappears. Fawning habitat for deer is reduced by

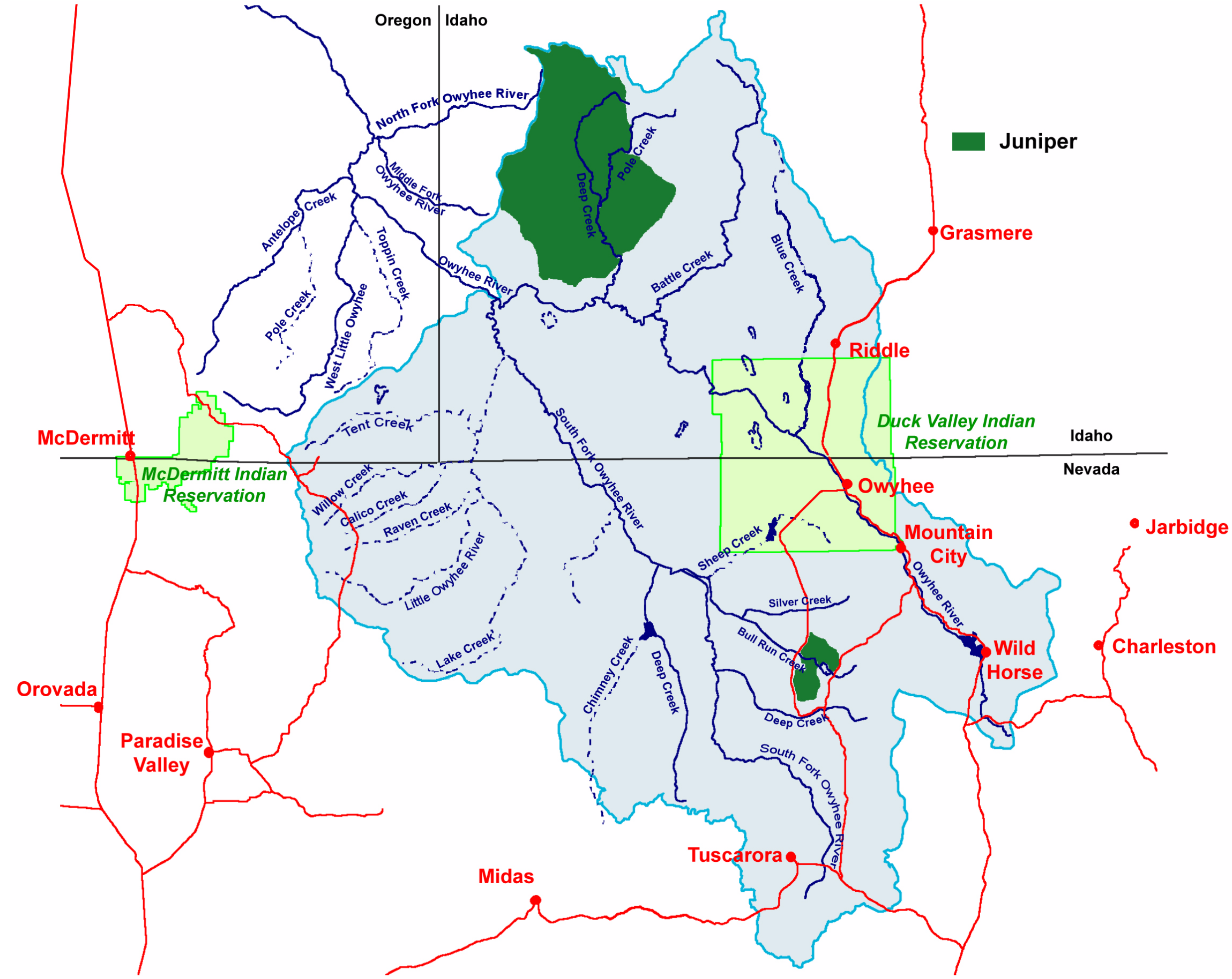


**Figure 7.5. Locations of juniper in the upper Owyhee subbasin.**[70]

replacement of big sagebrush with juniper. Some of the shrub-steppe communities which pronghorn antelope prefer in winter and spring disappear. The small mammal population is affected by both decreases in food and cover.[5,68,70,136]

With juniper encroachment, there are fewer shrub-steppe birds. How much the population of a species decreases with increasing western juniper varies. Species which require sagebrush, including the sage grouse, are very sensitive to juniper invasion into sagebrush communities. Nesting habitats for birds such as the sage grouse disappear.[5,68,70,136]

### *c. Changed hydrology*

"Juniper encroachment into shrub-grassland communities modified historical patterns on the land, and the new resident truncates the hydrologic cycle in the watershed. Juniper is a voracious water consumer, leaving less for sagebrush, grasses and forbs."[145]

Juniper roots extend over a wide area and deep into the soil, depleting water from the soil. In addition, the juniper canopy intercepts a large amount of precipitation, reducing the amount of moisture actually reaching the soil. Measurements below

**Photo 7.5. Juniper expansion into the rangeland of the upper Owyhee subbasin near Juniper Mountain**

juniper show a reduction in precipitation of 20% near the canopy edge to 75% under the canopy by the trunk.[5,68,70,136]

The structure of the changed plant community can affect infiltration rates and overland flow of water. Where plant cover has changed from more evenly dispersed to clumped plants, there is increased soil erosion. Hillsides with juniper had runoff in a thunderstorm with an intensity that occurs about every two years. Similar hillsides with no juniper only had runoff from the type of thunderstorm that occurs every 50 years. With a 50-year thunderstorm, the hillside without juniper lost no sediment, but the hillside with juniper lost 275 lb/acre of sediment. The loss of nutrients off site in sediment will ultimately change soil fertility and cause a reduction in plant community productivity.[68,69,70,103]

Juniper expansion may lead to the loss of sustained stream flow. There is ample anecdotal evidence that streams, springs, and meadows have dried due to increased juniper. Where juniper has been removed the flows have returned. Juniper expansion may be a substantial factor in the loss of stream function.[6,24,41,70,119]

An indication of the amount that juniper expansion may result in diminished stream flows is the result of changes in hydrology following juniper removal. In Eastern Oregon, two watersheds were paired and monitored for twelve years. Following this monitoring, in 2005 all juniper trees less than 140 years of age on one of the watersheds were cut. After two years, in the watershed where juniper were cut, the spring flow, groundwater, and soil moisture had all increased when compared to pre-treatment levels. There was no clear trend in the flows in ephemeral channels. The results suggested that juniper removal in the uplands can create a herbaceous groundcover across hillslopes. The resulting reduction in bare ground should decrease soil erosion.[23]

### *d. Previous range*

A characteristic of the location of older western juniper stands is that the sites where they are growing are mostly naturally shielded from fire. Old-growth juniper typically occupy rock outcrops, rocky ridges, or rimrock. Junipers grow in fractured bedrock in these spots .[15,14,69,70,121,136]

A small minority of juniper stands are ancient with trees that are 1,000 years old or older. One juniper tree growing east of Bend has been determined to be 1600 years old. Old juniper growth is a relative term. Younger juniper trees are between 80 and 130 years old and typically are an inverted cone shape. Older trees have a round-topped crown and become unsymmetrical in appearance with spreading canopies that may be sparse.[69,70,136]

About 10 percent of the existing western junipers were established before the 1870s. Stands of these older trees have long achieved a steady state. The other 90 percent of areas occupied by juniper are still in transition.[70,136]

### *e. Reasons for juniper expansion*

*i. Previous fire intervals*

Fire has been an important natural factor in the environment of southwestern Idaho and southeastern Oregon for "at least several centuries preceding white settlement."[15] Native Americans deliberately set fires to improve forage for game, maintain or increase the yield of certain wild edible plants, or increase seed production. In the 1820s Peter Skene Ogden noted abundant evidence of fires caused by Native Americans. These fires had probably been set throughout the 1700s, if not earlier, to add to the number of fires started naturally. Following a fire ignited naturally or by man, there would be a new flush of grasses and wildflowers. Young juniper would be killed.[68,136]

Young juniper is much more severely affected by fire than older trees. Just scorching of the crown and stem can kill young juniper, especially seedlings and saplings. In some recent burns nearly all the juniper less than 50 years old was killed. Prehistoric fire frequency was probably less than every 50 years. The plant species comprising sagebrush communities are a product of an environment which included relatively frequent fires and are adapted to survive periodic burning. Although big sagebrush is readily killed by fire, the stands generally regenerate quickly from

**Photo 7.6. Juniper trees on Juniper Mountain burnt by fire in 2007**

surviving plants and seed. Juniper, especially young juniper, is not adapted to survive burning. Juniper became established in areas which fires would not completely burn.[15,14,131]

In big sagebrush plant communities with Idaho fescue the fire return intervals typically ranged between 10 and 25 years. Large fires occurred about every 40 years. However, in the more arid areas with big sagebrush, fire return intervals could range up to 50 to 100 years. In Eastern Oregon large fires in sagebrush-steppe communities were preceded by at least one year with above-average precipitation. A series of wet years would allow greater quantities of fuels to accumulate that could carry fire. When fire return intervals become greater than 70 years, the probability that juniper will establish and successfully mature greatly increases.[15,69,70]

### *ii. Juniper encroachment*

Invasion of juniper and its phenomenal expansion is attributed to the reduced occurrence of fire. Fire return intervals now exceed 100 years and there has been a reduced role of fire since the 1870s with a large decline in the occurrence of fires since 1910.[15,69]

Livestock have grazed on the Owyhee Plateau since the late 1860s. When Griffiths crossed from Nevada to Ontario, Oregon in 1902, he commented that "no open-range lowland was seen on the whole trip which had much feed upon it excepting that consisting of the tough and persistent salt grass."[31] Overgrazing by domestic livestock reduced not only the supply of feed but also the supply of fine fuel available to carry fire. Fire was less effective and did not spread far. Fire suppression did not become a major factor in range management until after World War II.[5,15,68,69,70]

Overgrazing at the close of the 19th and beginning of the 20th centuries and fire suppression by state and federal agencies during the last 60 years have reduced the occurrence of fires that would have killed smaller juniper. Juniper expansion in eastern Oregon occurred at the same time fire return intervals increased.[5,15,17,24,68,69] Most of the upper Owyhee subbasin is part of the Owyhee Plateau where "A cause and effect relationship between the decline in periodic fires and the initiation and rate of juniper invasion on the Owyhee Plateau is suggested by the data."[15]

## ***f. Progression of invasion***

Overgrazing is not the direct cause of juniper invasion, but indirectly affects juniper expansion through decreasing fire frequency and intensity. Most older trees grew on ridges or rimrocks and juniper seedlings establish downslope from the old juniper. Most juniper seed is spread close to the parent plant, about 4½ feet downhill and two feet uphill. Seeds are apparently spread by small mammals as the seeds are found in the droppings of cottontail rabbits and ground squirrels. Although mule deer will eat juniper when other food is not available, this is generally after most juniper seeds have dropped to the ground. Birds also spread juniper seed. Seed buried in the soil can germinate a number of years later.[15,69,136]

Juniper seedlings establish in the protected areas under the crown of shrubs, usually big sagebrush, possibly because this is a bird perch. The density of seedlings is negatively related to bare ground and positively related to the presence of shrubs and trees. In an unusually dry year in the Owyhee uplands, 1967, 71% of seedlings survived the first year and 60% survived for two years.[5,15,56]

When juniper is first established the trees are widely scattered and the community is dominated by sagebrush and grasses. The understory of grasses and shrubs begins to decline when the trees reach 45 to 50 years old. Juniper begins to exclude other species through moisture competition and halting juniper expansion becomes more difficult. Eventually juniper outcompetes other native vegetation including smaller junipers, sagebrush, and grasses. By the time the trees are around 100 years old the juniper has become so dominant that it is unlikely that there is enough native understory community left to reestablish itself even if the trees are removed.[5,70,136]

Much of the sagebrush-steppe in the Owyhee uplands with juniper trees already growing on it is still developing into juniper stands. Juniper seedlings on these lands indicate that juniper is still in an establishment stage, and that the probability juniper on these lands will continue to increase in density is greater than for areas with a single old juniper.[5]

### *g. What to do*

Without treatment, areas of range that have been invaded will continue to decline in forage productivity due to the effect of young trees already present. The problems created by juniper invasion can not be solved by grazing manipulation alone. There is no reason to believe that competition from other vegetation will either crowd out existing juniper or prevent the establishment of new juniper plants. In the early and middle stages of development, juniper invasion can be successfully treated by various methods, particularly fire. Where native grasses, forbs, and shrubs were present in southeastern Oregon, they increased following juniper removal and there was a good chance they would regain dominance.[15,69,70,136]

The ability to predict the outcome of western juniper removal decreases when juniper becomes more dominant. Several reburns might be required to destroy all the residual seed in the soil in established juniper stands. The composition of the understory prior to juniper removal affects the chance of reestablishment of desirable species. Instead of reverting to native grasses and shrubs, the range can achieve a new steady state with invasive species such as cheatgrass or medusahead and leave the site in poorer shape than before.[17,68,69,70,136]

Chemical treatments to control western juniper have had limited success. Sites where chemical control is appropriate are limited. Prescribed fire and mechanical treatment have both been effective reducing juniper dominance of an area. The Sagebrush Steppe Treatment Evaluation Project has produced a field guide to selecting the appropriate management actions for different juniper woodlands.[71] (Available on-line at http://pubs.usgs.gov/circ/1321/). Appropriate management actions are determined by the composition of the vegetation layers, economic feasibility, and social acceptability. Where the understory vegetation is more sparse, fire will not necessarily carry well. Where fire will carry, preparation of the land for burning and predicting the r

**Photo 7.7. Adjacent plots in the upper Owyhee subbasin in the spring. The photo on the left shows the untreated area. The picture on the right shows the regrowth following juniper mastication the previous fall.**

esponse to fire are difficult. Mechanical treatments have been used successfully in many areas, frequently leaving cut trees or slash on the site.[71]

To remove encroaching junipers, the Owyhee County Sagegrouse Local Working Group partnered with the Jordan Valley Cooperative Weed Management Area and the Nature Conservancy on a mastication project on private land near Juniper Mountain within the upper Owyhee subbasin. Hayden-based Environmental Forestry used masticators to destroy juniper trees in the mud flat section of the subbasin in the fall of 2009. There was "minimal impact to the soil, sagebrush and bunchgrasses."[144] The principal goal for the local sagegrouse working group was to improve sagegrouse habitat by controlling juniper encroachment on ranch land. The site will also be monitored for forb and grass populations so that this conservation practice can be weighed against other juniper control methods.[47,143,144] The authors visited the site of the mastication project in early July, 2010. The treated area appeared to have more bunchgrasses and native forbs than the nearby untreated areas.

The current increase in juniper is aided considerably by human activity. Continued increase can affect the ecological functioning of the natural communities of juniper, sage, and bunchgrass. It's important to maintain functioning hydrological and nutrient cycles and healthy understory communities to provide habitat for sage grouse and food and shelter to a rich diversity of wildlife.

## 7. Invasive weed control

### *a. Fire*

Periodic fire has been mentioned above as a means to keep juniper from invading rangelands. However in some areas fires have become more frequent and severe. Historic overgrazing followed by vigorous fire suppression reduced the number of fires. Reduction in fires meant that sagebrush and juniper cover increased. With removal of overgrazing, fine fuels, especially cheatgrass, filled the interspaces between the shrubs allowing fires to spread. Increases in the continuous proximity of fuels allows rapid spread of fires. These fires can be very destructive to existing perennial vegetation and extremely difficult to control. Cheatgrass may become the dominate species following fire in some areas. Dominance by cheatgrass then promotes frequent burns to the detriment of existing or reestablishing shrubs and perennial grasses.[22,43,131]

Fire is an important tool in range management. Another grass which is invading areas of the upper Owyhee subbasin is medusahead rye. Although medusahead rye supports frequent fire cycles, prescribed burning has shown great success in the management of medusahead. Timing is critical. Medusahead seed maturity needs to be in the milk or soft dough stage. The fire is best set when the relative humidity is about 30% to 50% and it will burn slowly into a light breeze. A complete burn is necessary. There is no germination of medusahead seeds which are completely burnt. Uncharred seeds may still have 87% germination. Under wildfire conditions only 50% of the seed is usually destroyed.[25,100]

Controlled burns are also effective on yellow starthistle. Unfortunately the proper timing, early to mid-summer, is when the risk of escaped fires is very high. Also the seeds can survive three or more years in the soil and three consecutive years of burning are needed.[25]

Studies show that few non-target plants respond negatively to prescribed summer burning. Those that do respond negatively are generally non-native species. The most important positive impact of prescribed burning for invasive weed control is the potential increase in native perennial grasses. In general controlled burns increase the plant diversity, particularly of native plants. Most studies show that this is due to an increase in forbs. The amount of land covered by summer native legumes can increase. Although most species benefiting from burns are desirable, in some cases invasive perennials can increase following a prescribed fire.[25]

Controlled fires or wildfires have some effect on diffuse knapweed if the seeds are exposed to the direct heat from the flames of the burn. Prescribed burns don't control spotted knapweed, leafy spurge, or dalmatian toadflax regardless of the timing. Saltcedar is favored by fire. It readily resprouts from the base following fire or mechanical damage. In most cases, successful control of invasive perennial forbs involves integration of other control options.[25]

### *b. Integrated management*

Noxious rangeland weeds are highly competitive and persistent and control requires an integrated approach. Since invasive weeds know no boundaries, they can infect both public and private lands. Weed control efforts will be more successful if local public and private property managers develop coordinated management strategies. Fire, herbicides, and grazing management plans can all be part of weed control. An integral part of any control program is mapping where weeds exist.[22,25,64]

The most effective method for managing noxious weeds is to prevent their invasion into new areas. Possible methods to limit noxious weed encroachment include early detection and eradication of new weed introductions, limiting weed seed dispersal, containing neighboring weed infestations, minimizing soil disturbances, and establishing competitive species.[108,109]

Successful weed species have seed adapted to spread. Wildlife and livestock can ingest seeds which pass through unaffected and are introduced to new areas. Timing of livestock grazing on weed infested areas can minimize both the amount of seed which matures and the amount of mature seed which is carried to other areas. A vehicle driven through spotted knapweed can pick up 2000 seeds and still be carrying 10% of them 10 miles from the infestation. Flowers picked by hikers, campers, and recreationists can produce viable seed after they are discarded. Seed can stick to the coats of wildlife or livestock and to the clothing of people. [108,109]

Weed infestation can be contained to existing areas to protect neighboring uninfested rangeland. Spraying borders of infested areas may contain the weeds although it doesn't eliminate the infestation and is a long-term commitment to weed control. It also enhances the future success of eradication efforts. [108,109]

Eradication of existing weed species depends on using control techniques appropriate for the site and weed species. This includes the effectiveness of the technique, the availability of control agents including labeled uses of herbicides, the presence of grazing animals, and environmental considerations. Some control measures may need to be repeatedly applied until the weed seed bank and root reserves are exhausted. [25,109]

Herbicides with short half-lives need to be available for use whenever herbicides are part of the management program.

Reestablishment of native species can prevent reinfestation with noxious weeds. Replanting in the upper Owyhee subbasin needs to be with species that are competitive with cheatgrass and medusahead.

### *c. Weed control efforts*

Part of the upper Owyhee subbasin is within the Jordan Valley Cooperative Weed Management Area (CWMA). The Jordan Valley CWMA has brought together everyone with responsibility for weed management within the CWMA including, but not limited to, landowners, cattlemen, Owyhee and Malheur Counties and their weed departments, the Oregon and Idaho departments of agriculture, the Nature Conservancy, the local sage grouse working group, Oregon and Idaho BLMs, and the Oregon Watershed Enhancement Board. The Jordan Valley CWMA “developed common management objectives, set realistic management priorities, facilitated effective treatment methods, and coordinated efforts along logical geographic boundaries with similar land types, use patterns, and problem species. The CWMA has also provided educational opportunities to the general public as well as to local landowners raising their awareness of the problems associated with noxious and invasive weeds.”[12,99]

In addition to involvement in cooperative spray projects for selected weeds, the Jordan Valley CWMA has been involved with the release of biocontrol agents. Educational efforts have not only included monthly meetings but also the publication of information sheets on specific weeds and their control. Annual weed seminars have provided education about the problems associated with noxious and invasive weeds and treatment options for different weed species. Funding continues to be a hurdle to accomplishing the goals of the CWMA.[12,47]

Although the Elko County CWMA in Nevada focuses primarily on the Ruby Mountains to the south of the upper Owyhee subbasin, they have held an annual Elko Weed Summit to supply information to all residents of Elko County about noxious and invasive weeds, particularly on public lands. Ranchers have also been introduced to the idea of using ruminants to control weeds.[74]

The Elko County CWMA also was a sponsor of an extension manual for weed control in NE Nevada that contains guidelines for 24 invasive weeds and seven “nuisance” weeds. For each species, the weed is pictured and identified with distinguishing characteristics. Methods to control the weed are listed, along with the rates of chemicals to use when chemical control is indicated. In May of 2011, the guide was available on the Internet at http://www.unce.unr.edu/publications/files/ho/2005/eb0502.pdf.[64]

### *d. Special considerations*

Rush skeletonweed is hard to control with herbicides because of the deep taproots and spreading roots, and tilling it under can spread the rootstock.

Whitetop spreads by seed and vegetatively under the soil and is very competitive with native vegetation on disturbed or alkaline sites. It has also been found that one time tilling of the soil will spread this noxious weed, and that it takes 3 consecutive years of tilling to destroy the root system.

Russian knapweed can be successfully controlled with combinations of grazing and herbicides but control programs must persist for several years.[93]

Special species of fruit fly (*Urophora affinis* and *U. quadrimaculatus*) have been introduced as a partial biological control of spotted and diffuse knapweed. Larvae within galls on knapweed seedheads eat the developing seeds, leaving only 5-20 seeds instead of 30.[27]

The leafy spurge flea beetles (*Aphona czwalinae*, *A. lacertosa*, and *A. nigriscutis*) are a promising biocontrol for leafy spurge. Trials have shown that the flea beetles dramatically reduced the cover and expansion of leafy spurge. However, there is some indication that species richness of treated areas declined.[20,55]

Expanded biological weed control efforts are warranted.

## E. Fire suppression

Prescribed burns in the spring when the vegetation is still moist may be part of the management system of an area. However, wildfires when the vegetation in tinder dry are a different matter.

Fire is a natural component of many ecosystems. However, the invasion of cheatgrass has been fueling larger, more frequent fires. The more dense and continuous source of fuel extends the fire season and increases the frequency of fires. These fires may diminish or eliminate many of the native plant species. Cheatgrass also out-competes many of the native forb and grass species that are part of the ecosystems. The BLM actively fights most wildfires on BLM land.[105]

In 2005 and 2006, wildfires burnt significant areas of rangeland in the Nevada section of the upper Owyhee subbasin (Figures 7.6 and 7.7). In 2007, a wildfire on Juniper Mountain burnt an area in the Idaho section of the subbasin (Figure 7.8) . Figure 7.9 shows the areas of the upper Owyhee subbasin burnt by wildfires between 2001 and 2007. There were no significant fires in the subbasin in 2008 or 2009.

Following a fire on BLM land, cattle are removed from that section of range for at least two grazing seasons to allow the area to recuperate.[11] The primary goal of rehabilitation for a burned area is to protect the burned area from erosion and halt the spread of invasive species by developing a stable plant community. If a burned area will recover naturally, no reseeding is done. If it will not naturally recover, the burned area may be reseeded. Reseeding may be done with either native or non-native plants. An executive order of President Clinton directed that native forbs and grasses be used wherever possible.[45,105]

Restoration differs from rehabilitation. Restoration is the use of a mixture of only native species to obtain a plant community that is similar in appearance and function to the vegetation prior to European settlement. Restoration is designed to develop ecosystems such that they are self-sustaining. One challenge is to figure out whether these area were naturally dominated by sagebrush, grasslands, or both. Total

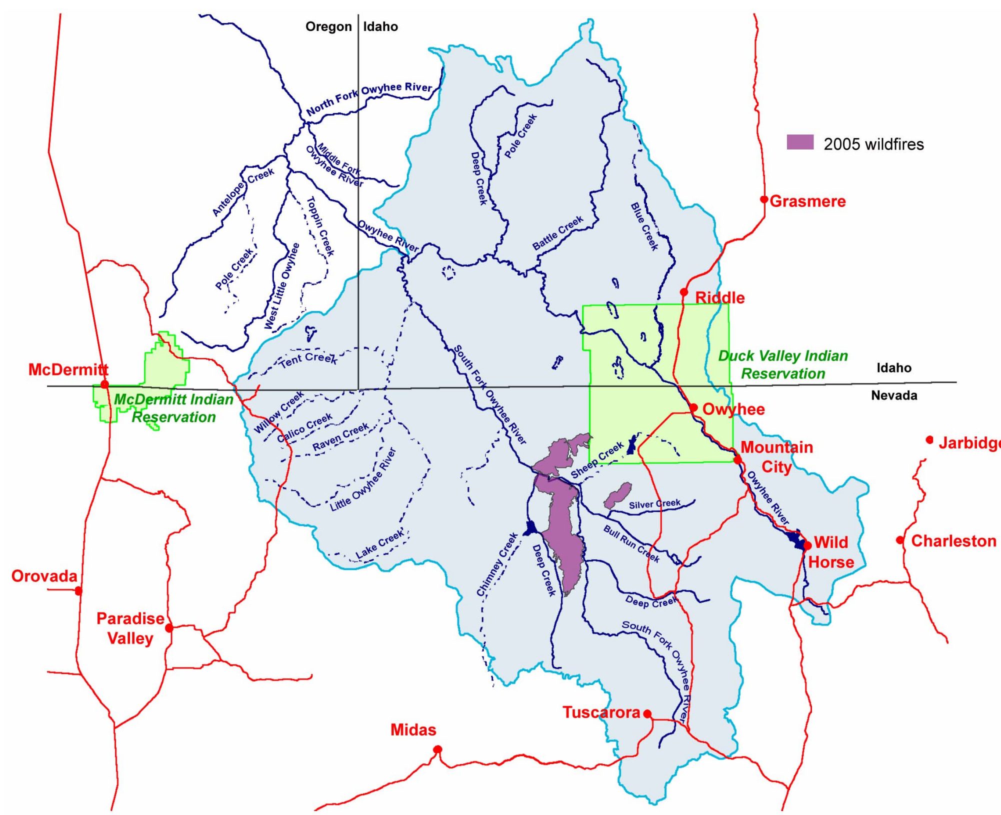

Figure 7.6. 2005 wildfires in the upper Owyhee subbasin.

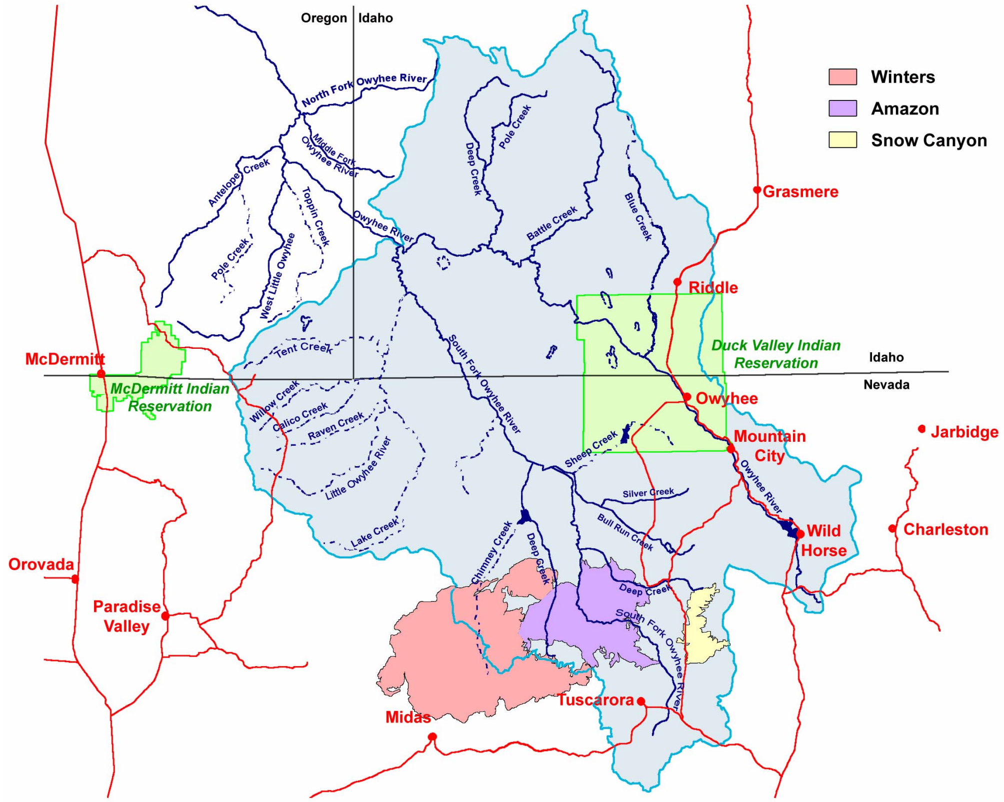


Figure 7.7. 2006 wildfires in the upper Owyhee subbasin.[Appendix A]

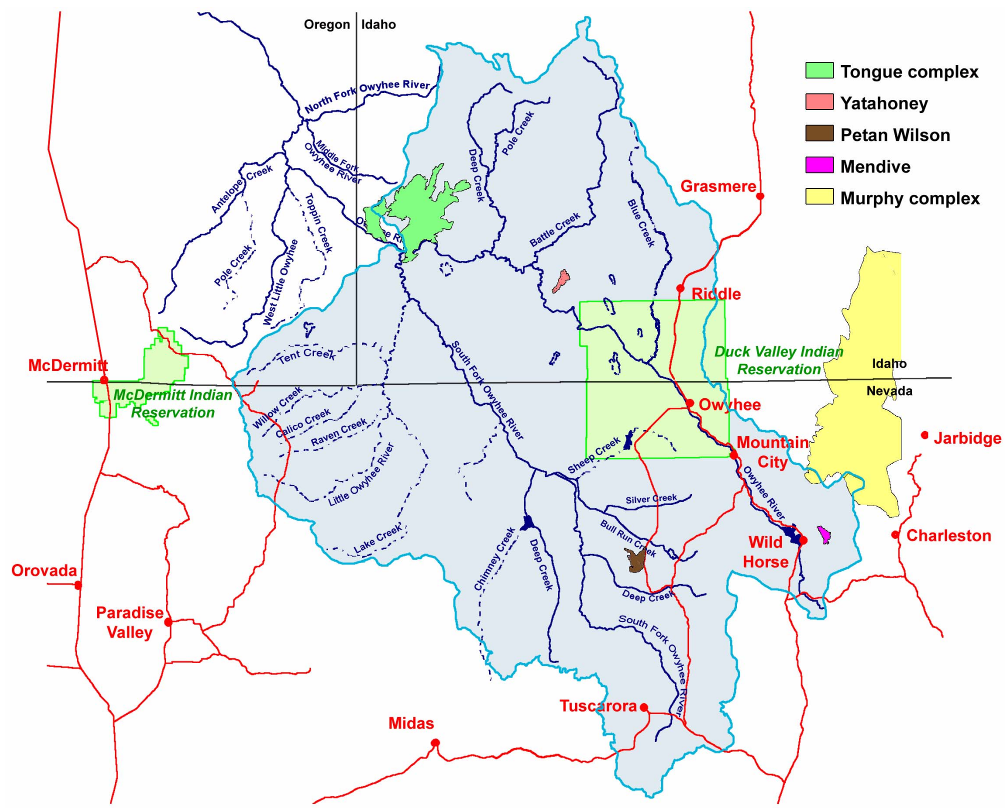


Figure 7.8. 2007 wild fires in the upper Owyhee subbasin.[Appendix A]

of a burned area is outside the scope of most fire rehabilitation programs.[45,105]

Following fire, non-native species tend to invade many burned areas. In the past many burned areas have been reseeded largely with grass species. Although native forbs are components of most native communities, their use in revegetation has been limited, largely due to inadequate seed supplies. The availability of native forb and grass species is developing. The Great Basin Native Plant Selection and Increase Project is a multi-state, multi-agency collaborative research project. The goal is not only to increase the availability of native plant materials for restoring Great Basin rangelands, but to both develop the seed technology and cultural practices to produce native seed and the practices necessary to improve the establishment of native seedings.[112,124]

## F. Wilderness study areas

Within BLM managed land, there are a number of wilderness study areas (WSAs). No new WSAs are being designated, but existing WSAs remain WSAs until Congress makes a decision to designate the area as wilderness or to release the area for non-wilderness uses. Wilderness study areas in the upper Owyhee subbasin are shown on Figure 2.9 in the background section of this assessment.

According to the BLM web site, management of wilderness study areas is less restrictive than management of wilderness areas. "For example off-highway vehicles may drive on designated routes in WSAs and WSAs are open to location of new mining claims. Both activities are prohibited in wilderness."[13] Similar to wilderness areas, in WSAs outdoor recreation is allowed, including hunting, fishing, hiking, horseback riding,

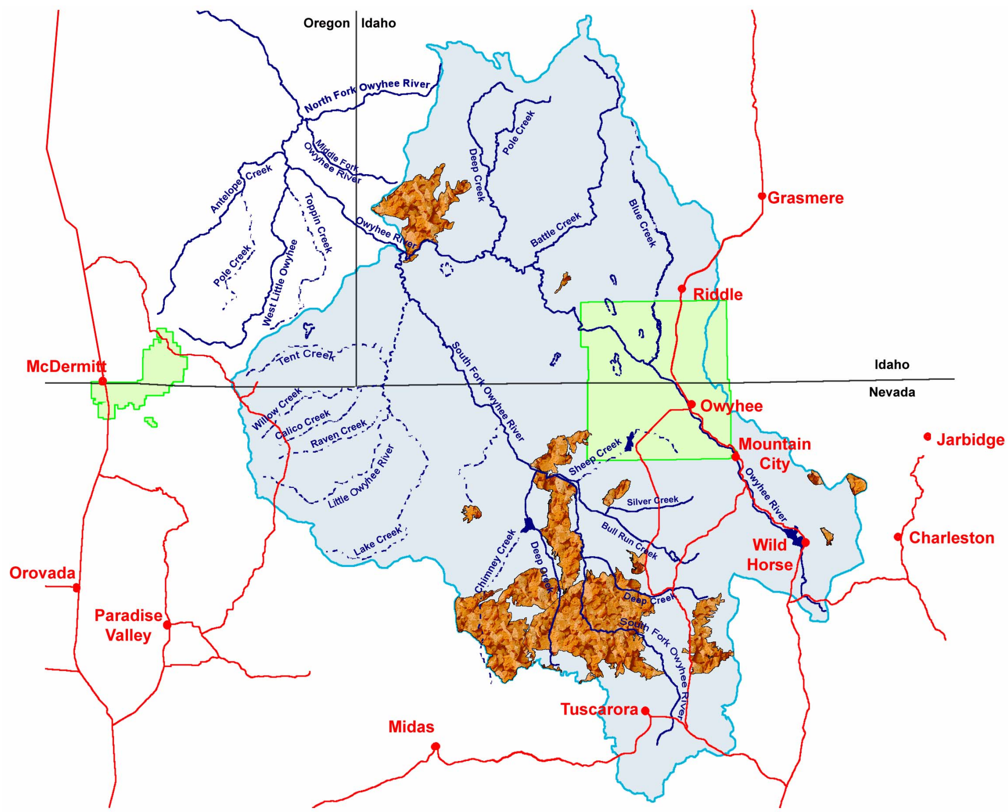


Figure 7.9. Areas of the upper Owyhee subbasin burnt by wildfires between 2001 and 2007.[Appendix A]

and camping. Although livestock grazing is permitted by law, some BLM districts interpret their mandate to manage WSAs to retain their wilderness character by restricting livestock grazing. If an area has previously been grazed and becomes wilderness, then the grazing may continue. There is no similar mandate that grazing continue to be permitted in a WSA.[13,4] However, the "majority of WSAs are grazed by domestic livestock. Livestock grazing may continue in the same manner and degree as it took place in 1976. Developments such as fences, wells, and pipelines may be maintained. New livestock facilities may be constructed if they are temporary, or they benefit overall management of wilderness values. Vehicles may be used on designated routes to support grazing management."[13]

## G. Use of the upper Owyhee subbasin rangeland

The majority of the rangeland in the upper Owyhee subbasin is used for grazing.

> "Ranchers in the Owyhee Uplands effectively manage their land, adeptly handling the arid landscape that hosts their family business. Operating a ranch requires financial capital, and the economic values depend on the composition of the range vegetation rooted in soil - the underlying natural capital. Driving from Jordan Valley, Oregon towards Juniper Mountain in Idaho, the visitor can view a mix of vegetation that survives on a meager 13 inches of annual precipitation. Every good manager recognizes constraints on production. The soil moisture limits productivity, and is a production cap faced by the range manager. . . The changing vegetation and soil moisture [from juniper expansion] further constrain range production for the rancher."[145]

BLM lands (Figure 2.8) are managed by the Elko field office of the BLM in Nevada, the Owyhee and Bruneau field offices of the BLM in Idaho, and the Vale field office of the BLM in Oregon. The agency has regulations, revised in 1995, for administering livestock grazing. Ranchers may "lease" portions of the public rangeland for grazing. These leased areas, called allotments, are grazed under a management plan which may include the season, the amount of time the grazing may occur, the number and kind of livestock permitted, and the distribution of the livestock over the landscape achieved by herding, water development, salting, fencing, or other methods. A management plan is developed for each allotment in coordination with the permittee.[146,147]

Permittees pay a fee based on the number and type of livestock they graze. "Grazing permittees purchase Animal Unit Months (AUMs) of livestock forage. An AUM is the amount of forage needed to sustain one cow and calf, five sheep, two burros, or one horse for one month."[147]

## H. Discussion

The native vegetation of the upper Owyhee subbasin was greatly changed at the end of the 19th and beginning of the 20th centuries. We have descriptions of what the area was like at the time of Euro-American settlement, but we don't really know the composition of the native species. Following the abusive livestock grazing which ended between the passage of the Taylor Grazing Act of 1934 and World War II, the rangeland has improved. Vegetation cover of the landscape has increased. The ecoregion is recovering. However the plant communities undoubtedly remain altered. There has been a public shift in the perception of the role of range. The idea of maintaining a sustainable long-term output of livestock products has been replaced by one of continuing to produce livestock products while maintaining ecological functions and multiple uses.

Wildlife, as well as livestock, is endangered by a perception that water which is currently stored in stock ponds could instead increase the flows into the river.

Current knowledge should provide for continued improvement in ecological conditions. Throughout the Great Basin ecoregion, the reintroduction of fire as a management tool is having a very positive effect in reducing the amount of late successional sagebrush and invasive juniper dominance that has occurred with past fire suppression practices. Livestock management for riparian zone enhancement is in its infancy, but where practiced significant positive results are occurring. However, any management activities on public land require an extensive paper trail and public scrutiny before implementation.[121]

## I. Conclusions

The use of the important resources of the rangelands of the upper Owyhee subbasin affects all of us. Therefore, proper use and management is vitally important.

> "Thou shalt inherit the holy earth as a faithful steward, conserving its resources and productivity from generation to generation. Thou shalt safeguard thy fields from soil erosion, thy living waters from drying up, thy forests from desolation, and protect thy hills from overgrazing by thy herds, that thy descendants may have abundance forever. If any shall fail in this stewardship of the land thy fruitful fields shall become sterile stony ground and wasting gullies, and thy descendants shall decrease and live in poverty or perish from off the face of the earth". - W.C. Lowdermilk [62]

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# Upper Owyhee Watershed Assessment

## VIII. Water quality



### Contents



The Oregon governor's strategic initiative for ensuring sustainable water resources for Oregon's future, Headwaters 2 Ocean, considers all water resources from the hilltops to the Pacific Ocean. The completion of the assessment of the upper Owyhee subbasin is consistent with the governor's initiative. The upper Owyhee subbasin contains the headwaters of the Owyhee River and two of its principal tributaries, the South Fork Owyhee River and the Little Owyhee River.

# VIII. Water quality

## A. Introduction

The water in the upper Owyhee subbasin is a valuable resource. Not only does it provide natural beauty, both within and downstream from the upper Owyhee subbasin, but the water supports farming, ranching, recreation, drinking water, wildlife, and aquatic life. We all want to maintain the quality of our water so that it can continue to meet human and habitat needs.

In examining the water quality of the rivers in the upper Owyhee subbasin, it is necessary to distinguish between naturally existing conditions and conditions caused by human activities (anthropogenic causes). A distinction also needs to be made between legacy use of the landscape and current use. Naturally existing conditions are not open to remediation.

## B. Regulatory background

The Federal Water Pollution Control Act (PL92-500, commonly known as the Clean Water Act) requires each state to develop a program to monitor and report of the status of its water quality. The 305(b) process evaluates the quality of all of the waters of the state. The 303(d) process identifies impaired waters. These are waters that the state classifies as too polluted or otherwise degraded to meet the water quality standards set by the states. A state develops Total Maximum Daily Loads (TMDLs) for these waters. A TMDL is a state's calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards.[8,9,10,33]

The national Clean Water Act (CWA) defined two principal goals: 1) to restore and maintain the chemical, physical, and biological integrity of the nation's waters and 2) where ***attainable***, to achieve water quality that promotes protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water. This goal is commonly known as "fishable/swimmable." "Federal regulations are not intended to result in standards that are so stringent that compliance would cause severe economic impacts."[11]

Under the legislation, the states are responsible for developing water quality standards to implement the goals of the CWA. The policies are supposed to protect, maintain, and conserve existing uses of the water. The water quality necessary to protect these existing uses needs to be maintained. This policy is known as the "antidegradation" policy.[19] It was developed "so that it minimizes adverse effects on economic growth and development and at the same time protects CWA goals."[11]

States are also responsible for establishing designated beneficial uses of a waterbody. In a way these uses are provisional, they are an initial guess as to how the waterbody can be used in addition to existing uses. This is obvious from the fact that the CWA clearly states that "Designated uses, on the other hand, may be changed upon finding that the use cannot be attained."[11]

The designated use can be modified if attainment is not possible because of one or more of the following factors: 1) naturally occurring pollutant concentrations; 2) natural, intermittent or low-flow water levels; 3) anthropogenic conditions or sources of pollution that cannot be corrected; 4) dams, diversions, or other hydrologic modifications; 5) physical conditions associated with the natural features of the waterbody, unrelated to quality; 6) more stringent controls would result in substantial and widespread economic and social impact.[11]

In the past each state submitted two documents to the EPA: a list of impaired waters in the state (303(d)) and a report summarizing the status of all the waters of a state (305(b)). Now the two documents are combined into one document called an Integrated Report.

## C. Naturally occurring conditions

The upper Owyhee subbasin is an extensive tract of land with extremely low population density. Developing information about the naturally occurring conditions relies on more limited information than is available in more densely populated areas.

### 1. Vegetation along water courses

#### *a. Historical*

Revisiting the descriptions in the historical section, the earliest Euro-Americans in the area noted a lack of any trees away from the Bull Run and Independence Mountains (see the "at contact" section of the history component of this assessment), even along the waterways.

If the banks of the rivers and streams did not have trees growing on them, what did they have? Ogden's statement "excepting a few willow on the banks of the river"[35] gives us some idea. Willows are mentioned when vegetation along the banks is discussed. Most of Ogden's references to willows indicated that in general they were sparse. "When we reach[ed] . . . a fork of [upper] Owyhee River but from all appearances destitute of beaver. . . also wood there being but a few willows and thinly scattered."[35] Traveling one day east of the Owyhee on the Snake River, Ogden records that "wormwood [sagebrush] is more abundant but wood of any other kind equally scarce with the exception of a few scattered willow on the banks of the river, and even these not in abundance."[35]

Ogden stated "If this was a country of wood we might soon make a canoe . . . but we cannot even find willow to make a raft still less scarcely a sufficiency to cook our victuals."[63] He reiterated this in another entry. "The country [is] level, soil sandy, no wood to be seen excepting a few willow on the banks of the river and not even in abundance."[63] The next day they "encamped on a small river destitute of wood" and the following day "In hopes of finding grass we continued on till near night, but in vain, and encamped without wood, food for ourselves, and no grass."[63]

The willow which the trappers mention is not a tree but coyote willow. It is an upright, deciduous shrub which may grow to 23 feet but is generally about 12 feet tall and about 15 feet wide. It grows in sagebrush country along creek bottoms, both on the shoreline and sometimes in the water. Willows form dense thickets of pure, even-aged shrubs. Short-lived, they are one of the most shade intolerant native species and are threatened by both fire and drought. They can not survive long if the water table becomes too low.[5,6]

Coyote willows along a waterway would provide limited shade, however the historical observations indicate that they were only found in some areas. They also would disappear in times of drought and would probably not be found along most sections of intermittent streams and never in draws identified as ephemeral streams.

### *b. Flooding*

High flows in the spring would send a river out of its banks. It could be a mile wide in some places when the water was high and cover vegetation not normally under water.[2] The high flows could carry ice and rocks and scour vegetation along the banks.[27]

## 2. Stream temperature

### *a. Stream flow*

There are tremendous natural variations in water flow in the Owyhee River and tributaries. These variations cause scouring of the banks and have been characterized by both flooding and diminution of the water flow to almost a trickle.

### *b. Climate*

The discussion in the background section characterizes the air temperatures in the upper Owyhee subbasin (see the climate section of the background component of this assessment).

The expectation from both the temperatures of the air above and the soil below the stream courses increasing during the summer months is that the stream temperature would be somewhere between the maximum and minimum temperatures.

### *c. Topography*

The lower reaches of the upper Owyhee River, of the South Fork Owyhee River, and of their tributaries frequently have cut and run through deep canyons. These canyons are generally 50 feet to 1300 feet below the level of the plateau.[44] Where there are sheer rock walls, they are frequently 600 to 1200 feet tall. Thus, in many places, the canyon itself provides shading for the river during part of the day.

## 3. Geological

Minerals which occur naturally in rocks can slowly leach and end up in river waters to be moved in solution. The minerals can also be carried in the rocks and sediment moved by the water.

### *a. Mercury*

"While mercury most frequently occurs as deposits in rock fractures and veins, it may also be found in low concentrations in other geological formations. Considering the entire Owyhee River watershed, mercury is commonly found as an anomaly, present in 12 of 23 random outcrop rock-chip samples."[2]

### *b. Arsenic*

Arsenic is naturally associated with volcanic activity and the hydrothermal activity following volcanism. In the upper Owyhee subbasin, the principle source of arsenic in surface water and groundwater is volcanism and the subsequent hydrothermal activity that has deposited arsenic in the rocks and soil.

## D. Legacy anthropogenic conditions

### 1. Mercury

Except for iron and platinum, all metals dissolve in mercury and chemists refer to the resulting mercury mixtures as amalgams. In the late 1800s into the early 1900s, gold miners in the upper Owyhee subbasin used mercury for processing much of the gold ore. The gold-bearing rock was crushed and treated with mercury to dissolve the gold out of the ore and form a gold amalgam. The amalgam of gold and mercury was then heated to separate the gold from the mercury by a process of distillation.[60] Silver ore can be recovered in a similar fashion. Precious metal separation by boiling off mercury works because the boiling point of mercury is 357°C but the boiling point of gold is 2808°C and silver is 2210°C. The volatilized (gaseous) mercury would be condensed and reused. "Due to inefficiencies and poor handling practices, large amounts of mercury vapor and liquid often escaped into the environment."[60]

The result of using a mercury amalgam process to recover gold and silver was elevated mercury levels "in steams located near the processing sites."[60]

### 2. Copper

The Rio Tinto Copper Mine near Mountain City processed copper-sulfide ore. The processing and reprocessing of the ore had the potential of introducing pollutants into environment.

## E. The upper Owyhee subbasin constituents

The area considered as the upper Owyhee subbasin for this assessment consists of the drainages of three rivers, the South Fork Owyhee River, the East Fork Owyhee River (or just Owyhee River), and the Little Owyhee River. The drainage of each of these rivers, respectively, defines the boundaries of a fourth-order HUC: the South Fork Owyhee HUC (17050105), the East Little Owyhee HUC (17050106), and the Upper Owyhee HUC (17050104) (Figure 2.2). For a discussion of 303(d) lists and Total Maximum Daily Loads (TMDLs) it is frequently convenient to refer either to a HUC or to a state or to the portion of a HUC within a state.

## F. 303(d) listings

CWA Section 303(d) requires the identification of waters that do not meet water quality standards where a Total Maximum Daily Load needs to be developed. Each state develops a 303(d) impaired waters list of all waters that the state has identified where "required pollution controls are not sufficient to attain or maintain applicable water quality standards. . . Once states submit their 303(d) list to EPA, EPA then has 30 days to approve or disapprove the 303(d) lists. If EPA disapproves a state list, EPA has 30 days to develop a new list for the state; although historically, EPA has rarely established an entire list for a state. Sometimes EPA partially disapproves a list because of omission and adds waters to the state's list."[7] Table 8.1 includes only 303(d) streams in the upper Owyhee subbasin, not other 303(d) water bodies. The EPA 303(d) identified streams are those listed on the EPA website for each of the fourth order HUCs as of September 2010 (Table 8.1).[13,14,15,40]

In Nevada, the EPA has approved the listing of all or part of the South Fork Owyhee River, Jack Creek, Jerritt Canyon Creek, and Snow Canyon Creek in the South Fork Owyhee HUC. In the Upper Owyhee HUC, Owyhee River, Mill Creek, Badger Creek and Tomasina Gulch are listed. In Idaho, the South Fork Owyhee River is listed for the South Fork Owyhee HUC. Battle Creek, Beaver Creek, Camel Creek and Nickel Creek are listed in the Upper Owyhee HUC. Idaho DEQ also has recommended water bodies to include on the next 303(d) list and these are included in Table 8.1. There are no water bodies listed in the East Little Owyhee HUC. Although no Oregon section of the upper Owyhee subbasin is 303(d) listed, Oregon has included the Owyhee River starting at the Idaho - Oregon border on its 303(d) list (Figure 8.1).[13,14,15,20,27] The initial inclusion of a waterbody on a 303(d) list includes the pollutant of concern.

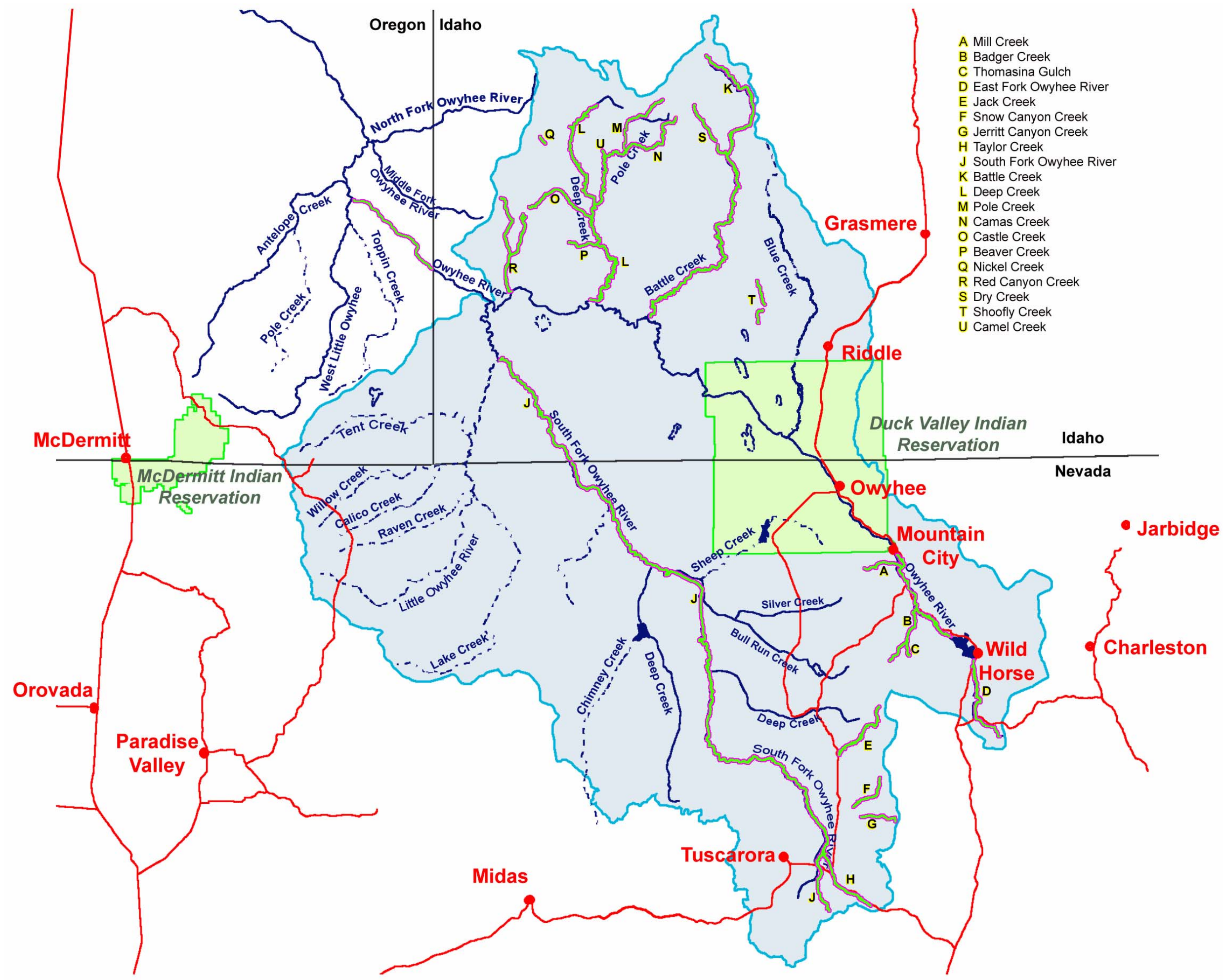

Figure 8.1. Streams in the upper Owyhee subbasin listed as 303(d) as of December 2010.

Table 8.1. Streams in the upper Owyhee subbasin listed on EPA and State 303(d) lists and existing TMDLs or regulations.[13,14,15,20,27]

| Subbasin (4th order HUC)<br>Stream name | State | EPA 303(d) listed | State 303(d) listed | State TMDL |
|---|---|---|---|---|
| South Fork Owyhee | | | | |
| South Fork Owyhee River from its origin to the Nevada-Idaho state line | Nev | X | | X |
| Jack Creek from its origin to its confluence with Harrington Creek | Nev | X | | |
| Jerritt Canyon Creek from its origin to the national forest boundary | Nev | X | | |
| Snow Canyon Creek from its origin to the national forest boundary | Nev | X | | |
| South Fork Owyhee River Nevada-Idaho border to confluence with the East Owyhee | Id | | X | X |
| Taylor Canyon Creek from its origin to its confluence with the South Fork of the Owyhee River | Nev | | | X |
| Upper Owyhee | | | | |
| Owyhee River from Wildhorse Reservoir to its confluence with Mill Creek | Nev | X | | X |
| Owyhee River from its confluence with Mill Creek to the border of the Duck Valley Indian Reservation | Nev | X | | X |
| Mill Creek from the Rio Tinto Mine to the Owyhee River | Nev | X | | X |
| Badger Creek from its origin to the Owyhee River | Nev | X | | |
| Tomasina Gulch from its origin to Badger Creek | Nev | X | | |
| Battle Creek from its headwaters to its confluence with Owyhee River | Id | X | | |
| Beaver Creek | Id | X | | |
| Camel Creek | Id | X | | |
| Nickel Creek from its headwaters to Mud Flat Road | Id | X | | X |
| Deep Creek From Mud Flat Road to its confluence with the Owyhee River | Id | | X | X |
| Castle Creek from its headwaters to its confluence with Deep Creek | Id | | X | X |
| Pole Creek from its headwaters to its confluence with Deep Creek | Id | | X | X |
| Red Canyon Creek from its headwaters to its confluence with Owyhee River | Id | | X | |
| Dry Creek | Id | | X | |
| Camas Creek | Id | | X | |
| Shoofly Creek from its headwaters to its confluence with Blue Creek | Id | | X | |
| Subbasin (4th order HUC)<br>Stream name | State | EPA 303(d) listed | State 303(d) listed | State TMDL |

The EPA is in the process of collecting TMDL information from the states. Since these efforts are ongoing, the table above only shows that a state has developed a TMDL, not whether or not it has been approved. If a TMDL has been developed, that waterbody may no longer be included in the 303(d) list. A state may also have a 303(d) list which has not been approved by the EPA. In Nevada administrative regulations rather than a TMDL set standards for the South Fork Owyhee River.[27,34,40]

Although Oregon does not have any 303(d) listed waterbodies in the upper Owyhee subbasin, the Owyhee River at the border with Idaho is on the 2006 EPA 303(d) list.

The Idaho Soil Conservation Commission (ISCC) and Idaho Association of Soil Conservation Districts (IASCD) point out in the Upper Owyhee Watershed TMDL implementation plan for agriculture that the East Fork of the Owyhee River itself is not 303(d) listed. “This indicates that the tributaries to the river are not negatively impacting the water quality in the East Fork of the Owyhee River.” The ISCC and IASCD assessment also points out that “other 303(d) stream segments are dry throughout most of the year with the exception of spring runoff during parts of May and June.”[57]

## G. Total maximum daily loads

The Clean Water Act mandates a water-quality based control program. Water quality standards define the goals for a waterbody by designating its uses and setting criteria to protect those uses. After a waterbody has been identified on the 303(d) listing as not meeting water quality standards, a Total Maximum Daily Load (TMDL) is developed. In the development of a TMDL the current condition of a waterbody is evaluated and, if needed, the amount of pollutant a water body can receive and still meet water quality standards is calculated. The TMDL attempts to assign part of the responsibility for improving the condition of the waters to each of the different contributing factors. Pollutants can either be attributed to a specific discharge into the water or they can be from nonpoint sources, sources with no one origin that can be pinpointed.[12,16,33,40]

Within a TMDL, the state either determines the most beneficial designated use of a particular water body or uses already established beneficial uses. After designating a waterbody's uses, water quality standards define goals for the waterbody, set criteria to protect those uses, and establish provisions to protect water quality from pollutants. To develop criteria protective of water quality, states are required to examine the effects of specific pollutants on plankton, fish, shellfish, wildlife, plants and recreational activities and determine the levels of pollutants that can exist without harming human and aquatic life.[12,16,24] When developing a TMDL for a waterbody, a state may not only establish limits for the pollutant initially identified when the waterbody was designated as 303(d) but may also set limits for other potential pollutants.

### 1. Existing TMDLs

The state of Nevada has written one TMDL for waterbodies in the upper Owyhee subbasin. The document presents the problems resulting in degraded water quality in the East Fork Owyhee River and Mill Creek and establishes amounts of pollutants those waterbodies can receive and still meet water quality standards. The TMDLs for those streams are detailed in Appendix F. In addition, standards set by proposed regulations of the State Environment Commission for the South Fork Owyhee River are included in the appendix. The remaining 303(d) listed streams in the upper Owyhee subbasin in

Nevada have the lowest priority on Nevada's prioritized list for developing TMDLs.[,22,31,32,34]

The Idaho Department of Environmental Quality (DEQ) has conducted assessments and developed TMDLs for the Upper Owyhee Watershed subbasin and the South Fork Owyhee River subbasin.  In addition to determining pollutant loads to meet water quality standards, the assessments looked at some of the characteristics of each watershed including the climate, geology, hydrology, land ownership and use, and fisheries.

Total maximum daily loads for previously listed 303(d) waterbodies in the Upper Owyhee hydrologic unit in Idaho are established in the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load*.  The assessment also includes action items for the next 303(d) list and for future TMDLs (Appendix G). In 2009, the Department of Environmental Quality (DEQ) produced a five-year review of that TMDL. The *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load* assessed the condition of the South Fork Owyhee in Idaho.  These assessments provided the information used to develop Appendix G summarizing the Idaho TMDLs for the upper Owyhee subbasin.[20,27]

The State of Oregon has not developed any TMDLs for the Owyhee River and its tributaries.

## 2. Designated beneficial uses

Designated beneficial uses are assigned to a specific water body by a state.  In designating beneficial uses, the Clean Water Act requires each state to include any existing uses, to consider the ability of the waterbody to support a future use, and to meet the basic goal of the Clean Water Act that all waters support aquatic life and recreation where attainable.[25]

Nevada considers the potential beneficial uses of a waterbody to be the watering of livestock, water supply for irrigation, habitat for fish and other aquatic life, recreation involving contact with the water, recreation not involving contact with the water, municipal or domestic water supply, industrial water supply, propagation of wildlife and waterfowl, extraordinary ecological or aesthetic value, and enhancement or improvement of water quality in any water which is downstream.[34]

Idaho's water quality standards establish the potential beneficial uses to be habitat for aquatic life, recreation, water supply, wildlife habitat, and aesthetics. The first three uses are further divided.  Aquatic life includes cold water, salmonid spawning, seasonal cold water where coldwater aquatic life may be absent or tolerate seasonally warm temperatures, warm water, and modified "with aquatic life limited by one or more conditions that preclude attainment of reference streams or conditions."[22]

Recreational uses are divided into primary contact recreation in the water with a chance of swallowing water and secondary contact recreation with possible occasional ingestion of water.  Water supply is further broken down to providing domestic drinking water, agricultural water for irrigation, drinking water for livestock, or industrial water.

Industrial water use as well as wildlife habitat and aesthetics are considered to apply to all of the surface waters of the state.[22]

The TMDLs for a waterbody identify the beneficial uses of that waterbody. For the Nevada streams these are included in Appendix F. For Idaho waterbodies, the beneficial uses are noted in Appendix G. Those identified by Oregon for the Owyhee River at the Oregon - Idaho border are included in Appendix H.

"Idaho presumes most undesignated waters will support cold water aquatic life."[22] In the Idaho administrative code, beneficial uses for the entire length of the Owyhee River, of the South Fork Owyhee River and of the Little Owyhee River are cold water aquatic species, salmonid spawning, and primary contact recreation.[19] In Oregon all of the waters of the Owyhee Basin are designated for redband or Lahontan cutthroat trout.[37]

### 3. Water quality assessment

The primary reason for including a waterbody on the initial 303(d) listings in Idaho was the probability that cold water biota and salmonid spawning might not be fully supported by existing conditions. Both assessments found that criteria established by the state as essential for the support of cold water fish and salmonid spawning did not exist in some of the streams considered.

The principal pollutants addressed in Idaho's *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load* are temperature and sedimentation. Sedimentation is covered in the sediment sources section of this assessment. Only temperature is considered to be a pollutant in the *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load.* All pollutants in both the Upper Owyhee HUC and the South Fork Owyhee HUC are identified by the Idaho DEQ as coming from nonpoint sources.[20]

A TMDL management plan allocates load reductions to different sources. In the Upper Owyhee HUC, the contributing factors, or "loads", are considered to be the different streams and the amounts of change which are required in each one, therefore some streams which are not listed as 303(d) have recommended shading requirements (Appendix G).

Idaho's 2010 integrated 303(d)/305(b) report attributed other pollutants to some of the waterbodies in the Upper Owyhee HUC. These included flow regime alterations, Escherichia coli, mercury, metals, organic enrichment, and inadequate dissolved oxygen. Additionally, bioassessments of aquatic plants and combined biota/habitat were included not as pollutants but as indicators of problems.[4,21,23]

In the *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load* temperature was also determined not to support either cold water biota or salmonid spawning. Although it was concluded that "a total maximum daily load management plan for temperature is an appropriate vehicle for addressing temperature concerns in the South Fork Owyhee River," it also concluded that the "load" should include an "allocation as water enters the State of Idaho."[27] The assessment recognizes that the naturally occurring "flashy nature of flows in the South Fork Owyhee River appears to be the limiting factor for the presence of large woody vegetation."[27]

In Nevada, the *Total Maximum Daily Loads for East Fork Owyhee River and Mill Creek* addresses not only temperature, but also dissolved and total copper, total iron, total phosphorus, total suspended solids, turbidity, dissolved and total cadmium, dissolved oxygen, total iron, and pH (Appendix F). Although the Rio Tinto Mine area is identified as a contributor for several of the pollutants, other natural and anthropomorphic (human-caused) sources are considered including elements in the soils. These may enter the waterbodies by erosion that would occur naturally or that is increased by human activities. Since the TMDL identifies many of the pollutants as coming from nonpoint sources, "a gross load allocation that accounts for all these sources has been set" for those pollutants.[32]

Although no TMDL has been written for the South Fork Owyhee River nor its tributaries identified as 303(d) in Nevada, pollutant levels have been established in Nevada administrative regulations (Appendix F). Before establishing a TMDL for the South Fork Owyhee River, the Bureau of Water Quality Planning of the Nevada Division of Environmental Protection had concerns about standard appropriateness and conducted a preliminary temperature source assessment. In the observations at the conclusion of the assessment, R. Pahl states "The data show that the temperature standard (21 degrees C) is exceeded for extended periods of times during various flow conditions. . . Unfortunately, it is not possible to accurately determine what temperature levels could be achieved . . . *without spending significant funds for monitoring*."[43] "It becomes difficult for us to develop appropriate temperature standards and/or a TMDL."[43]

Although Oregon has not developed a TMDL for the Owyhee River, on the 2006 EPA 303(d) list the Owyhee River at the border with Idaho is listed for temperature and arsenic. Oregon's draft 2010 integrated report retains these two pollutants and adds phosphate, phosphorus, alkalinity, pH, ammonia, chloride, and dissolved oxygen as pollutants that may impair water quality and have an Oregon water quality standard which is not fully attained (Appendix H).[41]

## H. Stream temperature

The principal pollutant of concern which has been identified in waterbodies in the upper Owyhee subbasin is water temperature based upon the beneficial use being cold water aquatic life or salmonid spawning. Water temperature is also identified as a pollutant where the Owyhee River leaves the upper Owyhee subbasin and enters the Middle Owyhee HUC in Oregon.

The East Fork Owyhee River and Mill Creek TMDL also includes temperature as a potential pollutant. However, there is also concern about the copper levels in these two streams below the old Rio Tinto copper mine.

### 1. Data collection locations

There are only a few locations in the upper Owyhee subbasin where water temperature measurements have been made and are readily accessed for analysis.

### *a. Upper Owyhee HUC in Nevada*

Nevada has several Nevada Division of Environmental Protection (NDEP) sites on the East Fork Owyhee River in the Upper Owyhee HUC. Miscellaneous water temperature readings have been taken on the river below Wild Horse Reservoir, above Mill Creek, below Mill Creek, and below Slaughterhouse Creek. There is also a site at the southern boundary of the Duck Valley Reservation run by the Shoshone-Paiutes. On Mill Creek the NDEP has taken miscellaneous water temperature readings above the Owyhee River confluence, at Patsville, and above the Rio Tinto mine site.

### *b. Upper Owyhee HUC in Idaho*

In Idaho the USGS does not have any sites with surface-water data in the upper Owyhee subbasin.[51] For the Idaho DEQ Upper Owyhee Watershed TMDL, water temperature data was based on available temperatures taken with recording thermographs from June 2000 through September 2001. Data was collected for Deep Creek at Mud Flat Road, at Castle Creek, and at Road Crossing. For Pole Creek it was collected near Mud Flat road, near Camel Creek, and upstream of Camel Creek. Water temperatures were also recorded for Castle Creek and Red Canyon Creek (Figure 8.2).

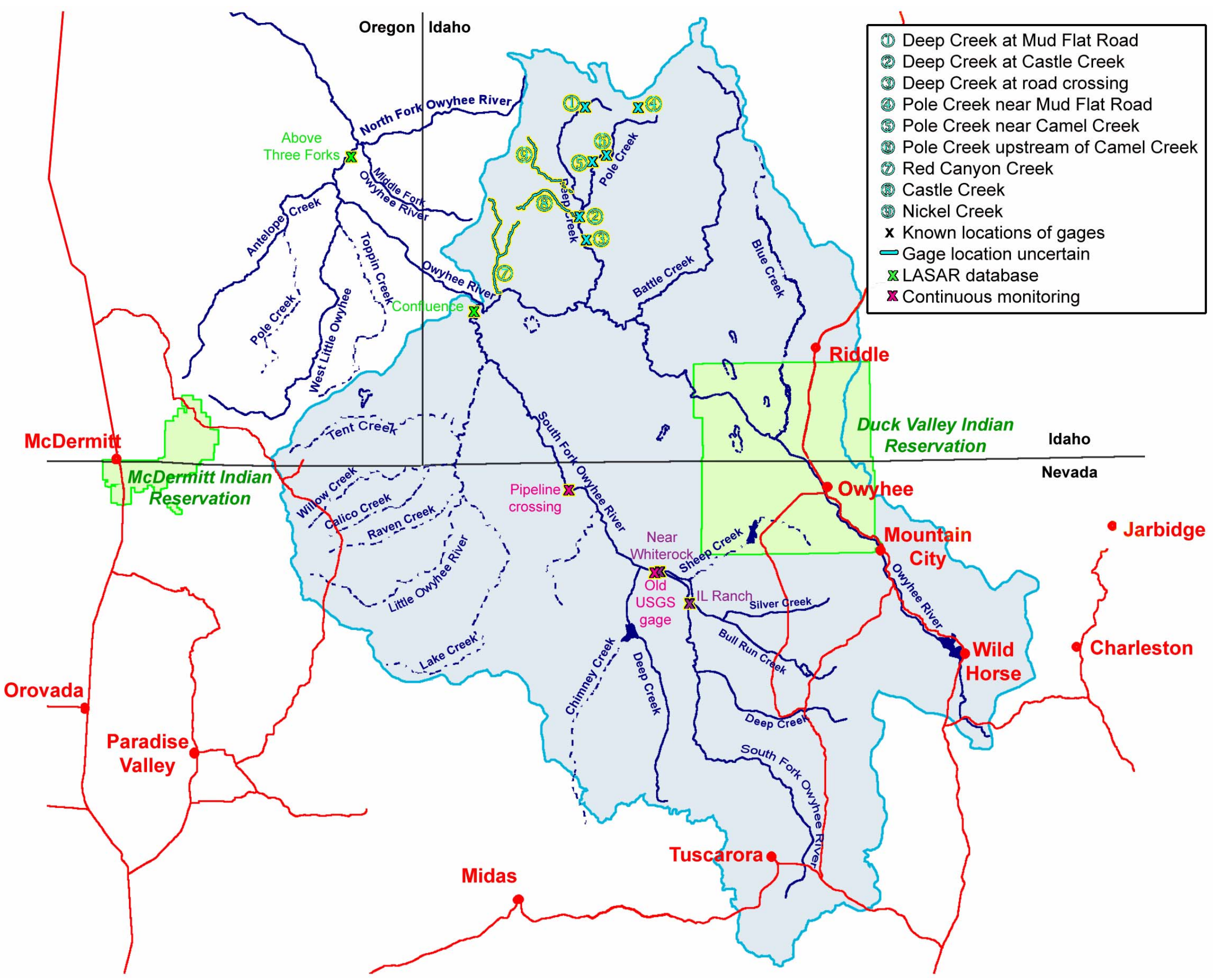


**Figure 8.2. Location of prior water temperature monitoring sites in the upper Owyhee subbasin.**

In the summer of 2004 the Bureau of Land Management (BLM) installed temperature loggers at six locations in the Upper Owyhee HUC. There was one logger on Nickel Creek, one on Pole Creek, two on the East Fork Red Canyon Creek, and one each on the West Fork Red Canyon Creek and on Red Canyon Creek.

### *c. South Fork Owyhee HUC in Nevada*

In 1999, a water temperature monitoring site was set up at the El Paso Pipeline Crossing in Nevada at river mile 36.8 from the Idaho-Nevada border. The water temperature of both the South Fork Owyhee at this site and at the old USGS gage upstream was recorded in 1999, 2000, and 2001, with only the old USGS gage recording in 2002 and only the pipeline gage with 2003 records. These data and miscellaneous temperature readings near Whiterock and at the IL Ranch were included in the preliminary temperature assessment of the South Fork Owyhee River in Nevada (Figure 8.2).

### *d. South Fork Owyhee HUC in Idaho*

For the South Fork Owyhee TMDL in Idaho the data from the monitoring site at the El Paso Pipeline Crossing in Nevada was used. In addition, water temperature was monitored at the 45 Ranch in Idaho. Samples were collected at these two sites in June, July, August and September of 1999 (Figure 8.2).

### *e. Oregon*

The Oregon DEQ operates a database of information on air and water quality monitoring data, the Laboratory Analytical Storage and Retrieval (LASAR) database. The information entered in the database comes from over 100 different entities as diverse as state agencies, watershed councils, BLM offices, the Idaho DEQ and the Denver USGS.[39] The database contains the record of continuous 2001 temperature readings on the South Fork Owyhee River above the confluence with the East Fork in Idaho and on the Owyhee River above Three Fingers in Oregon (Figure 8.2).[38]

## 2. Recorded temperature data

In the upper Owyhee subbasin, the measurements of water temperature are usually made in degrees Celsius (°C). Most Americans outside of scientific fields are accustomed to thinking in degrees Fahrenheit (°F). A five degree change in degrees Celsius is equal to a nine degree change in Fahrenheit. Complexity in converting a temperature from one scale to the other is introduced by 0°C equaling 32°F. Where comparisons are made between stream water temperature and criteria, the criterion for Oregon is 20°C (68°F), the criterion for Idaho is 22°C (71.2°F), and the criterion for Nevada is 21°C (69.8°F).

### *a. Upper Owyhee HUC in Nevada*

The water temperatures in the East Fork Owyhee River and in Mill Creek were measured at the same time that water samples were taken from these waterbodies. The data represent discrete moments in time. The data were collected over a number of years. Some of the data have the time of day that the sample was made recorded, but the majority do not (Table 8.2).

Table 8.2. Sample water temperature data in the Upper Owyhee HUC in Nevada from the *Total Maximum Daily Loads for East Fork Owyhee River and Mill Creek*

| Sample location | Years | Number of discrete samples | Number of samples over 21°C (69.8°F) | Maximum recorded temperature | |
|---|---|---|---|---|---|
| | | | | °C | °F |
| East Fork Owyhee below Wild Horse reservoir | 1996 - 2003 | 15 | 1 | 25.3 | 77.5 |
| East Fork Owyhee above Mill Creek | 1967 - 2003 | 81 | 11 | 25.0 | 77.0 |
| East Fork Owyhee below Mill Creek | 1995 - 2003 | 51 | 7 | 24.9 | 76.8 |
| East Fork Owyhee at the south boundary of Duck Valley Indian Reservation[a] | 1999 - 2003 | 10 | 0 | 18.3 | 64.9 |
| Mill Creek above Rio Tinto | 1995 - 2003 | 20 | 2 | 26.1 | 79.0 |
| Mill Creek at Patsville | 1997 - 2003 | 9 | 5 | 31.0[b] | 87.8 |
| Mill Creek above the East Fork Owyhee River confluence | 1995 - 2003 | 23 | 4 | 25.7 | 78.3 |

[a] All the temperature measurements were taken before 1:30 in the afternoon.
[b] Taken during a period of low flow. 26°C was the second highest temperature recorded.

### *b. Upper Owyhee HUC in Idaho*

The Idaho DEQ's TMDL for the Upper Owyhee Watershed did not present continuous data for water temperature at the monitored sites but only a tabular analysis of the 2000 and 2001 data without the inclusion of data other than the extreme high temperatures observed for the time period recorded (Table 8.3).

Table 8.3. Water temperature data analyses for the Upper Owyhee HUC in Idaho from the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load*.

| Location of the thermograph<br>Dates considered, year | | Maximum water temperature °C | Maximum water temperature °F | Days with maximums over 22°C (71.2°F) |
|---|---|---|---|---|
| Deep Creek at Mud Flat Road | | | | |
| | June 23 thru Aug 31, 2000 | 27.5 | 81.5 | 90% |
| | June 1 thru Aug 12, 2001 | 26.3 | 79.3 | |
| Deep Creek at Castle Creek | | | | |
| | June 23 thru Aug 31, 2000 | 29.1 | 84.4 | 98% |
| | June 1 thru Aug 31, 2001 | 28.3 | 82.9 | |
| Deep Creek at Road Crossing | | | | |
| | June 22 thru Aug 31, 2000 | 31.1 | 88.0 | 85% |
| | June 1 thru Aug 31, 2001 | 29.6 | 85.3 | |
| Pole Creek near Mud Flat Road | | | | |
| | June 23 thru Aug 31, 2000 | 25.5 | 77.9 | Went dry |
| | June 1 thru Aug 12, 2001 | 24.9 | 76.8 | Went dry |
| Pole Creek near Camel Creek | | | | |
| | July 12 thru Aug 31, 2000 | 25.6 | 78.1 | 90% |
| Pole Creek upstream of Camel Creek | | | | |

| | | | | |
|---|---|---|---|---|
| | July 12 thru Aug 31, 2000 | 22.7 | 72.9 | 16% |
| Castle Creek | | | | |
| | June 23 thru Aug 24, 2000 | 31.1 | 88.0 | 100%, went dry |
| | Not included 2001 | | | Went dry |
| Red Canyon Creek | | | | |
| | June 23 thru Aug 31, 2000 | 25.2 | 77.4 | 47%, went dry |
| | Not included 2001 | | | Went dry |

Each maximum shown in table 8.3 represents only one day's reading and provides little information. However, more information can be gleaned from the inclusion of the percentage of days with the maximum water temperature over 71.2°F. For all the reaches of Deep Creek, the maximum water temperature exceeded 71.2°F on at least 85% of the days between June 23 and August 31, 2000. Castle Creek and Red Canyon Creek went dry. Pole Creek went dry above the confluence with Camel Creek. The water temperature in a drying stream would tend to rise as the flow diminished.

The results of water temperature measurements made by BLM in the summer of 2004 are graphed in the five year review of the Upper Owyhee TMDL. These graphs show the maximum daily water temperature and the average daily water temperature. The minimum daily water temperature is absent.[46] Four of the monitored locations were in the Red Canyon Creek drainage.

From upper East Fork Red Canyon Creek (Figure 8.3) to downstream in lower East Fork Red Canyon Creek (Figure 8.4), the temperature loggers

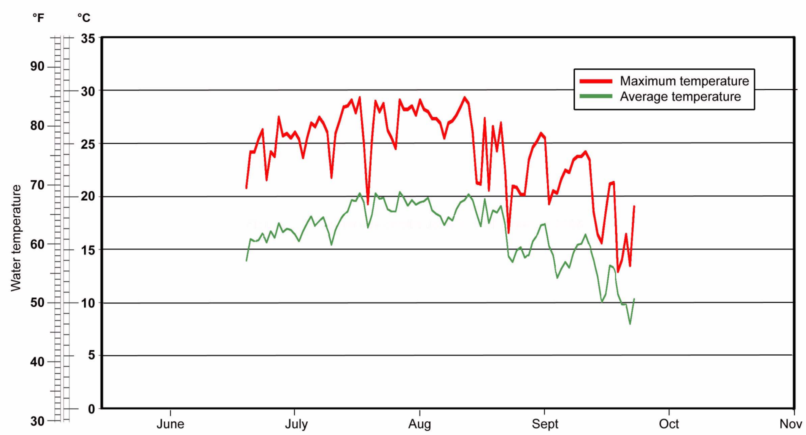

Figure 8.3. Daily maximum and average water temperatures in upper East Fork Red Canyon Creek, Idaho in 2004.

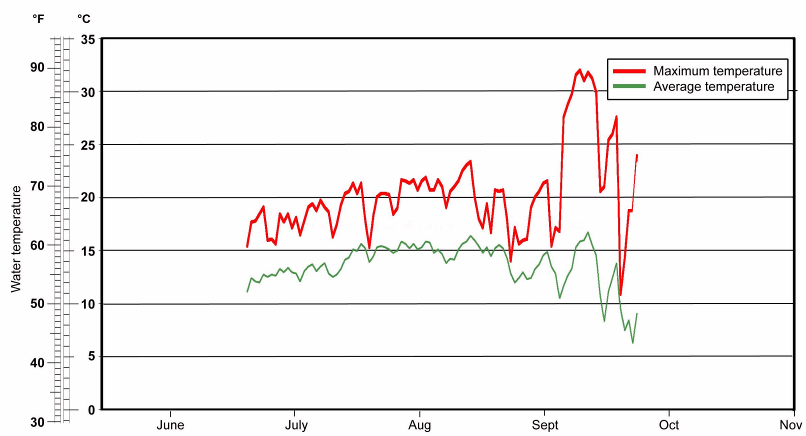

Figure 8.4. Daily maximum and average water temperatures in lower East Fork Red Canyon Creek, Idaho in 2004.

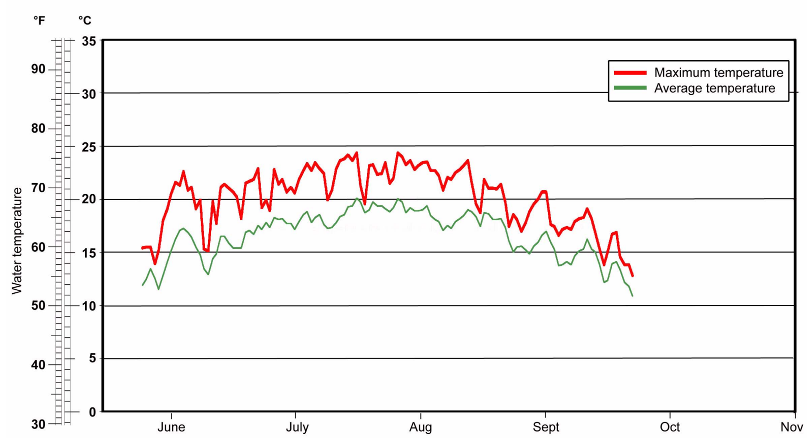

Figure 8.5. Daily maximum and average water temperatures in lower Red Canyon Creek, Idaho in 2004.

show a general decrease in water temperature. In the upper creek they tended to peak above 70°F and many of the maximum temperatures were over 77°F, up to 85°F. In lower East Fork Red Canyon Creek, most of the maximum water temperatures were between 60 and 70°F. Further downstream in lower Red Canyon Creek (Figure 8.5) the water temperatures tended to be slightly higher than in lower East Fork, but not as high as in the upper East Fork. The data for West Fork Red Canyon (Figure 8.6) span a much shorter time period, but during this time period the maximum water temperatures are also lower than downstream in lower Red Canyon Creek. The spikes in temperature at the end of July on the West Fork (Figure 8.6) and in September of the lower East Fork (Figure 8.4) were consistent with the creeks going dry.[46]

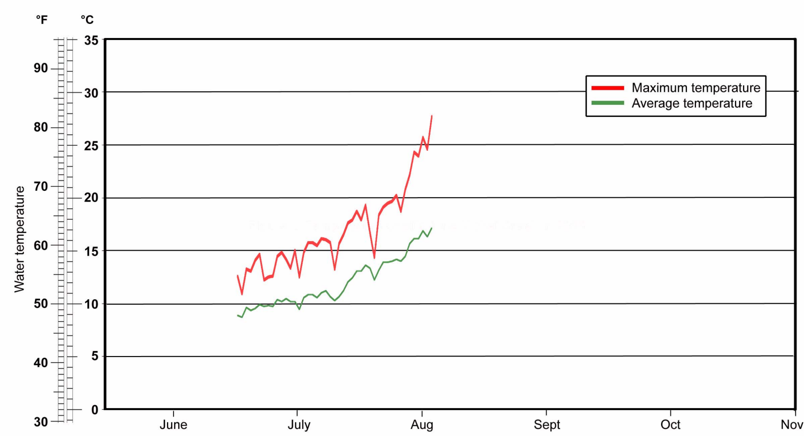


Figure 8.6. Daily maximum and average water temperatures in West Fork Red Canyon Creek, Idaho in 2004.

Data that is included in the five year review of the Upper Owyhee TMDL from the temperature loggers in Nickel Creek (Figure 8.7) and in Pole Creek (Figure 8.8) represent only about two months of monitoring at each location. The maximum water temperatures spike in each of these creeks in July. The large difference between the maximum water temperature and the average water temperature at Pole Creek indicates significant drops in temperatures at night, as much as 32°F.

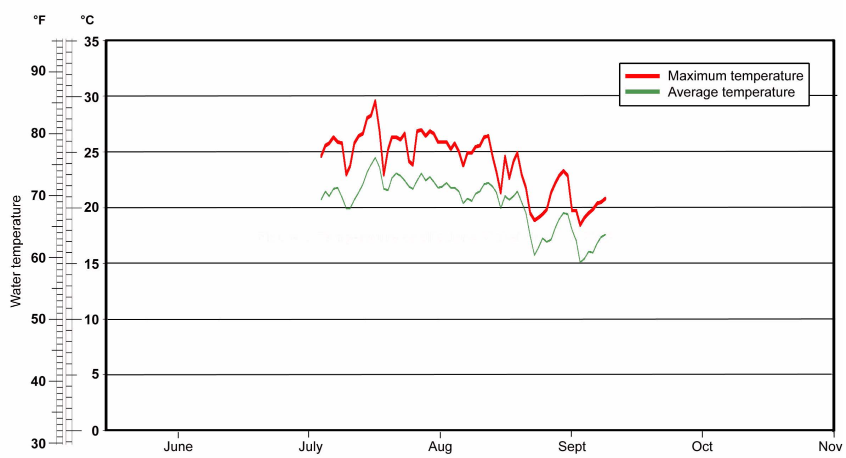


Figure 8.7. Daily maximum and average water temperatures in Nickel Creek, Idaho in 2004.

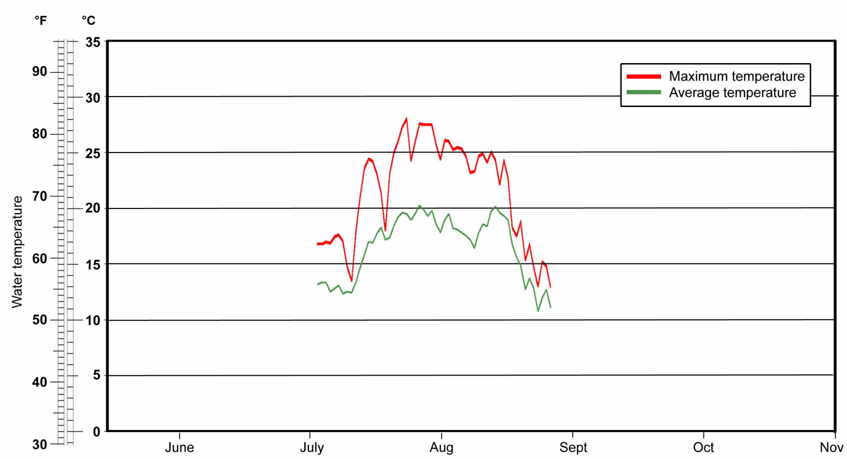


Figure 8.8. Daily maximum and average water temperatures in Pole Creek, Idaho in 2004.

### c. *South Fork Owyhee HUC in Nevada*

Sporadic readings of the water temperature were made on the South

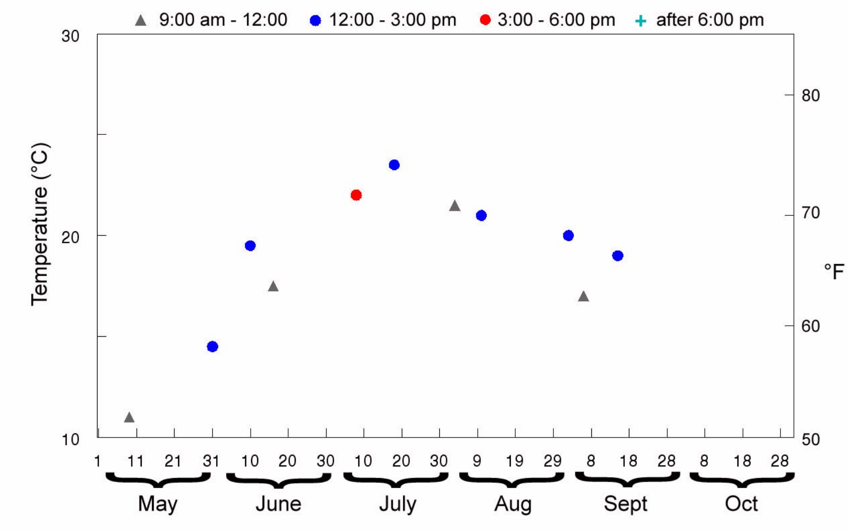


Figure 8.9. Miscellaneous water temperature readings on the South Fork Owyhee River near Whiterock, Nevada between 1977 and 1981.

Fork Owyhee River between 1977 and 1981 near Whiterock (Figure 8.9) and between 1966 and 1995 on the IL Ranch (Figure 8.10). Near Whiterock, these spot checks of water temperature in July or August were all above 19.5°C (67.1°F). One of these temperatures, 70.7°F, was recorded in the morning at 9:35 am on August 3, 1978.

The spot checks for the water temperature of the South Fork at the IL Ranch were made over a larger number of years than those near Whiterock. Of the sixteen readings made sometime in either July or August, only three were below 20°C (68°F). Of these three, two were made in the morning.

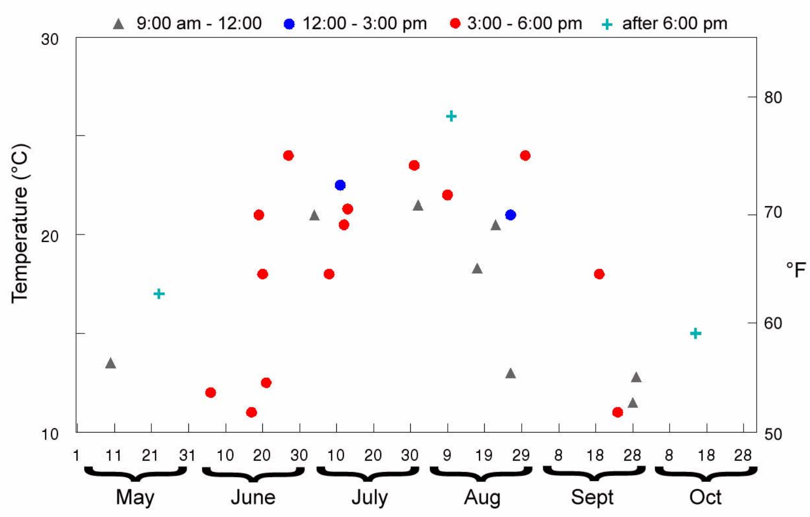


Figure 8.10. Miscellaneous water temperature readings on the South Fork Owyhee River at the IL Ranch, Nevada between 1966 and 1995.

In Nevada, the old USGS gage on the South Fork Owyhee River is upstream from the El Paso pipeline gage. The data from these two gages was recorded on the same graph in 1999, 2000, and 2001 (Figures 8.11, 8.12, and 8.13). The lines represent continuous data. Due to the compressed nature of the graph and the overlaying of two sets of data, the small differences within a day are not visible. The peaks show the maximum water temperature for a day and are followed by a dip to the minimum water temperature the next night. To visualize these graphs as graphs of maximum daily temperatures like those in Figures 8.3 to 8.8, imagine a line connecting the peaks.

At both the old USGS gage and the pipeline gage, there is a considerable difference between the daytime maximum water temperature and the nighttime minimum water temperature. The fluctuations in water temperatures at the two gages

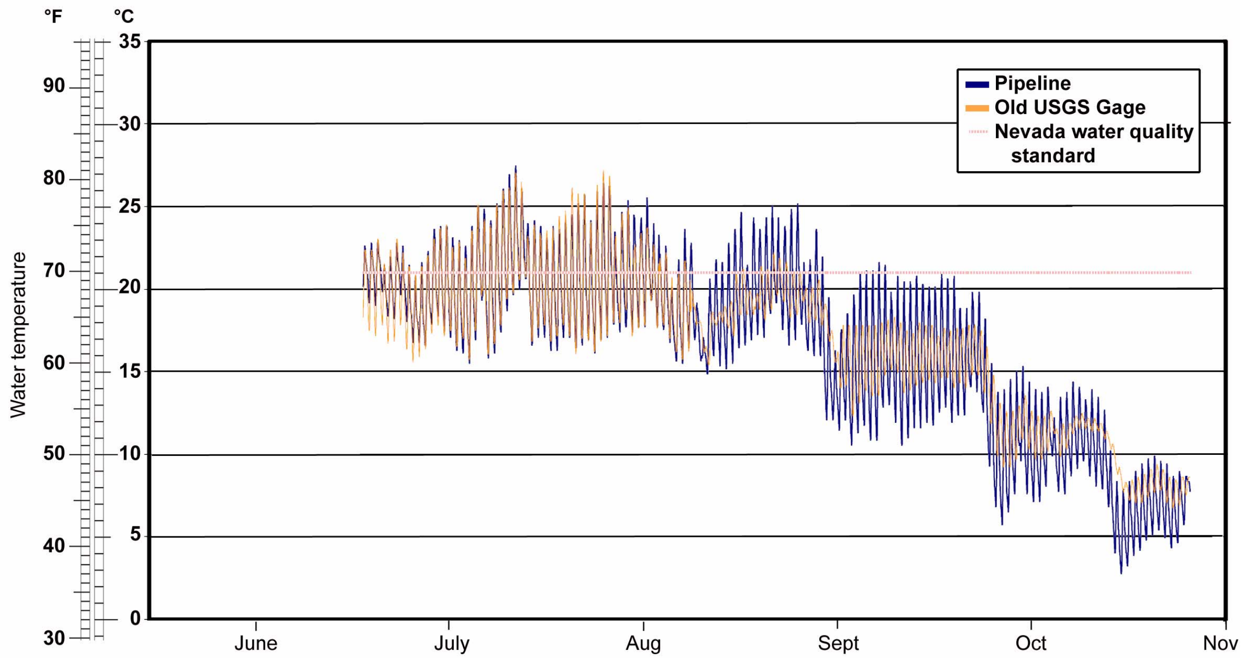


**Figure 8.11. Water temperature fluctuations at two gages in the South Fork Owyhee River, Nevada in 1999 .**

tend to have a similar pattern. At the end of summer and in the fall In 1999 the temperature of the water passing the pipeline gage was hotter during the day and was colder at night than the water upstream at the old USGS gage which maintained a more constant temperature. In 2000 and 2001 the water temperatures at the two gages accompanied each other more closely.

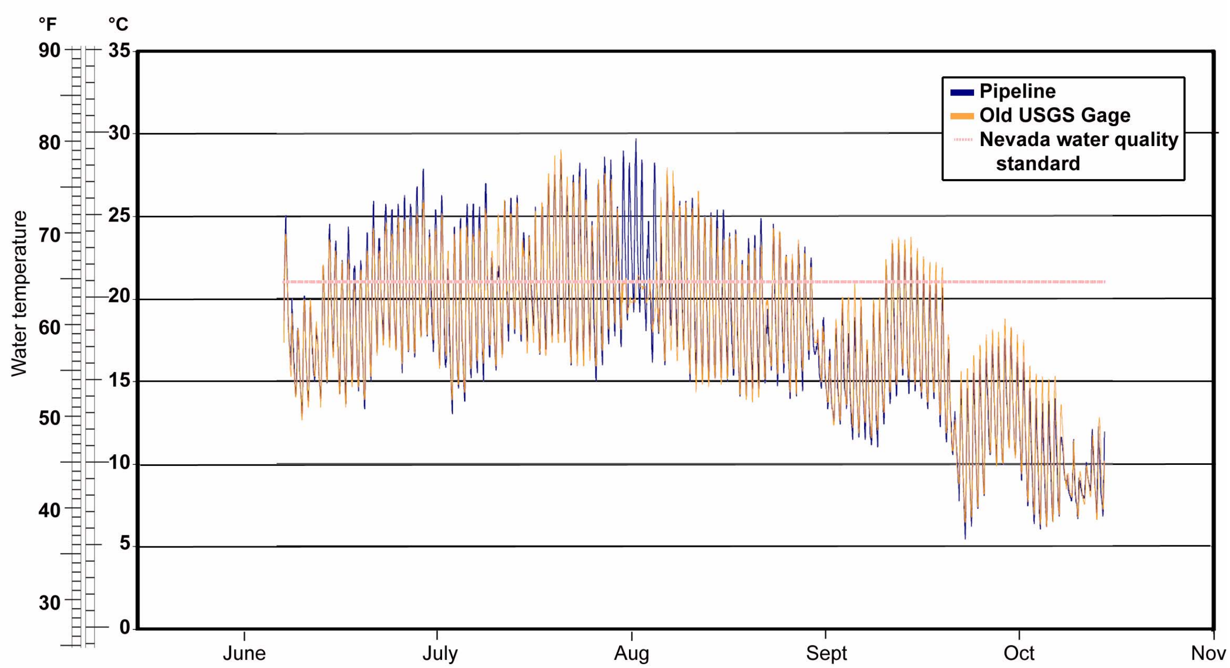


**Figure 8.12. Water temperature fluctuations at two gages in the South Fork Owyhee River, Nevada in 2000.**

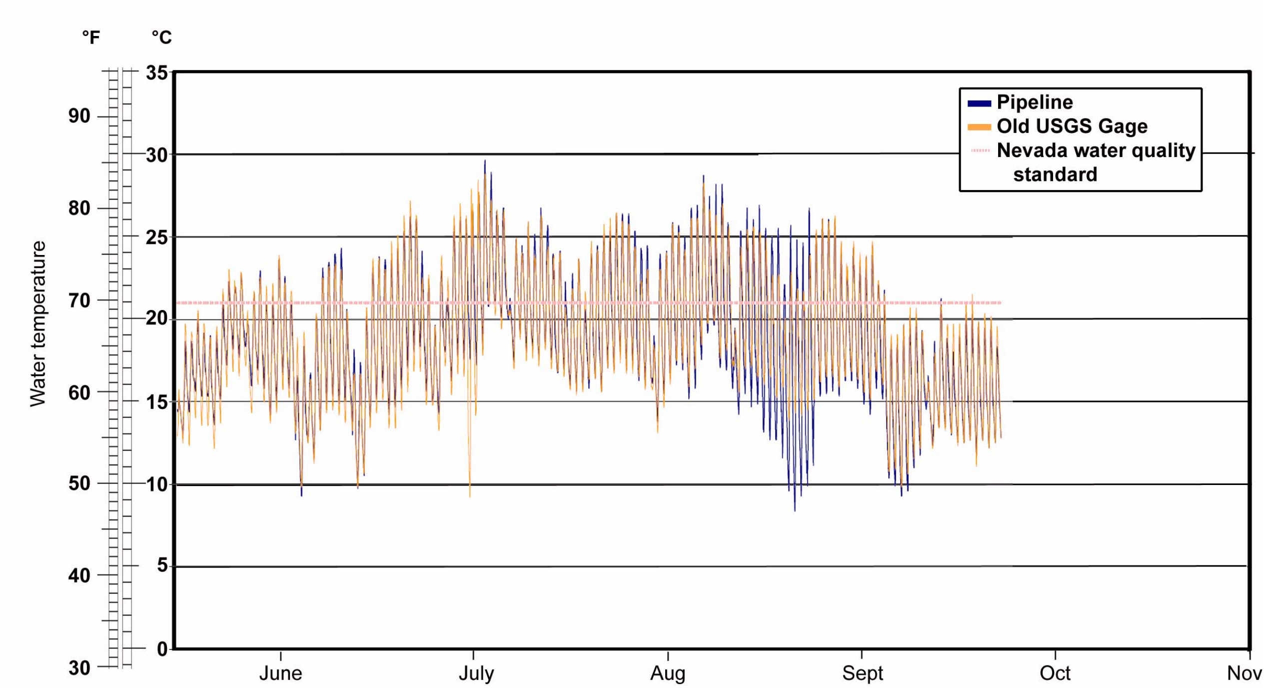


**Figure 8.13. Water temperature fluctuations at two gages in the South Fork Owyhee River, Nevada in 2001 .**

Only the data for the old USGS gage was available for 2002 (Figure 8.14). For 2003, only the water temperature data for the El Paso pipeline gage was available (Figure 8.15). Maximum daily temperatures in July and August of all reported years were constantly above the Nevada water quality standard of 21C (69.8°F).

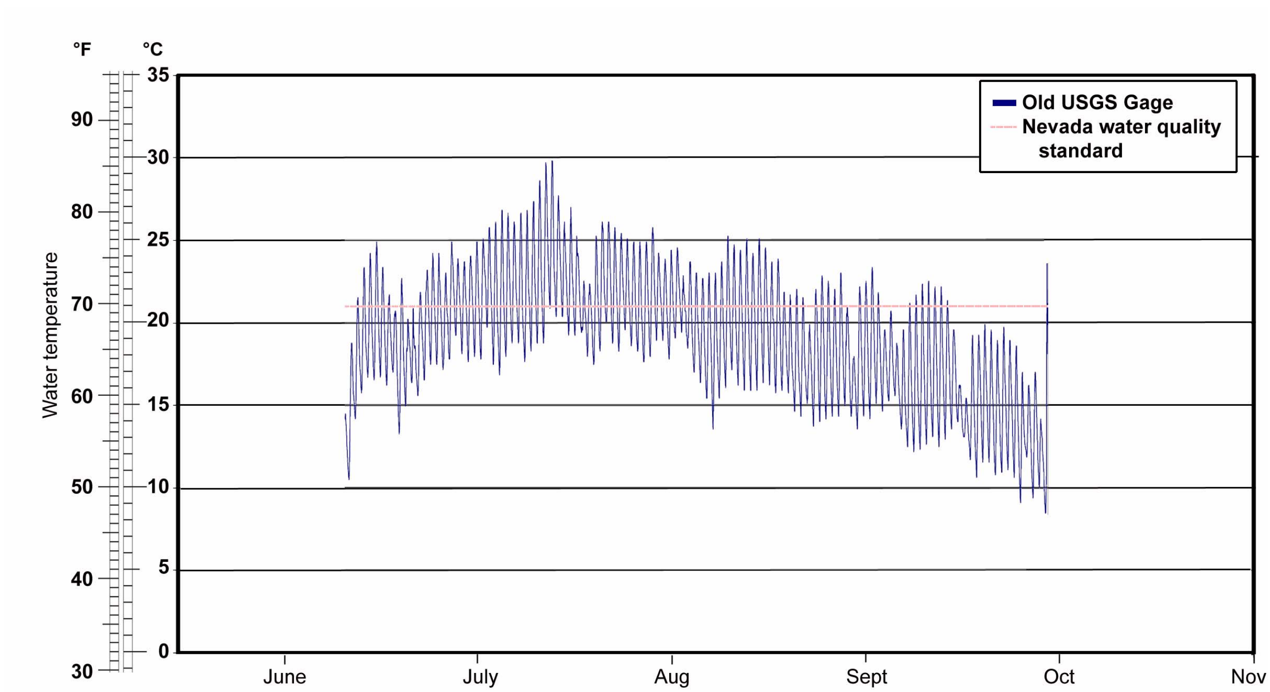


**Figure 8.14. Water temperature fluctuations at the old USGS gage in the South Fork Owyhee River, Nevada in 2002 .**

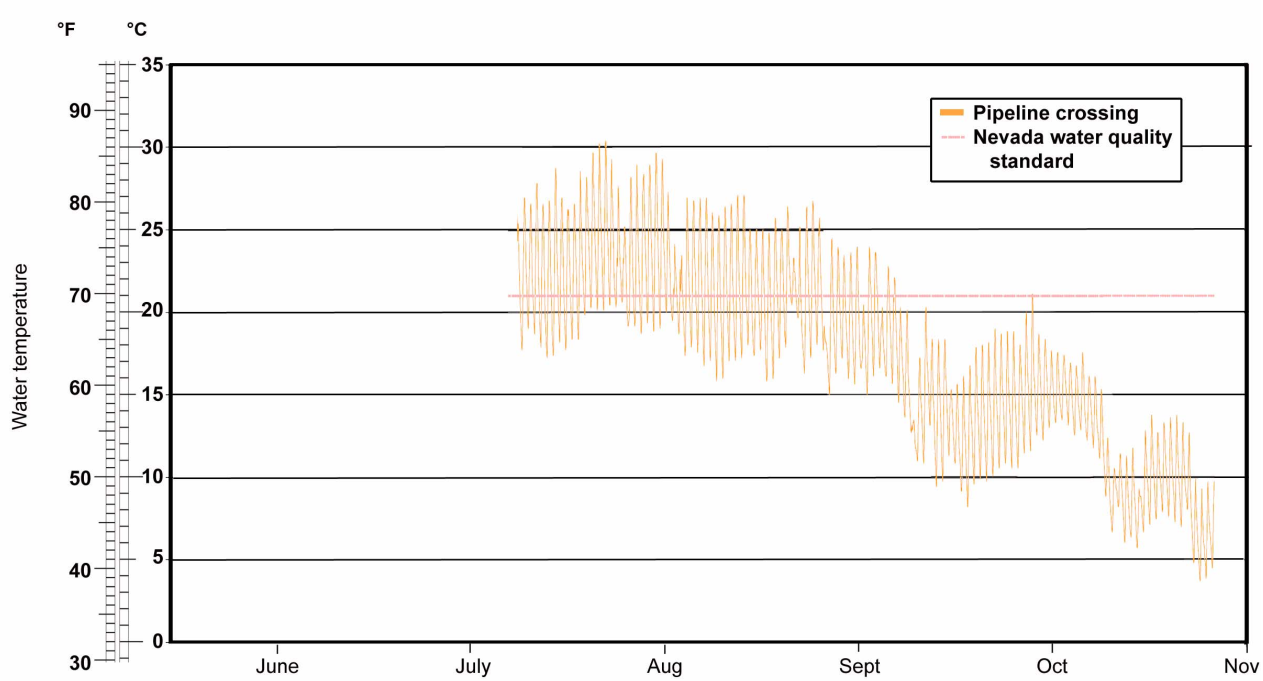


**Figure 8.15. Water temperature fluctuations at the pipeline crossing gage in the South Fork Owyhee River, Nevada in 2003.**

### *d. South Fork Owyhee HUC in Idaho*

In 1999, the water temperatures at the 45 Ranch on the South Fork Owyhee at the confluence with the Little Owyhee River in Idaho were compared to the recorded data from the El Paso pipeline site in Nevada. "Average maximum daily temperatures were similar at the 45 Ranch and the El Paso Pipeline sites." Regression analysis also showed that there was "a strong correlation between water temperatures entering Idaho and those recorded in Idaho at the 45 Ranch."[27] At the 45 Ranch, the diurnal (change between daily maximum and minimum) water temperature changes were less than upstream at the pipeline site.

In Idaho, just before the South Fork Owyhee River joins the Owyhee River, water temperature data was continually monitored during 2001 (Figure 8.16). During 2001 the water temperature was also monitored on the Owyhee River in Oregon above Three Forks (Figure 8.17). Above the confluence with the Owyhee River, the daily fluctuations in water temperature in 2001 were smaller than upstream at the pipeline site (Figure 8.13) . Farther downstream at the Three Forks site, the daily fluctuations were even less. Observing the graphs of the water temperatures at the pipeline site and at the Owyhee confluence, there doesn't seem to be much difference in temperatures.

Figure 8.18 shows the maximum daily water temperatures at the three successive downstream locations, the South Fork Owyhee River at the El Paso pipeline in Nevada, the South Fork Owyhee River above the confluence with the Owyhee River in Idaho, and farther downstream on the Owyhee River upstream from Three Forks in Oregon. The maximum water temperatures at the pipeline gage and above the confluence mirror each other fairly closely with the maximum temperatures at the pipeline gage being slightly higher than those downstream above the confluence. Over

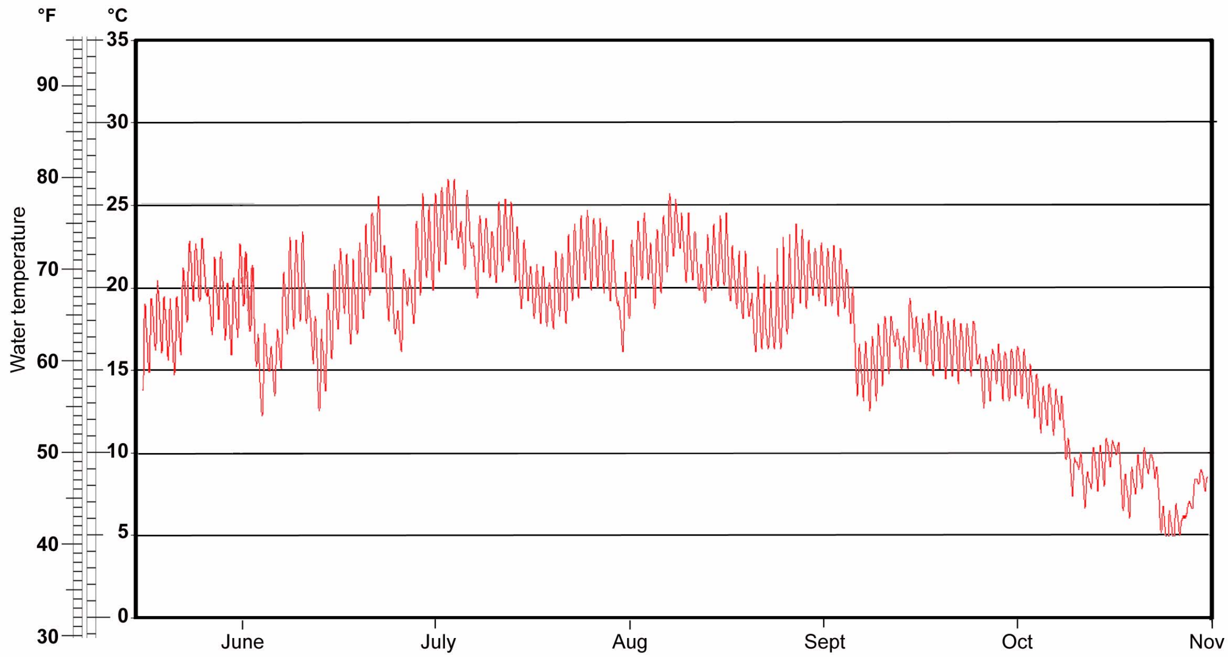


**Figure 8.16. Water temperature fluctuations in the South Fork Owyhee River above the confluence with the East Fork Owyhee River, Idaho in 2001.**

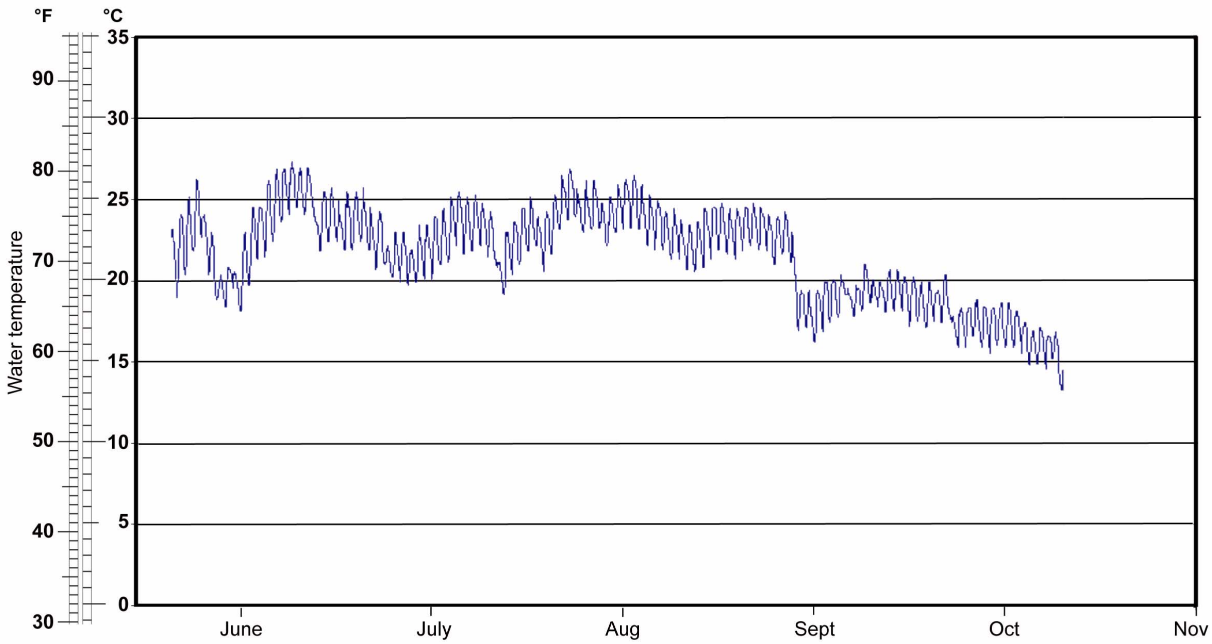


**Figure 8.17. Water temperature fluctuations in the Owyhee River above Three Forks, Oregon in 2001.**

the recorded season, the maximum water temperatures above Three Forks tended to be higher than the those at the other two sites. However, during some time periods the pipeline gage maximums were higher than at either of the other two sites. It would be difficult to determine to what extent the increase in water temperature and the decrease

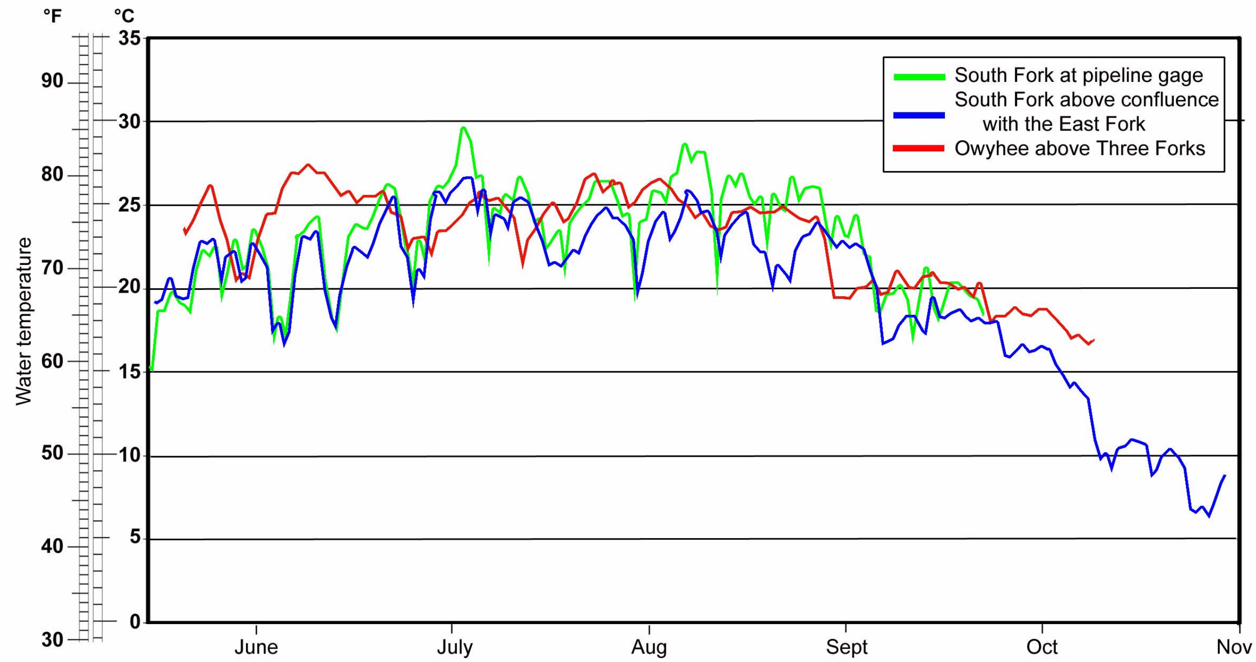


**Figure 8.18. Maximum daily water temperature at three successive downstream locations (Nevada, Idaho, Oregon) in 2001.**

in daily temperature fluctuations at the Three Forks site was due to the addition of the waters of the Owyhee River to the waters of the South Fork Owyhee River.

## 3. Discussion of stream temperature

Based upon the beneficial uses established for waterbodies in the upper Owyhee subbasin, temperature is identified as the major pollutant of concern. The most restrictive beneficial use assigned to the upper reaches of the Owyhee river in Oregon is redband and Lahontan cutthroat trout. In Idaho, Deep Creek, Pole Creek, Castle Creek, Red Canyon Creek, and South Fork Owyhee River are designated for cold water aquatic life and salmonid spawning. In Nevada the South Fork Owyhee River is considered habitat for redband trout, brook trout, and whitefish. East Fork Owyhee River and Mill Creek are designated for aquatic life. The standards established for the maximum water temperature for the designated use is 20°C (68°F) in Oregon, 22°C (71.6°F) in Idaho, and 21°C (69.8°F) In Nevada.

### *a. Summary of existing data*

The available data on current water temperatures in the streams of the upper Owyhee subbasin substantiate the fact that the water temperatures in those reaches frequently exceed the established standard. Twenty one percent of the temperature samples taken on Mill Creek were over 21°C. On the East Fork Owyhee River in Nevada, 13% of the samples showed temperatures over 21°C. In Idaho, during July and August of 2000, Deep Creek's maximum daily temperature exceeded 22°C over 85% of the time. In 2001, at the pipeline gage in Nevada and at the gage at the confluence of the South Fork Owyhee River with the Owyhee in Idaho, only four days recorded maximum water temperatures less the 20°C and most of the readings were above 22°C during July and August 2001. By the time the waters of the Owyhee reached the gage above Three Forks in Oregon, during July and August 2001, not only did the maximum water temperature remain above 20°C, but the minimum temperature only dipped below 20°C a couple of times.

The months of July and August have the highest water temperatures in the upper Owyhee subbasin. During these months the diurnal changes in water temperature at the 45 Ranch, at the South Fork - Owyhee confluence, and upstream from Three Fingers were relatively small compared to other sampled sites, frequently less than 15°F.

### *b. Attainability*

In defining the purpose of the clean water act, the EPA in their "Introduction to Water Quality Standards" stated that the goals of the act were applicable "where ***attainable,*** to achieve water quality . . ." The italics and bold attributes are from the EPA document. In examining the water quality in the rivers within the upper Owyhee subbasin it is essential to first consider what is attainable. If the realities of the situation are not taken into consideration, meeting the goals is doomed to failure.

Some of the assessments already conducted in the upper Owyhee subbasin express doubts about the attainability of the established water quality criteria. In his five year review of the Upper Owyhee TMDL, Stone says, "Originally, the targets for full support of beneficial uses were the temperature criteria in the water quality standards. These criteria are not appropriate for the sparsely flowing desert streams of the Upper Owyhee River watershed. A pristine stream in this area would probably still violate water quality criteria at certain times of the year."[46]

In the TMDL for the South Fork Owyhee River in Idaho, Ingham concludes "One of the influences on water temperature in the South Fork Owyhee River is ambient air temperature. With warm water temperatures originating from Nevada and the ambient air temperature, the South Fork Owyhee River may not ever have an opportunity to cool itself enough to meet State of Idaho water quality criteria for cold water biota and salmonid spawning."[27]

Not only does the East Fork Owyhee River and Mill Creek TMDL suggest that more monitoring might be appropriate, but it includes the statement that "Mill Creek temperature standards should recognize the ephemeral nature of the stream. Current temperature standards are “single value” standards, without any consideration of duration."[32]

### *c. Stream flow*

There are tremendous natural variations in water flow in the Owyhee River. These variations include both flooding and diminution of the water flow to almost a trickle and cause scouring of the banks. Downstream in Oregon, since 1950, the minimum flow at Rome was 42 cubic feet per second (cfs) on four different dates.[49] Gene Stuntz states that before the construction of the Owyhee Dam the amount of water in the Owyhee varied, dwindling to a small trickle in the hot summer time.[47] Before reservoir development in the watershed, Chesley Blake who also lived in an area now inundated by the Owyhee Reservoir remembers that when the river level went down the water would get warm, and the children would swim in the river.[3]

The hydrology section of this assessment discusses the stream flows in the upper Owyhee subbasin in greater detail. With naturally decreased flows, streams in the subbasin would be expected to experience heating similar to or greater than that recorded downstream on the Owyhee River.

### *d. Effect of climate*

How does climate affect the water temperatures in the upper Owyhee subbasin? The discussion in the background section characterizes the air temperatures in the upper Owyhee subbasin (see the climate section of the background component of this assessment). The greater part of the subbasin lies between 5000 feet and 5500 feet in elevation. Meteorological stations within and adjacent to the subbasin that are located between these elevations and might most closely represent a larger area are Il Ranch at 5203 ft, Owyhee at 5397 ft, and Grasmere at 5144 ft. In July, the respective average maximum air temperatures at these three stations are 88.1°F, 85°F and 87.7°F.

In studies in northeast Oregon, Meays et al. discovered that the atmosphere provided a strong buffer on stream temperatures. The effect of the atmosphere on stream temperature was to effectively set limits within which stream temperatures would occur.[29] Carr et al. also found that climatic factors, including air temperatures, were the dominant factors in stream temperature patterns.[4]

In the Truckee River at Reno, the stream temperature could be predicted using maximum air temperature and average daily flow as variables.[61] The Truckee River at Reno is also in a semiarid desert. Since maximum air temperature of the Truckee River at Reno was a large factor in predicting the stream temperature, it is quite probable that the maximum air temperatures in the upper Owyhee subbasin are major indicators of the expected water temperatures in the streams. Taylor et al. state that it is generally accepted that there is an inverse relationship between stream flow and the size of daily variation in stream temperature, the more water there is in a stream the less it will cool during the night or heat during the day.[48] Conversely, as the streams of the upper Owyhee subbasin carry less water in the summer, they would heat more during the day and cool more during the night than if they had greater flow. Meays et al. related the stream temperature to both the velocity and the distance. The more slowly the water traveled and the greater the distance that it traveled, the closer the stream came to achieving an equilibrium with mean air temperatures.[29]

The Malheur Experiment Station near Ontario, Oregon has recorded soil temperatures as well as air temperatures. Compared to air temperatures, the maximum soil temperature rises and falls in a similar pattern, but doesn't quite reach temperatures as high as the air temperatures. However, although the minimum soil temperatures follow a similar curve, they remain considerably higher than the minimum air temperatures (Figure 8.19).[52,56] Except for the maximum temperatures each day, the soil temperature is above the air temperature for much of the time.

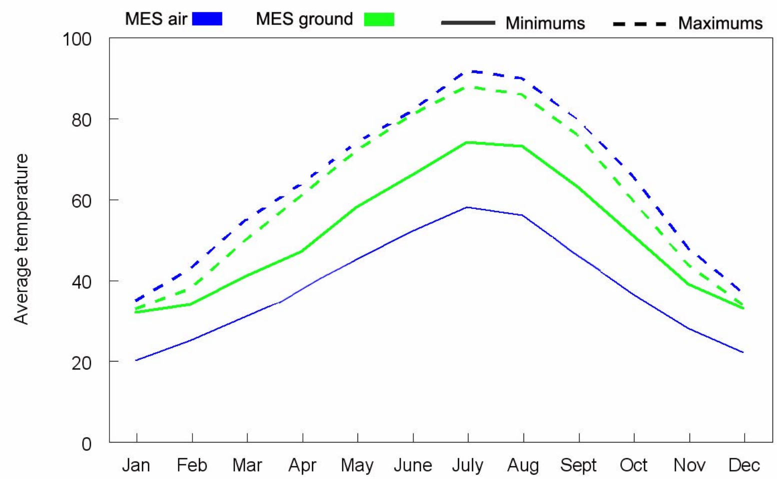


Figure 8.19. Average maximum and minimum air temperatures from 1942 to 2005 at Malheur Experiment Station Ontario, Oregon, compared to average maximum and minimum soil temperatures from 1967 to 2005 at 4-inch depth at the same location.

The histogram in Figure 8.20 indicates how often a combination of a specific air temperature and soil temperature occurred between 1992 and 2007. Shading of the dots on the graph varies from dark red for the fewest readings through yellow to green for the most readings. The points to the left of the blue line are the readings when the soil temperature was higher than the air temperature. There are many more particles in the soil than in the air, so the soil absorbs more of the sun's energy than the air does. At the Malheur Experiment Station Agrimet weather station the soil temperature is higher than the air temperature more of the time.[56]

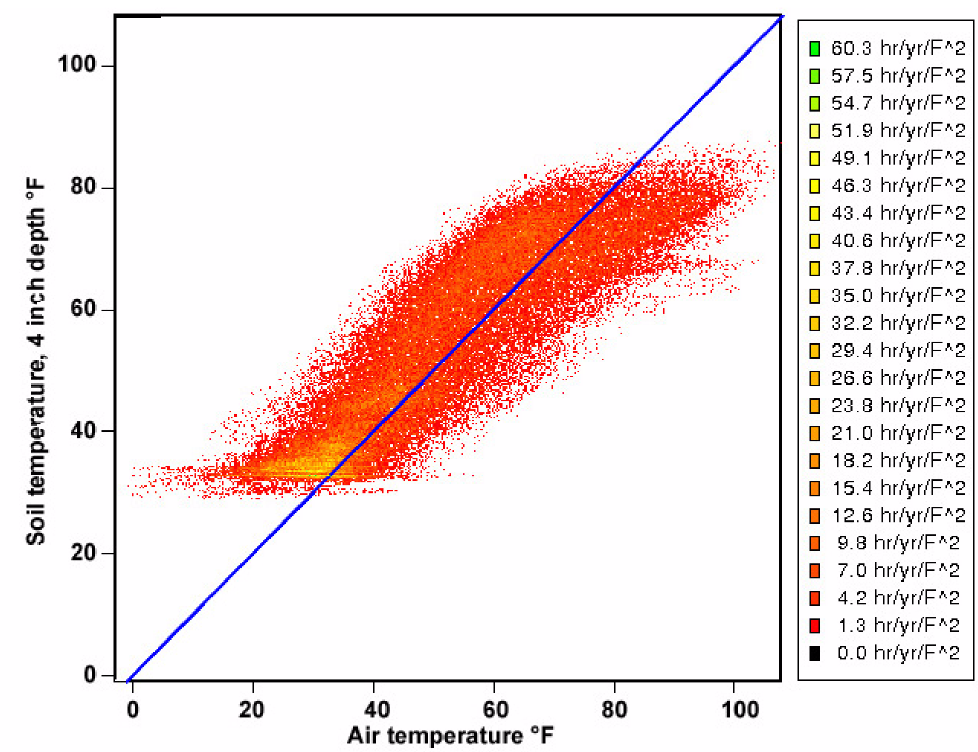


**Figure 8.20. Histogram of the soil temperature at 4 inch depth vs. the air temperature at the agrimet weather station, Ontario, Oregon from 1992 to 2007.**

If the air temperature is predictive of the water temperature, it doesn't matter whether the water is being heated by the air, by the soil, or by direct solar radiation. Probably the soil is absorbing solar radiation and reradiating it to both the air and elsewhere. In the upper Owyhee subbasin, no well developed understanding of the physics involved in stream heating has been used to determine stream temperature standards. It is possible that stream temperature standards have been established that violate physical principles of heating and cooling.

### *e. Effect of shading*

In Idaho DEQ's 2003 TMDL, Deep Creek, Pole Creek, Castle Creek, and Red Canyon Creek were judged to be water quality limited due to temperature. Therefore shade requirements were established for the different stream segments to achieve the predetermined temperature standards. Depending on the stream segment, the shading requirement ranged from 52% to 95% shade for July and 57% to 67% shade in August (Appendix G). No data have been developed that indicate the amount of shade that is feasible given the natural precipitation regime, natural vegetation types, natural scouring frequency, and natural fire frequencies.

When the relationship of shade to maximum stream temperatures was studied by Kruegar et al., they concluded that the "study does not provide evidence that shade is a driving force in temperature change on these streams."[28] Similarly Meays et al. found that canopy cover alone was not sufficient to prevent water temperature from trending toward equilibrium with air temperature.[29] Carr et al. concluded that shade functioned in a subordinate role to climate in affecting stream temperature.[4]

#### *i. Vegetation*

The primary way that more shade could be provided along a waterway would be to increase the amount of vegetation growing on the banks.

The present vegetation currently along the river banks seems to be similar to what it was at the time of the first entry of Euro-American trappers into the upper Owyhee subbasin in the early 19th century. There is no evidence that at the time of Euro-American contact there was substantial riparian vegetation anywhere along the streams outside of the Bull Run and Independence Mountains (see the at contact section of the history component of this assessment).

The woody species which exist at higher elevations in the Bull Run and Independence Mountains do not naturally extend to lower elevations. There is not enough precipitation on the Owyhee plateau to support these species. Even along the streams, these species would have difficulty obtaining adequate water during many years of lower flow. In addition, a large portion of the stream banks have little capability to support vegetation due to their deeply incised position in bedrock and lack of sediment. There is little possibility of vegetation shading the river at these incised locations.

There is evidence that any woody vegetation which starts to develop along the banks has been periodically scoured away by flooding. In the Idaho South Fork Owyhee River TMDL, Ingham states that on the South Fork, "This flashy flow is the predominant cause for lack of established large woody vegetation."[27] Moseley explains that the snow accumulation zone for the South Fork "constitutes a small percentage of the South Fork basin, however, with most of it being arid lowlands of the plains. There is virtually no snow pack on the plains and streams tend to be intermittent and ephemeral, largely flowing during winter and spring and in summer only during storms. This makes for a very flashy hydrologic regime where the river rises rapidly and dramatically in response to spring snow melt patterns and episodic storm events, quickly returning to near base flow."[30] Although the USGS gage near Whiterock recorded a high discharge of 3200 cfs in 1957 (Figure 5.18), in 1993, the "USGS gauging station at Rome, Oregon, recorded a flow of nearly 48,000 cfs. On quick observation, the hydrographs for the Rome and South Fork stations appear similar. If this is (statistically) true, the 1993 discharge on the South Fork was around 9300 cfs, three times greater than the recorded high in 1957."[30]

*ii. Models*

In the Upper Owyhee TMDL, both the temperature standard established and the amount of shade required to achieve the standard were calculated using the Stream Segment TEMPerature model (SSTEMP). A wide variety of data is needed for the SSTEMP.* Due to the relatively few meteorological stations in the upper Owyhee subbasin, particularly in Idaho (Figures 5.1 and 5.2) and to the lack of stream gages for flow (Figure 5.15), many of the underlying parameters used can not be specific to a stream. To utilize the model for the TMDL, assumptions must have been made about the parameters for which no data is available.

If there are assumptions about vegetation distributions in the subbasin which are significantly different than those species found at present, they would be not be based of actual specie distributions but on the theoretically generalized site potentials and hypothetical ranges of native species. The primary limiting factor to the actual existence of a specie is rainfall.

### *f. Geology*

A factor affecting the temperature of the South Fork Owyhee River and possibly stretches of other streams in the upper Owyhee subbasin is the underlying geologic material. "The South Fork Owyhee River meanders through volcanic material of either basalt or rhyolite. Both materials are dark in nature and have high heat absorbing capability. These factors may impact the ability for cooling to occur both within the water column and the ambient air temperature."[27]

### *g. Conclusion*

Major causes of the high water temperatures in the upper Owyhee subbasin are water scarcity and heat load from solar and other ambient sources. Riparian shading is naturally limited by precipitation, scouring, and fire frequency. Objective thermal potential studies have not been made for the upper Owyhee subbasin.

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* Data and parameters needed for SSTEMP:[50]

Average stream width, elevation, and slope; streambed thermal gradient; shade factor or site latitude and azimuth, vegetation height, offset, density, and crown measurement if the shade model is used.

Average daily discharge at upstream boundary; average daily tributary inflows and outflows; average daily lateral inflows and outflows.

Latitude, elevation, mean annual air temperature at a representative meteorological station; average daily relative humidity, average daily relative sunshine; average daily wind speed; average daily extraterrestrial solar radiation; average daily solar altitude; (optional) observed solar radiation at ground level.

Average daily temperature at upstream boundary.

Average daily dust and ground reflectivity coefficients.

## I. Other pollutants

In addition to temperature, each of the states has a different list of pollutants or candidate pollutants (Appendices F, G, and H). Where the waters enter Oregon, currently only arsenic is considered an additional pollutant. Since aquatic life is the primary beneficial use of the Owyhee River in Oregon at the Idaho border, in the 2010 integrated report, Oregon also included other factors thought necessary for aquatic life. Phosphate phosphorus, alkalinity, ammonia, chloride, dissolved oxygen, and pH were all listed as being of potential concern or only attaining some criteria.

The East Fork of the Owyhee River in Idaho at the border with Oregon is not 303(d) listed for any pollutant. There is a political dilemma introduced by a river with water quality criteria that change as the river crosses the border between states.

### 1. Historic anthropogenic activities

Underground mining of copper-sulfide ore was conducted at the Rio Tinto Mine from 1932 to 1947. The mine sits above Mill Creek about 2.5 miles south of Mountain City. Since the underground operation closed, old tailings have been reworked and there has been leaching of both stockpile ore and of the underground workings. Acid mine drainage has degraded the water quality of Mill Creek and the East Fork Owyhee River.[32]

This legacy mining is believed to be a "major contributor of cadmium loads to Mill Creek" and is "a known contributor of copper loads to Mill Creek and the East Fork Owyhee River."[32]

### 2. Geologic sources

#### *a. Iron*

In Nevada, iron is a fairly common constituent of rock and soil. Throughout Nevada, waterbodies show fairly high concentrations of iron introduced by natural run-off and seepage. Anthropogenic activity at the Rio Tinto Mine site may be a significant contributor to iron in the Mill Creek drainage.[32]

#### *b. Arsenic*

Traces of arsenic in the watershed are from natural volcanic and subsequent hydrothermal activity with no other significant source.

#### *c. Mercury*

There are many natural mercury deposits in the upper Owyhee subbasin (see the background section). Mercury occurs naturally in the environment and the occurrence of mercury is not an issue of concern. Only concentrated levels of mercury are of concern because there is an increased likelihood of mercury release by natural or human processes.[216]

Mercury has not been a major problem in the upper Owyhee subbasin. However, it is listed as a possible impairment in Shoofly Reservoir in Idaho's 2010 Integrated §303(d)/§305(b) Report.[23]

Mercury is a problem when it ends up in fish tissue. Although larger amounts may affect adults, small amounts of mercury can damage a child's brain resulting in behavioral and learning problems.[42]

### 3. Dissolved oxygen

Oxygen solubility in water is inversely related to temperature. In other words, as water temperature rises, the solubility of oxygen is reduced.[18] The reaches of the streams of the upper Owyhee subbasin where the temperature is high can be expected to also have lower levels of dissolved oxygen than are recommended for fish.

Although concentrations of oxygen rise during the day when algae are creating oxygen as a byproduct of photosynthesis, algae uses oxygen at night so the concentrations go down.[18] Since the temperature of the river is a product of the natural conditions in the upper Owyhee subbasin, the amount of dissolved oxygen is controlled, at least in part, by water temperature fluctuations.

### 4. Phosphorus

Both phosphorus and nitrogen are essential to aquatic plant growth. However, high levels of phosphorus may lead to too vigorous growth and algal blooms. The overabundance of phosphorus in warm surface water promotes the growth of algae. When unusually large amounts of phosphorus overpower a body of water, they cause a sharp increase in algae production known as an algal bloom. As the large mass of algae begin to die, vast amounts of oxygen are used in the decomposition. Little oxygen remains for the fish.[26]

Volcanic ash, lava flows, or basalt often contain relatively high concentrations of phosphorus as compared to many other rocks.[18] Some western SRP lavas contain anomalously high concentrations of phosphate.[54] Many soils in the upper Owyhee subbasin are believed to be naturally high in phosphorus.[32]

Where Idaho has monitored phosphorus in water samples, it has not found high phosphorus concentrations in the upper Owyhee subbasin that would indicate impairment of beneficial uses.[20,27] An anomaly exists on Nickel Creek. The system seems to be phosphorus deficient, limited by low phosphorus concentrations. The creek is spring fed, and "it would appear that phosphorus would be limited since natural bioavailable forms of phosphorus in ground waters are usually found in very low concentrations."[20]

The United States Geological Survey (USGS) sampled the Owyhee River at several points between the Oregon state line and the Owyhee Reservoir in 2001 and 2002 in cooperation with the Vale office of the BLM. The water at each site was sampled once each in April 2001 and April 2002.[18]

Figures 8.21 and 8.22 show graphical comparisons of the sediment and phosphorus in the water of the Owyhee River at seven sampling sites progressively downstream. OR7 is at the Idaho border, OR6 above the confluence with the West Little Owyhee River, OR5 at Three Forks, OR4 at Rome, OR3 below the Crooked Creek confluence, OR2 at Bull Creek, and OR1 at Birch Creek.[18]

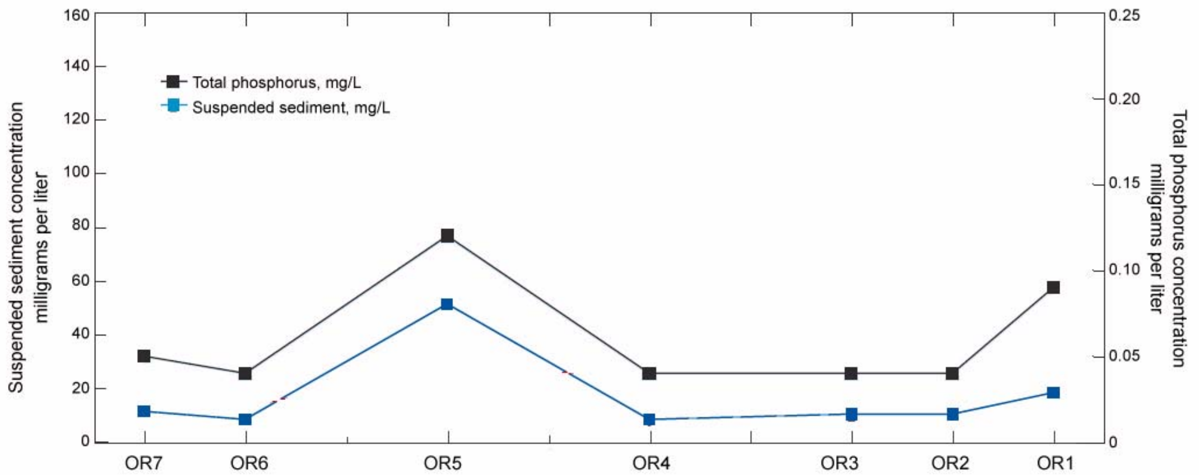


Figure 8.21. Comparison of phosphorus concentrations and suspended sediment concentrations in the Owyhee River, April 2001

An analysis of the data shows a linear relationship between the amount of sediment and the amount of phosphorus. As the amount of sediment increases, the amount of phosphorus increases. This indicates that much of the phosphorus load is being transported with the sediment. The highest concentrations of sediment increase exponentially with increased runoff.[45] We infer that the largest phosphorous loads being carried by the Owyhee River occur at times of peak flow.

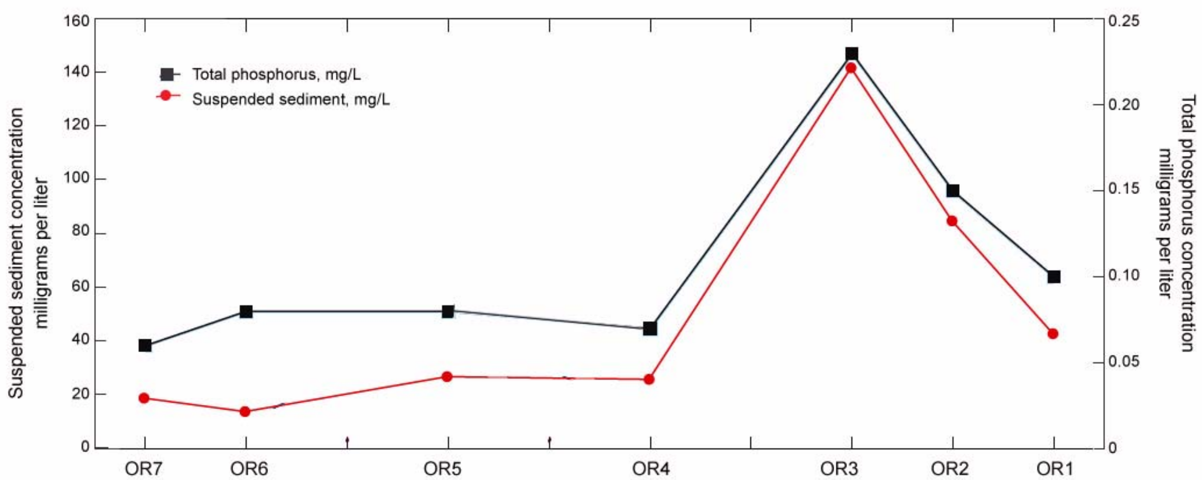


Figure 8.22. Comparison of phosphorus concentrations and suspended sediment concentrations in the Owyhee River, April 2002

Phosphorus loads may be originating from naturally occurring watershed and stream bank erosion. Other disturbed land may also be more subject to erosion. However, identifying the exact sources and pathways of phosphorus enrichment is difficult due to lack of detailed data.

## 5. pH

The pH of stream water tends to be increased by the photosynthesis of aquatic plants during the day and decreased by the respiration of plants and animals at night.[18]

Sulfides such as those found in the area of Mountain City-Patsville-Owyhee may also affect the pH. Calcium carbonate is widespread in the upper Owyhee subbasin and causes the waters to generally have a pH above 7.

## J. Beneficial uses

Since cold water aquatic life and salmonid spawning were beneficial uses assigned to Deep Creek, Pole Creek, Castle Creek, and Red Canyon Creek, in the Idaho 2003 TMDL, the DEQ judged these streams as being water quality limited due to temperature. The temperature criteria used in the TMDL for cold water aquatic life was less than a maximum of 22°C (72°F).

In their 1996 survey of streams of the upper Owyhee subbasin in Idaho, Allen et al. did not find any redband trout in the Little Owyhee River, the South Fork Owyhee River, Blue Creek, Little Blue Creek, or Shoofly Creek. Four redband trout were found on the Owyhee River above Crutcher's Crossing.[1] In 1993 and 1997 no redband trout were found in Deep Creek, although a 1977 survey had found redband trout. The 1997 survey found a low density of redband trout in Red Canyon Creek and in the Owyhee River near the mouth of the creek. Floating the Owyhee River in July 1997, five fish biologists "extensively fished the river while paddling downstream, and only one redband trout was captured by angling in the Idaho reaches of the Owyhee River."[2]

Desert redband trout inhabit streams which appear to have unusually high temperatures.[59] Several studies have investigated the possible mechanisms which the subspecies employs to deal with these high temperatures. In northeast Oregon stream reaches, when the afternoon stream temperatures were highest, 10-40% of the redband trout occupied thermal refugia.[58] "However, whether individual redband trout respond to summer temperature extremes by moving sizable distances has not been investigated."[59]

Although there are redband trout in some of the streams of the upper Owyhee subbasin, designating cold water aquatic and salmonid spawning as beneficial uses needs to be site specific and will not apply to many of the streams of the subbasin. Even in those streams with redband trout, they may be retained in stream reaches by isolated cold water refugia and cold water aquatic life may be an inappropriate designation for the whole stream.

The CWA provides a method of changing a designated use. This assessment presents data which should be taken into account in evaluating the attainability of water quality criteria mandated by a specific designated use.

## K. Need for water standard based on natural conditions

The basis of the temperature standards is rooted in opinions of what the temperature should be, not based on the environmental potential to provide cool and cold water.

The Idaho Division of Environmental Quality studied the inconsistencies between water temperatures and fish data that indicated viable, self-sustaining assemblages of fish existed. They concluded that "current water temperature criteria for Idaho appear to be not working well since they do not comport with biological reality"[17] and suggested that a scientific basis be developed for water quality to assure the relevance of temperature data. Climatic and geographic differences were postulated as primary factors affecting natural stream temperatures. A factor presented to account for the discrepancy between stream water temperatures and the presence of salmonids was the presence of thermal refugia.[17]

Redband trout "appear to have the capability to adapt to adverse conditions, such as low or intermittent flows, and water temperatures greater than 28°C."[27] In his preliminary assessment of the South Fork in Nevada, Pahl states that "According to NDEP files, the current temperature standard was set to protect rainbow trout. Under the current standards review process, the [actual] needs of the redband trout should be considered."[43]

The redband trout of the desert basins of the western states are thought "to have evolved adaptation to live in harsh environments characterized by extremes in water temperature and flow." They have been observed feeding at water temperatures of 28.3°C in Chino Creek, a Nevada tributary of the Owyhee River.[43]

There are inland redband trout in the upper Owyhee subbasin. The stream temperatures in the subbasin frequently exceed the criteria established for redband trout. The temperature criteria guidelines were developed by the EPA. They recognize that there may be inconsistencies and provide some alternatives to using the recommended "biological numeric" criteria. States may adopt a "narrative natural background provision that takes precedence over numeric criteria when natural background temperatures are higher than the numeric criteria. This narrative can be utilized in TMDLs to set water quality targets and allocate loads."[36] However, if the narrative standards are composed of unrealistic expectations of stream shading, an unattainable criteria of shade could be substituted for unattainable temperature standards. Realistic narrative standards could be based existing knowledge of geology, historic information including early accounts of vegetation and streamflow, and the last century's records for air temperatures and streamflows.

New temperature standards for the streams of the upper Owyhee subbasin need to be developed that take into account the natural condition of the water and the climate of the upper Owyhee subbasin. They also need to take into consideration the biological adaptations of species present in the environment.

## L. Conclusion

Immense data gaps exist in determining whether the streams of the upper Owyhee subbasin meet the goals of the Clean Water Act. What are the naturally occurring conditions of the subbasin? How do these conditions determine whether designated uses are actually attainable or are only an idealized vision of what would be desirable? Will establishing standards result in economic hardships directly contravening the CWA statement that "regulations are not intended to result in standards that are so stringent that compliance would cause severe economic impacts."[11]

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# Upper Owyhee Watershed Assessment

## IX. Sediment Sources



### Contents



The Oregon governor's strategic initiative for ensuring sustainable water resources for Oregon's future, Headwaters 2 Ocean, considers all water resources from the ridge tops to the Pacific Ocean. The completion of the assessment of the upper Owyhee subbasin is consistent with the governor's initiative. The upper Owyhee subbasin contains the headwaters of the Owyhee River and two of its principal tributaries, the South Fork Owyhee River and the Little Owyhee River.

# IX. Sediment sources

Sediment enters rivers from water runoff from the basin that is being drained. The greatest movement of sediment to the rivers is dependent upon extreme weather events that create substantial surface runoff. This section considers runoff as well as the resulting sediment loss, or erosion, principally from rangelands. As a precursor, soils are discussed. The composition and amount of the sediment that enters streams and rivers is influenced by the types of soils found within the drainage basin and the vegetation that covers the soil.

## A. Soils

### 1. Basics of soil

Soil can be defined as the product of weathering processes. Physical weathering breaks rock down into minerals, but does not change the composition of the original rock. The amount of physical weathering generally affects the grain size. Since chemical weathering alters the mineral composition of rocks, it slowly removes the least stable minerals.

The make-up of soil is controlled by six factors: the original bedrock, time, vegetation, slope, precipitation, and human action. The minerals that make up the soil begin with those which were in the **bedrock**. The bedrock breaks into smaller particles with weathering. **Time** is also a factor in soil development; the longer a soil has been exposed to the surface the more weathering can occur. **Precipitation** serves as a basic control on the amount of chemical weathering that goes on in the soil by providing water to carry away dissolved minerals and help facilitate soil development. The **vegetation** growing on any spot of soil can change the soil chemistry by taking up nutrients, by providing organic matter from fallen leaves and dead plant parts, by rain leaching nutrients from the plants into the soil, and by the root structure helping secure the soil in place. The **slope** of the land surface determines in part the stability of the soil surface. Steep slopes that are prone to landslides will have little chance for soil development as the slides remove developing soils. On a smaller scale, any hill slope will experience erosion while flat areas have greater opportunity to hold onto soil. **Human action** can change soils by adding organic matter, removing vegetation and adding mulch. Human action is most pronounced in areas with long term agriculture, road development, or urbanization, for example some soils in Europe have experienced so many years of mulching that their present composition is greatly influenced by human action. The development of a soil, also known as **pedogenesis,** is controlled by these six factors.

Soils are described on the basis of a **soil profile**, a description of the physical and chemical characteristics of the soil from the surface to the bedrock.[18] Researchers dig multiple holes across the landscape to map out a soil type and its variations. To describe soil, scientists designate **horizons**, or layers that have consistent physical and chemical characteristics. The combination of horizons found in a single hole allows a researcher to classify the type of soil they have found. In addition the soil scientist uses principles of geology to understand the distribution of soils because different parent materials and different land forms, like hills, slopes, and flood plains will have different types of soil.

## 2. Desert soils

"The climatic regime of arid lands can be expressed as one in which potential evaporation greatly exceeds precipitation during most of the year, and no or little water percolates through the soil. This implies of course a slow rate of chemical weathering and other water based chemical transformations, a low rate of biological activity because of water stress on plants of all kinds, and a consequent reduction of plant cover."[9:16] While semiarid climates, like the upper Owyhee subbasin, have a slightly higher quantity of precipitation than arid climates, chemical weathering is less rapid than physical weathering. One of the results of less chemical weathering is that, "soils inherit many of their characteristics from the parent material"[9:17] With physical weathering, the bedrock is broken down into smaller and smaller pieces, but it is not transformed chemically into another type of mineral.[19] Physical weathering in the form of extreme rainfall is recognized as one factor driving erosion and creating differing soils on slopes and flood plains.[54]

The other defining characteristic of soils in arid and semiarid environments is that regular precipitation events do very little leaching of minerals from the soils. This can leave layers within the soil with high concentrations of salts. "The most striking feature of desert soils is the presence of layers of accumulation of calcium carbonate [or lime], gypsum, sodium chloride or other salts."[9:17] At times these salt layers become so cemented that they inhibit the growth of plant roots. In arid and semiarid environments the development of salt concentrations is normally a factor of soil age.[9] Layers of sodium chloride and calcium carbonate (know locally as caliche) are commonplace in deeper soils. After rainfall, the water percolates through the soil to a depth determined by the amount of precipitation. In deep soils with semiarid climate, the water stops percolating before moving through all the soil. In lower low lying parts of the Owyhee drainage that were converted to irrigated agriculture, especially flood plains, caliche and salt layers had to be broken and dispersed by deep plowing to allow crop production. Many desert soils not suited to agriculture also have layers of caliche. Examples include deep soils of the YP desert and on Tuscarora’s alluvial fans. Where caliche exists, rain and snow melt water can not enter deep aquifers.

### *a. Factors in desert soil formation*

Soil formation does not occur in isolation from other ecosystem processes. Climate, vegetation and geology all influence soil. And, soil in turn influences the growth of vegetation and the break down of bedrock.

"The scarcity of vegetation limits the amount of residue available for soil organic matter production in arid climates. Since nitrogen is carried in soil organic matter, it is low in desert soils."[19:40] In addition, temperature controls the rate of decomposition of organic matter. In warm, moist climates, organic matter decomposition takes place year round, in colder climates decomposition only occurs in the warmer months. In semiarid climates decomposition only occurs during brief periods of warm and wet soil conditions. The cycling of organic material is dependent upon microorganisms in the soil that break leaf litter and branches into their component parts.[15,19]

In deserts most rain "falls rapidly. Soil washing, erosion and runoff are intense. The high runoff rate further reduces the rain's effectiveness for plant growth except along stream channels, arroyos, and valleys were water accumulates. Shrubs and trees grow more densely along these water drainageways, and soils show the effect of more organic matter."[19:40] "The consequences of the high-intensity rain are rapid runoff and accelerated erosion."[15:208] Low topographic areas accumulate soil while the high plateaus and slopes lose soil to erosion.[50]

While erosion of desert soils is often high, topography, vegetation, and storms play into how erosion actually works. Soil loss is greater when either the steepness or length of a slope increases. "Longer slopes are more susceptible to erosion on the lower end because more water accumulates on long than on short slopes. Vegetation directly affects the erosion hazard in two ways: (1) plant canopies and residues reduce the impact of raindrops on the soils surface; and (2) anchored vegetation slows water movement across the land"[15:208] Another aspect of erosion is the duration of rainfall; the longer the duration the more likely that the soil's maximum water infiltration rate will be exceeded. It is when infiltration rates are exceeded that water runs across the surface of the ground because it can not be absorbed. This is more likely if the rain is very intense or lasts for a long time.[15,38]

Soil moisture is controlled by infiltration rates (the rate at which soil can absorb rainfall) and the soil water holding capacity. The water holding capacity of a soil is based on the type and quantity of pores it has and its depth. "Rain in the arid regions tends to come in high-intensity storms in which the rainfall rate greatly exceeds the infiltration rate."[15:208] After rainfall, the water held within the soil will be depleted as atmospheric evaporation and plant transpiration use the water. "Water storage is greatest when the initial evaporation rate is high and a dry surface soil is formed rapidly."[15:211] This means that the flow of water between pores in the soil does not continue to bring deeper water to the surface where it will be evaporated. A study on water retention in semiarid soils of New Mexico showed that "moisture conditions most favorable for plants occurred in areas where: (1) the landscape was level or nearly level, with little or no evidence of erosion; (2) there was a thin coarse-textured surface horizon to permit maximum infiltration of moisture; and (3) the subsoil was fine textured and/or indurated [had a hardened layer] to prevent deep moisture movement. A coarse-textured surface soil not only permits rapid infiltration of water but also [the surface] dries rapidly and protects subsoil water from evaporation losses."[15:212]

### *b. Soil nutrients*

Certain types of desert vegetation alter the soil in which they live by accumulating soluble minerals, normally salts. "The soil located under and in close proximity to these plants may take on a wholly different physical character."[19:40-41]

The availability of soil nutrients to plant life is dependent upon the organic material produced by vegetation growing on the soil which is subsequently deposited as litter from leaves, seeds and wood.[50] Plants need nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and micronutrients.[18] Normally these nutrients become available for plant uptake from chemical weathering of the soil such that it is broken into component minerals. Because chemical weathering rates are reduced in desert soils, there are less nutrients available for plant use. Additionally, plants need a certain balance between nitrogen, phosphorus, potassium, and other nutrients. In desert soils, generally nitrogen and phosphorous levels are often insufficient for maximum growth.[18]

Desert soils are also known for their spotty distribution of nutrients. The areas around shrubs where organic litter is greatest generally have higher quantities of phosphorus, potassium and nitrogen.[40,41] This patchy distribution of nutrients is very good for the shrubs, but can have long lasting effects on fertility even after shrublands have been turned to grass.[41] The processes that lead to the development of shrub patches with high quantities of nutrients are still unknown.[41] Schlesinger and Pilmanis suggest that the formation of these islands of fertility may be due, in part, to the collection of a soil mound around the base of the shrubs, the sediment coming from wind erosion of the open spaces between shrubs.[40] The formation of nutrient rich zones around desert shrubs allows for the continuation of shrub vegetation. And, the replacement of grassy deserts with shrub deserts generates an increase in the amount of dust, and hence the patchy nature of the soil.[40]

### 3. Soil classification system

The United States has developed a classification system to describe all soils. The classification has orders, suborders, great groups, subgroups, families and series. Each stage of the classification process describes the soil profile in greater detail.[314,388]

The United States Geological Service (USGS) surveys show that most soils in the upper Owyhee subbasin fall into the orders of Aridisols, Entisols, or Mollisols.

"Aridisols are mineral soils of the arid regions. They have a low organic-matter content. During most of the time when temperature range is favorable for plant growth, the soils are dry or salty, with consequent restrictions on growth. During the warm season, there is no period of three months or more when soil moisture is continually available to plants, except in places where a water table is close to the surface."[15:42] Common aspects of aridisols are a layer of pebbles on the surface of the ground and a subsurface zone where salts have accumulated to form a hard or cemented layer. However, for soils to form distinctive layers throughout their depth they must be on relatively stable landforms, where erosion is minimal. On some desert tablelands with resistant geological layers, such as basalt, clay rich soils will form when the tableland is "isolated for tens or hundreds of thousands of years."[15:49]

Entisols have no development of layers within the soil that show distinctive physical or chemical modification to the parent material and, as such, are lacking layers referred to by soil scientists as pedogenic horizons. "Entisols are mineral soils showing little or no development of pedogenic horizons. . . . Pedogenic horizons have not formed because, primarily, the soils are too young due to recent deposition of fresh material or to [the natural] eroding away of the previous surface."[15:43] An example of an entisol would be a sand dune, where the is no differentiation between sand at the top where plants are growing and the mineral sand that formed the dune. Other entisols occur in areas of recent deposition such as flood plains and areas of ongoing erosion such as hill slopes.[15] Shallow stony soils over bedrock also fall in this category, including some soils of the basalt landscape of the upper Owyhee subbasin.

Mollisols are soils that generally develop under grasslands and steppe vegetation. They have a high content of organic matter that darkens the color of the soil and they are relatively fertile. The climate regimes where they develop vary from semiarid to semi-humid. Common parent materials are loess, sand, and limestone. The majority of the world's mollisols are used for agriculture.[6,52] In semiarid areas there is a subgroup of mollisols (xerolls) that develop on sites that are generally dry. "Those occurring in the United states have native vegetation of bunchgrass (e.g., *Festuca*, *Agropyron*, and *Pseudoroegnera* spp.) and shrubs (e.g., *Artemisia* spp. and *Purshia*), or savannas of grass with scattered trees. The xerolls are extensive in the Palouse loess region of Washington, Idaho, and Oregon and are widely scattered throughout the states west of the continental divide."[7:327]

### 4. Data on soils in the upper Owyhee subbasin

Soils in the upper Owyhee subbasin in Idaho and Nevada have been surveyed. The soil survey includes maps that break down every field into specific named soil series. The soil series are based upon physical and chemical characteristics and subsequently each series is divided by soil texture and slope. This detail can be overwhelming, but is very useful for planning purposes such as choosing appropriate locations for road construction or the installation of waste treatment facilities.[5,6,14,20]

Soils vary significantly across landscape features so that the soils found on flood plains, plateaus, and in the mountains are different. Generally areas where agriculture is productive have soils that are deeper, with less rock, and greater quantities of nutrients. Some of the soils found in the upper Owyhee subbasin are described below (Figure 9.1).

#### *a. Agricultural soils*

##### *i. Around Riddle*

The agricultural soils around Riddle are found in bottom lands and have deep deposits of fine grained sediments. The sediment derives from alluvium that has been transported by the creeks. The soil is classified as a mollisol.[20,48]

Properties and qualities
- Slope: 0 to 1 percent
- Depth to restrictive feature: More than 80 inches
- Drainage class: Poorly drained
- Depth to seasonally high water table: About 12 to 18 inches
- Available water capacity: High (about 11.2 inches)

Parent material: Loamy alluvium

Typical profile
- 0 to 9 inches: Loam
- 9 to 60 inches: Stratified sandy loam to silty clay loam

Runoff: Very slow

Hazard of erosion: Slight by water or wind

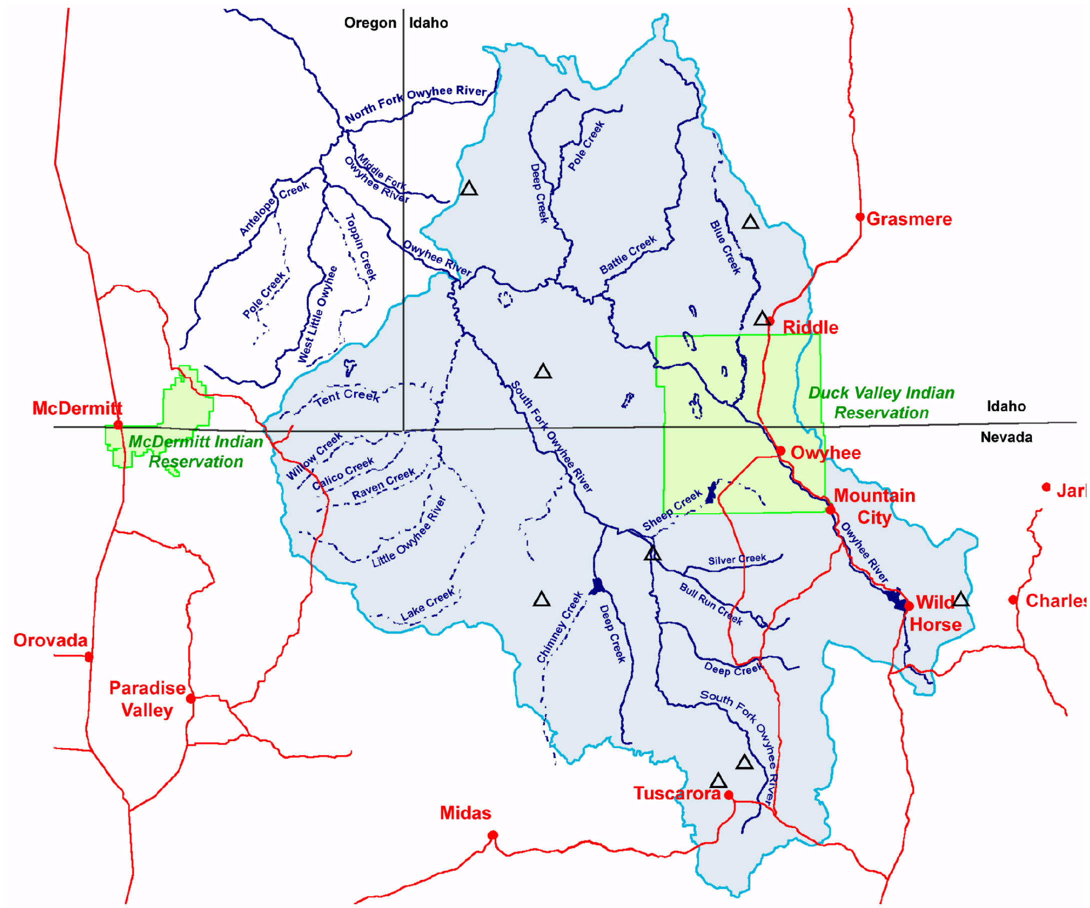


**Figure 9.1. Soils from the upper Owyhee subbasin discussed below are indicated with triangles on this map.**

### *ii. Flood plain sediments along the South Fork Owyhee River and tributaries*

Along flat creek courses in wider valleys flood plains can form. The soils found along the flood plains in the upper Owyhee subbasin are very important economically. These are areas where better stands of vegetation can survive the dry summers. The flood plains with productive soils are found outside the entrenched portions of stream channels. They are generally used for hay land and pasture. Locations in the subbasin where these soils can be found include some areas along the South Fork Owyhee River, Sheep Creek, Bull Run Creek, and Silver Creek.[6,48] In technical terms these flood plain soils are classified in the mollisol order.[7]

Properties and qualities
* Slope: 2 to 4 percent
* Depth to restrictive feature: More than 60 inches
* Depth to seasonal high water table: 48 to 72 inches
* Available water capacity: 9.6 to 13 inches (high)

Parent material: Alluvium derived from mixed rocks and volcanic ash

Typical profile
* 0 to 9 inches: Loam
* 9 to 61 inches: Stratified sandy loam to silty clay loam

Runoff: Very slow
Hazard of erosion: Slight by water or wind

Another type of flood plain is that immediately adjacent to the stream channels. It is composed of the same materials as the other flood plains, but it is more frequently flooded, of more recent deposition, and at greater risk for erosion from floods. Flood plains immediately adjacent to stream channels are often considered to be riparian areas. Along the South Fork Owyhee River and tributaries these sediments are more frequently, naturally eroded and deposited. The scientific evidence for this is that these soils are of more recent deposition.

**Photo 9.1. The greater availability of water and grassy vegetation on flood plains in the upper Owyhee subbasin led to the formation of soils distinct from those in surrounding uplands.**

In other locations along the creek corridors where the water course is steeper or confined to a narrow channel the recent erosive and depositional events are not recorded in the soil surveys. Beaches, gravel bars, and similar unconsolidated materials that are deposited naturally along the banks of steeper stretches of creeks are not considered to be soils for the purpose of survey (they can change and move quickly).

*iii. Independence Valley*

The flood plains of Independence Valley have very deep, poorly drained, and slowly permeable soils.[14] The soils are composed of fine grained materials that have

**Photo 9.2. Gravel bars deposited along river courses are not considered to be floodplain soils because they frequently change location.**

been transported into the valley by the creeks.[5,6,48] These soils have developed with grassland cover and are classified in the mollisol order.

Properties and qualities:
* Slope: 0 to 2 percent
* Depth to restrictive feature: More than 80 inches
* Drainage class: Poorly drained
* Depth to water table: About 12 to 18 inches
* Frequency of flooding: Frequent
* Available water capacity: High (about 10.6 inches)

Parent material: Mixed alluvium
Typical profile:
* 0 to 4 inches: Silty clay loam
* 4 to 37 inches: Silty clay
* 37 to 60 inches: Silty clay loam

Runoff: Slow
Hazard of erosion: Slight by water or wind

Much of Independence Valley is used to grow hay and pasture grass.

The soils in the upper Owyhee subbasin that are currently used for agriculture and irrigated along rivers and streams are loams. The soils have a high available water capacity, are often poorly drained and are periodically flooded by the nearby creeks.

The agricultural soils are classified in the mollisol soil order. The properties of the soil that led to this classification are the result of a long time of soil formation. The soils were formed by the deposition of clay and silt sized particles during flood events. These materials originated from erosion upstream. Soil formation also included the accumulation of organic debris and nutrients from grassland/shrub vegetation cover and periodic flooding.[7]

### ***b. Upland soils***

Upland soils are found across the wide expanses of the upper Owyhee subbasin. In area covered, these are the predominate soils. Comparatively, these soils support less vegetation and hold less moisture than those used for agriculture. Below are two examples of upland soils.

#### *i. YP Desert between Lookout Butte and the South Fork Owyhee River*

Soils of the tablelands of the YP Desert are derived from volcanic ash, loess and/or welded tuff.[20,48] A sample soil profile from this area comes from between Lookout Butte and the South Fork Owyhee River. It has a duripan between 20 and 40 inches in depth and a moderate hazard of erosion. In shallow excavations, the sides of a hole will cave in as the particles are not strongly held together.

Properties and qualities
* Slope: 2 to 8 percent
* Depth to restrictive feature: 20 to 40 inches to duripan
* Depth to water table: More than 80 inches
* Available water capacity: Low (about 4.4 inches)

Parent material: Volcanic ash, loess, and/or mixed alluvium derived from welded tuff and basalt
Typical profile
* 0 to 3 inches: Silt loam
* 3 to 20 inches: Clay loam
* 20 to 30 inches: Gravelly sandy loam
* 30 to 38 inches: Cemented material
* 38 to 60 inches: Very gravelly loamy sand

Runoff: Slow or medium
Permeability: Moderately slow
Hazard of erosion: Moderate by water and wind.

### *ii. Between Blue Creek Reservoir and Turner Table*

Soils in the upland area between Blue Creek Reservoir and Turner Table are very shallow ending in bedrock. There are many cobbles and rock fragments within the soil.[20,48]

Properties and qualities:
* Slope: 1 to 20 percent
* Depth to restrictive feature: 20 to 40 inches to lithic bedrock
* Depth to water table: More than 80 inches
* Available water capacity: Very low (about 2.4 inches)

Parent material: Volcanic ash and slope alluvium over bedrock derived from tuff breccia
Typical profile:
* 0 to 11 inches: Stony sandy loam
* 11 to 25 inches: Very cobbly sandy clay loam
* 25 to 28 inches: Extremely cobbly sandy clay loam
* 28 to 38 inches: Unweathered bedrock

Runoff: Slow to Rapid
Hazard of erosion: Water - slight to moderate, Wind - moderate

Where the bedrock is closer to the surface, 10 to 20 inches, the soil is stonier. These shallower soils are more common near hill summits.[20,48] The bed rock of volcanic origin provides all of the minerals found in the soil.

Parent material: Volcanic ash and colluvium over bedrock derived from volcanic rock
Typical profile:
* 0 to 5 inches: Stony loam
* 5 to 12 inches: Cobbly clay loam
* 12 to 19 inches: Very cobbly clay
* 19 to 29 inches: Unweathered bedrock

**Photo 9.3. A stony upland soil.**

**Photo 9.4. The shallow soils of the uplands in the upper Owyhee subbasin are subject to more erosion where they are disturbed by unimproved roads than where they are covered by vegetation.**

Across the uplands of the upper Owyhee subbasin the soils are similar to the examples above. They are typically stony and shallow. Many times the sediments are poorly held together so they can erode more easily than the agricultural soils. Where cut by road banks or excavation these soils lose the natural protection from erosion that is provided by the shallow slope of the plateaus. Plant growth is limited in these soils. The soils have bedrock or duripans close to the surface that restrict the depth to which plant roots can grow and the depth of soil that can hold useable water for plants. The soils are nutrient poor and dry for long portions of the year. They are classified in the Aridisol soil order.

### *c. Playa lake bed soils*

Playa lake beds are unique features in the landscape of the upper Owyhee subbasin. They occupy very little of the total region but are included here because their soils are significantly different from surrounding upland regions.

Playas are locations where water accumulates and evaporates. These are the end of the line for the sediment that water is carrying. The sediment in a dry lake bed is the smallest sized particles, clays and silts, that erode easily. The modern playa lakes in the upper Owyhee subbasin are fairly small and are only flooded occasionally. As flooding is occasional, the lake beds are ranked as only fair habitats for shallow water areas and wetland wildlife.[6,48]

Properties and qualities
* Slope: 0 to 2 percent
* Depth to restrictive feature: More than 80 inches
* Drainage class: Very poorly drained (percolation is slow)
* Depth to temporary water table: About 6 to 18 inches
* Frequency of flooding: Occasional
* Available water capacity: High (about 9.1 inches)

**Photo 9.5. Playa lake beds accumulate recent deposits of fine sediment with some rocks on the surface.**

Parent material: Alluvium derived from mixed rocks, loess and volcanic ash
Typical profile
* 0 to 4 inches: Silt loam
* 4 to 60 inches: Clay

During the last glaciation the climate was wetter and lots of clay sized particles were deposited over larger areas where the lakes from that era existed. The older playa surface has rock fragments over clay.[6,48] Differences in soil for a remnant playa include:

**Photo 9.6. The recently deposited, fine grained sediments at reservoirs are similar to those found at playa lakes and, likewise, are at risk for erosion.**

Properties and qualities:
* Depth to water table: More than 80 inches
* Frequency of flooding: Rare

Typical profile
* 0 to 5 inches: Cobbly silt loam
* 5 to 60 inches: Clay

Soils from playa lake beds were formed out of alluvium, derived from the local rocks, that was transported in runoff from the region. They are deep deposits of fine grained sediments with no structure holding them together. The soils are classified as entisols. They are the result of recent deposition and erode easily.

Playa lake bed sediments are the product of years of the same processes that are now going on around reservoirs in the upper Owyhee subbasin. Fine grained sediments derived from the loess and volcanic rocks in the subbasin are transported by water and deposited where the water accumulates and later the soil dries. Over time the clay particles deposited at reservoirs will form thick clay soils. The recently deposited sediments of clay and loam sized particles do not have a strong soil structure and erode easily.

### *d. Mountain soils*

Mountains by definition are high point on the landscape with steep slopes. At these high locations the soils are derived from immediately adjacent bedrock. By contrast, a flood plain will be composed of a mix of sediments derived from throughout the drainage basin above it. The steep slopes of mountains are at a greater risk of sediment erosion from rock fall and surface runoff. The hazard of erosion can be reduced by plant cover. Plant cover, however, will not stop all erosion. In some very steep mountainous regions there is no soil due to frequent rock fall and avalanche events. These areas are termed scree or talus slopes.[55]

*i. Juniper Mountain*

The east side of Juniper Mountain in Idaho is within the upper Owyhee subbasin. The soils are derived from the volcanic rocks prevalent in the area.

Properties and qualities
* Slope: 5 to 25 percent
* Depth to restrictive feature: 40 to 60 inches to lithic bedrock
* Depth to water table: More than 80 inches
* Available water capacity: Low (about 5.3 inches)

Parent material: Volcanic ash and colluvium over bedrock derived from basalt, tuff breccia and/or welded tuff

Typical profile
* 0 to 1 inches: Slightly decomposed plant material
* 1 to 10 inches: Stony loam
* 10 to 25 inches: Very gravelly loam
* 25 to 57 inches: Extremely gravelly sandy loam
* 57 to 67 inches: Unweathered bedrock

Runoff: Slow to moderate

Hazard of Erosion: Slight by water and wind

The mountain soils of Juniper Mountain are generally deep with a high quantity of rock. The vegetation cover is good because it contributes a layer of decomposed plant material to the soil surface, however, when the soil dries it can not hold much available water for plants.

In some of the mountainous terrain the rocks are closer to the surface and the soils are shallower. Where soils are shallower, less vegetation grows, runoff is moderate to rapid and there is a greater hazard of erosion.

*ii. Wild Horse*

East of Wild Horse the side of Haystack mountain has very rocky soils on steep slopes. This mountain is of the identical geological formation as the Bull Run and Independence Mountains. The soils generally end at unweathered bedrock. The suitability of these soils for wild herbaceous plants and shrubs is rated as fair and they are poorly suited to range seeding operations. Rapid runoff on these steep mountain slopes presents a high hazard of sediment erosion.[5,48]

**Photo 9.7. The steep talus slope of this peak in the Independence Mountains does not support soil.**

Properties and qualities
* Slope: 50 to 75 percent
* Depth to restrictive feature: 20 to 40 inches to lithic bedrock
* Drainage class: Well drained
* Depth to water table: More than 80 inches
* Available water capacity: Very low (about 2.8 inches)

Parent material: Residuum and colluvium derived from mixed rocks, loess, and volcanic ash

Typical profile
* 0 to 6 inches: Very gravelly loam
* 6 to 27 inches: Very gravelly clay loam
* 27 to 31 inches: Unweathered bedrock

Runoff: Rapid

Hazard of erosion: High by water, slight by wind

**Photo 9.8. The rubble left from historic mining operations around Tuscarora is unconsolidated.**

### *iii. Tuscarora*

The hillsides around Tuscarora have been heavily impacted by mining and travel of recreationists. On aerial photos it is possible to see the scars left on the landscape. In the immediate mine areas the original soils have been completely removed. The rubble left from mining is unconsolidated, has not been reclaimed, and has few soil properties. Loose rubble has a great erosion hazard. The majority of the visible mining scars are located on the hill slopes. The characteristics of soils from the hills of Tuscarora from spots not directly impacted by mining are discussed below.[6,48]

The landscape can be divided into hill slope soils with bedrock close to the surface and soils on alluvial fans closer to the valley floor.[6,48] Characteristics of a hill slope soil follow:

Properties and qualities
* Slope: 8 to 15 percent
* Depth to restrictive feature: 14 to 20 inches to lithic bedrock
* Depth to water table: More than 80 inches
* Available water capacity: Very low (about 1.6 inches)

Parent material: Residuum derived from volcanic rocks

Typical profile
* 0 to 12 inches: Very gravelly loam
* 12 to 17 inches: Very gravelly clay
* 17 to 21 inches: Unweathered bedrock

On the hill slopes the bedrock is very close to the surface of the soil. Even under undisturbed natural conditions the sediment is not held well in place and has little water holding capacity to support vegetation.

On the alluvial fans a duripan affects water movement. The duripan restricts the permeability and is restrictive to plant root growth. The soil has a hazard of erosion by water and blowing soil. Furthermore the soil is not suited for paths and trails because it erodes easily.[6] An alluvial fan soil description follows.[6,48]

Properties and qualities
* Slope: 2 to 15 percent
* Depth to restrictive feature: 20 to 36 inches to duripan
* Depth to water table: More than 80 inches
* Available water capacity: Low (about 4.9 inches)

Parent material: Alluvium derived from mixed rocks, loess and volcanic ash

Typical profile
* 0 to 10 inches: Gravelly loam
* 10 to 30 inches: Clay
* 30 to 48 inches: Indurated
* 48 to 60 inches: Stratified extremely gravelly sandy loam to gravelly sandy clay loam

Soils of both the hill slopes and fans around Tuscarora were susceptible to sediment erosion before mining. The intensive use of this area, building of trails, and piling of mining waste rock are additional human factors promoting erosion.

## 5. Soils summary

Most of the soils in the upper Owyhee subbasin have not been substantially modified by human occupation. Very little of the upper Owyhee subbasin has been developed. The soils in the region, as would be expected, share many characteristics with soils in other arid areas. Landform is a major component contributing to characteristics of soils, such as their depth, ability to support plant life, erodability, and particle size.

Soils in the mountains are generally shallow, support little vegetation growth, have lots of gravel, and are susceptible to erosion. The soils described above for mountainous regions of the upper Owyhee subbasin are xerolls, a subgroup in the mollisol soil order. These soils are rich in organic matter from the bunch grass and shrub vegetation that grows on them, but are dry for much of the year. Limitations to plant growth come from the semiarid climatic conditions and shallow soil depths.

Soils from the expanses of plateau are generally shallow, rocky and have a cemented layer close to the surface. These soils hold little moisture and fall within the aridisol order. Soils within the aridisol order were expected for this region because of the semiarid environment.

Soils from the flood plains and valley bottoms are classified in the mollisol order. From this we know that these areas have long been covered in organic rich grassland and/or shrub vegetation. The soil characteristics that will lead to this classification have formed over time and with specific vegetation.

On the playa lake beds the sediments are composed of very fine particles, clay and silt. These fine particles have been deposited recently. The soils are at a great hazard for erosion. Playa lake beds have soils similar to what would be expected to form at human made reservoirs that are seasonally flooded and dry.

Soils in the upper Owyhee subbasin are mostly composed of the weathering products of volcanic rocks. From particles of fine silt to cobble sized fragments in the soil derived from volcanic rock. The volcanic rock and its weathering products are of recent geological origin and the erosion products are largely fine silt.

The mineral content in soils of the upper Owyhee subbasin originates from minerals in the volcanic rocks. Predominately the minerals carried in erosion and runoff from the upper Owyhee subbasin come from the soils that came from the underlying rocks. These are not point sources. Some naturally occurring minerals of concern include mercury, antimony, uranium, and radon. The elevated concentrations of these minerals in the bedrock led and continues to lead to their natural occurrence in soils and water ways. Minerals are carried across state lines by rivers, but the non point sources are not very amenable to management solutions. There are very few point sources of mineral or chemical pollution in the upper Owyhee subbasin. Some concentrations of cyanide and mercury may be associated with abandoned, historical mining operations.[56] The pollution at mining sites could be cleaned up.

Many of the soils in the upper Owyhee subbasin can be at risk for erosion. While soils have erosion hazards or risks, the actual amount of erosion that occurs is based upon substantial rain or snow events, storms that bring heavy rainfall, and human activities that expose the sediments.

## B. Erosion

The sediment load transported by a river is obvious to most observers. Crystal clear stream water is not carrying substantial amounts of sediment, while murky brown waters are a result of a large sediment load within the river. The sediments in rivers come from erosion of soil and rock. Water carrying diatoms and algae that grow in the river water will appear to be hazy from carrying sediment but the suspended particles are created by plant life. The soils within the upper Owyhee subbasin are discussed above and the rocks are discussed in the geology section of the background component of this assessment. Wind erosion contributes a very minor amount of sediment directly to the rivers.

“Erosion is an intrinsic natural process but in many places it is increased by human land use.”[51] All of the river canyons and gullies we see as scenic locations today were created by natural erosion. The goal of assessing sediment sources and erosion is not to halt the movement of sediments, but to understand, and where possible, mitigate the effects of modern human activities on soil loss.

Management of sediment losses requires an understanding of how erosion functions naturally, what creates surface runoff within the upper Owyhee subbasin, and what cultural practices are management options.

### 1. Forms taken by erosion

When looking at the landscape to see where erosion is happening, there are three types of soil movement.[13,37] Sheet erosion moves sediment off the surface of a large area of ground and is generally more common in flat areas. Rill erosion consists of more or less parallel erosion paths across sloping ground. Gully erosion cuts through sediments in low areas where water accumulates during runoff events, creating features we call gullies.

Identification of what type of erosion has occurred will suggest the types of actions which can be taken to prevent erosion. In nature the quantity and speed of runoff water determine the form taken by erosion, and slopes will show a progression from sheet erosion at the top where they are nearly flat, to rill erosion on the slope, and finally gully erosion along the steepest incline.[13] On furrow irrigated fields the erosion occurring is analogous to rill erosion.

Erosion at a rate which has occurred historically in areas little impacted by human activity may not be amenable to any form of management. Similarly erosion where human activity has not significantly changed the composition of the soils or the nature of vegetative cover will be difficult to alter with human intervention.

### a. Management of sheet erosion

> "Sheet erosion can be prevented by maintaining plant cover and maximising infiltration of ponded water through the maintenance of soil structure and organic matter. Organic matter acts as a glue, stabilising pore spaces which transmit surface water deeper into the soil and thus reduce the volume of ponded water available for erosion."[12]

### b. Management of rill erosion

> "Once runoff has been initiated, rill erosion can be prevented by either reducing flow velocity, or hardening the soil to erosion. . . . Flow velocity can be reduced by either reducing the flow volume or roughening the soil surface. Increasing surface roughness through the use of grassed waterways and grassed filter strips causes entrained soil particles to fall out of suspension. Flow volume can be reduced by not allowing sheet flow to accumulate. Techniques such as ripped mulched lines and contour drains prevent runoff building up enough volume and speed to detach and entrain soil particles. . . . Where options to reduce runoff volume or velocity are limited, surface soils may be protected from scouring by hardening the surface."[11]

### c. Management of gully erosion

> "Once established, gully erosion can be difficult to control. In most cases a combination of approaches, including the use of vegetation, fencing, diversion banks and engineering structures are required. . . . Vegetation is the primary, long-term means by which gully erosion can be controlled. All gullies need to be fenced from stock and revegetated along the gully floor, sidewalls and surrounding areas. Establishing vegetation on gully sidewalls is often difficult due to moisture stress."[10]

Suggestions from Tasmania, Australia include, revegetating the gully floor with rapidly growing grasses and the sidewalls with trees, revegetating the catchment above the gully, and using irrigation hydroseeding and mulching.[10] In areas where the gully erosion can not be controlled with vegetation, “gully erosion may be able to be controlled if runoff can be diverted and safely disposed of.”[10] However this requires engineering expertise and carries the, “risk of transferring instability from one area to another.”[10] While we may think of Tasmania as being a world away, similar erosion problems are found in many semiarid regions of the world and their solutions are similar. At some sites the construction of upstream stock ponds can reduce runoff pressure aggravating gullies.

## 2. Erosion on rangelands

The effects of grazing on sediment erosion were examined in southwestern Idaho in the Reynolds Creek watershed. Reynold’s Creek is close to the upper Owyhee subbasin and has similar vegetation and rainfall patterns. Expected sediment losses were calculated on the basis of observable factors such as the percentage of ground covered by leaf litter and plant canopy, soil type, slope, and rainfall. The equation used, Universal Soil Loss Equation (USLE), is widely accepted as a predictor of erosion.[57,58] Nine locations were monitored from 1972 to 1978 with ungrazed and grazed range plots. Cattle grazed at moderate (2 plots), heavy (6 plots), and severe (1 plot) intensities, meaning the utilization of, respectively, 41-60%, 61-80%, and 81-100% of key forage species. Each grazed plot of rangeland was compared to an adjacent ungrazed plot to determine effects of grazing on sediment erosion. Reduction in plant cover and leaf litter that could lead to more sediment production was observed in only two plots. Both plots were on steeper slopes and one was grazed severely and the other heavily. The remaining seven locations did not experience significant changes in cover, these included two other steep locations with a heavy grazing regime.[57] Increased sediment production on rangeland would not be predicted for areas with standard practices of grazing management.

In the study of the Reynolds Creek watershed, it was not possible for the researchers to directly measure the sediment lost from the studied plots. However four of the drainages with test plots had measurements of actual sediment yield. The actual sediment yield was only 25 percent of the soil losses calculated from the plots. The difference between actual and calculated losses indicates that less soil is eroding across the surface of the rangelands than is predicted by the standard management equation USLE.[57] The authors of this assessment also found it interesting to note that the actual soil losses in four creek drainages in southwestern Idaho were 0.22, 0.29, 0.31, and 0.43 metric tonnes / ha / year, sediment yields significantly lower than the USDA soil loss tolerance for the shallowest soils, 2.24 metric tonnes / ha / year (1 ton / acre / year).[58]

## 3. What increases the amount of erosion during storms and snow melt?

### *a. Surface erosion*

Erosion is the natural process by which sediment is moved down slope. Gravity is the major force in action, as in a rock fall. But, gravity is assisted in creating erosion by water both loosening and carrying material. Two major factors contributing to how much erosion occurs are the slope of the land and type of precipitation. The greater the slope of the land, the more likely it is to undergo erosion. Steep slopes will lose more sediment than flat plains. High intensity and volumes of precipitation also increase the amount of erosion.[28] When heavy rains occur, the soil can not absorb all of the water and so some of the water starts running across the surface of the ground. Snow melt can also result in a large amount of water on the surface running across the ground, especially when the ground is still frozen. If the ground is frozen it will not absorb the water from the snow melt. If there is a large amount of surface runoff or the surface runoff is across a steep slope, this water will begin scouring the ground it is moving over and pick up sediment. Individual particles of sediment are small enough to be carried in the water and moved off of the land.[28]

Very large weather events have the power to dislodge both large particles and those which are held together firmly by forces in the soil. The influx of this sediment to the river system occurs over a short time period as the additional moving water has the force to carry these particles.[28]

Erosion is greater in areas where the landscape is in its early stages of formation. Many areas of the upper Owyhee subbasin are geologically recent (geology section of the background component of this assessment). These “new” rocks and the “new” landscape have not been smoothed from eons of erosion. Steep slopes increase erosion risks. Another implication of recent formation is that soils have only started to form, limiting the ability of the landscape to support vegetation and exposing the newly formed soils to erosion.

Soils vary in the amount of clay, silt and sand they contain. A soil composed of sand and silt particles is more likely to undergo erosion than one with a clayey surface. Soils of more recent origin have a tendency to have silt and sand particles near the surface. These particles can be dislodged more readily than clay particles. The large areas of basalt and volcanic ash in the subbasin weather to silt that is easily dislodged.

### *b. Stream channel erosion*

Storms and snow melt can cause large runoff events.[8] This water reaches stream courses. The greatest amounts of water flowing in a creek are recorded as peak flows. In the upper Owyhee subbasin the peak river flows occur with the runoff from snowmelt (see the hydrology section of this assessment). A large quantity of fast moving water in a creek can cause scouring of the stream bed and gully erosion of the stream banks.

> “Seasonal variations in stream flow are a major determinant of the structure and seasonality of ecosystem processes in streams and rivers. Periods of high flow in small streams, for example, scour stream channels, removing or redistributing sediments, algae, and detritus. In larger rivers, high flow events may lead to predictable patterns of bank erosion and deposition.”[8:94-95]

Researchers have documented characteristics of streams that are associated with greater erosion and scouring during floods. These characteristics include flashy changes in water flow, high channel gradient, abundant coarse material in the stream bed, relatively low bank cohesion (from less structured soils and/or fewer plant roots),

**Photo 9.9. The contrast between stream channels with (left) and without (right) bank erosion. On left a stream channel draining into the East Fork of the Owyhee River in Nevada. On right the East Fork of the Owyhee River above Wild Horse reservoir.**

and narrow channels that enable faster deep flowing flood water.[27] Arid and semiarid streams are known for rapid changes in flow, rocks in stream beds, and less structured soils in channel banks. In the upper Owyhee subbasin, these flashy water flows can carry sediment great distances so the sediment from one state can be carried into the next state downstream.

Floods can change the shape and composition of a river. In the Colorado River, for example, "The annual cycle of scour and fill had maintained large sandbars along the river banks, prevented encroachment of vegetation onto these bars, and limited bouldery debris deposits from constricting the river at the mouths of tributaries".[35] The increase in riparian vegetation along the Colorado River resulting from the removal of flooding after dam construction has been detrimental to aquatic life in the river.[35]

Floods are complicated from a management perspective. While they result in erosion and scouring, the effects of erosion and scouring can increase aquatic species diversity and the diversity of aquatic habitats.[35] For example, scouring can clean fine sediment out of gravel that fish use for spawning and natural flash floods can periodically reduce exotic and lake fishes that have been introduced to the streams.[35] In free-flowing rivers with episodic high flows, the plants in the riparian area are regulated by flood scour. Scour will remove plants.[35]

### 4. What will decrease the amount of erosion during storms?

Two factors important to decreased erosion during storms are the soil surface cover and the permeability of the soil to water. Soil surface cover can help hold sediment in place. Greater soil infiltration allows more water to be absorbed into the soil before it begins running across the surface of the ground.

The amount of erosion which occurs is largely controlled by the vegetative cover and type of soil. Vegetation and plant litter hold soils in place.[13,38] Soil that is being held in place is much harder to erode and will only be influenced by much more intense storm events. Soils covered in rock fragments also produce less sediment from rain based erosion.[45] Rocky cover leaves less sediment available for transport by runoff and slows the speed and power of run off water.

"Infiltration is the term applied to the process of water entry into the soil. The rate of this process, relative to the rate of water supply determines how much water will enter the root zone, and how much, if any, will run off. Hence, the rate of infiltration affects . . . the amount of surface runoff and the attendant danger of erosion."[38:382] Soils high in clay or covered in rocks do not absorb water quickly and can produce more surface run off in rapid downpours. Soils with a predominance of sand or coarser particles tend to absorb water very quickly.[8] The more water that is absorbed by the soil, the less water will become surface run off.

Revegetation of stream banks is the general management practice utilized to mitigate the effects of scouring and gully erosion during high water events.[10,35] This practice is necessary where human modification of the environment has been extreme. However, vegetation can only hold stream banks together up to the point where the floods have the power to remove the plants.[35]

Not all erosion can be controlled. The portion that management practices can address is the portion that is related to cultural practices.

## 5. Cultural practices related to soil losses

Erosion on rangeland has not been scientifically studied in the upper Owyhee subbasin. However, erosion can be observed by those who use the same areas year after year. People downstream can observe the muddied waters of rivers carrying sediment from upstream erosion. Large sediment loads delivered to the rivers are the result of either extreme storms or other problems.

### *a. Sources of problems and concerns*

Human land use, particularly related to vehicle travel is seen as a major source of sediment being delivered to waterways in the upper Owyhee subbasin.

#### *i. Unimproved roads*

Unimproved roads through rangelands create problems with erosion. Often the placement of dirt roads has developed as a matter of convenience, with no planning to minimize their effects on soil loss. Unimproved roads can erode more than improved roads. Improved roads will have runoff ditches along the sides which funnel water off the road and onto the range.

Unimproved roads erode in the tire tracks, collecting water running off the landscape and acting as sediment sources.[39] This happens because once water is in the wheel ruts, it can not escape. Water often flows within the wheel ruts for great distances, eroding deeper and deeper gullies into the land. Over time the erosion along one set of wheel tracks will lead drivers to move off of the existing road to drive on adjacent land. Those who use the range on a frequent basis notice that this problem becomes more pronounced with the steepness of the slope. Steep slopes have greater need of cuts designed to direct water off of the road at regular intervals.

**Photo 9.10. Erosion in the tire tracks of an unimproved road across the plateau in the upper Owyhee subbasin.**

Simple gutter improvements creating ways for water to escape from the wheel ruts of unimproved roads will decrease erosion.[39] Extensive descriptions for rural home owners, ranchers and rangeland managers on how to care for and improve rural roads are provided in the online publication "A Ditch in Time".[39] Many of the unimproved dirt roads in the upper Owyhee subbasin are already acting as gullies and will likely continue to do so even without vehicle traffic because the gullies will not magically grow plants to hold the soil in place.

*ii. ATV tracks and off road recreation*

Off road recreation by both small 4 wheelers and large 4x4 vehicles disturbs the surface of the soil. Repeated use of an area or paths for off road recreation kills vegetation. Soil compaction, which results from vehicles driving over the soil, greatly increases the chance of precipitation flowing across the surface of the land.[13] These factors leave areas used for off road recreation extremely susceptible to erosion from rainstorms or snow melt. Areas which have been used repeatedly for off road recreation contribute disproportionately larger amounts of sediment to the rivers.

*iii. Stream bank erosion*

Steam bank scouring can be a natural process. This scouring can also be aggravated by excessive animal pressure on riparian vegetation, leaving stream banks excessively vulnerable to erosion.

*iv. Irrigation-induced erosion*

There is very little irrigation in the upper Owyhee subbasin, so there is little runoff from irrigation. The concern with irrigation water is that runoff will be returned to the river. This runoff can carry sediment, nutrients, and animal wastes. Cattle are fed over winter on some pastures in the upper Owyhee subbasin and flood irrigation can carry material from these pastures.

*v. Confined animal feeding operations*

In some regions, concern has been expressed that sediments at confined animal feeding operations are extremely susceptible to erosion and that during storm events the sediment might be lost into the rivers, carrying with it a high concentration of animal wastes. This is not a widespread concern in the upper Owyhee subbasin.

*vi. Urban areas*

Urban areas can significantly increase the amount of runoff water. Urban areas have less soil area to absorb rain water. Large amounts of fine sediment are produced in construction areas.[32] The upper Owyhee subbasin has few urban areas so this is not expected to contribute much sediment to the waterways.

*vii. Timber harvest*

Timber harvest is associated with the addition of fine sediments to streams.[32] Large scale timber harvesting is uncommon in the upper Owyhee subbasin.

## 6. Erosion in the upper Owyhee subbasin.

There have been few evaluations of erosion in the upper Owyhee subbasin. The Idaho Association of Soil Conservation Districts and the Idaho Soil Conservation Commission conducted stream channel inventories on privately owned land in the upper Owyhee subbasin. The conclusion was that areas upland from the stream channel contributed little excessive erosion or deposition to the stream channels. The primary sources of erosion for the stream channel came from the stream channel and riparian areas themselves.[23]

### *a. Possible solutions to current problems*

*i. Unimproved roads*

Unimproved roads through rangelands eventually need to be repaired or replaced. Simply prohibiting vehicle traffic will not halt erosion which is already carrying sediment off the road. As replacement and repairs are necessary, minimal design considerations can be implemented to divert water strategically from the roadway at reasonable intervals. In some places, routes can be chosen with less erosive potential.

*ii. ATV tracks and off road recreation*

Education of ATV and other off road vehicle users needs to be both more energetic and effective.

*iii. Stream bank protection*

Where stream banks are accessible to animals and people, maintenance of good riparian cover can diminish erosion. In many places in the upper Owyhee subbasin, the streams run in deep canyons with little livestock access and all erosion along the streams is natural.

*iv. Irrigation-induced erosion*

It is not known how much sediment or animal wastes are lost from irrigated fields and pastures in the upper Owyhee subbasin.

In the upper Owyhee subbasin, most irrigation is of hayfields and pasture. The traditional method of irrigating hayfields has been surface flood irrigation. This irrigation method is usually inefficient in water use for the crop. In some areas, central pivot irrigation systems have been adopted. Central pivot irrigation systems use water more efficiently.[Section XI, Agriculture, this document]

More efficient water use means less runoff. Efficient water use practices are being adopted and further adoption will result in less sediment loss from fields. Possibly the best way to deal with concerns with runoff water from agricultural fields is to eliminate the runoff altogether. This can be done with controlled water application. If all of the irrigation water applied to a field stays on the field, there will be no run-off and no worry of accompanying sediment, nutrients, and bacteria entering creeks.[47] Both sprinkler irrigation and drip irrigation systems can be designed to eliminate runoff from agricultural fields.[26,42,43,44] For hayfields and pasture, sprinkler irrigation is more cost effective than drip irrigation systems.

Other improvements to limit sediment losses include leveling and settling ponds. Leveling makes fields flatter, and flatter fields are less subject to erosion because the water in furrows is moving slowly. Slower water has less power to pick up and move sediment. An additional method to eliminate most sediment and water returning to the rivers is through the use of settling ponds in constructed wetlands or catchment ponds with pump-back systems. Settling ponds allow the sediment to fall out of suspension in the water and gather on the bottom of the pond.[44] After sediment has settled, water is returned clean to tail ditches and creeks.

### 7. Questions that need to be answered about soil losses

How much vegetation is needed on the rangeland to avoid erosion related to thunderstorm events? Do different types of vegetation have different amounts of sediment losses? Is the amount of vegetation needed possible within the constraints of semiarid environmental conditions?

What is the difference in sediment loss between rangeland on a flat plain and that on the slope of a hill? How does grazing affect sediment losses?

How is the amount of soil erosion changing with invasive weeds? With expanding juniper cover?

How much vegetation is needed along a stream bank for stabilization? What species of vegetation that are adapted to local environmental conditions would grow in these places? How often is this vegetation lost to natural scour?

To what extent are there soil loss problems following wildfires and controlled burning of rangeland?

There is no survey of locations with active erosion within the upper Owyhee subbasin to document the erosion rate and study whether the current rate is what would be expected to occur naturally or is being aggravated by human activities. Only the latter would be amenable to remediation. Naturally occurring erosion has been substantial and is responsible for much of the beauty and incredible landscape of the upper Owyhee subbasin.

To what extent has legacy historic overgrazing on upper Owyhee subbasin rangelands altered soil properties that influence modern sediment production? (Changes to surface cover, infiltration rates, and sediment production have been documented in other arid historically overgrazed areas.[38]) To what extent has the past legacy of overgrazing been overcome by range management practices during the last half century?

## C. Sediments in waterways

One of the TMDL concerns about erosion is that increased amounts of sediment are entering the river systems. A background on how sediment enters waterways, how it is measured, and how sediment is transported by creeks and streams is presented below. This is followed by a general discussion of stream biota, the fish and macroinvertebrates that live in the water ways and may be affected by sediment in the water. The data on sediments in the water ways of the upper Owyhee subbasin and data gaps close the section.

### 1. Sources of runoff water

The sources of water entering the rivers in the upper Owyhee subbasin have not been delineated. The water flow in the subbasin depends upon the flow of the various perennial, intermittent and ephemeral streams. In addition, the amount of sediment carried by runoff and streams varies based upon the source. This is a data gap.

Sediments entering streams can be discussed in terms of their origin: that coming from springs and seeps, that originating in storm events, that from urban areas, and that being transported in return water from irrigation.

Water from underground aquifers, such as springs and seeps will carry little to no sediments. However this water may carry mineral concentrations picked up from the natural elements in the rocks the water has passed through.

Thunderstorms and rapid snow melt can produce massive surface runoff. This runoff will likely carry sediment from the area it passes over. The floods that may result in narrow stream channels also have the potential to scour sediments from the banks of the channels. Storms are natural and some erosion will always accompany them. Human management of sediment entering streams from storm events can only address man made sources of loose sediments.

Agricultural lands that are barren during rain storms may have greater sediment erosion.[32] In addition, these lands are deliberately irrigated. Irrigation tail ditches will carry sediments from the fields that the irrigation water ran across. This is of concern to water quality since the soil may contain high quantities of phosphorus, nitrogen, bacteria, and pesticides.

### 2. Sediment transport in rivers

Limiting human provoked soil losses can limit the sediment entering a river system. However not all sediment comes from human actions. The amount and types of sediment within river systems in the past are poorly known.

Erosion is a natural process by which sediments are added to the streams and rivers, and likewise rivers are the natural way that these sediments are transported to lakes and seas. While river systems carry eroded sediments, they “can also be depositional, accumulating sediment within channels and floodplains.”[31:129] How river systems transport and deposit sediment is dependent upon a number of factors including sediment supply, the river gradient, total river discharge, bed sediment size, and seasonal variations in flow.[31,36]

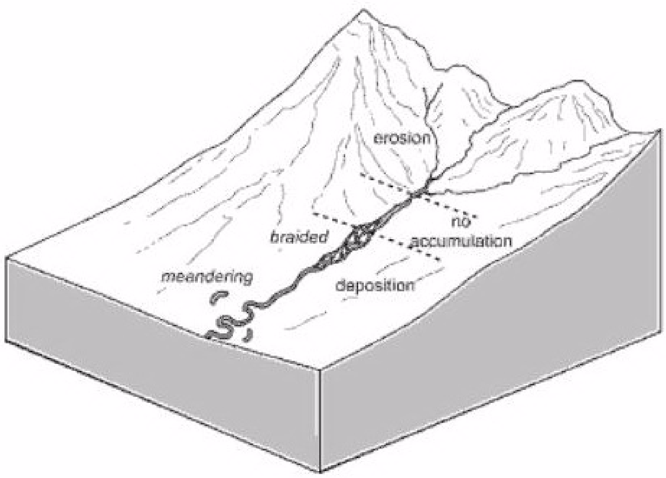


**Figure 9.2. Schematic locations of erosional, transfer, and depositional zones.** Adapted from 31, Figure 9.1

**Gradient** will determine if a portion of a river system is within the erosional, transfer, or depositional zone (Figure 9.2). "In the erosional zone the streams are actively downcutting, removing bedrock from the valley floor and from the valley sides via downslope movement of material into the stream bed. In the transfer zone the gradient is lower, streams and rivers are not actively eroding, but nor is this a site of deposition. The lower part of the system is the depositional zone, where sediment is deposited in the river channels and on the floodplains."[31:129] When looking at a river system within a landscape, the more mountainous portions will undergo erosion while rivers running across flat lands will be subject to deposition of sediments.

The gradient and water flow are related to **bed sediment size**. Bed sediments can range is size from boulders to fine silts. The size of sediment found in a given location is based upon ease of transport. Smaller particles are more easily moved by water. The sediments that a creek or river can carry within the water are termed the suspended load.[31] Those particles that can be moved along the bed of a creek by rolling are termed bed load. The suspended sediment load that water can carry is based upon its power. A greater suspended load can be carried by a creek with a steeper gradient and thus greater power of the flowing water. The greater the sediment load that can be carried in the water the more fine sediments will be preferentially removed. Creeks with more gravel in the beds tend to have higher gradients where water is moving quickly. Creeks with lower gradients and where water is moving more slowly will have finer sediments in the bed.[31] As water slows down, the sediment load it can carry is less and fine sediments settle out of suspension. For example, when the suspended load carries both silt and clay sized particles, the heavier silt particles will settle out before and upstream of where the clay is deposited. Creeks are dynamic systems with many different types of beds that are not necessarily all rock or all fine sediment.

**Photo 9.11. The Jack Creek canyon shows how gradient changes from erosional slopes to transitional zones near the valley bottom.**

Many physical characteristics in a river system alter sediment transport and bed sediment size, some examples are the erosion of parent material, the confluence of tributaries, and dams.[36] Rock can be introduced anywhere along a stream where the local rock deposits are breaking up. Rock introduced locally will be more angular as the transport of rocks by the stream tends to round off the edges. Where tributaries join a major channel there is an increase in the volume of water that is moving. This increased power can move more sediment and stream beds will have larger particle sizes.[36] Dams alter sediment transport as the water slows down and loses sediment that it has been carrying. The bed sediment in reservoirs and upstream of the reservoir where the water has already slowed is often fine.

Floods change sediment transport in rivers. The increase in water flow increases the power of the creek or river. With greater flow and power, more and larger particles can be moved as suspended and bed load. Sediment transport as suspended load increases during a flood. Visually this can be seen as murkier water. Floods also have the power to move larger material as part of the bed load. The rolling of rocks during a flood is the movement of bed load that, over time, leads to rounded cobbles and rounded gravel. Greater transport of sediments by flood waters is natural.[31] The greater water flow during flooding also carries the suspended sediments further downstream, sometimes for great distances.

Less pronounced seasonal variations in water flow will also change the ability of a creek to transport sediment. The lowest sediment transport can be predicted for times of the year with the lowest flows. Meanwhile the peak flows during spring snow melt would likely correspond with high levels of sediment transport.

The highest flows may account for almost all sediment movement in creeks. Singh and Durgunoglu state that, "80-90% of the sediment load is carried during the highest 10-15% of the flows."[59:199]

### 3. Measuring sediment in water

To the naked eye water that has suspended sediment looks murky. The haziness results from very small particles that remain suspended in the water. Suspended sediment is frequently measured in terms of this haziness, or turbidity.[53] While it is easiest to see the sediment transported in suspension, creeks and rivers also move sediment as part of the bed load. These particles move by tumbling along in the bed. They are pushed along but are too heavy to be held within the water.

#### *a. Suspended sediment*

Suspended sediment is measured based on how clear the water is (turbidity) or the amount of sediment found within the water (suspended sediment concentration).

Turbidity is related to how much light will pass through the murky water. One rough estimate can be made from recording the depth at which a black and white disk can no longer be seen. The common laboratory measure of turbidity is based on the scattering of light in water. The Nephelometric Turbidity Unit (NTU) is higher for murky water and lower for water with no particulate matter (Figure 9.3). The treated drinking water in your home is not permitted by the EPA to exceed 1 NTU.[16] "A turbidity of 3000

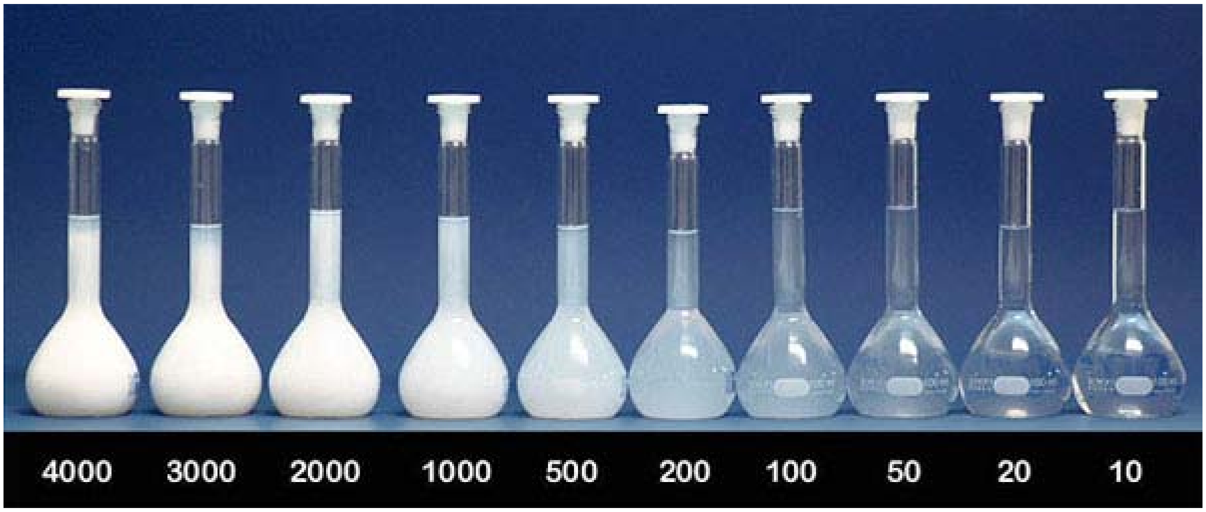


**Figure 9.3. Examples of water turbidity measured in NTU.[33]**

NTU typically corresponds to a suspended sediment concentration of 3 g/l but this will vary depending on the characteristics of the particles in suspension."[25:14] When a water sample is taken to measure turbidity it must be analyzed in a timely manner.

Turbidity is measured on the basis of all particles in water. Sediment, while often a major factor in high turbidity, is not the only source of haziness in water. Turbidity "is caused by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms, organic acids, and dye."[49:TBY-3] Turbidity measurements also are effected by particle size, "for a given sediment concentration a reduction in particle size results in an increase in turbidity."[25:14]

Manual water sampling is the oldest method of obtaining measurements of suspended sediment concentration. "Manual sediment sampling is highly time-consuming and cumbersome but is reliable and accurate and remains a reference (and so used for calibration of other methods) as it is the most widely and often used and allows the determination of the size distribution. The sampling can be done manually (grab sample) or using a pump."[25:1] Sediment is then separated from water and weighed. The total suspended sediment measured in this manner is generally expressed in the units milligrams per liter (mg/l). The Federal Interagency Sedimentation Project provides information on sampling methodologies.[17]

When examining the sediment carried by streams and rivers, the scale of measurement is important. The flux of sediment is more variable in smaller watersheds than in larger ones due to localized, short duration events like landslides or flash floods. "Larger watersheds integrate the stochastic pulses of sediment occurring within their smaller subcatchments and thus dampen the variability of sediment fluxes through reaches that drain large areas."[32:2748] Measurements of turbidity and suspended sediment load naturally vary between creeks, between years, and between seasons. Large fluctuations are expected in smaller creeks due to local events.

There are very few turbidity measurements for streams and rivers in the upper Owyhee subbasin. There are very few measurements of suspended sediment concentration. Measurements have not been collected systematically (such as by week) to provide data on seasonal river changes. These are a data gaps. The contributions of algae and diatoms to the turbidity of upper Owyhee subbasin water is unknown, another data gap.

### *b. Bed load*

The sediment and gravel that move along the bottom of a creek is the bed load. The amount of material that is moved along will be based on the power of the water flowing in a creek and the creek gradient. This means that more of these materials will move during high flow events and far less during low flows. During high flow events the large scale movement of bed sediments can cause scouring.

> "Bed-load transport is even more difficult to estimate in alluvial streams than suspended sediment and poses a particular problem in high-energy bedrock rivers. So far, no sediment-monitoring agencies have been able to devise a standard sampler that can be used without elaborate field calibration or that can be used under a wide range of bedload conditions. The samplers used are giving quite different results depending on river characteristics so a combination of sampling methods should be used."[25:2-3]

The most widespread method for measuring bed load is with traps for the materials that are moving. Portable bed load traps can be installed at riffles to measure the movement of particles larger than 4 mm size.[25] Particles of this size are small gravel. The traps would not measure movement of sediment that is a major concern in discussions of stream characteristics.

**Photo 9.12. The stream bed of this intermittent creek in the upper Owyhee subbasin is covered with sediment. This creek would only move sediment in its bed load.**

Measurements of sediment and gravel moved as bed load are not available for the upper Owyhee subbasin. This is a data gap.

The suspended and bed loads of creeks are moving continually downstream and inevitably cross state boundaries.

### 4. Sediments and stream biota

Streams are home to many organisms. The complexity of stream habitats has a positive influence on the diversity of macroinvertebrates and fish that inhabit them.[36,46] Complex habitats have many different types of cover, slow and fast moving water, different stream beds, variation in water temperatures, and variation in aquatic vegetation.

### a. Macroinvertebrates

Macroinvertebrate fauna are known to respond to the physical characteristics of streams.[36] The aquatic insects found on stream bottoms are benthic macroinvertebrates. They are important in water quality assessments because they have short life cycles, are generally sedentary, are a primary source of food for fish, and are easy to sample.[21]

Where stream flows change and the type of stream beds are diverse more types of macroinvertebrates can be found. “Species diversity is generally higher in heterogeneous environments, and positive relationships between sediment sorting and taxa diversity have been reported.”[36:831] Within a stream the macroinvertebrate populations will vary based upon the location they are sampled. Variation can occur on a small scale. “Species diversity is likely to decline downlink and increase at significant LSSs [Lateral Sediment Sources]”[36:831] The influx of more water and sediment at a tributary, for example, will increase local macroinvertebrate species diversity.

Some macroinvertebrate populations are intolerant of sediment in the creek bed. “Macroinvertebrates (Plecoptera) intolerant to sediment are mostly found where substrate cover is less than 30% (<6mm). More sediment tolerant macroinvertebrates (Plecoptera) are found where the substrate cover is greater than 30% (<6mm).”[22:48] The specific populations that prefer different bed sediment sizes are used in some assessments of aquatic habitat to indicate the type of creek bed.

#### *i. Stream Macroinvertebrate Index*

Since sediment can impair creek bed habitat for macroinvertebrates, samples of these populations are used to classify the stream habitats. The stream macroinvertebrate index (SMI) is a measure commonly used in assessments of water quality. The index includes measures of the macroinvertebrate population that are predicted to increase or decrease with increasing perturbation. Measures include richness, composition, pollution tolerance, diversity, feeding group, and habit.[21]

According to the Idaho Department of Environmental Quality (DEQ), “The SMI is a direct biological measure of cold water aquatic life.”[21:6-4] The index is based upon measures of the macroinvertebrate populations in streams that are ‘unimpaired’ within a bioregion. The distribution of index scores, calculated ‘unimpaired’ macroinvertebrate populations in a given bioregion, is determined. From this distribution, if a population falls below the 10th percentile of the reference collection (the ‘unimpaired’ macroinvertebrate populations) then it is given a condition rating of 1, and if it falls between the 10th and 25th percentile the rating is 2. Above this the rating of 3 is assigned. According to the Idaho DEQ, this distribution accurately assigned approximately 85% of ‘impaired’ streams to rating 1 and 90-97% of ‘impaired’ streams to rating 2.[21]

Unimpaired streams should receive a condition rating of 3, the best. However, the authors of this assessment would like to point out that the way the rating system has been constructed, approximately 25% of the 'unimpaired' reference streams would fall into the condition ratings of 1 and 2. The SMI values for some 'unimpaired' streams, those below the 25th percentile, overlap numerically with the SMI values of 'impaired' streams. Caution must be exercised in the interpretation of the SMI index given that there is a substantial overlap between values for the 'unimpaired' and 'impaired' streams that were used to establish the condition ratings.

The stream macroinvertebrate index is based upon populations within a specific bioregion.[21] This means that there are various SMI bioregions for Idaho, including the 'Snake River Basin' bioregion.

The SMI is used in some assessments to determine if sediment is impairing existing beneficial uses of a creek for fish.[22]

Local baseline data on macroinvertebrate populations in the upper Owyhee subbasin are needed since the SMI is based upon macroinvertebrate populations in healthy local streams. The macroinvertebrate populations in the Owyhee River drainage may be distinct from those in the larger Snake River Basin bioregion. Filling this data gap is imperative if the SMI index is going to be used to classify the health of stream systems. Designation of a stream as 'impaired' must be based on a large body of scientific knowledge and accurate assumptions about the natural temperature regimes of streams.

### *b. Fish*

Fish communities are part of complex aquatic ecosystems. The complexity of these systems makes management decisions very complicated. Some elements of these ecosystems include creek structure, cover, temperature, nutrients, suspended sediment, seasonality, depth, velocity, geographic region, other species present, amount of available habitat, temperature refugia, and the life stage of the fish.[46] One major goal in the management of fish habitats is to maintain the productive capacity of these habitats, a goal that requires knowledge of the productive capacity prior to development.[46] This knowledge is a data gap for the upper Owyhee subbasin.

#### *i. Fish known to be in the upper Owyhee subbasin in Idaho*

In 1974 a fishery survey was conducted of Big Blue Reservoir on Blue Creek, Little Blue Reservoir on Little Blue Creek, Paine Creek Reservoir on Paine Creek, Juniper Basin Reservoir on Juniper Creek, Squaw Creek Reservoir on Squaw Creek, and Bybee Reservoir on Shoo-fly Creek. The survey was conducted to evaluate the potential of the reservoirs for stocking with game fish. In Big Blue Reservoir they collected suckers, shiners, and squawfish. Upstream they also found sculpins. In Little Blue Reservoir suckers and shiners were gathered. Paine Creek Reservoir had shiners but "was apparently stocked in the 40s and early 50s and produced large trout up to 4 to 6 pounds." The fish populations of Juniper Basin, Squaw Creek and Bybee Reservoirs were "unknown".[34]

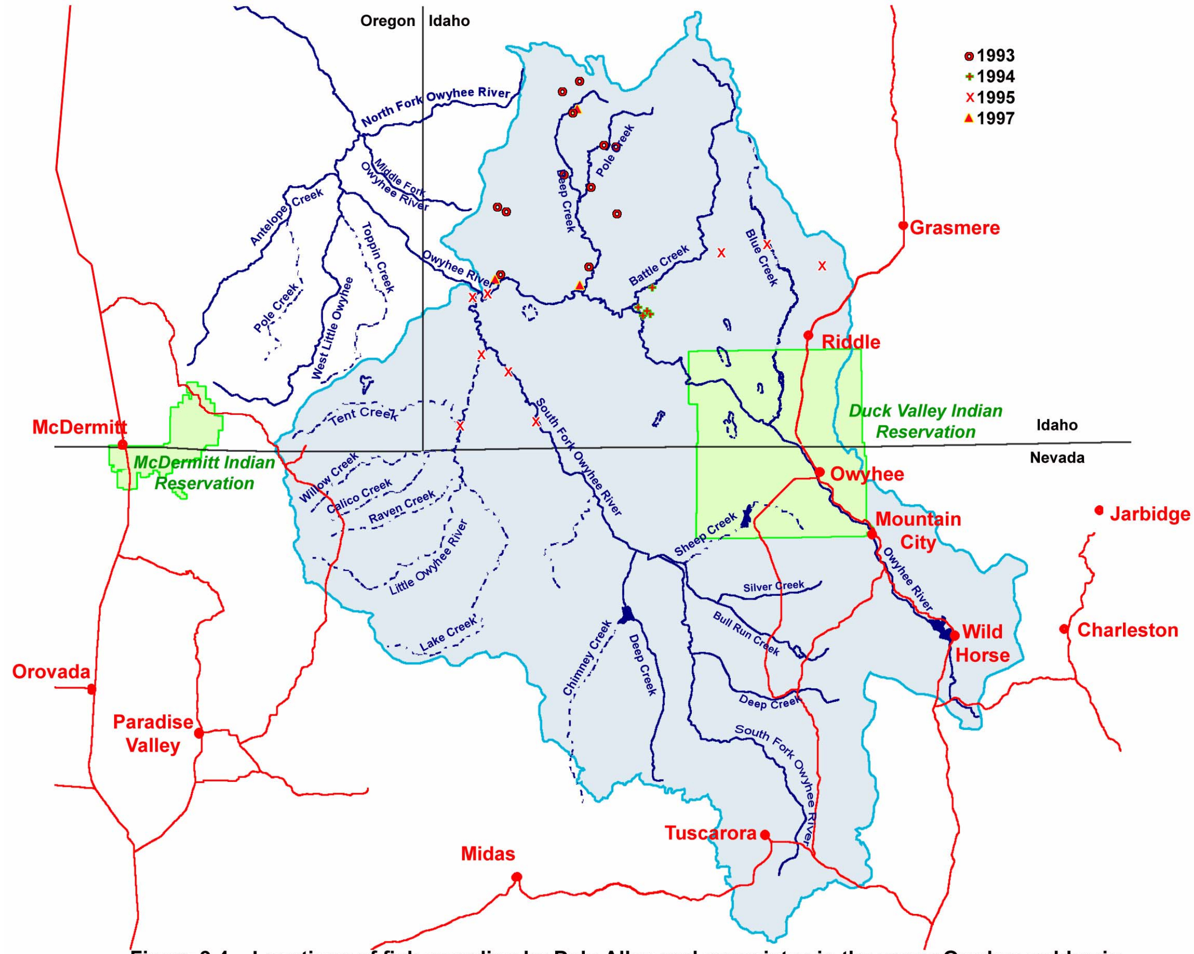


**Figure 9.4. Locations of fish sampling by Dale Allen and associates in the upper Owyhee subbasin in Idaho**

Surveys for redband trout (*Oncorhynchus mykiss gairdneri*), the only salmonid in the upper Owyhee subbasin, have been conducted by Dale B. Allen and associates on different stream reaches in the upper Owyhee subbasin in Idaho (Figure 9.4). In 1993 stream segments at least 200 feet long were sampled in the Red Canyon Creek and Deep Creek drainages. Redband trout were found in three of the four reaches sampled in the Red Creek drainage. Eight of the nine stream segments in the Deep Creek drainage had no redband trout. The section sampled on Nip and Tuck Creek had a high density of redband compared to other sections sampled both in these drainages and in the Jordan Creek drainage outside the upper Owyhee subbasin. Other fish species collected during the 1993 surveys were longnose dace (*Rhinichthys cataractae*), leopard dace (*Rhinichthys falcatus*), speckled dace (*Rhinichthys osculas*), redside shiner (*Richarsoniuis balteatus*), mountain sucker (*Catostomus platyrhynchus*), chiselmouth (*Acrocheilus alutaceus*), northern squawfish (Ptychocheilus oregonensis), smallmouth bass (*Micropterus dolomieui*), and sculpin species (*Cottus* spp.).[4]

In 1994 surveys were conducted on reaches of Battle Creek and Owyhee River. No redband trout were found in either of these watercourses. Other fish identified in at least one of the sampled stream segments were smallmouth bass, redside shiner, speckled dace, bridgelip sucker (*Ptychocheilus oregonensis*), longnose dace, mottled sculpin (*Cottus bairdi*), chiselmouth, mountain whitefish (*Prosopium williamsoni*) and northern squawfish.[1]

The 1995 fish surveys were conducted on stream reaches of Little Owyhee River, South Fork Owyhee River, Owyhee River, Blue Creek, Little Blue Creek, and Shoofly Creek. The survey for redband trout found no redband in the Little Owyhee River, the South Fork Owyhee River, or the three creeks. In a segment of the Owyhee River just above Crutchers Crossing four redband were found by electrofishing. Other nongame species collected on South Fork Owyhee River and Owyhee River were small mouth bass, bridgelip sucker, longnose dace, northern squawfish, sculpin species and

**Photo 9.13. Fish observed at Wiley Ranch along the East Fork of the Owyhee River, July 2010.**

largescaled sucker (*Catostomus macrocheilus*). No fish were found in the Little Owyhee River or Shoofly Creek as they were dry.[2]

In 1997 a survey was conducted of the redband trout population at two sites on Deep Creek and one site on Red Canyon Creek. There were no redband at either of the Deep Creek sampling sites. The Red Canyon site contained a low density of redband trout. Other fish species present at the sampling sites were bridgelip sucker, chiselmouth, longnose dace, redside shiner, sculpin species, smallmouth bass, speckled dace, and sucker species.[3]

During July 1997, five biologists floated the Owyhee River for a week. During that time only one redband was collected by angling the river; it was caught just below the confluence with Deep Creek. Redband were observed but not caught or sampled near the mouth of Red Canyon Creek. No other redband were observed. The conclusion of the participants was that “redband trout were almost entirely absent in these reaches of the Owyhee River.” The angling catch consisted of smallmouth bass and northern squawfish.[3]

On the South Fork Owyhee River a study in 1995 found no redband trout. Electrofishing at the 45 Ranch on the South Fork Owyhee in 1999 also found no redband but located smallmouth bass, northern squawfish (pikeminnow), mottled sculpin, and largescaled sucker.[24]

Within the Upper Owyhee HUC, spawning of salmonid species has not been documented. Thus the 2003 TMDL for this area of the upper Owyhee subbasin does not designate spawning as a beneficial use for any water body.[23]

*ii. Redband trout in the Snake River and Owyhee River drainages*

Meyer and colleagues studied the occurrence of redband trout in waterways of the Snake and Owyhee River drainages.[29] Their work examined the occurrence of redband trout (*Oncorhynchus mykiss gairdneri*) in relationship to environmental factors and stream characteristics at sample locations. They do not provide data on the specific sample locations. This means that the creeks in the Owyhee River drainage are not singled out. The major division in Meyer and colleagues’ study was between desert and montane streams. Data from sites in the upper Owyhee subbasin are included in the group of samples from desert streams south of the Snake River. The majority of studied desert streams sites are in the Owyhee River, Bruneau River, and Salmon Falls Creek drainages. By contrast the montane streams are from north of the Snake River in the drainages of the Boise River, Payette River, Big Wood River, and Weiser River.

The locations sampled for this study were randomly chosen. However, when these locations were visited between late June and early October, samples were only taken if the stream had enough water to support fish life, was less than 25 meters wide (114 ft), and averaged less than 0.7 meters (27 inches) deep.

Redband trout were found in greater densities in desert streams:

> “Of the 615 sites that contained [enough water to support] at least one species of fish, redband trout were found at 384 (62%) of the sites, including 176 (65%) of the 273 study sites in desert streams and 208

> (61%) of the 342 study sites in montane streams. For sites that contained redband trout, mean density was 21 redband trout · 100 $m^{-2}$ (95% CI 17–26) for desert streams and 11 redband trout · 100 $m^{-2}$ (95% CI 10–13) for montane streams."[29:82]

Using the map published with Meyer's study, the authors of this assessment counted at least 20 sample locations on streams within the upper Owyhee subbasin. It is not known if trout were encountered in these locations or not (97 of the surveyed desert creek sites had no trout).

Meyer and colleagues statistically analyzed their large data set. Some of the environmental and stream characteristics of the sampled areas are related to the occurrence of redband trout. In desert streams redband trout were found where there was a greater percent of cobble-boulder stream bed, a lower percentage of fine sediment stream bed, greater amounts of stream shading, lower populations of pikeminnow and smallmouth bass, and greater stream gradient. In montane streams redband trout were found in streams at lower elevations, where there was more stream bed in cobble/boulder sized particles, and in lower gradient steams. Variables that did not contribute statistically to explaining redband trout occurrence in either desert or montane streams included the percent unstable stream banks, density of nonnative trout (not including the hatchery rainbow trout numbers as they were eliminated from analysis), stream width, water conductivity, and the percent gravel sized particles in the stream beds.[29]

Further analysis was conducted to better understand the population density of redband trout where there were redband trout. For desert streams these models can account for 43% of the variation in density based on stream order (smaller streams have more fish), stream shading (more fish in streams with more shading), percentage of cobble/boulder substrate (more fish where there are more cobbles), and either unstable banks (more fish where the banks were less stable) or width:depth ratio of the stream (deeper, narrower creeks have more trout). The best models for montane creeks only explained 17% of the variation in the density of redband trout. This means that the environmental variables and stream characteristics analyzed do not describe why the densities of redband trout vary in mountain creeks.[29]

Water temperature data was recorded at 51 arbitrarily selected study sites over the summer (June-August). In the montane streams, the mean summer water temperatures (<18°C, 64°F) had no relationship to redband trout density. In the desert streams, the mean water temperatures varied between approximately 11 and 22°C (52-72°F) and streams with higher temperatures had lower redband trout population densities.[29] The high maximum water temperatures did not mean there were no trout. Meyer and colleagues "captured redband trout at 6 sites with maximum water temperatures >28 °C and at 2 sites with >30 °C. These results concur with Zoellick's (1999) finding of redband trout in stream reaches with maximum stream temperatures of 29 °C. These temperatures exceed the thermal tolerance reported for other native salmonids that occupy arid climates in the western United States"[29:86] Meyer and colleagues suggest that with higher stream temperatures, some of the trout may move to cooler streams or find pockets of cooler water.

The study "results suggest that, in general, environmental conditions were more suitable for redband trout in desert streams than in montane streams."[29:87] Limiting factors to the range and density of redband trout populations in arid streams include summer stream temperatures and the presence of piscivorous fish. In the case of the latter, it is unknown if the of piscivorous fish (pikeminnow and smallmouth bass) prefer different habitats or if they prey on redband trout.

Meyer and colleagues' work highlights the complex relationships between fish and their environment. Redband trout do not live in all of the desert streams and characteristics of their preferred environments have been given as the factors associated with their occurrence. The authors of this assessment would like to highlight that factors that are related to the occurrence and density of redband trout in desert streams are predominantly natural environmental characteristics. Stream gradient, creek depth to width ratio, percent cobble/boulder substrate, percent fine sediment substrate, and occurrence of native pikeminnow are related to the local geography, type of bed rock under the stream, type of rock being weathered upstream, and native fish species. Meanwhile, the occurrence of smallmouth bass is a product of sport fishing. The other element that enters into preferred habitat locations is stream shading which is a product of the local vegetation and frequency of stream scour.

Meyer and colleagues' study demonstrates that redband trout prefer to live in specific types of natural stream environments and, in their preferred desert stream locations, the population densities are higher than in mountain streams. Whether streams in the upper Owyhee subbasin sampled in the study contained redband trout is unknown.

*iii. Stream beds*

Stream beds generally have a mix of material of different sizes from fine sediments, like silt, up to boulders. Different fish have different habitat preferences.

Stream bed structure is a factor in the fish that use a creek system. For example:

> "Salmonids have been shown to have a preference for larger and varied substrates, and to avoid sand or other fine substrates. On the other hand, some species, such as prairie river cyprinids or the Eastern sand darter (*Ammocrypta pellucida*), may be most abundant over fine substrates, avoiding gravel and large rocky substrate. Substrate composition has been implicated as a factor in fish growth, varying by species."[46:21]

While the species mentioned in the above quote are not found in the upper Owyhee subbasin, it is important to note that there is no one perfect type of stream bed for all fish. In the upper Owyhee HUC some of the fish species preferences are as follows:

> "The small mouth bass species (*Micropeterus dolomieui*), found throughout the Upper Owyhee River Watershed, require adequate substrate for nest building. This substrate could be sand or gravel. The sucker species found in the area (*Catostomus macrohelus*) prefers gravel

> to rocky substrate. Northern pikeminnow (*Ptychocheilus oregonensis*) uses streams and rivers for spawning activity, but is more of a broadcast spawner than nest builder. Sculpin (*Cottus baird*) are also known to inhabit waters in the Upper Owyhee Watershed. Sculpin prefer clean water and clean gravel for habitat."[22:48-49]

Different fish live, spawn and feed in different types of stream beds.

- *Sediments on stream beds as a pollutant*

Erosion adds sediments to the rivers. The addition of fine sediments to a stream by human induced erosion can fill in pools and the spaces between cobbles. This changes the stream bed.

The addition of fine sediment to stream beds is seen as a pollutant because of its detrimental effects to fish populations. "Bedload sediment can disturb habitat for macroinvertebrates, fill in interstitial spaces required for spawning and rearing areas, and fill in pools needed for refuge."[22:48]

Sediment in stream beds has been identified as a deterrent to spawning and as a possible limiting factor to populations of salmonids. "Sedimentation has been identified as one possible agent degrading freshwater ecosystems and limiting the persistence and recovery of salmonid populations. High levels of fine sediment (<2 mm diameter) in spawning gravels are correlated with low survival of salmonid eggs and alevins*."[32:2740-2741]

Gravel is discussed as the best stream bed type in many habitat restoration projects and management reports, in large part due to the desire to increase fish spawning habitat:

> "Many valued fish species use gravel for spawning, and therefore the restoration of spawning gravel has frequently been an objective of habitat enhancement projects where gravel is assumed to be limiting. Placement of instream structures may trap gravel and improve spawning habitat, and the addition of large cobble and boulder habitat can increase localized densities of salmon and trout but the effect may be temporary if fines inundate interstitial spaces over time. Demonstration of increased spawning activity in newly created spawning habitat does not necessarily translate to an increase in total egg deposition or adult abundance.[46:22]

Gravels in creeks and rocky areas in lakes are both used more frequently as spawning areas. However this does not necessarily change the population numbers. The creation of new rock areas in lakes, while attracting more fish, shows no apparent change in fish productivity or biomass.[46]

Stream beds low in sediment and high in gravel are necessary for the spawning of some fish species. It is not known what portion of a stream needs to have a gravel bed for fish to spawn in the stream. It is not known whether human activity has

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* Alevins are tiny fish carrying a food supply (a sac of egg yolk) attached to their bellies.

increased or decreased the amount of fine sediment in the rivers and streams of the upper Owyhee subbasin.

*iv. Suspended sediments in fish habitat*

Sediment is considered to be a pollutant because of the haziness that it introduces to the water where fish live. "Suspended sediment can impair sight feeding fish by reducing their capability to find food. It may also aggravate gills and reduce oxygen intake."[22:48] "Most studies have demonstrated that turbidity levels exceeding 25-30 NTUs will impair aquatic life use by causing reduced fish growth, reduced survival, reduced abundance, respiratory stress, and increased ventilation. Avoidance, reduced energy intake and displacement can occur at turbidity levels of 22 to greater than 200 NTUs."[22:48] It is not known if human activity in the upper Owyhee subbasin has increased or decreased the NTU of waterways.

## 5. Sediment data for the upper Owyhee subbasin

TMDL studies of streams and rivers in parts of the upper Owyhee subbasin have identified sediment as a pollutant in some streams and reservoirs within the upper Owyhee subbasin. Sediment measurements have been taken during these studies and these data are summarized below.

### *a. South Fork Owyhee River*

In 1999 a TMDL study was carried out for the South Fork Owyhee River. "Turbidity/suspended sediment samples were taken at eight sites during the May reconnaissance trip. Except for the two sites in Nevada, all turbidity results were below 25 Nephelometric Turbidity Units (NTUs). Suspended sediments results varied from 50 to 77 mg/l in Idaho, to 24 to 75 mg/l in Nevada."[24:27]

Turbidity measurements below 25 NTUs are favorable because these levels do not impair aquatic life. Yet with less than 10 samples for the South Fork Owyhee River, there is a great data gap:

> "Turbidity information is limited. During a five day monitoring trip on the South Fork Owyhee River, turbidity samples were collected at sites in Nevada and in Idaho. However, due to the limited holding time for turbidity samples, all samples collected exceeded the recommended holding time for submittal to the laboratory. The data is still important, but may be more of an indicator of inorganic material than organic material. The information obtained in May is also important to determine water quality conditions originating from Nevada."[24:30]
>
> "Obtaining "background" turbidity information may even pose a larger problem. Without long term temporal information, the background levels needed to compare to State of Idaho standards may not be obtainable."[24:30]

Macroinvertebrate populations were measured in 1999 in the upper Owyhee subbasin at the El Paso Pipeline Crossing and 45 Ranch. Measurements taken in July and August at both locations indicate the abundance and expected species for the type of river.[24] In fact, the El Paso Pipeline Crossing sample from July received the maximum possible score, 23, using the Idaho River Index for macroinvertebrates.

The riparian areas of the South Fork Owyhee River on the 45 Ranch allotment have been assessed. Alongside this, the river channel has been documented. "The upstream segment [of the South Fork] had a greater percentage of channel bottom covered with coarse material (cobbles and gravel) than the lower segment. This may reflect sediment input from the Little Owyhee system that would tend to dump sand and silt into the South Fork during flash floods."[30:10] In discussing the South Fork, Moseley states, "it appears to me that the erosional and depositional processes are in balance. The terraces are actively being degraded to a moderate degree and contribute to the sediment load of the river, including both bed load and suspended load. Bed load deposits are being laterally accreted (minimal vertical accretion) in the deeply entrenched floodplain and are colonized by the sandbar willow communities. Some of the suspended load settles out within the channel below bankfull stage. If it's deposited in slack water or eddies, it creates the fine-textured substrates colonized by the sharp bulrush community. Cattle have virtually no effect on these processes on the 45 Allotment."[30:14-15]

### *b. Upper Owyhee HUC*

According to a 1998 Idaho DEQ report five streams and two reservoirs in the Upper Owyhee HUC within Idaho were polluted by sediment (Table 9.1).[22]

Table 9.1. 1998 DEQ listed water quality limited segments (§303(d) listed streams) in the Upper Owyhee HUC, Idaho. (CWAL = cold water aquatic life, SS = salmonid spawning, PCR = primary contact recreation).[22]

| Stream | Pollutants of Concern | Stream Miles | Impaired Uses |
|---|---|---|---|
| Blue Creek Reservoir | Sediment | 185 Acres | CWAL, SS |
| Juniper Basin Reservoir | Sediment | 750 Acres | CWAL, SS |
| Deep Creek | Sediment, Temperature | 46.1 | CWAL, SS |
| Pole Creek | Sediment, Temperature, Flow Alteration | 24.0 | CWAL, SS |
| Castle Creek | Sediment, Temperature | 11.5 | CWAL, SS |
| Battle Creek | Bacteria | 62.3 | PCR |
| Shoofly Creek | Bacteria | 22.9 | PCR |
| Red Canyon Creek | Sediment, Temperature, Flow Alteration | 5.2 | CWAL, SS |
| Nickel Creek | Sediment | 2.8 | CWAL, SS |

These water bodies have been described in the 2003 *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load Owyhee County, Idaho* and the 2004 *Upper Owyhee Watershed TMDL Implementation Plan for Agriculture.*[22,23]

While Sediment has been identified as a pollutant in some creeks, the quantity of sediment in the waters of Deep Creek, Pole Creek, Castle Creek, Red Canyon Creek, and Nickel Creek is not known. It is not known if monitoring of these creeks for the TMDL report included sampling for sediment.

In the following discussion it is important to note that there is a difference between 'designated beneficial uses' and 'existing uses'.

*i. Reservoirs*

The two reservoirs discussed in the reports have single measurements of sediments. It is not known if measurements were made when livestock were grazing in the allotment. Livestock watering or substantial runoff events can increase the amount of sediment suspended in water.

- *Blue Creek Reservoir*

The Blue Creek Reservoir is used to store irrigation water. "The listed pollutant of concern is sediment. Biological monitoring conducted in 2001 indicated sediment is impairing the biological communities."[22:xviii] The major biological community within the reservoir is stocked fish. "In 2000, the Idaho Department of Fish and Game introduced domestic Kamloops trout in the reservoir. With the stocking of the Kamloops, the reservoir has been determined to have cold water aquatic life as an existing use and criteria to support this existing use therefore applies."[22:xviii] Prior to the introduction of Kamloops trout the designated beneficial uses of the reservoir were listed as water supply, aesthetics, and wildlife habitat. "There is no indication that these uses are impaired."[22:32]

There is one measurement of sediment within Blue Creek Reservoir. On July 7, 2001 the turbidity was measured at 67 NTUs at the reservoir surface (0.5 meters) and 64 NTUs at the reservoir bottom (3.2 meters).[22] At the same time the total suspended solids were measured at 23 mg/l at the surface and 25 mg/l at the bottom. Representative sediment and NTU data is a data gap for this water body.

- *Juniper Basin Reservoir*

"Juniper Basin Reservoir constructed in 1923, was designed as a storage reservoir for irrigation water. It has since fallen into disrepair. The reservoir is mainly used for livestock watering."[22:11] The reservoir has a depth of 2 meters below the outlet (6.5 feet) and 5 meters (16 feet) at full capacity. The sediment on the bottom of the reservoir is fine grained. At present the only agricultural use may be livestock watering as it is unknown if the reservoir release valve is capable of functioning.

"Juniper Basin Reservoir does not have designated beneficial uses except for water supply, aesthetics and wildlife habitat (IDAPA§ 58.01.02140.04.). There is no indication that these uses are impaired. Existing uses include PCR [Primary Contact Recreation] or SCR [Secondary Contact Recreation]. The listed pollutant is sediment. It is not clear how Juniper Basin Reservoir was placed on the 1998 §303(d) list."[22:32]

There is one measurement of sediment within Juniper Basin Reservoir. On July 6, 2001 turbidity was measured at 72 NTUs at the reservoir surface (0.5 meters) and bottom (1.2 meters).[22] Total suspended solids for the same day were 11 mg/l at the surface and 14 mg/l at the bottom of the reservoir.

Although the Idaho DEQ did not find the reservoir in 2003 to have impaired uses, the authors of this assessment noticed that the use of Juniper Basin Reservoir for watering of cattle had resulted in an extreme concentration of cattle around the reservoir in 2010 at the expense of the aesthetic appearance and all other uses.

**Photo 9.14. Cattle using the Juniper Basin Reservoir as a water source in July 2010.**

*ii. Creeks*

Sediment has been identified as a pollutant in five creeks within the Upper Owyhee HUC. The suspended sediment concentration and turbidity in these creeks have not been directly measured. The Stream Macroinvertebrate Index was used as an indirect measure of sediment pollution. The SMI rates the health of a creek's macroinvertebrate community in comparison to reference collections from 'unimpaired' creeks. The SMI scores used to designate sediment as a pollutant in these creeks are given in Table 9.2. The dates of the sample collections are not known.

Table 9.2. Stream Macroinvertebrate Index scores for five creeks in the Upper Owyhee HUC between 1995 and 1999. Higher numbers indicate better health of the macroinvertebrate population.[22:34]

| Creek | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| Deep Creek (location 1) | 22.33, 24.33 | 65.82 | 50.73 | 60.57 | |
| Deep Creek (location 2) | 45.55, 41.78 | 48.5 | 46.48 | 51.46 | 62.17 |
| Pole Creek | | | | | 50.55 |
| Castle Creek | | 34.49, 21.58 | | | |
| Red Canyon Creek | | | | | 63.36 |
| Nickel Creek | 9.97 | | | | |

* >58 Condition Rating 3 (best); 49-57 Condition Rating 2; 31-48 Condition Rating 1; <31 Minimum Threshold

The creeks were revisited in 2000 and 2001 for the 2003 Idaho DEQ assessment, "macroinvertebrates and periphyton* samples were collected on those systems listed as being impaired by sediment. Two sets of samples were collected in 2000 and two sets in 2001."[22:49] SMI scores were not calculated. No comparison was made with the macroinvertebrate population data from previous years. Instead, the presence and absence of species known to be tolerant or intolerant to sediment was used as an indirect measure of sediment pollution. In addition a siltation index was calculated. Of the five creeks where sediment was listed as a pollutant, three did not show sediment pollution in the 2000 and 2001 samples. Sediment was not a limiting factor to fish populations in Pole Creek, Red Canyon Creek, or Nickel Creek. Castle Creek and the upper course of Deep Creek were impaired by sediment.[22] While Nickel

* Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems.

Creek did not show signs of sediment pollution, the general lack of macroinvertebrate and periphyton species in the creek (maybe due to metal toxicity), put sediment back on the pollutant list. Data and recommendations from the 2003 assessment were set aside in the subsequent summary report with no explanation. Both Pole Creek and Red Canyon Creek are listed as polluted with sediment in the 2004 report.[23]

*iii. Feasibility of addressing the Upper Owyhee HUC TMDL*

Resolving the sediment pollution in suspended and bed load of creeks is one goal of the TMDL. Flooding, or high water flow episodes are a major contributor to suspended sediment. During a flood there is more water moving with greater power. This results in greater turbidity and thus more sediment in the running water. Floods also move a greater amount of bed load.

Other factors that influence the amount of sediment within water vary between still and running water bodies.

- *Reservoirs*

As water in reservoirs and lakes tends to be calm, the sediment carried by a stream will settle on the bottom of reservoir or lake. This fine grained sediment can be remixed with the water due to disturbances such as higher than normal water flows, stock watering, or wind.

The Juniper Basin Reservoir is currently used for watering stock. As the majority of the reservoir is shallow the entrance of stock into the reservoir may result in significant disturbance of the lake bed and reintroduction of sediment into suspension. All riparian vegetation around the reservoir has been consumed.

Exclusion of stock from the Juniper Basin Reservoir would limit disturbance of the water and fine sediments on the reservoir bed and would allow the establishment of riparian vegetation. Stock exclusion from reservoirs is a good management practice that can be implemented by the development of off reservoir water sources for stock. Whether stock exclusion will meet the pollution requirements of the TMDL reports is unknown.

The TMDL report from 2003 stated that, “It is not clear how Blue Creek Reservoir was placed on the 1998 §303(d) list.”[22:32] However, this placement indicates that sediment was recorded for the reservoir in 1998, prior to stocking of domestic Kamloops trout in 2000.[22] These fish are considered to be at risk from this sediment. The actual sediment pollution and the factors contributing sediment pollution at Blue Creek Reservoir are unknown.

It is unknown how much new sediment is introduced to the reservoirs each year.

- *Creeks*

Some creeks have sediment exceeding that desired for salmonid fish habitat. Limiting human made sources of sediment erosion will limit additional silting in of the creek beds if it is a factor. Improvement of fords should be considered as vehicle traffic and erosion of the road bed can contribute sediment to a creek. The sediment which would occur in the absence of anthropomorphic activities is not open to amelioration.

The fine sediments that are already in creek beds will be best removed naturally by successive high flow events that scour and remove the fine sediments. The speed with which fine sediments are removed is outside of human control.

The majority of the region has not been heavily impacted by humans. Erosion of sediment off of the rangelands and erosion of the stream channels during weather events and high water flows will continue.

Direct measurements of sediment in suspension and on the creek beds are needed to understand some of the natural variation.

Future monitoring of the creeks should include observation and sampling at various locations along the stream as changes in topography and the location of tributaries impact the stream bed's properties. The health of a stream system should be assessed from multiple points of data collection. The lack of this extent of information is a data gap as is the understanding of the stream system which would result from having the information.

Whether the goals for sedimentation of the TMDL can be met is unknown. Stream bank erosion is assumed to be a major contributor of sediment to the creeks and reservoirs with sediment pollution. The TMDL sets limitations on streambank erosion rates.[22] There is no current implemented way to measure streambank erosion rates. Calculating streambank erosion requires measuring the tons of sediment lost per mile per year. Another limitation has been placed on the total sediment load in tons per year. It is unknown how much sediment is actually moving through the creeks each year so it is unknown if the sediment load allocation figures can be met.

## 6. Sediment standards

### *a. Idaho*

"The state of Idaho utilizes narrative sediment criteria and numeric turbidity criteria to determine if there are violations of WQS [Water Quality Standards]".[22:47]

> "With an absence of a numeric criterion for sediment, some TMDLs in Idaho have set targets for total suspended solids (TSS), suspended sediment and/or substrate embeddedness or percent fines. Once impairment to the beneficial uses has been determined, as described in IDAPA§ 58.01.02.200.08, an interpretation or an extrapolation is made with the use of literature values. These values can either define a water column allocation, substrate targets and/or both."[22:47]

> "Section 250 of the WQS describes applicable turbidity levels. IDAPA§ 58.01.02.250.02.d. states 'Turbidity, below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than fifty (50) Nephelometric Turbidity Units (NTUs) instantaneously or more than twenty-five (25) NTU for more than ten (10) consecutive days.'"[22:47]

Determining the background turbidity level for the WQS requires an area where there are no anthropogenic sources that would affect the water quality. These levels would also be creek specific. The lack of this information is a data gap.

### *b. TMDL of Upper Owyhee HUC*

Limits for suspended sediment concentrations, turbidity, and particle size in the channel beds have been delineated by the EPA for the Idaho portion of the upper Owyhee watershed:

> "A draft Subbasin Assessment and TMDL for the Upper Owyhee Watershed was completed by IDEQ and approved by the EPA in March 2003. Pollution load allocations were included for the 303(d) listed stream segments as well as other non-listed stream segments within the Upper Owyhee Watershed and ranged as follows: 87-100 percent shading for temperature; 50 mg/L monthly average and 80 mg/L durational targets for suspended sediment; 25 NTUs target for reservoirs; 27 percent fine material reduction for channel substrate; and stream bank erosion targets ranging from 3.4 to 43.5 tons/mile/year."[23:9-10]

There are no plans for monitoring sediment in association with the limits set within the TMDL.[23:35-37] The natural background of sediment load and for channel shading are unknown data gaps.

### 7. Sediment transport

A major data gap is an understanding of how sedimentation of upstream rivers and creeks affects the amount of sediment downstream.

How much of all the sediment transport is accounted for by unusually high flow events?

Will direct measurements of sediments in creeks agree with the conclusion drawn from the populations of macroinvertebrates?

How much of a stream course would naturally have a gravelly bed for fish to find desirable habitat? How do short periods of increased water turbidity (such as those associated with storm and runoff events) affect fish health? Are fish moving between stream segments over the course of the year with fluctuations is water flow, temperature, and bed habitat?

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# Upper Owyhee Watershed Assessment

## X. Riparian



### Contents



The Oregon governor's strategic initiative for ensuring sustainable water resources for Oregon's future, Headwaters 2 Ocean, considers all water resources from the hilltops to the Pacific Ocean. The completion of the assessment of the upper Owyhee subbasin is consistent with the governor's initiative. The upper Owyhee subbasin contains the headwaters of the Owyhee River and two of its principal tributaries, the South Fork Owyhee River and the Little Owyhee River.

## X. Riparian

### A. What is a riparian zone?

A riparian zone is an area that supports vegetation requiring more moisture than the adjacent uplands. In arid and semiarid regions, riparian areas exist in the narrow strip of land along the borders of creeks, rivers, or other bodies of water where surface water influences the surrounding vegetation.[7,18,27,39]

Riparian ecosystems exist between the uplands where there is seldom standing water and the stream, river, or lake where free flowing or standing water is common. They may also exist on intermittent streams where plants have access to the water table. Riparian zones have widely varied hydrology, soil, and vegetation types. There are different interactions between the topography, soil, geology, elevation, hydrology, vegetative cover, evapotranspiration, animal use, and alterations by people. Consequently riparian zones vary considerably and may be difficult to delineate.[7,18,32,38,39]

Because of the proximity of riparian zones to water, the plant species are considerably different from those of the drier surrounding areas. Riparian zones are generally more productive in terms of plant biomass and are a critical source of diversity

**Photo 10.1. A riparian section of vegetation along an intermittent stream coming out of the Independence Mountains.**

in rangelands. They create well-defined habitat zones but make up a minor proportion of the overall area in arid-land watersheds. Riparian plant communities are disproportionately important in the upper Owyhee subbasin, but there is "probably less known about them"[7] than other plant communities. Riparian zones represent an extremely significant component of the overall landscape.[7,18,27,32,33] "Wetlands and riparian zones generally cover only a small percentage of the landscape in arid regions, but in the Owyhee Uplands ecoregion the percentage is even smaller than that of the Great Basin. Again, the reason for this is the lack of large playa lakes or internal basins . . . that are often comprised almost solely of alkaline wetlands."[26]

## B. Why are riparian areas important?

The vegetation in riparian areas affects the hydrology of the ecosystem. During high stream flows, water can be stored in the adjacent soil and in ponds, lessening the destructive effects of downstream flooding. The stored water can be a source of groundwater recharge, helping maintain stream flows later into the season.[18,38] Where willows grow along the stream banks, passing water fills the soil profile to the sides of the stream. The water is released slowly back into the stream, helping stabilize the flow in the channel.

Stream banks with well developed riparian vegetation are less prone to erosion. The roots of riparian vegetation stabilize the soil. Water slowed by riparian vegetation has less power to erode the stream bank. Also, slower water will carry less sediment and sediments from floodwaters may be deposited in riparian vegetation.[18]

Riparian vegetation filters water both before and after it reaches a stream, removing sediments and nutrients, providing clean water and building up the soil.[18,32]

Abundant forage, water, and wildlife habitat attract a greater amount of use of riparian zones by wildlife than proportional for their small land area. In addition to providing habitat for fish and wildlife, riparian areas in the upper Owyhee subbasin provide scenic beauty. They are disproportionately important for many other uses. They provide opportunities for hunters, fishermen, and birdwatchers. Recreationists concentrate their use in and along such areas. Riparian zones tend to have relatively gentle topography which makes them attractive locations for roads or housing. Frequently, stream margins are highly productive forage sites. Cattle concentrate in

**Photo 10.2. The green of the riparian area along Tent Creek contrasts with the grey-green vegetation of the hillside**

riparian areas not only to drink, but because of the shade, relatively gentle topography and vegetation that remains green after upland forage dries.[18,32,33,39,40]

**1. Importance to wildlife**

The riparian zone is the most important wildlife habitat type in managed rangelands and is used more than any other type of habitat. Of course aquatic species such as fish and amphibians use the water in these zones, but many other semi-aquatic animals, such as waterfowl and muskrats, are found only in riparian zones. Riparian areas are critical to the life cycles of many other wildlife species.[18,33]

Stream side vegetation is also extremely important in the food chain. The organic detritus from the vegetation is a food source for aquatic organisms. The vegetation is an important habitat for terrestrial insects that form part of the diet of many bird and fish species.[18]

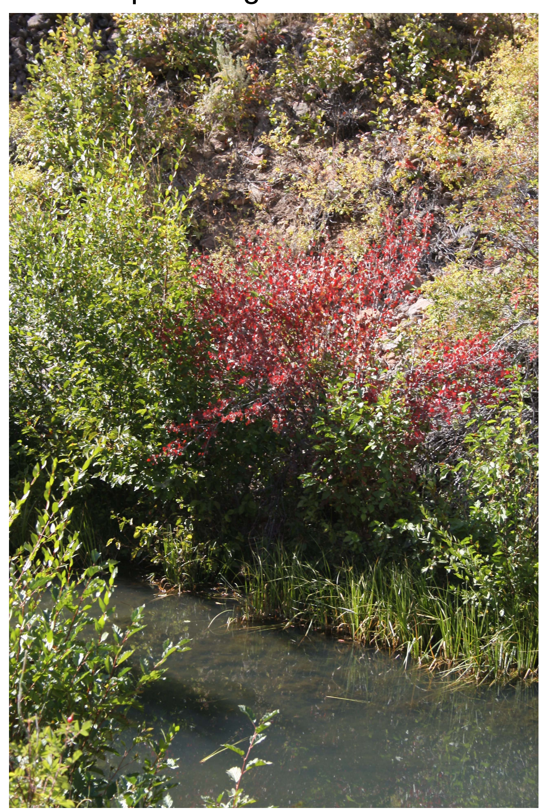

**Photo 10.3. Changing types of vegetation in a riparian zone along a small creek in the upper Owyhee subbasin.**

In the upper Owyhee subbasin most non-bird wildlife species are directly dependent on riparian zones or use these areas more than other habitats. Wildlife habitat consists of food, cover, and water. Riparian areas offer water. Many riparian zones also provide an unusually large part of forage for big game as well as livestock.[32,33]

Because riparian zones are a transitional zone, there are often several changes in vegetation between the wetland and the land with no subsurface water. This provides a number of different microhabitats so that there is a large diversity of breeding and forage sites. Some of these microhabitats tend to be more humid with more shade. Some wildlife species including deer and elk are attracted by the microclimate produced by the vegetation.[18,33,38]

Every riparian zone has different site attributes, but riparian zones are important to wildlife for many reasons.

## C. Vegetation

Riparian plant communities are complex and highly variable in structure, number of species, species composition, productivity, and size. Plant species adapted to the upland may be unable to grow near river channels because they can't tolerate continuously wet soil and similarly species adapted to the river environment usually will not tolerate drier, less frequently flooded sites. Many riparian species must survive complete inundation some years or soil that may dry out completely other years, and sometimes both within the same year. [7,13,32,39]

Stream conditions vary considerably over the course of a year and from year to year. Vegetation in riparian zones is even more variable than streams. There is not only a greater availability of water to plants, but frequently there are deeper soils. This leads to a great diversity of plant species. Riparian communities include many combinations of grasses, forbs, shrubs, and even trees. The density of the vegetation varies considerably.[7,9,13,32,33]

Riparian and wetland natural communities in the Owyhee Uplands are generally assumed to be similar to those present in the Great Basin except that there are few large, high elevation aspen groves and the extent of alkaline wetland habitats is limited.[26]

**Photo 10.4. Coyote willows reflected in Hurry Back Creek in the upper Owyhee subbasin.**

Willows are the common woody riparian species in the upper Owyhee subbasin. The coyote willow is an upright, deciduous shrub which is generally about 12 feet tall and about 15 feet wide. It grows along creek bottoms, both on the shoreline and sometimes in the water. Coyote willow forms dense thickets of pure, even-aged shrubs. Short-lived, they are threatened by both fire and drought. They can not survive long if the water table becomes too low.[6,5]

Sedges and rushes are common herbaceous riparian species.

These species are well adapted to riparian areas. Numerous growing points and stems allow water to flow over and through a plant. A high density of roots or underground stems (rhizomes) which form a dense mat protect the stream bank from erosion and contribute to steam bank stability during high water.[3,32,38]

The dramatic contrasts between the plant communities of the riparian zone and the general surrounding upland range vegetation adds to the visual appeal.

## D. Proper functioning

A properly functioning riparian area will have adequate vegetation to filter sediment, to stabilize the stream bank, to protect the stream bank from erosion, to store and release water, and to recharge the aquifer. A properly functioning riparian area along a perennial stream would result in some of the following characteristics: late summer stream flows, high forage production, good water quality, and vegetation and roots that protect and stabilize the banks. It could provide shade, cooler water, good fish habitat, and a high diversity of wildlife habitats.[2,15,27] In order to determine whether a riparian area is functioning properly, it is necessary to examine site-specific characteristics. The potential vegetation for that spot is based on the interaction of geology, soil, and the physical processes and attributes of the stream.[4,25]

## E. Historical use

Some of the earliest use of riparian areas in the upper Owyhee subbasin by Euro-Americans was for wintering cattle. Since the cattle remained close to the existing water supplies, they would completely consume the nearby forage, mainly winterfat, and Indian ricegrass. In the dry upper Owyhee basin, the wetter riparian areas were the first areas farmed, mostly for hay. In 1901 north of Winnemucca, David Griffiths listed alkali bullrush, cattail tine, and spike rush which grow in freshwater marshes and seasonal lakes as important hay species. The floodplains adjacent to creeks were the first areas used to plant hay and other domestic plants.[10,41]

**Photo 10.5. The Wiley Ranch on the Owyhee River. Counterclockwise from upper left: the site looking towards the river, the old farm house, the Owyhee River, abundant riparian vegetation.**

To provide enough water and irrigable land to grow hay to feed their herd through the winter, ranchers acquired tracts of private property. During the summer the herds drank from streams and springs on the public lands where they were grazing, but established water rights were crucial for the success of a ranch.[31,11] Since the riparian areas were the most productive lands, they were used for farming and ranching. Irrigated lands are usually located within the historic floodplains of stream and river corridors which expanded the riparian areas.[11] Meadows were enlarged on private land by diverting water by gravity flow along the lateral edges of the floodplains and using surface irrigation.[41] Today it is difficult to distinguish natural wetlands and pastures from the areas that have been continually expanded through human intervention.

In the Nevada section of the upper Owyhee subbasin, the agricultural lands have been irrigated from the streams running out of the Independence and Bull Run mountains. The channelization and spread of irrigation water has largely transformed the native riparian areas in the few agricultural areas (see Agriculture section of this assessment).

In the upper Owyhee subbasin in Idaho, only 4% of the area is riparian. The historical acquisition of waterways and associated riparian areas in this section of the subbasin is evidenced by 18% of the stream miles being on private land although only 6.5% of the land is privately held. Some of the old wet meadow riparian areas have been converted to irrigated pasture or hay fields.[12,11] "All privately owned stream segments assessed during the 2003 [Idaho TMDL] Riparian Assessment . . . still have active riparian livestock grazing."[12]

## F. Fragility

Since riparian zones occupy relatively small areas, they should be considered vulnerable to severe alteration. The distinctive vegetative community is important to the ecology of the whole region. There are many activities that can impact riparian areas.[2,33,39]

Indiscriminate recreational use can seriously disturb or destroy habitat in riparian zones. In riparian zones, recreational use per unit area is many times that for other vegetative communities. Campgrounds in riparian zones increase the opportunity for viewing wildlife but decrease the effectiveness of the riparian zone as wildlife habitat due to the "disturbance by humans, trampling, soil erosion, compaction, and loss of vegetation."[2,33]

The increased presence of vehicles and people on existing roads along riparian zones affects how wildlife use the area. New road construction in riparian zones would alter the size of the zone and of the vegetative community. It may impact water quality and alter the microclimate, destroying wildlife habitat. Road maintenance can disturb riparian areas.[2,33]

The U.S. Forest Service has identified the major factors affecting riparian areas in the Owyhee River basin as livestock grazing, floods, and dams.[39] There are some areas of the upper Owyhee subbasin where livestock grazing continues to affect riparian areas. Continuous or intensive grazing of riparian zones may alter vegetation with a reduction in plant productivity, a change in the plant community, or the encroachment of dry land vegetation. The change may result in a lack of adequate vegetation for bank protection and sediment filtering. The resulting erosion may lower the streambed and change the adjacent water table. Cattle in an eroded streambed may create further bank erosion with "hoof shear".[2,7,33,38]

Management actions such as fire suppression may also alter riparian areas.[38]

## G. Riparian areas in the upper Owyhee subbasin

**Photo 10.6 Hoof shear beginning to affect a stream bank.**

Since riparian areas only exist where there is some connection to the water table, these will primarily be along perennial streams (see Figure 5.13 in the hydrology component of this assessment). Some intermittent streams may also have riparian areas. However, the majority of the non-perennial stream reaches in the upper Owyhee subbasin have not been evaluated as to whether they are ephemeral or intermittent.

Sagebrush dies when flooded. Sagebrush does not tolerate saturated soil, and if the soil stays saturated for two weeks, the sagebrush dies. Spreading water across sagebrush land for two weeks is a well known method of sagebrush control, since the root systems die from lack of aeration.[24] Stream channels that have well developed sagebrush growing directly in the bottom of the wash are not connected to the water table and are ephemeral and will not support riparian vegetation. However, sagebrush seedlings can germinate and begin growing where they can't survive subsequent flooding.

### 1. Landsat imagery

Using Landsat data, maps have been developed showing the probable plant associations in the upper Owyhee subbasin. Sensors aboard the Landsat satellites measure both visible and infrared wavelengths coming from small sections of the earth. The resolution of the pictures generated from these measurements is about 30 meters (98 feet) by 30 meters.[34] Details smaller than 30m by 30m will not be apparent. The Gap Analysis Program is designed to map vegetation using the Landsat spectral bands. The upper Owyhee subbasin lies within two of the completed projects: the Northwest Regional Gap project and the Southwest Regional Gap Analysis projects completed in 2004 and 2007. In the rangeland section of this assessment on Figure 7.1, plant associations mapped by the Northwest Regional Gap project and the Southwest Regional Gap project, it is possible to locate the course of many of the perennial streams and rivers in the upper Owyhee subbasin by the light green coloration indicating *intermountain basins semi-desert grassland* plant associations (Figure 7.2). "These grasslands occur in lowland and upland areas and may occupy swales, playas, mesa tops, plateau parks, alluvial flats, and plains, but sites are typically xeric [dry]."[22] A similar, but slightly more olive, green denotes mesic [with a well-balanced supply of moisture] meadows in the mountainous area.

The blue-green adjacent to the drier *intermountain basins semi-desert grassland* plant associations is the *Great Basin foothill and lower montane riparian woodland and shrubland* plant association which also exists along streams in the mountains*. The plant association designated by a slightly darker blue green is called *Columbia Basin riparian woodland and shrubland*. Other riparian and wetland plant associations in the upper Owyhee subbasin are less widely spread. Streams draining into the basin from South Mountain and a number of the intermittent streams draining into the Little Owyhee River from the east side of Capitol Peak have *Rocky Mountain lower-montane riparian woodland and shrubland, Rocky Mountain subalpine-montane riparian shrubland* or *Rocky Mountain subalpine-montane riparian woodland* plant associations along their banks, indicated by the turquoise areas.[19,22,35,36,20] Descriptions of these riparian plant associations are found in Appendix J.

There are also plant associations of wetlands or seasonal wetlands identified by Landsat analysis in the subbasin. These include *Columbia Plateau silver sagebrush seasonally flooded shrub-steppe*, *North American arid west emergent marsh*, *Rocky Mountain subalpine-montane mesic meadow*, *Rocky Mountain subalpine mesic meadow*, and *Rocky Mountain alpine-montane wet meadow* (Appendix J).[19,22,35,36,20]

## 2. 45 Ranch

The Gap analysis project provides a broad description of the probable vegetation of an area. A more detailed classification system has been adopted by the Environmental Protection Agency and the US Geological Survey (USGS) and focuses on existing vegetation actually growing at a site. The lowest level in this classification system, the National Vegetation Classification System, is delineated by the association of two or more species and called a community.[37,Rangeland component]

The only extensive survey of riparian plant communities in the upper Owyhee subbasin was conducted by the Nature Conservancy on the 45 Ranch and the associated BLM allotment. The Nature Conservancy's survey showed riparian communities existed along the floodplains of the South Fork Owyhee River and the Little Owyhee River, in the spring systems of the canyons, and in intermittent lakes and creeks. In addition to the riparian communities in and along the perennial and intermittent streams, the terrace communities were also assessed. Although the reports of the inventory and assessment are specific to a particular location, to a certain extent the results summarized below can serve as an indication of the types of riparian vegetation which might be found in other areas of the plateau lands of the upper Owyhee subbasin. The South Fork Owyhee River may be considered representative of deeply incised perennial streams, the Little Owyhee River of intermittent streams, and the intermittent lakes and pools of similar pools throughout the plateau region.

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* Although montane means inhabiting mountain areas, the area specifically referred to as *montane* “is the highland area located below the subalpine zone. Montane regions generally have cooler temperatures and often have higher rainfall than the adjacent lowland regions, and are frequently home to distinct communities of plants and animals.”[16]

The assessment identified 275 riparian species (Appendix E) and 21 riparian and wetland plant communities (Table 10.1).[17] Plant communities are named by the dominant specie found within them and a forward slash ( / ) separates this from a specie in a different tree, shrub, or plant group.[21]

Table 10.1. Riparian and terrace plant communities identified on the 45 allotment.[17]

| Common name | Scientific name | Principal location |
|---|---|---|
| **Woodlands** | | |
| Western juniper/California oatgrass | *Juniperus occidentalis/Danthonia californica* | Intermittent creek |
| **Tall Shrub** | | |
| Sandbar willow*/Barren | *Salix exigua/*Barren | South Fork |
| Sandbar willow*/Mesic graminoid | *Salix exigua/*Mesic graminoid | South Fork |
| **Low Shrub** | | |
| Silver sagebrush/Dry graminoid | *Artemisia cana/*Dry graminoid | Little Owyhee, intermittent creek |
| Silver sagebrush/Mat muhly | *Artemisia cana/Muhlenbergia richardsonis* | Intermittent lake |
| Owyhee sagebrush shrubland comm. | *Artemisia papposa* shrubland comm. | Intermittent creek |
| **Graminoid** | | |
| Nebraska sedge | *Carex nebrascensis* | Intermittent creek |
| California oatgrass | *Danthonia californica* | Intermittent creek |
| Creeping spike-rush - vernal pool | *Eleocharis palustris* (vernal pool) | Intermittent lake |
| Creeping spike-rush - palustrine | *Eleocharis palustris* (palustrine) | Little Owyhee |
| Wandering spike-rush | *Eleocharis rostellata* | South Fork, intermittent creek |
| Baltic rush | *Juncus balticus* | Little Owyhee, intermittent creek |
| Common reed | *Phragmites australis* | South Fork, intermittent lake |
| Threesquare bulrush | *Scirpus americanus* | South Fork |
| Sharp bulrush | *Scirpus pungens* | South Fork |
| **Forb** | | |
| Prairie sage | *Artemisia ludoviciana* | Little Owyhee, intermittent lake |
| Cut-leaved water-parsnip | *Berula erecta* | Intermittent creek |
| Davis peppergrass vernal pool | *Lepidium davisii* vernal pool community | Intermittent lake |
| **Transition zone communities** | | |
| Smooth scouring rush | *Equisetum laevigatum* | |
| Smooth brome | *Bromus inermis* | |
| **Non-riparian river terrace communities** | | |
| Basin big sagebrush/basin wildrye | *Artemisia tridentata* ssp. *tridentata/Elymus cinereus* | South Fork terrace |
| Greasewood/Sandberg bluegrass | *Sarcobatus vermiculatus/Poa secunda* | South Fork terrace |
| Basin big sagebrush/needle-and-thread grass | *Artemisia tridentata* ssp. *tridentata/Stipa comata* | South Fork terrace |
| Wyoming big sagebrush/Thurber's needlegrass | *Artemisia tridentata* ssp. *wyomingensis/Stipa thurberiana* | South Fork terrace |

* Sandbar willow is also commonly called Coyote willow

### *a. South Fork Owyhee River*

The plant communities occurring in the floodplain of the South Fork Owyhee River were not diverse and were very different from those on the adjacent stream terraces. The principal communities were identified: Sharp bulrush (*Scirpus pungens*) which tolerates prolonged flooding but has poor palatability for big game and livestock; Common reed (*Phragmites australis*), a tall perennial stand which floods annually; and Sandbar or Coyote willow (*Salix exigua*) communities containing the only woody species with significant cover in the floodplain.[17]

**Photo 10.7. The Owyhee River on the 45 Ranch.**

The assessment concludes that the "riparian vegetation of the South Fork floodway [sic] is represented by communities in high ecological condition. The sharp bulrush community, especially, armors most of the river banks along the South Fork. The maintenance and condition of these communities is more affected by the larger fluvial (river) processes of the watershed than by local livestock grazing."[17] "Most of the South Fork's flow originates in the mountains of Nevada, where snow accumulates in the winter. This snow accumulation zone constitutes a small percentage of the South Fork basin, however, with most of it being arid lowlands of the plains. There is virtually no snowpack on the plains and streams tend to be intermittent and ephemeral, largely flowing during winter and spring and in summer only during storms. This makes for a very flashy hydrologic regime where the river rises rapidly and dramatically in response to spring snow melt patterns and episodic storm events, quickly returning to near base flow."[17]

Between the floodplain communities and the terrace communities there is a narrow transition zone on the river banks with species which may withstand at least some flooding. The Smooth scouring rush (*Equisetum laevigatum*) and Smooth brome (*Bromus inermis*) appear to stabilize steep banks during floods. [17]

Considered by the assessment to be important and unique, the "river terrace communities never flood and are marginally riparian, but their distribution is restricted to valley bottoms along the South Fork and Little Owyhee rivers because of alluvial substrates and higher water table than surrounding uplands."[17] "On the 45 Allotment nearly all terraces support the basin big sagebrush/basin wildrye plant community."[17]

The Basin big sagebrush/basin wildrye (*Artemisia tridentata* ssp. *tridentata/Elymus cinereus*) plant community, with few exceptions, occupies all of the terraces along the South Fork Owyhee River. Greasewood/Sandberg bluegrass *(Sarcobatus vermiculatus/Poa secunda*) community was observed on a few terraces. On slightly higher terrace surfaces there were upland communities of Basin big sagebrush/needle-and-thread grass (*Artemisia tridentata* ssp. *tridentata*/*Stipa comata*) and Wyoming big sagebrush/Thurber's needlegrass (*Artemisia tridentata* ssp. wyomingensis/*Stipa thurberiana*).[17]

The assessment concluded that 57 percent of the terraces were in good to excellent condition. The "concentration of high quality examples of the basin big sagebrush/basin wildrye community is the greatest of anywhere in Idaho."[17]

### *b. Little Owyhee River*

The Little Owyhee River is intermittent, probably flowing only during spring runoff and summer storm events. The large size of the drainage area into the Little Owyhee River is unusual for an intermittent stream. There are some perennially wet habitats in the floodplain although the surface flow is intermittent. There are open-water pools in the channel with aquatic species growing in them. The floodplain riparian communities are quite varied. [17]

The last flood event my have scoured the floodplain surface and deposited a new layer of sand, gravel or cobble. The gravel and cobble deposits are mostly devoid of plants. However, new sand deposits may contain a suite of annual plants if the deposits remain moist. "Where the water table is at or near the surface, the channel can be dominated by lush graminoid wetland communities"[17] (Table 10.1). Sharp bulrush and willow species are less common than on the South Fork Owyhee River. The willow occur in the channel or along its edge. The high cobble bars in the middle of the channel are covered by prairie sage and a high diversity of associated species. Silver sagebrush can dominate small bars on the edge of the dry channel. At high flows, this silver sage/dry graminoid community is clearly under water, probably for only short periods of time.[17]

The terrace plant communities were similar to those along the South Fork with basin big sagebrush/basin wildrye community types and greasewood. However, the perennial understory species were uniformly replaced by exotic annuals "as a legacy of past livestock grazing."[17] "The big terraces along the lower Little Owyhee are easily accessible and have been grazed hard since settlement."[17]

### *c. Canyon spring systems*

Although numerous, all of the canyon spring systems are small. Most of them are isolated sources of perennial water. The associated riparian habitats of the springs contain very different riparian plant communities.[17]

### *d. Intermittent lakes and creeks*

On the upper Owyhee subbasin plateau there are both intermittent creeks and internally drained basins that have an intermittent lake or small pool at the lowest point. Across the subbasin these intermittent creeks, natural lakes and pools are widespread.

Vegetation in these habitats is different than that in the surrounding uplands. Although they have water in them only part of the year and sometimes not every year, they are influenced by high water tables or standing or flowing water. "Little is known about the succession, disturbance, and management of these communities."[17]

*i. Intermittent pools*

The intermittent wetland basins, locally called playas, are defined by Keeley and Zedler as vernal pools. They "define vernal pools as precipitation-filled seasonal wetlands inundated during periods when temperature is sufficient for plant growth, followed by a brief waterlogged-terrestrial stage and culminating in extreme desiccating soil conditions of extended duration."[14] In the 45 allotment the basin areas vary in size from a few acres to several hundred acres. The principal plant communities of the intermittent lakes and pools of the allotment are silver sagebrush/matmuhly (*Artemisia cana/Muhlenbergia richardsonis*), creeping spike-rush - vernal pool (*Eleocharis palustris*), and Davis peppergrass vernal pool (*Lepidium davisii*). In small pools Davis peppergrass is often the only plant.[17]

*ii. Intermittent creeks*

Although the Little Owyhee River is intermittent and shares some of the same communities as intermittent creeks, its size makes it a special case. Within the 45 allotment there were five community types on the intermittent creeks. Prairie sage (*Artemisia ludoviciana*) communities were common in intermittent drainages and along the Little Owyhee. Silver sagebrush/dry graminoid community was also found along the Little Owyhee. California oatgrass communities are common in the Owyhee uplands. However, both the Western juniper/California oatgrass *(Juniperus occidentalis/Danthonia californicus*) and Owyhee sagebrush (*Artemisia papposa*) communities were uncommon in the 45 allotment.[17]

***e. Weeds***

Although 17 percent of the riparian flora consisted of non-native species, only four of the 48 non-native plants were deemed to be of concern by the author of the 45 Ranch assessment. White-top was widespread, usually in the transition zone between the wetter floodplain and the drier terrace, frequently on the upper edge of river banks. Canada thistle and Scotch thistle were growing in small patches of the terraces. There were five mature tamarisk (*Tamarix* sp.) plants mapped along the South Fork Owyhee River floodplain.[17]

Although there were no new plants of tamarisk (salt-cedar) observed, the authors of this upper Owyhee watershed assessment consider this to be a major potential threat to riparian areas. Tamarisk is known to replace native vegetation, use prolific amounts of water and dry out riparian areas. It has a habit of mining salts from the soil profile and exuding them on the surrounding soil, rendering those areas unable to support plant species that cannot tolerate saline conditions. Salt cedar is at or near the top of the list of noxious invasive weeds for all agencies. There is a high probability that established salt cedar will limit the ground flow of water to an extent that it may affect fish and wildlife. Tamarisk has very prolific seed production and can out compete native riparian trees and shrubs. [1,27,23]

## H. Invasive species.

Tamarisk (or salt cedar) is a major potential invasive species of riparian areas in the upper Owyhee subbasin (Figure 7.3). A single tamarisk plant can use up to 200 gallons per day of water in the summer time. Tamarisk has very prolific seed production, grows very rapidly, and sends roots down deep. It provides very poor stream bank stabilization and erosion control.[23,30,28]

Tamarisk could be controlled today, but it is poised to replace native riparian vegetation. There is a high probability that expanded salt cedar could limit the flow of ground water which will obviously affect water for wildlife and push some species toward extinctions.[23,28] Insects which rely on vegetation which has been replaced by tamarisk will disappear and species which feed off the insects will lose a food source. Larger wildlife which frequent the wetter spots of intermittent streams to obtain water may be pushed out of the habitat due to lack of water availability.

Other invasive species in the upper Owyhee subbasin which adversely affect riparian areas include perennial pepperweed, white top, poison hemlock, houndstongue, and purple loosestrife (see invasive species discussion in the rangeland component of this assessment).

## I. Upper Owyhee Agricultural TMDL

The 2003 *Upper Owyhee Watershed TMDL Implementation Plan for Agriculture* assesses riparian zones in the Idaho section of the upper Owyhee subbasin. The authors, the Idaho Soil Conservation Commission (ISCC) and the Idaho Association of Soil Conservation Districts (IASCD), determined that many best management practices (BMPs) “have already been established by producers within the watershed. The BMPs included watering facilities developed away from streams (watering troughs and tanks), spring development, heavy use area protection, fencing, and prescribed grazing (shorter duration grazing and moving livestock to prevent overgrazing). With proper installation and maintenance these BMPs can improve water quality and help restore stream function. Most of the riparian areas that were evaluated during the 2003 Upper Owyhee Riparian Assessment displayed an upward trend. This indicates that existing BMPs have already provided water quality improvements on the stream segments with TMDL targets within privately owned parcels.”[12]

“According to some ranchers in the area, there has already been a change in grazing duration. This has greatly improved stream channel condition and riparian health along several stream reaches. The primary reason to reduce duration and adjust timing is to increase and protect riparian vegetation. Allowing new vegetation growth each year will create multiple age classes, which increases both the quantity and quality of stabilizers along the stream bank and ensures long-term bank stability.”[12]

All of the areas assessed by the ISCC and IASCD were riparian areas on privately owned stream reaches (Figure 10.1). The assessment determined that there were several privately owned parcels with riparian areas that needed site-specific changes, primarily in grazing management. The authors felt that these improvements could be made without “the use of structural components such as fencing; however, additional pasture fencing and water developments in these areas would certainly make it easier to control livestock distribution and grazing intensity."[12]

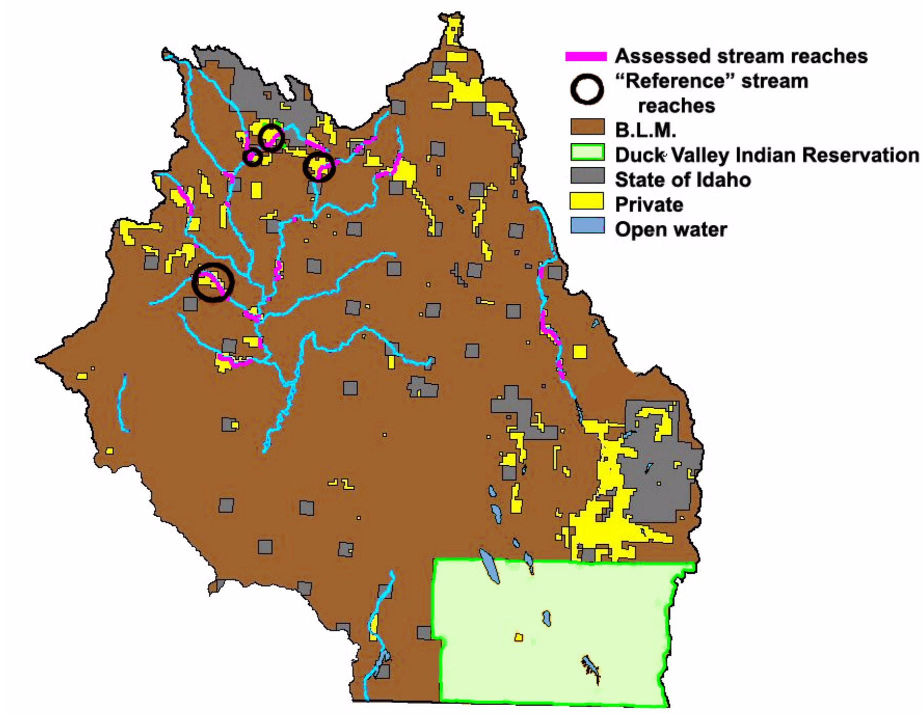


**Figure 10.1. Riparian areas of stream reaches assessed in the Idaho section of the upper Owyhee subbasin.[12]**

The base materials of the stream channels next to the majority of the riparian areas surveyed by the ISCC and IASCD consisted mostly of gravel, sand, and silt. These channels had an average slope (gradient) of 0.7% with the largest gradient being 2.1%. The channels are important to the development of riparian vegetation since the "upland areas above streams have minimal impact on riparian function and stream conditions. The upland area begins at the outside edge of the riparian area along a stream and continues upward to the subwatershed boundary. There was little evidence of excessive erosion or deposition within stream channels from upland areas within each of the evaluated subwatersheds. The primary sources of erosion and deposition are within the stream channel and riparian areas themselves."[12]

The ISCC and IASCD assessment rated the "outward floodplain development" as adequate on 73% of the stream reaches assessed. However, the "inward floodplain development" into the stream channel was rated as adequate in only 15% of the assessed stream segments. A trapezoidal stream channel was considered to indicate adequate inward floodplain development while a dish shaped channel indicated needed improvements in inward floodplain development.[12]

The assessment found that certain stream reaches of Camas Creek, Castle Creek, Deep Creek and Pole Creek represented "potential riparian stability, vegetation health, and diversity within the stream." These streams were deemed to be "reference" streams for the subbasin with good to excellent riparian conditions (Figure 10.1). All of these stream reaches are near the headwaters of the respective creeks. Considering the diversity of geological, hydrological and physical aspects of riparian zones, these stream reaches may not be representative of what can be achieved elsewhere in the subbasin, especially downstream where streams may be highly confined or subject to great natural fluctuations in high and low flows.

## J. Discussion

The management of riparian areas is a vital environmental and economic issue. Although riparian zones in the upper Owyhee watershed are extremely limited, there are many different groups who feel the areas should be managed in different fashions and this poses the potential for conflicts. Riparian resources are utilized by livestock, wildlife, fish, vegetation, invertebrate animals, river rafters, hunters, fishermen, hikers, campers, boaters, birdwatchers, homesteaders and others. As a result, riparian zones are critical zones for multiple-use planning.

Some riparian areas are obviously not subject to management such as those in deep canyons inaccessible except by boat.

All ecosystems are dynamic and change over time. Riparian systems are probably more dynamic than the surrounding uplands.[32] Planning for riparian zones needs to consider their dynamic nature and attempt to maintain them as fully functioning ecosystems.[18] These ecosystems will vary from what they were during other climatic periods, from what they were before the Spanish introduced horses to the new world, and from what they were at the turn of the 19th century or the turn of the 20th century. There is no going back to some "pristine condition." Invasive species have affected riparian zones. Recreational use of riparian areas in the upper Owyhee subbasin is increasing as the urban population in the western United States grows.

**Photo 10.8. Riparian areas along an inaccessible stretch of the Owyhee River.**

It is extremely important to consider all uses of riparian zones. No one use is inherently detrimental or beneficial.

Cattle grazing is sometimes cited as a primary negative factor in riparian areas. Although many riparian areas in the United States were mismanaged and degraded by improper livestock grazing, modern livestock grazing practices are substantially different from those of early in the last century. The negative effects of grazing can be minimized or eliminated with proper management.[18,33,40,15,8]

Management decisions about livestock grazing need to be made on a case by case basis since there are site factors that change from one riparian community to another. Techniques that attract livestock away from riparian areas, that promote avoidance of riparian areas, or that exclude livestock from riparian areas can all diminish the impact of grazing in one location. Grazing systems may also limit the duration or time of year when livestock graze in or near a riparian area. With livestock exclusion, consideration must also be given to the effect on wildlife.[7,15,33,40,15,8]

Water developments for livestock away from riparian areas may also benefit wildlife. Proper placement and design of water impoundments can create new wildlife habitat as well as providing water for cattle. "Small, wet meadows can also be created by piping overflow water from livestock troughs into fenced areas thereby creating and maintaining such meadows."[33]

Because of the greater moisture in riparian areas and generally a deeper soil, riparian zones generally have a high rate of recovery of vegetation when they are appropriately managed and protected.

## K. Unknowns

How will the expansion of tamarisk into many of the riparian areas of the upper Owyhee subbasin affect the hydrology and vegetation of the area? How would the hydrology and vegetative changes affect wildlife? Will public agencies respond before drastic losses occur?

Not all the riparian areas in the upper Owyhee subbasin have been identified or characterized. In the upper Owyhee subbasin, the potential of riparian areas based on physical, biological, and chemical conditions is not known. The site specific physical, biological, and chemical conditions of riparian areas have not been surveyed. Due to the variability in factors influencing riparian zones and the resulting diversity, a small sample can not necessarily be taken as representative of the whole.

The relative impacts of different uses of riparian areas in the upper Owyhee subbasin are not known. What impacts are river rafters having on riparian areas? There are limited camping areas along the Owyhee River rafting corridor and these tend to be in riparian areas.

What are the actual impacts of livestock on riparian areas? What reaches are not affected and what reaches are affected? An inventory of heavily impacted riparian sites or reaches has not been made. Information on how grazing systems may be used to accomplish such goals as maintenance of woody stream bank vegetation and the prevention of bank crumbling and soil compaction is being developed by experience and research.[33] The management that will result in maintaining, restoring, improving, or expanding riparian areas in the upper Owyhee subbasin is poorly defined.

Information on the site potential for riparian vegetation is lacking.[12] “Studies have shown [that following restoration activities] the improvement to stream morphology, riparian conditions, streambank stability and stream hyporheic conditions may take anywhere from 20 to 100 years.”[12]

What are the cultural resources of riparian zones? The same attributes that lead to a high intensity of modern use in riparian zones have been present for millennia. A greater number of archaeological sites have been reported near water sources than in adjacent uplands.[29] These areas should also have sites of historical significance. River terraces are nice places to live. Where are these sites and which, if any, of them should be protected or preserved.

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# Upper Owyhee Watershed Assessment

## XI. Watershed Condition Evaluation



### Contents



The Oregon governor's strategic initiative for ensuring sustainable water resources for Oregon's future, Headwaters 2 Ocean, considers all water resources from the hilltops to the Pacific Ocean. The completion of the assessment of the upper Owyhee subbasin is consistent with the governor's initiative. The upper Owyhee subbasin contains the headwaters of the Owyhee River and two of its principal tributaries, the South Fork Owyhee River and the Little Owyhee River.

### XI. Watershed condition evaluation

To evaluate the condition of the upper Owyhee subbasin, it is necessary to look at all of the interacting factors within the ecosystem. The subbasin has changed since the first Native Americans took up residence here at least 13,000 years ago. There have been changes in climate, changes in population densities, and changes in the effects of humans on the ecosystem.

Native American inhabitants of the region modified the environment. The pre-European land use practices affected the abundance of game and promoted the propagation of economically important plant species. With the arrival of Euro-Americans and with advances in technology, the types of modifications to the environment have changed and are continuing to change. These more recent modifications can be considered both beneficial and harmful.

Ecosystems are dynamic. The ecosystems of the upper Owyhee subbasin have changed from what they were before the Spanish introduced horses and European diseases to the western hemisphere. They have changed from what they were at the time of Euro-American contact, and they have changed from what they were at the turn of the last century.

Some things have remained relatively constant over the last two hundred years. The upper Owyhee subbasin is still an arid to semi-arid desert with little water and less runoff. The land is geologically very young so soils are not well developed. The combination of poor or nonexistent soils with a lack of water has meant that the human population of the area has remained low.

The tremendous geological and erosive forces which shaped the landscape in the more distant past have been relatively inactive in the recent past. Unchanged by bulldozers and subdivisions, the natural beauty of the landscape has not been spoiled.

## A. Evaluation of watershed condition

The upper Owyhee subbasin occupies a large, sparsely populated area. There is a paucity of data about many aspects of the region, both as it may have existed before Euro-American entry into the region and as it exists now. Many of the unknowns, or data gaps, have been enumerated in the other sections of this assessment.

There are some conclusions which can be made from the data which is available.

The upper Owyhee subbasin has complex geography. It varies in elevation from 4,800 feet to over 10,000 feet. The parent materials are from widely different geological origins. There is a resulting diversity across the subbasin in local hydrology, native vegetation, land use, and other characteristics.

A landscape that was devoid of trees except in the Bull Run and Independence Mountains at the time of Euro-American contact now has trees growing along parts of many of the streams and rivers.

Large game, extremely scarce at the time of Euro-American contact, now roam the Owyhee uplands.

Over grazing in the late 1800s and early 1900s left broad expanses of rangeland largely denuded and unprotected from erosive events. Grazing management has led to renewed vegetative cover on most of these rangelands.

Hundreds of species of native plants still grow in the upper Owyhee subbasin. Native animal species can be observed in all areas.

Water developments throughout the subbasin have increased the availability of water to both livestock and wildlife.

The potential expansion of tamarisk poses one of the greatest threats to the continued availability of water originating within the upper Owyhee subbasin. This would affect wildlife, riparian areas, and downstream uses. Additional weed species and juniper are poised to expand within the watershed.

Further off-stream water developments are needed to remove livestock from some riparian areas during times when the riparian vegetation would be sensitive to grazing pressure.

The expansion of agriculture on the western side of the Bull Run and Independence Mountains in Nevada has led to the channelization of streams in the area, including long reaches of Bull Run Creek.

## B. Discussion

We cannot know what the condition of the watershed would be in the absence of humans. The geology and climate affecting the area would be little different, although even the climate may be changing due to the activities of people elsewhere in the world.

### 1. Invasive species

In comparison with other areas of the Owyhee watershed, the upper Owyhee subbasin has a lower incidence of invasive species.

Evolution occurs slowly over time. The native plant stands of the rangelands and riparian areas in the upper Owyhee subbasin evolved with grazing pressure,[1] without nonnative invasive species, and with periodic fires. Now there are invasive species, a low fire frequency, and in some areas the absence of grazing. Native plants are not adapted to compete well under the changed conditions.

Major efforts are needed to halt and reverse the spread of invasive species. Many of the invasive species are just obtaining a toehold and need to be stopped while treating them is still relatively easy. Newer, less dangerous herbicides with shorter half lives are being successfully used by ranchers cooperating with the Jordan Valley Cooperative Weed Management Area. The continued spread of invasive weed species will result in a degraded, non native environment without the vegetative community which was (and in many places still is) an important component of the ecosystem. The whole web of native insect and higher animal life depends on the continued vigor of native plant species both on the rangeland and in riparian areas.

Tamarisk is known to be present along both the South Fork Owyhee River and the east fork Owyhee River (Figure 7.3). It is still relatively infrequent. These isolated occurrences pose a serious threat by providing a source of seed which can both spread and expand the population around the existing plants and disseminate seed downstream where it can establish new colonies along the banks of the river. A program now to eliminate the existing plants could significantly avert undesirable effects resulting from decreased water production. The use of biological controls of tamarisk has been severely limited by court cases.

**Photo 11.1. Tamarisk in bloom.**

Although halogeton occupies large stretches of the center of the road in the southwest corner of Owyhee county, it has obviously been in the area for quite some time since the area to the east of the Little

**Photo 11.2. Halogeton on the left hand side of the road. Little Owyhee River Canyon in the background.**

**Photo 11.3. A well established halogeton plant.**

Owyhee River is named Halogeton Flats. And yes, the flats are contaminated with halogeton.

Management of invasive species may be the most time sensitive issue for maintaining healthy watershed conditions.

### 2. Rangeland

The rangeland of the upper Owyhee is extensive. Some of the range is in great shape with a mix of perennial forbs, grasses, and shrubs. There are large areas that have sparse vegetation but have about as much vegetation as the climate and soil will support.

There is an area of the upper Owyhee subbasin in southeast Malheur County and southwest Owyhee County along the border with Nevada which is overstocked with woody vegetation. There are very few forbs or grasses, either native or introduced, in the understory. In July 2010, there were no signs of grazing. The excessive growth of sagebrush may be the result of a long period with systematic fire suppression or with no fires.

**Photo 11.4. Rangeland overstocked with woody vegetation in southwest Owyhee County**

### 3. Riparian

The riparian areas in the steep-sided, deeply incised canyons of the Owyhee River and the South Fork Owyhee River are in close to pristine condition. There is limited access to these areas for large wildlife, cattle, or most humans.

The elimination of most of the beaver by trappers in the early 1800s changed the hydrology of the upper reaches of streams. We do not know the extent of changes in the associated riparian vegetation. The early trappers noted that much of the riparian system in the upper Owyhee subbasin was useless for trapping beaver. The confined nature of the streams and their routine scouring rendered them inappropriate for support of beaver.

**Photo 11.5. Looking down from steep canyon walls on riparian vegetation along the Owyhee River.**

## 4. Hydrology

The river flows in the upper Owyhee subbasin vary significantly from year to year. Occasionally there may be a larger volume of flow in one day than the total volume for the driest years. The upstream water impoundments have had a slight mitigating effect on the "flashy" nature of the flows.

Exceptionally large flows, especially when accompanied by ice, are responsible for removing riverside vegetation, transporting sediment, and causing stream bank erosion.

## 5. Mercury and other legacy mining minerals

Much of the mining activity in the upper Owyhee subbasin ended at the end of the nineteenth century or early in the twentieth century. The individuals or companies responsible for any lingering pollutants are no longer around and can not be held accountable for cleanup. Private individuals and local governments do not have the economic resources to contain the sources of any legacy pollutants which continue to flow into the streams of the upper Owyhee subbasin. Federal and state agencies need to be actively involved in preventing the ongoing and future contamination and eliminating this threat to the water quality.

## 6. Federal ownership of the land

The major portion of land in the upper Owyhee subbasin is federal land. With a small tax base, it is a hardship on the counties and other local agencies to provide services to this vast area.

The BLM has served as the steward of much of the land in the upper Owyhee subbasin. Much of the past recuperation of degraded areas of rangeland was accomplished with BLM support and oversight. However, the public land is managed by bureaucracy and bureaucracies are frequently slow in responding or unresponsive to local needs.

### 7. Recreation

Growing population in SW Idaho and elsewhere is increasing the use of the area for recreation. This use today tends to be concentrated in the more easily reached areas. Recreationists do not necessarily have conservation ethics and may leave behind trash, human waste, and scars upon the landscape. New roads appear where recreationists don't respect the fragility of the landscape. Some individuals lack respect for private property and fences, especially during hunting season.

Some recreationists may not be prepared for the conditions in the high desert. A lack of experience may result in catastrophic ends to a trip. Inexperience may lead to not realizing how unmaintained roads may have become impassable or to being unprepared for unexpected delays in a remote area with no cell phone access and carrying inadequate provisions such as water, jackets, and spare tires. Counties or other public agencies can be forced to expend huge resources looking for lost individuals who have failed to leave clear indications of where they are going.

Despite the increased use of some areas, a large portion of the beautiful places within the subbasin are seldom visited.

### 8. Private ownership

Although only 6.5% of the land in the Idaho section of the upper Owyhee subbasin is private, 18% of the total stream miles are on private property. These private lands "are usually the most productive areas".[2] The private land water rights are essential to being able to productively use the federally owned rangeland.

The land in the upper Owyhee subbasin in Idaho is not particularly attractive to investors to hold speculatively. However, the purchase of these holdings by entities intending to acquire the associated grazing rights can have detrimental consequences if the purpose is to leave the BLM land ungrazed. Land removed from use will have less management and day-to-day oversight with a greater potential for the spread of invasive weeds and juniper.

Speculative investments in land can raise the price of property and greatly restrict attempts by young people to maintain the traditions of family farming and ranching.

## C. Large gaps in data

Much basic information about the conditions within the upper Owyhee subbasin is lacking and there is a very poor understanding of the ecological interactions in the subbasin. These data gaps and unknowns have been enumerated in the other sections of this assessment. A few of these are highlighted here.

### 1. Hydrology

There is a popular misconception that published maps showing flow lines are showing streams.

There has been no ground verification of which streams in the upper Owyhee subbasin are ephemeral, intermittent, or perennial. Since the USGS maps do not distinguish between intermittent and ephemeral streams, ground surveys are necessary to make these determinations. In the upper Owyhee subbasin this information is not available for most drainages. The three stream types can not be evaluated in the same fashion and have dissimilar responses to restoration efforts. Intermittent streams are those which flow for only certain times of the year, when they receive water from springs or runoff. During dry years they may cease to flow entirely or they may be reduced to a series of separate pools. Ephemeral streams only carry water during and immediately after runoff events.

### 2. Rangeland

We do not understand the impact of juniper expansion on watershed function and water resources. Likewise, we don’t know how watershed function and water resources are affected by the conversion of rangeland vegetation to invasive annuals.

What effect will rangeland overstocked with woody shrubs have on watershed function?

Studies are needed on ways to restore native perennial vegetation to rangelands. Is there an acceptable ratio of cheatgrass to native plants where the ecological processes of rangeland still function? We have little information on the response of different vegetative communities to livestock grazing, timing of the grazing, or removal of grazing. Can the removal of livestock accelerate conversion of rangeland to cheatgrass or other invasive species?

Has a lack of fire resulted in overstocking of some areas with sagebrush and a concomitant decrease in grass and forbs essential to wildlife and grazing? Does a predominant sagebrush cover change runoff and erosion processes?

### 3. Riparian

In the upper Owyhee subbasin, the potential of riparian areas based on physical, biological, and chemical conditions is not known. The site specific physical, biological, and chemical conditions of riparian areas have not been surveyed. The management practices that will result in maintaining, restoring, improving, or expanding riparian areas in the upper Owyhee subbasin are poorly defined.

Some areas identified as lakes with wetlands appear to only occasionally become temporary lakes. Although they may support special sage species more tolerant to water scarcity, they are not wetland bird habitat (e.g. Lookout Lake).

Seasonal observations of suspected and known riparian habitats will be necessary to learn about fluctuations in the natural water flows from floods to intermittently available water. Understanding seasonality in available water will be essential to management decisions and expectations of rehabilitation.

### 4. Fish

There have been no studies of the interactions between the species of fish in the upper Owyhee subbasin. Little is known about the distribution of each specie within the subbasin. There is extremely little information on the non-game fish populations, fluctuations in their populations, or reasons for the fluctuations.

There are many introduced fish species in the upper Owyhee subbasin. How do the nonnative fish compete for food and habitat with the native fish? What effects are the hatchery trout stocked into the subbasin having on the native redband trout populations?

### 5. Water quality

In the upper Owyhee subbasin, the relative contribution to stream heating from solar radiation, from the air, from the ground, and from cliffs have not been described.

Even though water quality criteria are in place, the basic information is lacking on site response to climate, hydrology, geology, soil, slope, plant and animal communities, and other environmental features needed to develop water quality criteria for the upper Owyhee subbasin.

There are no data or models that show that the current water quality temperature criteria are consistent with the thermal potential of the streams in the upper Owyhee subbasin. How will new water rights in Idaho and Nevada which will reduce stream flows affect probable, but unknown, increases in downstream temperatures?

No comprehensive survey has been done to precisely locate possible sources of mercury, arsenic, or other pollutants in the upper Owyhee subbasin nor to identify geologic locations in the upper Owyhee subbasin that have mercury or arsenic concentrations which might contribute to mercury or arsenic in the river system if the sites become disturbed in the future.

### 6. Wildlife

The interactions between different wildlife species, introduced wild horse populations, and cattle are poorly understood including forage preferences and usage over the year. Few studies are available pertinent to the upper Owyhee subbasin on the effects of specific ranching practices on forage for wildlife.

How many cougar and wolves are actually in the upper Owyhee subbasin? At what level do these predator populations significantly affect wildlife populations and ranching?

How are wildlife populations being influenced by the expansion of weeds? How would wildlife populations be affected by the elimination of any of the stock ponds?

### 7. Wilderness areas

We do not know how designation of wilderness areas will affect fire management, watering sites, or the control of invasive species. Have some of the invasive species already become widespread and established enough that, without management, they will continue to spread, eliminating the very diversity of native vegetation that should exist in a preserved area?

Will uncontrolled burns, typical management of wilderness areas, or controlled burning, possible in managed range, best promote native vegetation and limit erosion?

## D. Conclusion

The people who made their living in the upper Owyhee subbasin through the 1930s were exceedingly poor. They utilized whatever resources they could. The stewardship of the land, both private and public, has greatly improved since the 1930s.

Valuable information developed in other regions can be applied to some extent to future decision making processes affecting the upper Owyhee subbasin. However, because of the relative isolation and low potential productivity, much of the specific information necessary to make informed decisions about future actions has not been developed. Generalizing from other areas without the locally developed information can lead to decisions guided by misinformation resulting in possibly disastrous consequences to the ecological integrity of the upper Owyhee subbasin.

Local information needs to be developed so that future choices can be based on facts and the best scientific knowledge available. Decisions need to be guided by what is best for the ecology of the subbasin and the people that it supports, not by a political agenda. Uncontrolled increased exploitation of resources or complete abandonment of use are both ecologically untenable.

The upper Owyhee subbasin contains many areas of natural beauty. The people of the area have been able to work together to solve many problems. The coming changes in climate and the world economy can not be foreseen, but the upper Owyhee subbasin contains individuals who will continue to cooperate to solve local challenges.

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# Upper Owyhee Watershed Assessment

## Appendix A. Notes on mapping



### 1. Description of how maps were created

The information included as maps in this assessment came from many different sources. The earth's surface is part of a sphere. Maps are flat. There are many different ways of orienting and shaping, "projecting", the spherical surface onto the flat plane. Our brains are capable of taking the landmarks which we recognize and correctly interpreting how the other features are related. However, for comparative purposes it is nice to have all data on paper in a similar projection.

The projection used for the base map is a Universal Transverse Mercator projection optimized for this region of the globe (UTM 11N), using the North American Datum of 1927 (NAD27) as a coordinate system for the placement of objects. The rivers, highways and outline of the upper Owyhee subbasin make up the base map. This is the map that serves as the background on which other information like vegetation can be charted.

There are computer programs to create maps using available "coverages", digitized information about where features are located. The programs used in this assessment were Adobe Photoshop 7.0 for Windows, QGIS 0.11.0 for Linux, and GRASS 6.3.0 for Linux. The original projections of a coverage (map of one characteristic) can be "reprojected" so they match the orientation of the base map.

All data were reprojected into the NAD27 (North American Datum of 1927), UTM11N (Universal Transverse Mercator Zone 11 North) projection. Although NAD83 (North American Datum of 1983) might be a more appropriate choice, the decision was made early in the project. The maximum difference between these data is approximately 82 meters in the area being assessed, but this difference is reduced to a few meters using GIS software with an appropriate mapping between the data. The ultimate mapping resolution is 1:960,000, representing exactly 100mx100m per pixel. The resolution was dictated by the limitations of the software approach used. Alignment error accounts for at most one pixel, meaning the data are aligned to within 182m (1/9 mile) of the correct NAD83 locations.

QGIS was used to view and export GRASS data to image files, which were imported into Adobe Photoshop. Adobe Photoshop 7.0 was used to combine maps from different sources. Some of the maps in this assessment contain information which was originally only available as an image. In that case the original map has been overlaid on the base map using the rivers to orient the information to the base map using Adobe Photoshop 7.0. All maps created in GRASS and QGIS were imported into Adobe Photoshop for final editing.

## 2. Sources of map data

**Coolbaugh M. 2004. Major roads in the state of Nevada.**

Major roads in the state of Nevada are represented by this digital line graph (vector map layer). The data were reprojected into the UTM11N NAD27 projection using QGIS.

**Daly C, Taylor G. 2000. United States Average Annual Precipitation, 1961-1990. 2000.**

"This map layer shows polygons of average annual precipitation in the contiguous United States, for the climatological period 1961-1990. Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created. PRISM is an analytical model that uses point data and a digital elevation model (DEM) to generate gridded estimates of annual, monthly and event-based climatic parameters."

Precipitation is represented at a scale of 1:2,000,000 by this polygonal graph (vector map layer with areal data) corresponding to the PRISM rainfall model. The data were reprojected into the UTM11N NAD27 projection using QGIS.

**Department of Commerce/National Oceanic and Atmospheric Administration/Western Regional Climate Center. 2009. Western Regional Climate Center SNOTEL Station Data. NRCS National Water and Climate Center. Accessed 7/10/2009.**

"The Natural Resources Conservation Service (NRCS) installs, operates, and maintains an extensive, automated system to collect snowpack and related climatic data in the Western United States called SNOTEL (for SNOwpack TELemetry). The system evolved from NRCS's Congressional mandate in the mid-1930's 'to measure snowpack in the mountains of the West and forecast the water supply.' The programs began with manual measurements of snow courses; since 1980, SNOTEL has reliably and efficiently collected the data needed to produce water supply forecasts and to support the resource management activities of NRCS and others.

Climate studies, air and water quality investigations, and resource management concerns are all served by the modern SNOTEL network. The high-elevation watershed locations and the broad coverage of the network provide important data collection opportunities to researchers, water managers, and emergency managers for natural disasters such as floods."

All SNOTEL sites within the subbasin were identified. Locations of sites were manually entered as a latitude-longitude map layer in the QGIS Geographic Information System.

**Department of Commerce/National Oceanic and Atmospheric Administration/Western Regional Climate Center. 2009. Western U.S. Climate Historical Summaries. Accessed 7/10/2009.**

"The Regional Climate Centers (RCC) deliver climate services at national, regional and state levels working with NOAA partners in the National Climatic Data Center, National Weather Service, the American Association of State Climatologists, and NOAA Research Institutes. This successful effort resulted in jointly developed products, services, and capabilities that enhance the delivery of climate information to the American public, and builds a solid foundation for a National Climate Service. As NOAA and Congress work to help society adapt to climate change, these collaborative efforts form a framework for the service, data stewardship, and applied research components of the National Climate Service."

All weather stations within the subbasin were identified. Locations of sites were manually entered as a latitude-longitude map layer in the GRASS Geographic Information System.

**Department of the Interior/Bureau of Land Management/Idaho State Office/Geographic Sciences. 2009. Surface Management Agency for Idaho (Federal, State, and Private Lands). Version 1. Accessed 7/11/2009.**

"This spatial data contains Surface Management Agency (SMA, also sometimes called Land Status) information for Idaho. It shows categories for Federal and State agencies as well as Private lands in Idaho.

For government land, this data displays the MANAGING AGENCY of the land, which may or may not be the same as the "owning agency" of the land. SMA is sometimes referred to as "ownership", although this term is inaccurate when describing public lands.

The Bureau of Land Management (BLM) in Idaho creates and maintains this spatial data. This dataset is derived by dissolving based on the "owner_type" field from the master SMA GIS dataset (which is edited often) kept by the BLM Idaho State Office.

Originally, the primary source of the GEOMETRY of the features was the BLM Geographic Coordinate Database (GCDB). In areas where GCDB records are unavailable, the spatial features are taken from a variety of sources including the BLM Idaho Resource Base Data collection, US Geological Survey Digital Line Graphs (DLGs), and US Forest Service Cartographic Feature Files (CFFs), among others (see Process Steps). It should be stressed that the geometry of the data may NOT be GCDB-based, and the GCDB-based features are not necessarily being edited to match improved GCDB, therefore this data should NOT be considered actual "GCDB data". For the latest GCDB spatial data, please download it from http://www.geocommunicator.gov

The source of the ATTRIBUTE information is an ongoing effort to coordinate between the BLM Master Title Plats (MTPs), the BLM case files and Realty Staff, the BLM LR2000 database, cooperation with other government agencies that own or manage land parcels, and users of the data. The data for other agencies may not be accurately represented if the information was not provided to the BLM by the managing agency. BLM gives its best effort to attribute the parcels properly, but when errors are found, please contact the BLM Idaho State Office Geographic Sciences department at 208-373-3950.

Please get a fresh copy of this data a couple times a year as the SMA data is constantly changing. Official actions that affect the managing agency are finalized each day, and changes to correct found errors are always being updated.

Nevada SMA data was acquired from the BLM Nevada web site and clipped to the area that is managed by Idaho BLM Boise District.

Purpose: This layer is intended to be a source of surface management agency spatial information in Idaho. Uses of this data include spatial analysis and cartographic products. This data will be made available to all users as BLM corporate data.

The surface management agency data (land "ownership") should be used as a general guide only. Official land records, located at the Bureau of Land Management (BLM) and other offices, should be checked for up-to-date information concerning any specific tract of land. Roads crossing public lands may be used unless closed by signs or notice by the land management agency. Public domain lands surrounded by private land may not be accessible. Permission is required from private landowners to cross private land, unless access is provided by a Federal, State, or County road or a BLM road with legal access."

This digital polygon model digitized at 1:100,000 resolution indicates federal, state, and private management of lands within the state of Idaho. The model was reprojected to the standard UTM11N NAD27 projection using GRASS and subsequently accessed with QGIS.

**Department of the Interior/USGS. 2009. National Elevation Dataset. Accessed 7/10/2009.**

"The National Elevation Dataset (NED) is the primary elevation data product of the USGS. The NED is a seamless dataset with the best available raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands. The NED is updated on a nominal two month cycle to integrate newly available, improved elevation source data. All NED data are public domain. The NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure. NED data are distributed in geographic coordinates in units of decimal degrees, and in conformance with the North American Datum of 1983 (NAD 83). All elevation values are in meters and, over the conterminous United States, are referenced to the North American Vertical

Datum of 1988 (NAVD 88). The vertical reference will vary in other areas. NED data are available nationally (except for Alaska) at resolutions of 1 arc-second (about 30 meters) and 1/3 arc-second (about 10 meters), and in limited areas at 1/9 arc-second (about 3 meters). In most of Alaska, only lower resolution source data are available. As a result, most NED data for Alaska are at 2-arc-second (about 60 meters) grid spacing, Part of Alaska is available at the 1- and 1/3-arc-second resolution, and plans are in development for a significant improvement in elevation data coverage of the state.

The NED serves as the elevation layer of The National Map, and provides basic elevation information for earth science studies and mapping applications in the United States. Scientists and resource managers use NED data for global change research, hydrologic modeling, resource monitoring, mapping and visualization, and many other applications.

The Seamless Data Distribution System (SDDS) offers seamless data for a user-defined area, in a variety of formats, for online download or media delivery.

Historic Digital Elevation Models (DEMs) are now available."

The National Elevation Dataset was used at a resolution of 1 arc-second. The files for four separate sectors were patched into a seamless dataset. Contours as digital line graphs at 500-ft, 1,000-ft, 2,500-ft, and 5,000 ft intervals were created using the GRASS contour function. The data were reprojected into the UTM11N NAD27 projection using GRASS.

**Department of the Interior/USGS. 2009. National Hydrography Dataset.**

"The National Hydrography Dataset (NHD) is the surface water component of The National Map. The NHD is a comprehensive set of digital spatial data representing the surface water of the United States using common features such as lakes, ponds, streams, rivers, canals, and oceans. These data are designed to be used in general mapping and in the analysis of surface-water systems using geographic information systems (GIS). In mapping, the NHD is used with other data themes such as elevation, boundaries, and transportation to produce general reference maps. Customized maps can be made to meet specific needs of the user by emphasizing certain aspects of the data. A map emphasizing hydrography can be produced by displaying more of the content embedded in hydrography.

The NHD often is used by scientists, specifically in surface-water analysis using GIS technology. This takes advantage of a rich set of embedded attributes that can be processed by a computer system to generate specialized information. This information can then be portrayed in specialized maps to better understand the results. These analyses of hydrography are possible largely because the NHD contains a flow direction network that traces the water downstream or upstream. It also uses an addressing system to link specific information about the water such as water discharge, water quality, and fish population. Using the basic water features, flow network, linked information, and other characteristics, it is possible to study cause and affect relations, such as how a source of poor water quality upstream might affect a fish population downstream."

The National Hydrography Dataset was used to create data for water bodies, flowlines, and perennial streams. This dataset contains in vector format artificial flowlines, connectors, canals/ditches, flows through lakes and ponds, flows through playas, flows through swamps and marshes, and perennial streams. The artificial flowlines and perennial streams were used to generate digital line graphs of the flows in the Upper Owyhee subbasin.

Also included in the National Hydrography Dataset are polygon maps of the lakes, reservoirs, ponds, playas, swamps, and marshes in the Upper Owyhee subbasin. These maps were used for mapping of major water bodies in the subbasin.

All data were imported into GRASS and reprojected into the UTM11N NAD27 projection using GRASS.

**Department of the Interior/USGS. 2009. USGS Water-Data Site Information for the Nation. Accessed 7/10/2009.**

"The Site Inventory System contains and provides access to inventory information about sites at stream reaches, wells, test holes, springs, tunnels, drains, lakes, reservoirs, ponds, excavations, and water-use facilities.

About 300 components make up the descriptive elements of the site inventory. The retrieval program can be used for retrieving information about sites in summary lists, in detailed tables, or a file suitable for input to other programs."

USGS Water-Data Site Information for the Nation comprises all streamflow gages. The latitude-longitude data for these sites (in NAD27) were used to place the gages on the corresponding map. This was done via direct latitude-longitude entry of points in QGIS.

**Department of the Interior/USGS/U.S. Board on Geographic Names. 2009. Geographic Names Information System (GNIS). Accessed 7/10/2009.**

"The Geographic Names Information System (GNIS) is the Federal and national standard for geographic nomenclature. The U.S. Geological Survey developed the GNIS in support of the U.S. Board on Geographic Names as the official repository of domestic geographic names data, the official vehicle for geographic names use by all departments of the Federal Government, and the source for applying geographic names to Federal electronic and printed products.

The GNIS contains information about physical and cultural geographic features of all types in the United States, associated areas, and

Antarctica, current and historical, but not including roads and highways. The database holds the Federally recognized name of each feature and defines the feature location by state, county, USGS topographic map, and geographic coordinates. Other attributes include names or spellings other than the official name, feature designations, feature classification, historical and descriptive information, and for some categories the geometric boundaries.

The database assigns a unique, permanent feature identifier, the Feature ID, as the only standard Federal key for accessing, integrating, or reconciling feature data from multiple data sets. The GNIS collects data from a broad program of partnerships with Federal, State, and local government agencies and other authorized contributors, and provides data to all levels of government, to the public, and to numerous applications through a web query site, web map and feature services, file download services, and customized files upon request."

GNIS was used for determination and placement of both populated places and mine sites. Direct latitude-longitude entry was used to bring the data into QGIS.

**Department of the Interior & Department of Agriculture/GeoMAC (Geospatial Multi-Agency Coordination). 2009. Historic Fire Data. Accessed 7/10/2009.**

"The Geospatial Multi-Agency Coordination Group or GeoMAC, is an internet-based mapping application originally designed for fire managers to access online maps of current fire locations and perimeters in the conterminous 48 States and Alaska. Using a standard web browser, fire personnel can view this information to pinpoint the affected areas. With the growing concern of western wildland fires in the summer of 2000, this application has also become available to the public. We hope that you find this important information both timely and helpful."

Historic fire data are available on an annual basis and on a multi-annual basis. The data were reprojected into the UTM11N NAD27 projection using QGIS.

**Environmental Protection Agency/Office of Water/OST. 1998. Counties and County Equivalents Boundaries in the United States for BASINS. Accessed 7/10/2009.**

"This coverage is of the county boundaries of the conterminous United States. It was derived from the U.S. Geological Survey State Boundaries, which were derived from Digital Line Graph (DLG) files representing the 1:2,000,000-scale map in the National Atlas of the United States."

BASINS was used to generate boundaries both within QGIS and within GRASS for reference purposes and to generate baseline reference data. BASINS was used to generate basemaps for both systems in the native UTM11N NAD27 projection.

**Environmental Protection Agency/Office of Water/OST. 1998. Hydrologic Unit Boundaries of the Conterminous United States in BASINS. Accessed 7/10/2009.**

"This metadata describes various delineations of watershed boundaries being stored in the EPA Spatial Data Library System (ESDLS). These delineations are based on the Hydrologic Unit Maps published by the U.S. Geological Survey Office of Water Data Coordination, together with the list descriptions and name of region, subregion, accounting units, and cataloging units. This metadata set describes the spatial data sets as they exist after downloading the data from ESDLS.

The changes made to the data sets from ESDLS are as follows:

1) Reprojected the ARC/INFO coverages to a geographic projection.

2) Derived accounting unit and cataloging unit layers only from original data.

3) Convertted ARC/INFO coverages to Arcview Shapefiles with ARCSHAPE

command in Environmental Systems Research Institute (ESRI) GIS software."

BASINS was used to generate boundaries both within QGIS and within GRASS for reference purposes and to generate baseline reference data. BASINS was used to generate basemaps for both systems in the native UTM11N NAD27 projection.

**Geographic Information Services Unit, Oregon Department of Transportation (ODOT). 2006. Highways. 2006. Accessed 7/11/2009.**

"This statewide file represents an annual snapshot and includes all state owned or maintained highways, spurs, connections, frontage roads, temporary traveled routes (TTR) and located lines."

Oregon publishes all GIS data in the Oregon Lambert Projection, a conical projection base on the NAD83 datum. These data were reprojected into the UTM11N NAD27 projection in GRASS, and then imported into QGIS. One road from north of McDermitt, OR to the Nevada border was manually projected with a linear transformation from the ODOT county map system in Oregon Lambert to the UTM11N NAD27 coordinate sytem.

**GRASS Development Team. 2009. Geographic Resources Analysis Support System (GRASS) Software. Open Source Geospatial Foundation.**

GRASS software was used for sophisticated reprojection and data analysis problems, including creating contours from the NED (National Elevation Dataset) and counting census data. GRASS represents the state-of-the-art in open-source geographic information systems.

**Idaho Transportation Department, GIS Section. 2004. Idaho State Highways. 2004. Accessed 7/11/2009.**

"Idaho State Highway System (US Highways, State Highways, Interstate Highways and Rest Areas/POEs)."

Idaho's state highway map is published in a GIS-friendly format. The data were reprojected with minimal error from UTM11N NAD83 into the UTM11N NAD27 projection using QGIS.

**Multi-Resolution Land Characteristics Consortium (MRLC). 2008. National Land Cover Database (NLCD) 1992/2001 Retrofit Land Cover Change.**

"New developments in mapping methodology, new sources of input data, and changes in the mapping legend for the 2001 National Land Cover Database (NLCD 2001) will confound any direct comparison between NLCD 2001 and the 1992 National Land Cover Dataset (NLCD 1992). Users are cautioned that direct comparison of these two independently created land cover products is not recommended. This NLCD 1992/2001 Retrofit Land Cover Change Product was developed to offer users more accurate direct change analysis between the two products.

The NLCD 1992/2001 Retrofit Land Cover Change Product uses a specially developed methodology to provide land cover change information at the Anderson Level I classification scale (Anderson et al., 1976), relying on decision tree classification of Landsat imagery from 1992 and 2001. Unchanged pixels between the two dates are coded with the NLCD 2001 Anderson Level I class code, while changed pixels are labeled with a "from-to" land cover change value (Change Code Table). Additional detail is available in the metadata included in the multizone downloadable zip file. This product is designed for regional application only and is not recommended for local scales.

The 65 CONUS mapping zones (excluding Alaska) have been grouped into 14 larger zonal areas to facilitate distribution and download. A mouse click on an area of interest will follow the link to the multizone download site. A shapefile with the standard NLCD zone attributes and multizone attributes is also available."

This 30-meter-resolution product classifies land cover and land cover change over a nine-year period between 1992 and 2001. Data were reprojected from the Albers conical equal-area projection to UTM11N NAD27 using GRASS GIS software.

**Multi-Resolution Land Characteristics Consortium (MRLC). 2008. National Land Cover Database 2001 (NLCD 2001).**

"New developments in mapping methodology, new sources of input data, and changes in the mapping legend for the 2001 National Land Cover Database (NLCD 2001) will confound any direct comparison between NLCD 2001 and the 1992 National Land Cover Dataset (NLCD 1992). Users are cautioned that direct comparison of these two independently created land cover products is not recommended. This NLCD 1992/2001 Retrofit Land Cover Change Product was developed to offer users more accurate direct change analysis between the two products.

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The 65 CONUS mapping zones (excluding Alaska) have been grouped into 14 larger zonal areas to facilitate distribution and download. A mouse click on an area of interest will follow the link to the multizone download site. A shapefile with the standard NLCD zone attributes and multizone attributes is also available."

This 30-meter-resolution product classifies land cover in the calendar year 2001. Data were reprojected from the Albers conical equal-area projection to UTM11N NAD27 using GRASS GIS software.

**National Atlas of the United States. 2006. Federal Lands of the United States.**

"This map layer consists of federally owned or administered lands of the United States, Puerto Rico, and the U.S. Virgin Islands. Only areas of 640 acres or more are included. There may be private inholdings within the boundaries of Federal lands in this map layer. This is a revised version of the December 2005 map layer."

**National Atlas of the United States. 2006. Indian Lands of the United States.**

"This map layer shows Indian lands of the United States. Only areas of 640 acres or more are included. Federally-administered lands within a reservation are included for continuity; these may or may not be considered part of the reservation and are simply described with their feature type and the administrating Federal agency. This is an updated version of the December 2005 map layer."

This map layer was used to map the boundaries of the Duck Valley Indian Reservation.

**National Atlas of the United States. 2004. Cities and Towns of the United States. Accessed 7/10/2009.**

"This map layer includes cities in the United States, Puerto Rico and the U.S. Virgin Islands. These cities were collected from the 1970 National Atlas of the United States. Where applicable, U.S. Census Bureau codes for named populated places were associated with each name to allow additional information to be attached. The Geographic Names Information System (GNIS) was also used as a source for additional information. This is a revised version of the December 2003 map layer."

This map is a point map (vector map without lines). The map was dynamically reprojected in QGIS to the standard UTM11N NAD27 projection used for this project.

**National Atlas of the United States. 2005. Streams and Waterbodies of the United States. Accessed 7/10/2009.**

"This map layer shows areal and linear water features of the United States, Puerto Rico, and the U.S. Virgin Islands. The original file was produced by joining the individual State hydrography layers from the 1:2,000,000- scale Digital Line Graph (DLG) data produced by the USGS. This map layer was formerly distributed as Hydrography Features of the United States. This is a revised version of the January 2003 map layer."

The map layer was edited in QGIS to remove all but principal water courses outside of the Upper Owyhee subbasin. The map was dynamically reprojected in QGIS to the standard UTM11N NAD27 projection used for this project. The map forms the basis for hydrological mapping within this project.

**National Atlas of the United States. 2006. Major Dams of the United States Accessed 7/10/2009.**

"This map layer shows areal and linear water features of the United States, Puerto Rico, and the U.S. Virgin Islands. The original file was produced by joining the individual State hydrography layers from the 1:2,000,000- scale Digital Line Graph (DLG) data produced by the USGS. This map layer was formerly distributed as Hydrography Features of the United States. This is a revised version of the January 2003 map layer."

This map is a point map (vector map without lines). The map was dynamically reprojected in QGIS to the standard UTM11N NAD27 projection used for this project.

**Quantum GIS Development Team. 2009. Quantum GIS Geographic Information System. Open Source Geospatial Foundation.**

QGIS is the most user-friendly open-source GIS application.

**USDA Service Center Agencies. 2004. National Coordinated Common Resource Area.**

"A CRA map delineation is defined as a geographical area where resource concerns, problems, or treatment needs are similar.  It is considered a subdivision of an existing Major Land Resource Area (MLRA) map delineation or polygon.  Landscape conditions, soil, climate, human considerations, and other natural resource information are used to determin the geographic boundaries of a CRA (Title 450, Technology, General Manual, Part 401, Technical Guides, Section 401.21, Definitions).

The National Coordinated CRA Geographic Database, Version 1.1, provides:

1) A consistent CRA geographic database;

2) CRA geographic data compatible with other Geographic Information System (GIS) data digitized from 1:250,000 scale maps, such as land use/land cover, political boundaries, Digital General Soil Map of the U.S. (updated STATSGO), and ecoregion boundaries;

3) A consistent (correlated) geographic index for Conservation Management Guide Sheet information and the electronic Field Office Technical Guide (eFOTG); and

4) A geographic linkage with the national MLRA framework."

Polygon maps at a resolution of 1:250,000 were imported into GRASS and reprojected into the standard UTM11N NAD27 projection used for this project. They were subsequently accessed with QGIS.

### 3. USGS topographic maps

**Inside Idaho. Idaho USGS 1:24,000-scale digital raster graphic (DRG) collection search and download. Accessed 2/10/2009. http://maps.insideidaho.org/WebMapping/Search/DownloadDRG/index.asp**

This interactive map was used to identify the USGS 7.5' quadrangles in the Idaho and Oregon sections of the upper Owyhee subbasin.

**Idaho Geospatial Office. 2009. DRG: 24K UTM with collar. In: Gail Eckwright, Director. *Inside Idaho:Interactive Numeric & Spatial Information Data Engine.* Accessed 2/20/2009. http://inside.uidaho.edu/asp/drgnameUTM.asp?Letter=A**

A Digital Raster Graphic (DRG) is a georeferenced raster image of a scanned USGS topographic map. A DRG is useful as a source or background layer in a GIS, as a means to perform quality assurance on other digital products, and as a source for the collection and revision of other data.

This site was the source of the topographic maps of Idaho retrieved for reference while writing this assessment.

**W. M. Keck Earth Sciences and Mining Research Information Center. 2001. 1:24,000 scale topos clickable map. Accessed 2/11/2009. http://keck.library.unr.edu/data/drg/nv24k_clickable.html**

This interactive map was used to identify the USGS 7.5' quadrangles in the Nevada section of the upper Owyhee subbasin.

**W. M. Keck Earth Sciences and Mining Research Information Center. 2003. USGS topographical maps (DRGs). Retrived 2/20/2009. http://keck.library.unr.edu/data/drg/drgs.html**

Digital raster graphic (DRGs) are scanned images (minimum resolution of 250 dots per inch) of USGS standard series topographic maps, including all collar information. The image is georeferenced and fit to the Universal

Transverse Mercator projection. Most DRGs on this site are North American Datum (NAD) 1927_UTM_Zone11. Exceptions are the 1:24000 clipped/no collar files which are NAD 83 and the California DRG's which are NAD_1927_California_Teale_Albers.

This site was the source of the topographic maps of Nevada retrieved for reference while writing this assessment.

**Oregon USGS Digital Raster Graphics (DRG) Index. Accessed 7/21/2009. http://libremap.org/data/state/oregon/drg/**

The sources of topographic maps have changed over time. Oregon no longer has a state web site with the maps. However, as of July 21, 2009 the topographic maps for all the states of the United States were available from the Libre Map Project at http://libremap.org/

## The USGS 1:24,000 scale topographic quadrangles in the upper Owyhee subbasin:

### In Idaho:

Battle Creek Lakes
Bedstead Ridge
Big Springs Ranch
Brace Flat
Bull Basin Camp
Bull Camp Butte
Castro Table
Clover Mountain
Coyote Hole
Crab Spint Butte
Defeat Butte
Dickshooter Ridge
Flying H Ranch
Four Corners
Frying Pan Basin
Grassy Ridge
Hat Peak
Hurry Up Creek
Indian Meadows
Jarvis Pasture
Juniper Basin
Juniper Basin SE
Little Blue Table
Lost Valley
Mountain View Lake
Nadine Butte
Nichol Flat
Piute Basin East
Piute Basin West
Pleasant Valley
Red Basin
Riddle
Ross Lake
Rubber Hill
Shoofly Springs
Slack Mountain
Smith Creek
Snow Creek
Spring Creek Basin
Star Valley
Star Valley Knoll
Star Valley Ridge East
Star Valley Ridge West
State Line Camp
Turner Table
Wagon Box Basin
Wickiup Creek

### In Nevada:

Badger Creek
Big Cottonwood Canyon
Bull Run Reservoir
Burner Hills
Button Lake
Button Lake Well
Calico Butte
Capitol Peak
Chicken Creek Summit
Cornucopia Ridge
Cornwall Mountain
Corral Lake
Cottonwood Peak
Deep Creek
Desert Ranch
Dry Creek Reservoir
Fourmile Butte
Greeley Flat
Greeley Flat SE
Groundhog Reservoir
Haystack Peak
Hicks Mountain
Humboldt Hill
I-L Ranch
Jacks Peak
Lake Mountain
Maggie Summit

Maiden Butte
Maiden Butte SE
McAfee Peak
McCleary Wells
Merritt Mountain
Middle Draw Reservoir
Mountain City
Mount Blitzen
Owyhee
Peterson Table East
Red Cow Creek
Rodear Flat
Sheep Creek Reservoir
Silver Lake
Soldier Cap
Star Valley Ridge SE
Star Valley Ridge SW
Sugarloaf Butte
Tennesee Mountain
The Point
Tuscarora
Twelvemile Flat
Twelvemile Flat SE
Ungina Wongo
Water Pipe Canyon
Wild Horse
Wilson Reservoir
Winter Ridge
Winters Ranch Reservoir

## In Oregon:

Defeat Butte
Oregon Butte
Lookout Lake
Star Valley Knoll


**Figure A.1. USGS 1:24,000 scale topographic quadrangles in the upper Owyhee subbasin.**

# Upper Owyhee Watershed Assessment

## Appendix B. Mining Districts.



| | |
|---|---|
| **Aura** | |
| Other names: | Bull Run, White Rock, Centennial, Columbia, Blue Jacket, Edgemont |
| Discovered: | 1867 |
| Organized: | 1869 |
| Period Active: | 1869-1879; 1899-1919; 1934-37 |
| Commodities: | gold, silver, copper, lead, zinc, antimony |
| Comments: | The Aura district covers the east slope of the Bull Run Mountains, formerly the Centennial Range, north of the site of Aura in Bull Run Basin and extends east to include the drainages of Trail, Badger, and Doby George Creeks in the northern Independence Range. This is the eastern portion of the original Bull Run district which also included the present Edgemont district. Bull Run was later changed to White Rock, then to Centennial. The Aura name dates from about 1906 when the town of Aura grew on Columbia Creek, below the old town of Columbia. |
| **Burner** | |
| Other names: | Burner Hills |
| Period Active: | Early 1880s to 1893 |
| Commodities: | silver, lead, zinc, arsenic |
| Comments: | District covers the Burner Hills, an isolated group of hills about 2 by 3 miles across which rise out of the Owyhee Desert. The district is about 16 miles north of Midas and 10 miles west of Good Hope. |
| **Cornucopia** | |
| Discovered: | 1872 |
| Organized: | 1872 |
| Commodities: | silver, gold, copper, lead, antimony |
| Comments: | Located about 15 miles north of Tuscarora, north of the South Fork of the Owyhee River in low mountains bordering the southeast margin of the Owyhee Desert. The main mines are located in sections 18-19, T42N, R51E. |
| **Divide** | |
| Other names: | Rock Creek |
| Discovered: | 1916 |
| Period Active: | 1916-1929 |
| Commodities: | silver, gold, antimony |

| | | | |
|---|---|---|---|
| | Comments: | This district is located at the head of Dry Creek, about 8 miles northwest of Tuscarora, and covers the drainage divide northeast of McCann Creek Mountain. The district is sometimes included in the adjacent Rock Creek district. | |
| **Edgemont** | | | |
| | Other names: | Bull Run, White Rock, Centennial | |
| | Discovered: | 1890s | |
| | Commodities: | gold, silver, lead, copper, zinc, tungsten, molybdenum, uranium, arsenic | |
| | Comments: | This district covers the west slope of the Bull Run (Centennial) Mountains and includes the western portion of the original Bull Run district. The site of the early town of White Rock is located in the northwest corner of the district and the town of Edgemont was located near the west center. The Edgemont name came into use for the western part of the historic Bull Run district following activity in the 1890s. The eastern part of the old Bull Run district is now within the Aura district. | |
| **Good Hope** | | | |
| | Other names: | Aurora, Amazon | |
| | Discovered: | 1873, 1875 | |
| | Commodities: | silver, antimony, gold, arsenic | |
| | Comments: | Located about 25 miles northwest of Tuscarora in T41N, R49E. Two historic districts, Amazon and Aurora, are included in the present Good Hope district; Amazon (1873) was in the northeast corner of the township, Aurora (1875) was in the west half of the township. According to Smith (1976), the area was renamed Good Hope, probably in 1878. | |
| **Independence Mountains** | | | |
| | Other names: | Jerritt Canyon, Jerritt, Burns Basin, Big Springs, Gance Creek | |
| | Commodities: | gold, silver, antimony, mercury, barite, titanium | |
| | Comments: | The Independence Mountains district was defined by LaPointe and others (1991) to include all of the Independence Mountains north of Taylor Canyon and south of the Aura district, including the old Burns Basin antimony district and the gold-mining areas of Jerritt Canyon (Jerritt), Big Springs, and Gance Creek. The Wood Gulch Mine area at the north end of the Independence Mountains is included in the separate Aura district. | |
| **Island Mountain** | | | |
| | Other names: | Gold Creek, Bruno, Bruneau, Wyoming, Penrod | |
| | Organized: | 1869 | |
| | Commodities: | silver, lead, zinc, antimony, copper, gold, tungsten, uranium, barite, arsenic | |

| | | |
|---|---|---|
| | Comments: | Organized in 1869 as the Wyoming district which included what is presently known as Martin Creek (Crystal Creek), Penrod Creek, west of Cornwall Mountain, and the town of Bruno, on “Crystal Creek.” The present district extends northeast and southwest from Island Mountain to include most of the drainage basin of Penrod Creek. The district occupies the southeastern flank of Tennessee Mountain and the area to the south, including Cornwall Mountain, Cornwall Basin, and Rosebud Mountain. |
| **Lime Mountain** | | |
| | Other names: | Deep Creek, Independence |
| | Commodities: | copper, silver, gold |
| | Comments: | Includes all of Lime Mountain, a ridge about 6 miles long extending northward from Deep Creek toward Bull Run Creek. Smith (1976) used Independence and Deep Creek as alternate names for this district. |
| **Mountain City** | | |
| | Other names: | Cope, Rio Tinto, Fairweather, Fair Weather, Murray, Murrey, Sooner, Marseilles, Van Duzer, Van Duzen, Van Duyser, Vanduser |
| | Discovered: | 1869 |
| | Organized: | 1869 |
| | Commodities: | copper, silver, gold, lead, zinc, antimony, uranium, tungsten, molybdenum, arsenic |
| | Comments: | Located on the Owyhee River, 7 miles south of the Idaho state line. The original district name was Cope. The district now includes the old districts of Cope, covering California Creek, Hansen Gulch, Grasshopper Gulch, and Mill Creek; Murray, to the northwest; Sooner, about 10 miles to the east; Marseilles, in section 21, T45S, R53E; the Van Duzer placer district on Van Duzer and Cobb Creeks; and the Rio Tinto Mine area, southwest of Mountain City. The Van Duzer placers are sometimes considered to be a separate district. |
| **Tuscarora** | | |
| | Organized: | 1867 |
| | Commodities: | gold, silver, lead, copper, mercury, arsenic |
| | Comments: | The Tuscarora district is at the town of Tuscarora on the southeastern slope of Mount Blitzen in the Tuscarora Range. The district was organized to include placers along McCann Creek below Beard Hill in the western part of the present district. The district was enlarged to include lode mines in and north of the present town of Tuscarora and now also includes Berry Basin, west of McCann Creek. |

# Upper Owyhee Watershed Assessment

## Appendix C. Descriptions of the ecoregions in different systems of classification



All descriptions are from the identified source. Some descriptions may have material edited out, but no material has been added.

### A. Description of the NRCS common resource areas in the upper Owyhee subbasin (see Figure 2.5)

**25.2 – Owyhee High Plateau - Dissected High Lava Plateau:** This unit consists of alluvial fans, rolling plains, and shear-walled canyons that are cut into extrusive rock. Sagebrush grassland is common, and scattered areas of woodland are on the rocky uplands. This unit supports cooler season grasses than do the valleys to the south, and it does not support saltbush and greasewood. Frigid and mesic Aridisols and Mollisols are in this unit. Grazing is the primary land use. Cropland is less common on this unit than it is on the Snake River Plain. High-quality water and native fish assemblages are in isolated canyons.[3]

**25.3 – Owyhee High Plateau - Owyhee Uplands and Canyons:** This unit contains deep, precipitous river canyons, barren lava fields, badlands, and tuffaceous outcroppings that are riddled by caves. The unit supports sagebrush grassland.[4]

**25.4 - Owyhee High Plateau - High Desert Wetlands**: The High Desert Wetlands ecoregion is critical habitat for nesting and migratory birds. Sedges, meadow barley, creeping wildrye, and Nevada bluegrass are found in wetter areas. Water levels in its lakes and wetlands fluctuate seasonally and annually.[4]

**25.6 - Owyhee High Plateau - Semiarid Uplands** : The disjuct semiarid uplands ecoregion includes mid-elevation zones in the Bull Run and Independence mountains and volcanic cones, buttes and rocky outcrops that rise out of neighboring, drier lava plains. Mountain sagebrush, western juniper, mountain brush and grasses grow in the ecoregion. The density and extent of juniper woodland varies with long term climate changes, grazing pressure, and fire suppression.[3]

**25.8 - Owyhee High Plateau - Upper Humboldt Plains**: This unit consists of broad fans and rolling tuffaceous hills and plains. Isolated low mountains and hills also occur. Soil temperature regime is mostly mesic and frigid. Soil moisture regime is mainly aridic bordering xeric. Common vegetation includes Wyoming big sagebrush, basin big sagebrush, low sagebrush, bluebunch wheatgrass and basin wildrye.[3]

### B. EPA (See Figure 2.6)

**80a - Northern Basin and Range - Dissected High Lava Plateau ecoregion**: The Dissected High Lava Plateau ecoregion is a broad to gently rolling basalt plateau cut by deep, sheer-walled canyons, with perennial and intermittent streams draining to the Snake River. Elevation varies from 4,000 to 7,300 feet. Potential natural vegetation is mostly sagebrush steppe; Wyoming big sagebrush and black sagebrush are abundant, as well as Douglas rabbitbrush, Idaho fescue, bluebunch wheatgrass, western wheatgrass, Thurber's needlegrass, bottlebrush squirreltail, Great Basin wildrye, Sandberg's bluegrass, Indian ricegrass, and cheatgrass. Juniper-pinyon woodlands grow on rocky and gravelly uplands.[2]

**80e - Northern Basin and Range - High Desert Wetlands ecoregion**: The nearly level High Desert Wetlands ecoregion consists of high desert lakes and surrounding wetlands that provide critical habitat for nesting and migratory birds and associated upland birds and mammals. Elevation varies from 4,000 to 5,200 feet (1,219 to 1,646 m). The fine-textured soils are poorly-drained, and basins collect water seasonally. Water levels fluctuate from year to year. Sedges, rushes, black greasewood, tufted hairgrass, mat muhly, meadow barley, creeping wildrye, and Nevada bluegrass occur in wetter areas. Drier areas support basin big sagebrush, Wyoming big sagebrush, silver sagebrush, bluebunch wheatgrass, basin wildrye, Idaho fescue, Thurber's needlegrass, and cheatgrass.[2]

**80f - Northern Basin and Range - Owyhee Uplands and Canyon ecoregion**: The Owyhee Uplands and Canyons ecoregion is a sagebrush steppe containing deep river canyons, barren lava fields, badlands, and tuffaceous outcrops that are riddled by caves. Elevation varies from 2,500 to 6,600 feet (762 to 2,012 m). Although the region's climate and vegetation are similar to the Dissected High Lava Plateau, its lithology is more varied, stream density is higher, and water availability is greater. These attributes, combined with its remote location, make the region a particularly valuable refuge for wildlife. The steppe is characterized by Wyoming big sagebrush, basin big sagebrush, Douglas rabbitbrush, bluebunch wheatgrass, Idaho fescue, bottlebrush squirreltail, Sandberg's bluegrass, and cheatgrass. Rocky areas support scattered western juniper. Cheatgrass has replaced depleted bunchgrasses in overgrazed areas.[2]

**80j - Northern Basin and Range - Semiarid Uplands ecoregion**: The disjunct Semiarid Uplands ecoregion includes scattered hills, low mountains, volcanic cones, buttes, and rocky outcrops that rise out of the drier Dissected High Lava Plateau and High Lava Plains. Elevation varies from 4,800 to 9,700 feet (1,463 to 2,957 m). Finely textured soils support big sagebrush, low sagebrush, antelope bitterbrush, serviceberry, snowberry, mountain-mahogany, and associated grasses, such as Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass, Nevada bluegrass, Great Basin wildrye, bottlebrush squirreltail, mountain brome, and Thurber needlegrass. Aspen and chokecherry are found in protected snow pockets, with willow and chokecherry in riparian areas. Rockier soils support juniper steppe woodlands. The density and extent of juniper varies over time and is dependent on long-term climate fluctuations, grazing pressure, and fire suppression.[2]

**80k - Northern Basin and Range - Partly Forested Mountains ecoregion**: The Partly Forested Mountains ecoregion occupies the elevational belt above the Semiarid Uplands the Independence mountains, from 6,500 to 10,900 feet. These are partially glaciated, high, rugged mountains with glacial features including moraines, cirques, and tarn (lake)s. Perennial or intermittent, high gradient, cold streams are fed by snowmelt and springs. Riffle segments have cobble or boulder substrates. Annual precipitation is sufficient to support a Great Basin pine forest community of Douglas-fir, subalpine fir, ponderosa pine, and limber pine, with whitebark pine near the tree line, and aspen stands in riparian meadows, moist draws, and wet depressions. The understory features low juniper, mountain big sagebrush, mountain brush, serviceberry, snowberry, mountain-mahogany, Idaho fescue, sheep fescue, rough fescue, bottlebrush squirreltail, prairie lupine, mountain brome, bluebunch wheatgrass, and Sandberg bluegrass. Small areas of tundra and alpine meadows are found at the highest elevations.[2]

**13m - Central Basin and Range - Upper Humboldt Plains ecoregion**: The Upper Humboldt Plains ecoregion is an area of rolling plains punctuated by occasional buttes and low mountains. It is mostly underlain by volcanic ash, rhyolite, and tuffaceous rocks. Low sagebrush is common in extensive areas of shallow, stony soil, as are cool season grasses, such as bluebunch wheatgrass, Idaho fescue, and Sandberg bluegrass. Lightning fires are common and a post-fire monoculture of cheatgrass tends to replace the native grasses and shrubs. Grazing is the major land use.[2]

## C. USDA Forest Service

**Section 342B--Northwestern Basin and Range** - This section has nearly level basins and valleys bordered by long gently sloping alluvial fans with linear mountain ranges. Soils are formed mostly from rocks of volcanic origin. Vegetation consists of sagebrush and desert shrub cover types.[1]

> Geomorphology. This area occurs within the Basin and Range physiographic province. Northwestern Basin and Range Section is located in the northern portion of Nevada, southeastern Idaho, and south-central Oregon. It extends into northern Utah also. Nearly level basins and valleys are bordered by long, gently sloping alluvial fans. North-south trending mountain ranges and few volcanic plateaus rise sharply above the valleys. Large alluvial fans have developed at the mouths of most canyons. Elevation ranges from 4,000 to 7,200 ft (1,200 to 2,200 m).[5]
>
> Lithology and Stratigraphy. Pliocene volcanic and shallow intrusive igneous rocks occur, along with andesite, breccias, and basalt flows. Alluvial deposits, playas, marshes, and flat deposits occur in the valleys.[5]
>
> Soil Taxa. There are Aridisols in combination with frigid and mesic soil temperature regimes, along with xeric and aridic soil moisture regimes. Large areas have saline-sodic affected soils.[5]
>
> Potential Natural Vegetation. Kuchler vegetation types include sagebrush steppe. The Soil Conservation Service identifies the potential natural vegetation as shrub-grass with saltbush-greasewood vegetation.[5]
>
> Fauna. A major migration route for waterfowl crosses this Section. It is characterized particularly by tundra swans, lesser snow geese, American widgeons, and pintail, canvasback, and ruddy ducks, which use the wetlands around interior basin lakes. Sandhill cranes, western snowy plovers, and white-faced ibis nest here. California bighorn sheep and California quail

characterize the uplands. Small bands of bison once roamed the margin of Malheur Lake but disappeared prior to white settlement. Rare kit foxes live in the desert lowlands. Pronghorn and mule deer are present. Wolverines are occasionally found. Gray flycatchers, Townsend's solitaires, northern sage sparrows, and broad-tailed hummingbirds are characteristic. Spotted frogs and Malheur shrews are uncommon riparian species. Antelope ground squirrels occupy areas of pale desert soils. Sharptail grouse, once common, are no longer present. Warner Lake suckers, Alvord chubs, and Soldier Meadows desertfish are endemic fishes of interior basin lakes and springs. Lahontan cutthroat trout also characterize this Section.[5]

Climate. Precipitation ranges from 4 to 20 in (100 to 790 mm) annually; mountains receive as much as 20 in annually. Precipitation is evenly distributed throughout fall, winter, and spring, but is low in the summer. Summers are hot and dry and winters are cold and dry. Temperature averages 41 to 50°F (5 to 10°C). The growing season ranges from 30 to 140 days.[5]

Surface Water Characteristics. Water is scarce except at higher elevations. Few streams and little water storage occurs in this Section. Large ground water supplies have been untapped. Pyramid Lake is the major lake in this Section.

Disturbance Regimes. Short duration and low intensity brush fires occur due to summer thunderstorms. Water and wind erosion is also occurring.[5]

Land Use. Livestock production is the primary use, with little farming. Some mining has also occurred.[5]

**Section 342C--Owyhee Uplands**- This section consists largely of a nearly flat, deeply dissected plateau where block-faulted mountain ranges are less pronounced than in other parts of the Basin and Range physiographic province to the south. Annual rainfall averages from 4 to 8 inches. Unlike the Basin and Range province, however, drainage is not internal and erosion by surface streams has formed steep-walled canyons. Rock formations are mostly volcanic tuffs and basalts, with some granites. Soils on plains are generally shallow and clayey, but are deeper and loamy on slopes. The main vegetation consists of sagebrush and pinyon-juniper cover types.[1]

Geomorphology. This area occurs within the Columbia Plateau physiographic province, also known as the Columbia Intermontane province. The Owyhee Uplands Section is part of southwest Idaho, southeast Oregon, and northern Nevada. This area is an uplifted region with doming and block-faulting common. It is deeply dissected from erosional processes. Lavas are older than that of the Snake River Plains. The Owyhee Mountains are made of granite; however, most of the uplands are rhyolites and welded tuffs with silicic volcanic flows, ash deposits, and wind-blown loess. Elevation ranges from 4,000 to 8,000 ft (1,200 to 2,500 m).[5]

Lithology and Stratigraphy. Miocene basalt rocks occur here. Rhyolites, welded tuffs, and silicic volcanic flows are also found in this Section. Columbia basalts occur along the Snake River.[5]

Soil Taxa. Aridisols, Entisols, Alfisols, Inceptisols, and Mollisols occur in combination with mesic and frigid soil temperature regimes, and xeric and aridic soil moisture regimes. Cryic temperature regimes occur at higher elevations.[5]

Potential Natural Vegetation. Kuchler vegetation types are sagebrush steppe with *Artemisia* and *Agropyron* and small areas of wheatgrass-bluegrass. The Soil Conservation Service identifies the area as having a sagebrush-grass potential natural vegetation.[5]

Fauna. A major migration route for geese crosses this Section, and it is used particularly by the intermountain population of Canada geese. This Section also is a major wintering area for mallards and common mergansers. California bighorn sheep live in rocky canyons. Gray flycatchers, northern sage sparrows, and mountain quail live in the sagebrush and juniper uplands. Wolverine once lived here but have not been seen for decades. Once common, sharptail grouse are scarce in grasslands and sagebrush foothills. Spotted frogs have been found here. Small bands of elk roam the uplands year-round, and elk from surrounding Sections winter here. Pronghorn, mule deer, and sage grouse inhabit this Section. Remnant bull trout populations are found in cold headwater streams. Other Columbia and Snake River system species include northern squawfish, biglip sucker, bridgelip sucker, Utah sucker, and Columbia redside shiners.[5]

Climate. Precipitation ranges from 7 to 15 in (200 to 400 mm) annually; it is close to evenly distributed throughout the year, but is low from mid summer to early autumn. Precipitation is only 20 percent of the evaporation potential during the frost-free period. Summers are dry with low humidity. Temperature averages 35 to 45 °F (2 to 8 °C). The growing season ranges from 90 to 120 days but is less than 60 days at higher elevations.[5]

Surface Water Characteristics. Water supply from precipitation and streamflow is small and unreliable, except along the Owyhee, Bruneau, and Humboldt Rivers. Snow accumulation at the higher elevations contributes to streamflow. Few small lakes and reservoirs are found in this Section.[5]

Disturbance Regimes. After fire, grasses and forbs replace higher seral species. Water and wind erosion is also occurring.[5]

Land use. Livestock grazing, and dryland and irrigated farming are the major land uses. Recreation is also important.[5]

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# Upper Owyhee Watershed Assessment

## Appendix D. Reservoirs



There are many dams on small reservoirs and stock ponds in the upper Owyhee subbasin. This appendix provides a brief description of only the larger reservoirs.

## Idaho

The information for the reservoirs in the Idaho section of the upper Owyhee subbasin is taken from a 1974 survey by the Idaho Fish and Game Department. The information on fish has been removed since it would no longer be timely, but the other information is printed verbatim.

### *Big Blue Reservoir*

Big Blue Reservoir is located at an elevation of 5,400 feet in Sections 2 & 11, T13S, R2E, Boise Meridian and is fed by Blue Creek. Surface area (full) is 131 acres, volume (full) is 1,131 acre-feet and the maximum depth (full) is 29 feet. Watershed condition and cover: This is a sagebrush-grass watershed. Cattle were observed all around the reservoir (August 15, 1972). In June, there were about 60 resident nesting Canada geese on this reservoir. The Blue Creek watershed and vegetative cover is in fair condition. Source and Quality of Water: Fed by Blue Creek which flows year-round. Access: It is necessary to go through private land to get to this reservoir and the present owner would like to have it posted. This access problem needs to be resolved. Ownership is by BLM. Used for irrigation with an annual maximum drawdown of about 8 feet. Built in 1914.[3]

### *Little Blue Reservoir*

Little Blue Reservoir is located at an elevation of 5,400 feet in Section 17 and the reservoir extends into Section 16, T13S, R3E, Boise Meridian. Surface area (full) is 188 acres, volume (full) is 800 acre-feet, the maximum depth (full) is 33 (down about 10 feet, August 15, 1972). Watershed condition and cover: Is about the same type of watershed and terrain as Big Blue Reservoir. Watershed and vegetative cover is in fair condition. Source and quality of water: Just a little bit of algae on the water back of the dam. Fed by Little Blue Creek which is intermittent in summer. Access: Same as Big Blue Reservoir. Ownership is by BLM.[3]

### *Paine Creek Reservoir*

Paine Creek Reservoir is located at an elevation of 5,500 feet in the Riddle Ranch complex, Sections 27 and 34, T13S, R3E, Boise Meridian. Surface area (full) is 55 acres, volume (full) is 2,120 acre-feet and the maximum depth is 29 feet and there is an average drawdown of about 8-12 feet. Height of the dam is 40 feet. Watershed condition and cover: The watershed doesn't look large and is mostly sagebrush-grass. Range is in good shape. Source and quality of water: Fed by Paine Creek, a small stream which flows all summer with some nice springs up the creek 1-2 miles. The upper half of the reservoir is shallow. The entry into it with one exception either state or BLM land. Construction and relocation of the 4.1 miles of the present road would be required to provide public access. The reservoir is used for irrigation of the Riddle Ranch meadows and was constructed in 1930.[3]

### *Juniper Basin Reservoir*

Juniper Basin Reservoir is located at an elevation of 5,100 feet in Sections 4 & 5, T16S, R1W, Boise Meridian, 4 miles west of Duck Valley Indian Reservoir, 4 miles north of the Nevada line and entirely on public land. Approximately 200 surface acres when full, volume (full) unknown, and maximum depth reported as 25 feet. The dam height is 35 feet. Watershed condition and cover: Sage and grassland, moderately grazed. Source is Juniper Creek. Access: Poor, 4-wheel-drive roads through Nevada are the only access.[3]

### *Squaw Creek Reservoir*

Squaw Creek Reservoir is located at an elevation 5,400 feet in Section 22, T14S, R3E, Boise Meridian 1 mile northeast of Riddle on private land. Surface area (full) is estimated at 80 acres, volume (full) 1,200 acre-feet, and maximum depth, 35-40 feet. Source of water is Squaw Creek which carries water from Squaw Reservoir on the Indian Reservation. Squaw Reservoir is on upper Squaw Creek and filled by water diverted from Mary's Creek. Access: About 1/2 mile of gravel road through private land and the state gravel pit off Idaho Highway 51 near Riddle. Drawdown doesn't occur until upstream reservoir is empty.[3]

### *Bybee Reservoir*

Bybee Reservoir is located at an elevation of 5,350 feet in Section 31, T13S, R2E, Boise Meridian on BLM land. Surface area is approximately 70 acres when full, and the maximum depth is estimated at 30 feet. Source of water is Shoo-fly Creek. Big Blue Creek Reservoir is 5 miles to the northeast. Access: By fair dirt roads 14 miles west of Idaho Highway 51 at Riddle.[3]

## Nevada

The State of Nevada Division of Water Resources of the Department of Conservation and Natural Resources maintains an inventory of the dams in the state with their IDs, names, heights, location, storage capacity, tributary area, owner and last date inspected.

In the upper Owyhee subbasin there are four dams owned by the Petan Company of Nevada, Inc. Wilson Reservoir is the largest with a storage capacity of 8,000 acre-feet. The 37 foot tall dam impounds water from Wilson Creek which drains about 26 square miles. The Dry Creek Dam is on Dry Creek. It is 50 feet tall. The reservoir has a capacity of 1,940 acre-feet draining an area of 10.36 square miles. There are two reservoirs on Bull Run Creek, Bull Run Reservoir and Rawhide Reservoir. Bull Run Reservoir is further upstream with 60.3 $mi^2$ of tributary area. It holds 1,000 acre-feet of water. Rawhide Dam downstream holds 1,500 acre feet of water with 129.4 $mi^2$ draining into it. Both Bull Run Dam and Rawhide Dam are 37 feet tall.[4] Although the dams are primarily to provide irrigation water, Wilson Reservoir is also used for recreation by the public. The campground and boating are operated by the Bureau of Land Management.[3]

The Agri-beef Company has two dams in the upper Owyhee subbasin, Chimney Creek Dam and Deep Creek Dam. Chimney Creek Dam can impound up to 5,000 acre feet of water from Chimney Creek in Desert Ranch Reservoir. The 22 foot tall dam captures water draining off of 345.7 square miles of watershed. The Deep Creek Dam on Deep Creek collects water from 71.2 $mi^2$ of drainage. When full, the reservoir can hold 1,410 acre-feet of water behind a 42 foot tall dam.[4]

The largest dam in the upper Owyhee subbasin is the Wild Horse Dam owned by the United States Department of the Interior, Bureau of Indian Affairs. The stored irrigation water is for agriculture in the Duck Valley Indian Reservation. The original dam was found to be weak and a new one was constructed in 1969. This doubled the size of the reservoir. When full, the reservoir has a surface area of 2,830 acres and holds 73,500 acre feet of water. The spillway elevation is 6,205 feet above sea level.[1] The dam is 101 feet tall and holds water from a 60 $mi^2$ watershed.[4]

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# Upper Owyhee Watershed Assessment

## Appendix E.

### A non exhaustive list of plants identified in the upper Owyhee subbasin with species names, common names, and source of information.



Although a species is not listed in the following table, it does not indicate that the species is absent from the upper Owyhee subbasin.  The species included here are those that have been positively identified as being within the subbasin.  There are undoubtedly numerous species which have been omitted, particularly since the personal observations were mostly made following the flowering season for most of the wildflowers so that they would not have been very obvious.

A.  Species found on the 45 Ranch[2]
B.  Atlas of Nevada Conifers[1]
P.  Personal observations
M. Pictures available on the Mid-Snake River Watershed Vegetation Database[3]

| Scientific name | Common name* | Source | | |
|---|---|---|---|---|
| | **Grasses** | | | |
| *Achnatherum hymenoides* | indian ricegrass | A | P | M |
| *Agropyron cristatum* | crested wheatgrass | A | P | |
| *Agropyron intermedium* | intermediate wheatgrass | A | | |
| *Agropyron repens* or *Elymus repens* | quackgrass | A | | |
| *Agropyron smithii* | bluestem wheatgrass, western wheatgrass | A | P | |
| *Agropyron spicatum* | bluebunch wheatgrass | A | | |
| *Agropyron trachycaulum* or *Elymus trachycaulum* | slender wheatgrass | A | | |
| *Agrostis exarata* | spike bentgrass | A | | |
| *Agrostis stolonifera* | creeping bentgrass | A | | M |
| *Alopecurus aequalis* | little foxtail, shortawn fescue | A | | |
| *Alopecurus geniculatus* | water foxtail, water fescue | A | | |
| *Alopecurus pratensis* | meadow foxtail, field meadow-foxtail | A | P | M |
| *Apera interrupta* | interrupted apera, dense silkybent | A | | |
| *Beckmannia syzigachne* | American sloughgrass | A | | |
| *Bromus inermis* | smooth brome, pumpelly's brome | A | | |
| *Bromus japonicus* | Japanese brome | A | | |
| *Bromus tectorum* | cheatgrass, downey brome | A | P | M |
| *Calamagrostis inexpansa* | narrow-spiked reedgrass | A | | |
| *Crypsis alopecuroides* | foxtail pricklegrass | A | | |
| *Dactylis glomerata* | orchardgrass | A | | |
| *Danthonia californica* | California oatgrass | A | | |
| *Deschampsia cespitosa* | tufted hairgrass | A | | |
| *Deschampsia danthonoides* | annual hairgrass | A | | |
| *Distichlis spicata* | desert saltgrass | A | P | |

| | | | | |
|---|---|---|---|---|
| *Echinochloa crus-galli* | barnyard grass | A | | |
| *Elymus cinereus* or *Leymus cinereus* | great basin wildrye, giant wildrye, basin wildrye | A | P | M |
| *Elymus elymoides* | squirreltail | | P | M |
| *Elymus triticoides* | creeping wildrye | A | | |
| *Eremopyrum triticeum* | annual wheatgrass | A | | |
| *Festuca arundinacea* | tall fescue | A | | |
| *Festuca idahoensis* | Idaho fescue | A | | |
| *Glyceria elata* | tall mannagrass, fowl mannagrass | A | | |
| *Glyceria grandis* | American mannagrass | A | | |
| *Hordeum brachyantherum* | meadow barley | A | | |
| *Hordeum jubaturm* | squirrel-tail, foxtail barley | A | | M |
| *Koeleria cristata* or *Koeleria nitida* or *Koeleria macrantha* | Prairie Koeler's grass, prairie Junegrass | A | | |
| *Muhlenbergia asperifolia* | scratchgrass muhly | A | | |
| *Muhlenbergia richardsonis* | mat muhly | A | | |
| *Panicum capillare* | witchgrass, old witchgrass | A | | |
| *Phalaris arundinacea* | reed canarygrass | A | P | |
| *Phleum pratense* | timothy | A | | |
| *Phragmites australis* | common reed | A | | |
| *Poa ampla* | big bluegrass | A | | |
| *Poa bulbosa* | bulbous bluegrass | A | P | M |
| *Poa compressa* | Canada bluegrass | A | | |
| *Poa cusickii* | Cusick’s bluegrass | A | | |
| *Poa interior* | inland bluegrass | A | | |
| *Poa nevadensis* | Sandberg bluegrass, Nevada bluegrass | A | | |
| *Poa pratensis* | Kentucky bluegrass | A | | |
| *Poa sandbergii* or *Poa secunda* | Sandberg's bluegrass, curly blue grass | A | | |
| *Puccinellia nuttalliana* | Nuttall’s alkaligrass | A | | |
| *Sitanion hystrix* | bottlebrush squirreltail | A | P | |
| *Spartina gracilis* | alkali cordgrass | A | | |
| *Sphenopholis obtusata* | wedgegrass, prairie wedgescale | A | | |
| *Stipa comata* or *Hesperostipa comata* | needle-and-thread | A | | |
| *Stipa thurberiana* or *Achnatherum thurberianum* | Thurber's needlegrass | A | | |
| *Stipa webberi* or *Achnatherum webberi* | Webber’s needlegrass | A | | |
| *Taeniatherum caput-medusae* | medusahead rye | | P | M |
| *Vulpia bromoides* | brome fescue, barren fescue | A | | |
| | **Grasslikes** | | | |
| *Carex athrostachya* | slender-beaked sedge | A | P | |
| *Carex douglasii* | Douglas’s sedge | A | | |
| *Carex lanuginosa* | wooly sedge | A | | |
| *Carex nebrascensis* | Nebraska sedge | A | | |
| *Carex praegracilis* | clustered field-sedge | A | | |
| *Cyperus aristatus* | awned flatsedge | A | | |
| *Eleocharis palustris* | creeping spike-rush, common spikerush | A | | |
| *Eleocharis rostellata* | beaked spikerush | A | | |
| *Juncus balticus* or *Juncus arcticus* | mountain rush, Baltic rush | A | | |
| *Juncus ensifolius* | swordleaf rush, dagger-leaf rush | A | | |
| *Juncus longistylis* | long-styled rush | A | | |
| *Juncus nevadensis* | Sierra rush | A | | |
| *Juncus orthophyllus* | straight-leaved rush | A | | |

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|---|---|---|---|---|
| *Schoenoplectus americanus* or *Scirpus americanus* | chairmaker’s bulrush, Olney threesquare | A | | |
| *Schoenoplectus fluviatilis* or *Scirpus fluviatilis* | river bulrush | A | P | |
| *Schoenoplectus pungens* or *Scirpus pungens* | common threesquare | A | | |
| *Schoenoplectus tabernaemontani* or *Scirpus validus* | softstem bulrush | A | | |
| *Sparganium emersum* | simplestem bur-reed | A | | |

**Forbs**

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|---|---|---|---|---|
| *Achillea millefolium* | white yarrow | A | P | M |
| *Acroptilon repens* | Russian knapweed | | P | M |
| *Agastache urticifolia* | horse mint, nettle-leaf horse-mint | A | P | M |
| *Agoseris glauca* | pale agoseris, short beaked agoseris | A | | M |
| *Agoseris heterophylla* | annual agoseris | A | | |
| *Agoseris* sp. | Agoseris | A | | |
| *Aliciella leptomeria or Gilia leptomeria* | sand gilia | A | | |
| *Alisma plantago-aquatica* | water-plantain | A | | |
| *Allium acuminatum* | tapertip onion | A | | M |
| *Allium lemmonii* | Lemmon’s onion | A | | |
| *Allium nevadense* | Nevada onion | A | | |
| *Allium parvum* | dwarf onion, small onion | | P | M |
| *Allium tolmiei* | Tolmie’s onion | A | | |
| *Alyssum desertorum* | desert madwort, desert alyssum | A | | |
| *Amaranthus albus* | prostrate pigweed, white pigweed | A | | |
| *Amaranthus blitoides* | prostrate pigweed | | P | M |
| *Amaranthus californicus* | California amaranth | A | | |
| *Amsinckia lycopsoides* | tarweed fiddleneck | | P | |
| *Amsinckia menziesii* | common fiddleneck, Menzies’ fiddleneck | A | P | |
| *Amsinckia retrorsa* | rigid fiddleneck | A | P | M |
| *Angelica kingii* | King’s angelica, Nevada angelica | A | | |
| *Antennaria dimorpha* | low pussytoes, cushion pussytoes | A | | |
| *Antennaria luzuloides* | woodrush pussy-toes | A | | |
| *Antennaria microphylla* | littleleaf pussytoes, rosy pussytoes | A | | |
| *Apocynum cannabinum* | Indianhemp, common dogbane | A | P | |
| *Arabis holboellii* | Holboell's rockcress | A | | M |
| *Arabis microphylla* | littleleaf rockcress | A | | |
| *Arabis puberula* | silver rockcress, hoary rockcress | A | | |
| *Arabis* sp. | rockcress | A | | |
| *Arabis sparsiflora* | sicklepod rockcress, elegant rockcress | A | | |
| *Arenaria congesta* | ballhead sandwort | A | | M |
| *Arenaria kingii* | King’s sandwort | A | | |
| *Arnica longifolia* | spearleaf arnica, seep-spring arnica | A | | |
| *Arnica sororia* | twin arnica | A | | |
| *Artemisia biennis* | binennial wormwood | A | | |
| *Artemisia dracunculus* | dragon sagewort, tarragon | A | P | M |
| *Artemisia ludoviciana* | prairie sage, silver wormwood | A | P | M |
| *Artemisia packardiae* | Packard’s wormwood, Packard’s mugwort | A | | |
| *Asclepias incarnata* | swamp milkweed | A | | |
| *Asclepias speciosa* | showy milkweed | A | | M |
| *Aster ascendens* or *Symphyotrichum ascendens* | western aster | A | | |

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|---|---|---|---|---|
| *Aster eatonii* | Eaton’s aster | A | | |
| *Aster frondosus* | alkali aster, short-rayed aster | A | | |
| *Aster hesperius* or *Symphyotrichum lanceolatum* | white panicle aster, western lined aster | A | | |
| *Aster scopulorum* | lava aster,crag aster | A | | |
| *Astragalus atratus* | mourning milkvetch | A | | |
| *Astragalus calycosus* | matted milkvetch, Torrey’s milkvetch | A | | |
| *Astragalus convallarius* | lesser rushy milkvetch | A | | |
| *Astragalus curvicarpus* | curvepod milkvetch, sickle milkvetch | A | | M |
| *Astragalus eremiticus* | hermit milkvetch | A | | |
| *Astragalus filipes* | threadstalk milkvetch | A | P | M |
| *Astragalus kentrophyta* | spiny milkvetch, thistle milkvetch | A | | |
| *Astragalus lentiginosus* | freckled milkvetch | A | | |
| *Astragalus newberryi* | Newberry’s milkvetch | A | | |
| *Astragalus obscurus* | arcane milkvetch | A | | |
| *Astragalus purshii* | wooly-pod milk-vetch | A | | |
| *Astragalus* sp. | milkvetch | A | P | |
| *Astragalus tetrapterus* | fourwing milkvetch | A | | |
| *Atriplex patula* | spear saltbush, spear orache | A | | |
| *Balsamorhiza hookeri* | Hooker's balsamroot | A | P | M |
| *Balsamorhiza sagittata* | arrowleaf balsamroot | A | P | M |
| *Bassia hyssopifolia* | fivehorn smotherweed | A | | |
| *Bassia scoparia* or *Kochia scoparia* | burningbush | A | | M |
| *Berula erecta* | cutleaf waterparsnip | A | | |
| *Blepharipappus scaber* | blepharipappus | A | | |
| *Brickellia microphylla* | littleleaf brickelbush | A | P | M |
| *Brickellia grandiflora* | tasselflower brickelbush, largeflower brickellia | A | | |
| *Brickellia oblongifolia* | Mojave brickelbush, narrow-leaved brickellia | A | | |
| *Callitriche hermaphroditica* | northern water-starwort, autumnal water-starwort | A | | |
| *Calochortus bruneaunis* | Bruneau mariposa lily | A | | |
| *Calochortus eurycarpus* | white mariposa lily, wide-fruit mariposa | A | | M |
| *Calochortus macrocarpus* | sagebrush mariposa lily | A | | |
| *Camassia quamash* | camas | | P | M |
| *Camelina microcarpa* | littlepod falseflax, hairy falseflax | A | | |
| *Camissonia boothii* | Booth’s evening primrose, alyssum evening primrose | A | | M |
| *Camissonia claviformis* | browneyes, club fruit evening primrose | A | | M |
| *Camissonia pterosperma* | wingfruit suncup | A | | |
| *Camissonia tanacetifolia* | tansyleaf evening primrose | A | P | |
| *Capsella bursa-pastoris* | shepherd's-purse | A | P | M |
| *Cardaria chalapensis* | chalapa hoarycress | | P | M |
| *Cardaria draba* | heart podded hoarycress, hoary whitetop | A | P | M |
| *Castilleja chromosa* or *Castilleja angustifolia* | desert paintbrush, violet desert paintbrush, Northwest paintbrush | A | | |
| *Castilleja linariifolia* | Wyoming Indian paintbrush | A | | |
| *Castilleja minor* or *Castilleja exilis* | annual paintbrush, lesser Indian paintbrush | A | | |
| *Castilleja pallescens* | pale Indian paintbrush | A | | |
| *Castilleja* sp. | Indian paintbrush | A | P | M |
| *Caulanthus crassicaulis* | thickstem wild cabbage | A | | |
| *Centaurea maculosa* | spotted knapweed | | P | M |
| *Centaurium exaltatum* | Great Basin centaury, desert centaury | A | | |
| *Ceratophyllum demersum* | coon’s tail, hornwort | A | | |
| *Chaenactis douglasii* | hoary false-yarrow, hoary chaenactis | A | | M |
| *Chamaesyce serpyllifolia* | thymeleaf sandmat, thyme leafed spurge | A | | |

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|---|---|---|---|---|
| *Chenopodium album* | lambsquarters | A | P | |
| *Chenopodium botrys* | Jerusalem oak goosefoot, Jerusalem-oak | A | P | |
| *Chenopodium fremontii* | Fremont's goosefoot | A | P | |
| *Chenopodium glaucum* | oakleaf goosefoot | A | | |
| *Chenopodium leptophyllum* | narrowleaf goosefoot, slimleaf goosefoot | A | | |
| *Chorispora tenella* | crossflower, blue mustard, chorispora | A | P | M |
| *Chorizanthe watsonii* | fivetooth spineflower, Watson's spineflower | A | | |
| *Cicuta douglasii* | western water hemlock | | | M |
| *Cicuta maculata* | spotted water hemlock | A | | |
| *Cirsium arvense* | Canada thistle | A | P | M |
| *Cirsium canovirens* | greygreen thistle | A | | |
| *Cirsium subniveum* | intermountain thistle | | P | |
| *Cirsium utahense* | Utah thistle | | P | M |
| *Cirsium vulgare* | bull thistle | A | P | M |
| *Clarkia pulchella* | pink fairies, ragged robin | | P | M |
| *Claytonia lanceolata* | spring beau ty | | P | M |
| *Claytonia perfoliata* or *Montia perfoliata* | miner's lettuce | A | | M |
| *Clematus lingusticifolia* | western clematis, virgin's bower | A | P | M |
| *Cleome serrulata* | rocky mountain beeplant | | P | M |
| *Collinsia parviflora* | small flowered blue-eyed Mary | A | | M |
| *Conyza canadensis* | Canadian fleabane, horseweed | A | | |
| *Cordylanthus ramosus* | bushy bird's beak | A | | |
| *Crepis acuminata* | long-leaved hawksbeard | A | | M |
| *Crepis atrabarba* | hawksbeard | A | P | |
| *Crepis occidentalis* | largeflower hawksbeard | A | | |
| *Crepis* spp. | hawksbeard | A | P | |
| *Cryptantha circumscissa* | cushion cryptantha, matted cryptantha | A | | M |
| *Cryptantha echinella* | prickly cryptantha | A | | |
| *Cryptantha* sp. | cryptantha | A | | M |
| *Cryptantha spiculifera* | Snake River cryptantha | A | | |
| *Cryptantha watsonii* | Watson's cryptantha, Watson's cat's eye | A | | |
| *Cymopterus longipes* | longstalk springparsley | A | | |
| *Cymopterus petraeus* or *Pteryxia petraeus* | rockloving wavewing, rockloving cymopterus | A | | |
| *Cymopteris* spp. | springparsley | | P | M |
| *Cystopteris fragilis* | brittle bladderfern | A | | |
| *Damasonium californicum or Machaerocarpus califonicus* | fringed waterplantain, california damsonium | A | | |
| *Delphinium andersonii* | Anderson's larkspur, desert larkspur | A | | |
| *Delphinium* sp. | larkspur | A | P | M |
| *Descurainia incana or Descurainia richardsonii* | mountain tansymustard | A | | |
| *Descurainia sophia* | flixweed | A | P | M |
| *Dodecatheon jeffreyi* | Sierra shootingstar, Jeffrey's shooting star | A | | |
| *Downingia insignis* | calicoflower, harlequin calicoflower | A | | |
| *Downingia laeta* | Great Basin calicoflower, Great Basin downingia | A | | |
| *Draba douglasii* or *Cusickiella douglasii* | alkali cusickiella, Douglas' draba | A | | |
| *Draba verna* | spring whitlow grass | A | P | M |
| *Eatonella nivea* | white false tickhead | A | | |
| *Epilobium brachycarpum* | tall annual willowherb, panicled willowherb | A | | M |
| *Epilobium ciliatum* | fringed willowherb, American willowherb | A | | |

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|---|---|---|---|---|
| *Epilobium pygmaeum* | smooth spike-primrose | A | | |
| *Epilobium torreyi* | Torrey's spike-primrose, Torrey's willowherb | A | | |
| *Epilobium* spp. | | | P | M |
| *Epipactis gigantea* | stream orchid, giant heelborine | A | | |
| *Equisetum arvense* | common horsetail, field horsetail | A | P | M |
| *Equisetum laevigatum* | smooth scouringrush, smooth horsetail | A | | M |
| *Equisetum variegatum* | variegated horsetail, variegated scouringrush | A | | |
| *Eriastrum sparsiflorum* | Great Basin woollystar | A | | |
| *Erigeron aphanactis* | rayless shaggy fleabane, basin raylee daisy | A | | M |
| *Erigeron bloomeri* | scabland fleabane | A | | |
| *Erigeron chrysopsidis* | dwarf yellow fleabane | A | | |
| *Erigeron compositus* | dwarf mountain fleabane, cutleaved | A | | |
| *Erigeron latus* | broad fleabane | A | | |
| *Erigeron linearis* | desert yellow daisy, lineleaf fleabane | A | | |
| *Erigeron lonchophyllus* | shortray fleabane, spearleaf fleabane | A | | |
| *Erigeron poliospermus* | purple cushion fleabane, cushion fleabane | A | | |
| *Erigeron pumilus* | shaggy fleabane | A | | |
| *Eriogonum caespitosum* | matted buckwheat | A | | |
| *Eriogonum heracleoides* | parsnipflower buckwheat, Wyeth buckwheat | A | | M |
| *Eriogonum microthecum* | slenderbush buckwheat | A | | |
| *Eriogonum ovalifolium* | cushion backwheat, oval-leaved eriogonum | A | | M |
| *Eriogonum sphaerocephalum* | round-headed eriogonum, rock buckwheat | A | | |
| *Eriogonum strictum* | Blue Mountain buckwheat | A | | M |
| *Eriogonum umbellatum* | sulfur-flower buckwheat | A | P | M |
| *Eriogonum vimineum* | wickerstem buckwheat, broom buckwheat | A | | |
| *Eriogonum* spp. | | | P | M |
| *Eriophyllum lanatum* | woolly sunflower, Oregon sunshine | A | P | M |
| *Erodium cicutarium* | filaree | A | | M |
| *Euthamia occidentalis* | western goldentop, western goldenrod | A | | |
| *Fritillaria pudica* | yellow bell | A | | M |
| *Galium aparine* | stickywilly, goose-grass cleavers | A | | M |
| *Galium multiflorum* | shrubby bedstraw | A | | |
| *Gayophytum* Juss. spp. | groundsmoke | A | | |
| *Gayophytum ramosissimum* | pinyon groundsmoke, hairstem groundsmoke | A | | |
| *Gerannium carolinianum* | Carolina cranesbill, Carolina geranium | A | | |
| *Geranium viscosissimum* | sticky geranium | | P | M |
| *Geum triflorum* | old man's whiskers, prairie smoke avens | A | | |
| *Gilia aggregata* or *Ipomopsis aggregata* | scarlet gilia, skyrocket gilia | | P | M |
| *Gilia inconspicua* | shy gilia | A | | |
| *Gilia sinuata* | rosy gilia | | | |
| *Glycyrrhiza lepidota* | wild licorice, American licoriceroot | A | P | M |
| *Gnaphalium palustre* | western marsh cudweed, lowland cudweed | A | | |
| *Grindelia* sp. | gumweed | | P | M |
| *Hackelia ophiobia* | Owyhee River stickseed | A | | |
| *Halogeton glomeratus* | saltlover, halogeton | A | P | M |
| *Helianthus nuttallii* | Nuttall's sunflower | A | | |
| *Hesperochiron pumilus* | false strawberry | | P | M |
| *Heuchera parvifolia* | littleleaf alumroot, common alumroot | A | | |
| *Heuchera rubescens* | pink alumroot, red alumroot | A | | |
| *Hydrophyllum capitatum* | ballhead waterleaf | | P | M |
| *Iva axillaris* | poverty sumpweed | A | P | M |
| *Ivesia baileyi* | Bailey's ivesia | A | | |

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|---|---|---|---|---|
| *Kochia scoparia* | kochia | A | P | M |
| *Lactuca tatarica* or *Lactuca pulchella* | blue lettuce | A | | |
| *Lactuca serriola* | prickly lettuce | A | P | M |
| *Lappula redowshi* | western stickseed | A | | |
| *Layia glandulosa* | whitedaisy tidytips | A | | |
| *Lemna minor* | common duckweed | A | | |
| *Lepidium campestre* | field pepperweed, pepperwort | A | | |
| *Lepidium davisii* | Davis's pepperweed | A | | |
| *Lepidium latifolium* | perennial pepperweed | | P | M |
| *Lepidium perfoliatum* | clasping pepperweed, clasping peppergrass | A | P | M |
| *Leptosiphon septentrionalis* or *Linanthus septentrionalis* | northern linanthus | A | | |
| *Lesquerella kingii* | King's bladderpod | A | | |
| *Lesquerella* sp | bladderpod | | P | |
| *Leucocrinum montanum* | sandlily | A | | M |
| *Lewisia rediviva* | bitterrooot | A | | M |
| *Lilaea scilloides* | flowering quillwort, awl-leaf lilaea | A | | |
| *Limosella aquatica* | water mudwort | A | | |
| *Lepidium perfoliatum* | perfoliate pepperweed | | P | M |
| *Leptosiphon septentrionalis* or *Linanthus septentrionalis* | northern linanthus | A | | |
| *Linum lewisii* | wild blue flax, prairie flax | | P | M |
| *Lithophragma glabrum* | bulbous woodland-star, smooth prairiestar | A | | |
| *Lithophragma tenellum* | slender woodland-star, slender prairiestar | A | | |
| *Lomatium* spp. | desertparsley | A | P | M |
| *Lomatium cous* | cous biscuitroot, cous desertparsley | A | | M |
| *Lomatium dissectum* | fernleaf biscuitroot, fern-leafed desert parsley | A | P | M |
| *Lomatium grayi* | Gray's lomatium, Gray's desert parsley | | P | M |
| *Lomatium leptocarpum* | gumbo lomatium | A | | |
| *Lomatium macrocarpum* | bigseed biscuitroot, large-fruit desert-parsley, | A | | |
| *Lomatium nudicaule* | barestem biscuitroot, barestem lomatium | A | P | M |
| *Lupinus argenteus* | silvery lupine, tailcup lupine | A | | |
| *Lupinus brevicaulis* | shortstem lupine, sand lupine | A | | |
| *Lupinus lepidus* | dwarf lupine, prairie lupine | A | | |
| *Lupinus* spp. | lupine | A | P | M |
| *Lupinus uncialis* | inch-high lupine | A | | |
| *Lygodesmia spinosa* | spiny skeletonweed | A | | |
| *Machaeranthera canescens* | hoary aster | A | | M |
| *Madia exigua* | little tarweed, threadstem madia, little tarplant | A | | |
| *Madia gracilis* | grassy tarweed, common tarweed | A | | |
| *Maianthemum racemosum* or *Smilacina racemosa* | false spikenard, feathery false lily of the valley | A | | |
| *Malacothrix torreyi* | Torrey's desertdandelion | A | | |
| *Marrubium valugare* | horehound | | P | |
| *Marsilea vestita* | hairy cloverfern, hairy waterclover | A | | |
| *Medicago lupulina* | black medic, hop clover | A | | M |
| *Medicago sativa* | alfalfa | A | P | M |
| *Melilotus alba* | white sweet clover | A | P | M |
| *Melilotus officinalis* | yellow sweet clover | | P | M |
| *Melilotus* sp. | sweetclover | A | | |
| *Mentha arvensis* | field mint | A | | |
| *Mentzelia albicaulis* | whitestem blazingstar | A | P | M |
| *Mentzelia laevicaulis* | smooth-skin blazingstar, blazing star | A | | M |

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| *Mertensia oblongifolia* | sagebrush bluebells | A | P | |
| *Microseris nutans* | nodding microseris | A | | M |
| *Microseris troximoides* | false-agoseris | A | | |
| *Microsteris gracilis* | pink microsteria | A | | |
| *Mimulus floribundus* | Mayflowered monkeyflower | A | | |
| *Mimulus guttatus* | seep monkeyflower | A | | |
| *Mimulus nanus* | dwarf monkeyflower, dwarf purple monkeyflower | A | | M |
| *Mimulus suksdorfii* | Suksdorf's monkeyflower, miniature monkey-flower | A | | |
| *Monardella odoratissima* | mountain monardella | A | P | M |
| *Monolepis nuttalliana* | patata, Nuttall's povertyweed | A | | |
| *Montia chamissoi* | water miner's lettuce, water montia | A | | M |
| *Myosurus aristatus* | bristly mousetail | A | | |
| *Myosurus minimus* | tiny mousetail | A | | |
| *Nama densum* | leafy fiddleleaf, leafy nama, matted nama | A | | |
| *Navarretia intertexta* | Great Basin navarretia, needleleaf navarretia | A | | |
| *Nemophila breviflora* | Great Basin baby-blue-eyes | A | | |
| *Nestotus stenophyllus* or *Haplopappus stenophyllus* or *Stenotus stenophyllus* | narrowleaf mock goldenweed | A | | |
| *Nicotiana attenuata* | coyote tobacco | A | P | |
| *Oenothera caespitosa* | rock-rose, desert evening primrose | A | | M |
| *Oenothera elata* | Hooker's evening primrose | A | | |
| *Oenothera villosa* | hairy evening primrose, common evening primrose | A | P | |
| *Onopordum acanthium* | Scotch thistle | A | P | M |
| *Orobanche* sp. | broomrape | A | | M |
| *Orobanche corymbosa* | flat-top broomrape | A | | |
| *Orobanche fasciculata* | clustered broomrape | A | | |
| *Orthocarpus luteus* | golden-tongue owl-clover, yellow owl's-clover | A | P | M |
| *Pectocarya setosa* | moth combseed | A | | |
| *Pediocactus simpsonii* | mountain ball cactus | A | | |
| *Penstemon deustus* | scabland penstemon, hot-rock penstemon | A | P | M |
| *Penstemon gairdneri* | Gairdner's beardtongue | A | | M |
| *Penstemon humilis* | low beardtongue, lowly penstemon | A | | |
| *Penstemon janishiae* | Antelope Valley beardtongue | A | | |
| *Penstemon* sp. | penstemon | A | | M |
| *Penstemon speciosus* | showy penstemon, royal penstemon | A | P | M |
| *Perideridia gairdneri or Perideridia montana* | common yampah | A | | M |
| *Phacelia glandulifera* | sticky phacelia, glandular-hair scorpion-weed | A | | |
| *Phacelia hastata* | whiteleaf or silverleaf phacelia | A | | M |
| *Phacelia heterophylla* | varileaf phacelia | A | | |
| *Phacelia linearis* | threadleaf phacelia | A | | M |
| *Phacelia rattanii* | Rattan's phacelia | A | | |
| *Phlox hoodii* | Hood's phlox | A | | M |
| *Phlox longifolia* | long-leafed phlox | A | | M |
| *Phlox* spp. | | | P | |
| *Phoenicaulis cheiranthoides* | daggerpod | A | | M |
| *Plagiobothrys leptocladus* | firebranched popcornflower,slenderbranch popcornflower | A | | |
| *Plagiobothrys scouleri* | Scouler's popcornflower | A | | |
| *Plantago major* | common plantain | A | | |
| *Plectritis macrocena* | longhorn plectritis, white plectritis | A | | |
| *Polygonum aviculare* | doorweed, prostrate knotweed, | A | P | |

| | | | | |
|---|---|---|---|---|
| *Polygonum confertiflorum* | fruitleaf knotweed, closeflowered knotweed | A | | |
| *Polygonum heterosepalum* | oddsepal knotweed,dwarf desert knotweed | A | | |
| *Polygonum hydropiperoides* | common waterpepper, swamp smartweed | A | | |
| *Polygonum lapathifolium* | curlytop ladysthumb, pale smartweed, curlytop knotweed | A | | |
| *Polygonum persicaria* | spotted ladysthumb, redshank | A | | |
| *Potamogeton nodosus* | longleaf pondweed | A | | |
| *Potamogeton pectinatus* or *Stuckenia pectinata* | sago pondweed | A | | |
| *Potamogeton pusillus* | small pondweed | A | | |
| *Potentilla anserina* or *Argentina anserina* | silverweed cinquefoil | A | P | |
| *Potentilla glandulosa* | sticky cinquefoil | A | | |
| *Potentilla gracilis* | slender cinquefoil | A | | |
| *Potentilla recta* | sulfur cinquefoil | | P | |
| *Potentilla rivalis* | brook cinquefoil | A | | |
| *Pseudognaphalium stramineum* or *Gnaphalium chilense* | cottonbatting plant, cudweed | A | | |
| *Psilocarphus brevissimus* | short woollyheads, dwarf woollyheads | A | | |
| *Pyrrocoma carthamoide* or *Haplopappus carthamoides* | largeflower goldenweed | A | | |
| *Pyrrocoma hirta* or *Haplopappus hirtus* | tacky goldenweed, sticky goldenweed | A | | |
| *Pyrrocoma lanceolata* or *Haplopappus lanceolatus* | lanceleaf goldenweed | A | | |
| *Pyrrocoma uniflora* or *Haplopappus uniflorus* | plantain goldenweed, one-flowered goldenweed | A | | |
| *Ranunculus aquatilis* | white water crowfoot, water buttercup | A | | |
| *Ranunculus cymbalaria* | alkali buttercup, shore buttercup | A | | |
| *Ranunculus testiculatus or Ceratocephala testiculata* | burr buttercup, hornseed buttercup, curveseed butterwort | A | P | M |
| *Rorippa islandica* | marsh yellowcress | A | | M |
| *Rorippa nasturtium aquaticum* | watercress | A | | |
| *Rumex acetosella* | sheep sorrel | | P | M |
| *Rumex crispus* | curly dock | A | P | |
| *Rumex aquaticus* or *Rumex occidentalis* | western dock | A | P | |
| *Rumex salicifolius* | willow dock, narrowleaf dock | A | P | |
| *Rumex venosus* | veiny dock | A | P | M |
| *Sagittaria cuneata* | wapato, arumleaf arrowhead | A | | |
| *Salsola kali* | Russian thistle | | P | M |
| *Scrophularia lanceolata* | lanceleaf figwort | A | | |
| *Scutellaria angustifolia* | narrowleaf skullcap | A | | |
| *Scutellaria antirrhinoides* | snapdragon skullcap | | | |
| *Scutellaria nana* | dwarf skullcap | A | | |
| *Sedum debile* | orpine stonecrop, weak-stemmed stonecrop | A | | |
| *Senecio integerrimus* | western groundsel | A | | M |
| *Sidalcea sp.* | checker mallow | | P | M |
| *Sisymbrium altissimum* | Jim Hill mustard, tumble mustard | A | P | M |
| *Sium suave* | hemlock waterparsnip | A | | |
| *Solidago canadensis* | Canada goldenrod | A | | M |
| *Solidago missouriensis* | Missouri goldenrod | A | | |
| *Sonchus asper* | prickly sowthistle, spiny sowthistle | A | | |

| | | | | |
|---|---|---|---|---|
| *Sphaeralcea munroana* | orange globemallow, Munto's globemallow | A | P | M |
| *Stachys palustris* | swamp hedgenettle, marsh hedgenettle | A | | |
| *Stanleya viridiflora* | green princesplume | A | P | |
| *Stenotus acaulis* or *Haplopappus acaulis* | stemless mock goldenweed | A | | |
| *Stephanomeria minor* or *Stephanomeria tenuifolia* | narrowleaf stephanomeria, narrowleaf wirelettuce | A | | |
| *Streptanthus cordatus* | heartleaf twistflower, heartleaved streptanthus | A | | |
| *Taraxacum officinale* | common dandelion | A | P | M |
| *Tetradymia canescens* | gray horsebrush | | P | M |
| *Thelypodium flexuosum* | nodding thelypody | A | | |
| *Thelypodium laciniatum* | thickleaved thelypody | A | | M |
| *Thermopsis rhombifolia* | mountain yellowpea, prairie golden bean | A | P | |
| *Thlaspi arvense* | field pennycress, fanweed | | P | M |
| *Tragopogon dubius* | yellow salsify, western salsify | A | P | M |
| *Trifolium cyathiferum* | cup clover | A | | |
| *Trifolium dubium* | suckling clover, least hop clover | A | | |
| *Trifolium eriocephalum* | woollyhead clover | A | | |
| *Trifolium fragiferum* | strawberry clover | A | | M |
| *Trifolium longipes* | longstalk clover | A | | |
| *Trifolium macrocephalum* | big-head clover | A | | M |
| *Trifolium repens* | white clover | A | | M |
| *Trifolium variegatum* | whitetip clover | A | | |
| *Triglochin palustre* | marsh arrowgrass | A | | |
| *Typha latifolia* | cattail, broadleaf cattail | A | P | M |
| *Urtica dioica* | stinging nettle | A | P | M |
| *Veratrum californicum* | false helebore, skunk cabbage, corn lily | | P | M |
| *Verbascum thapsus* | mullein, flannel mullein | A | P | M |
| *Veronica americana* | American speedwell | A | P | M |
| *Veronica anagallis-aquatica* | water speedwell | A | | |
| *Veronica peregrina* | purslane speedwell | A | | |
| *Viola* sp. | violet | A | | M |
| *Wyethia amplexicaulis* | northern mule's-ears | A | P | M |
| *Xanthium strumarium* | cocklebur | | P | M |
| *Zannichellia palustris* | horned pondweed | A | | |
| *Zigadenus elegans* | mountain deathcamas | | P | M |
| *Zigadenus paniculatus* | panicled death-camas, foothill deathcamas | A | | M |
| *Zigadenus venenosus* | meadow deathcamas | A | P | M |
| | **Shrubs** | | | |
| *Acer glabrum* | Rocky Mountain maple | A | | M |
| *Amelanchier alnifolia* | western service berry | A | | M |
| *Artemisia arbuscula* | low sagebrush, dwarf sagebrush | A | P | |
| *Artemisia cana* | silver sage, silver sagebrush | A | P | M |
| *Artemisia longiloba* | early sagebrush | A | | |
| *Artemisia papposa* | Owyhee sagebrush | A | | |
| *Artemisia spinescens* or *Picrothamnus desertorum* | bud sagebrush | A | P | |
| *Artemisia tridentata* ssp. *tridentata* | basin big sagebrush | A | P | M |
| *Artemisia tridentata* var. *vaseyana* | mountain big sagebrush | A | P | |
| *Artemisia tridentata* ssp. *wyomingensis* | Wyoming big sagebrush | A | P | |
| *Atriplex canescens* | fourwing saltbush | | P | M |

| | | | | | |
|---|---|---|---|---|---|
| *Atriplex confertifolia* | sheepfat, shadscale saltbush | A | P | | M |
| *Atriplex nuttalli* | saltsage | A | | | |
| *Ceanothus cuneatus* | buckbrush | | P | | |
| *Cercocarpus ledifolius* | curl-leaf mountain mahogany | | P | | M |
| *Chrysothamnus humilis* | Truckee rabbitbrush | A | | | |
| *Chrysothamnus vicidiflorus* | green rabbitbrush | A | P | | M |
| *Ericameria nauseosa or Chrysothamnus nauseosus* | rubber rabbitbrush, gray rabbit-brush, little rabbitbrush | A | P | | M |
| *Grayia spinosa* | spiny hopsage | A | | | M |
| *Gutierrezia sarothrae* | broom snakeweed | | P | | M |
| *Haplopappus nanus* | dwarf goldenweed | A | | | |
| *Holodiscus dumosus* | glandular oceanspray, rock spirea | A | P | | M |
| *Krascheninnikovia lanata* or *Eurotia lanata* | winterfat, white sage | A | P | | M |
| *Leptodactylon pungens* | granite prickly-phlox, prickly phlox | A | | | |
| *Philadelphus lewisii* | Syringa | | | | M |
| *Prunus virginiana* | common chokecherry | A | P | | M |
| *Purshia tridentata* | bitterbrush, antelope bitterbrush | | P | | M |
| *Ribes aureum* | golden currant | A | P | | M |
| *Ribes cereum* | wax currant, squaw currant | A | P | | M |
| *Ribes inerme* | whitestem gooseberry | A | | | |
| *Ribes velutinum* | desert gooseberry | A | | | |
| *Rosa woodsii* | Woods' rose, pearhip rose | A | P | | M |
| *Salix exigua* | coyote willow, sandbar willow | A | | | M |
| *Salix lasiandra* | Pacific willow | A | | | |
| *Salix lasiolepsis* | arroyo willow | A | | | |
| *Salix lutea* | yellow willow | A | | | |
| *Salvia dorrii* | purple sage, gray ball sage | A | | | M |
| *Sambucus cerulea* or *Sambucus mexicana* or *Sambucus nigra* | blue elderberry | A | | | M |
| *Sarcobatus vermiculatus* | greasewood | A | P | | M |
| *Symphoricarpos oreophilus* | mountain snowberry | A | | | M |
| *Tetradymia canescens* | gray horse-brush, spineless horse-brush | A | P | | M |
| *Tetradymia glabrata* | little leaf horse-brush | A | P | | |
| *Tetradymia spinosa* | cottonthorn horse-brush | A | P | | |
| | **Trees** | | | | |
| *Abies lasiocarpa* | subalpine fir, alpine fir, balsam fir | | P | B | M |
| *Juniperus communis* | common juniper, dwarf juniper | | | B | |
| *Juniperus occidentalis* | western juniper | A | P | B | M |
| *Juniperus scopulorum* | Rocky Mountain juniper, Rocky Mountain red cedar | | | B | |
| *Pinus albicaulis* | whitebark pine | | P | B | |
| *Pinus contorta* | lodgepole pine, tamarack pine, black pine (planted, expected to naturalize) | | | B | M |
| *Pinus flexilis* | limber pine, Rockyee Mountain white pine | | P | B | M |
| *Populus alba* | Lombardy poplar | A | P | | |
| *Populus tremuloides* | quaking aspen | | P | | M |
| *Pseudotsuga menziesii* | Douglas fir | | P | B | M |
| *Robinia pseudoacacia* | black locust | A | | | |
| *Salix amygdaloides* | peach-leaf willow | | P | | M |
| *Tamarix parviflora* | salt cedar, tamarisk | A | | | M |

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# Upper Owyhee Watershed Assessment

## Appendix F. Nevada TMDLs



### 303(d) water bodies listed by the EPA or by the state.

Table F.1. Pollutants of concern for impaired water bodies in Nevada in the upper Owyhee subbasin. Water bodies are included either on the 303(d) federal list, in a TMDL, or in Nevada's administrative regulations.

Reasons for impairment

a. Temperature
b. Sediment
c. Zinc
d. Total dissolved solids
e. Salinity
f. Sulfates
g. Chlorides
h. Arsenic
i. Fluoride
j. Manganese
k. Nickel
l. pH
m Total phosphorus

| **Nevada waterbody** | a | b | c | d | e | f | g | h | i | j | k | l | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Fork Owyhee River | x | | | | | | | | | | | | |
| Jack Creek | | | x | | | | | | | | | | |
| Jerritt Canyon Creek | | | | x | x | x | x | | | | | | |
| Snow Canyon Creek | | | | x | x | x | x | | | | | | |
| Mill Creek | | | x | x | | | | | x | x | x | | |
| Badger Creek | | | | | | | | x | | | | | |
| Owyhee River | | | x | | | | | | | x | | | |
| Tomasina Gulch | | | | | | | | x | | | | | |
| Wildhorse Reservoir | | | x | | | | | | | x | | x | x |
| | a | b | c | d | e | f | g | h | i | j | k | l | m |

### Nevada TMDLS

Some of the reaches of streams in the upper Owyhee subbasin have had Total Maximum Daily Loads (TMDLs) established by Nevada. These TMDLs are detailed in *Total Maximum Daily Loads for East Fork Owyhee River and Mill Creek*. In addition, a regulation proposed by the state environmental commission sets pollutant levels for the South Fork Owyhee River.

"The TMDLs and load allocations presented in this report are in a form unique for Nevada. Through the use of equations, the defined TMDLs and load allocations vary with flow thereby addressing the EPA requirement to consider seasonal variations and critical flow conditions in the TMDL process."[2] The tables below include the pollutant levels but do not include all of the formulas for changes in flow which are included in the Mill Creek and East Fork Owyhee assessment.  The TMDL with formulas for the region can be acquired from the Department of Conservation and Natural Resources and in May 2011 was available at http://ndep.nv.gov/bwqp/owyhee_tmdl.pdf.  The statewide formulas for calculating ammonia criteria are included at the end of this appendix.

Nevada considers the potential beneficial uses of a waterbody to be the watering of livestock, water supply for irrigation, habitat for fish and other aquatic life, recreation involving contact with the water, recreation not involving contact with the water, municipal or domestic water supply, industrial water supply, propagation of wildlife and waterfowl, extraordinary ecological or aesthetic value, and enhancement or improvement of water quality in any water which is downstream.  In the tables these are labeled respectively livestock, irrigation, aquatic, contact, noncontact, municipal, industrial, wildlife, aesthetic, and enhance.  In Tables F.2 through F.5, an x under one of the uses indicates that the use is a designated beneficial use for the waterbody.

## Definitions used in the tables:

"S.V." means single value.

"△ T" means change in temperature in Celsius.

"△ pH" means the change in pH.

"NTU" means nephelometric turbidity units, a measure of turbidity that is described in the sediment sources section of this assessment.

"PCU" means platinum cobalt unit, a measure of color.

"No./100ml" means the number of organisms present in 100 milliliters of the water.

"SU" means standard pH units.

"AGM" means annual geometric mean_________.

Table F.2. Nevada TMDL for the Owyhee River from Wildhorse Reservoir to its confluence with Mill Creek.

| Parameter | Requirements to maintain existing higher quality | Water quality standards for beneficial uses | Livestock | Irrigation | Aquatic | Contact | Noncontact | Municipal | Industrial | Wildlife | Aesthetic | Enhance | Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature - °C Maximum | $\Delta$ T=0 | S.V. May-Oct. <21°<br>S.V.Nov.-Apr. <7°<br>$\Delta$ T<1 | | | X | X | | | | | | | |
| pH - Units | $\Delta$ pH ±0.5 | 6.5 - 9.0 | | | X | X | | X | | | | | |
| Total Phosphorous (as P) - mg/l | | ≤ 0.1 | | | X | X | X | X | | | | | |
| Nitrogen Species (as N) - mg/l | Nitrate S.V. <1.0 | Nitrate S.V. ≤ 10<br>Nitrite S.V. ≤ 0.06 | | | X | X | X | X | | | | | |
| Total Ammonia (as N )- mg/l | | See formulas below | | | X | | | | | | | | |
| Dissolved Oxygen - mg/l | | ≥ 6.0 | X | | X | X | X | X | | X | | | |
| Suspended Solids - mg/l | | S.V. ≤ 25 | | | X | | | X | | | | | |
| Turbidity - NTU | | S.V. ≤ 10 | | | X | | | X | | | | | |
| Total Dissolved Solids - mg/l | S.V. ≤ 200 | S.V. ≤ 500 | X | X | | | | X | | | | | |
| Chlorides - mg/l | S.V. ≤ 8.0 | S.V. <250 | X | X | | | | X | | X | | | |
| Sulfate - mg/l | S.V. ≤ 250 | | | | | | | X | | | | | |
| Alkalinity (as CO3) - mg/l | | <25% change from natural conditions | | | X | | | | | X | | | |
| E. coli - No./100 ml | | AGM ≤ 126<br>S.V. ≤ 410 | | | | X | X | | | | | | |
| Fecal Coliform - No./100ml | | S.V. ≤ 1000 | X | X | | | X | X | | X | | | |
| Color - PCU | | S.V. ≤ 75 | | | | | | X | | | | | |
| | | | Livestock | Irrigation | Aquatic | Contact | Noncontact | Municipal | Industrial | Wildlife | Aesthetic | Enhance | Marsh |

Table F.3.  Nevada TMDL for the Owyhee River from its confluence with Mill Creek to the border of the Duck Valley Indian Reservation.

| Parameter | Requirements to maintain existing higher quality | Water quality standards for beneficial uses | Livestock | Irrigation | Aquatic | Contact | Noncontact | Municipal | Industrial | Wildlife | Aesthetic | Enhance | Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature - °C Maximum | △ T=0 | S.V. May-Oct. <21°<br>S.V. Nov.-Apr. <7°<br>△ T<1 | | | X | X | | | | | | | |
| pH - Units | △ pH ±0.5 | 6.5 - 9.0 | | | X | X | | X | | | | | |
| Total Phosphorous (as P) - mg/l | | $\leq$ 0.1 | | | X | X | X | X | | | | | |
| Nitrogen Species (as N) - mg/l | Nitrate S.V. <1.0 | Nitrate S.V. $\leq$ 10<br>Nitrite S.V. $\leq$ 0.06 | | | X | X | X | X | | | | | |
| Total Ammonia (as N )- mg/l | | See formulas below | | | X | | | | | | | | |
| Dissolved Oxygen - mg/l | | $\geq$ 6.0 | X | | X | X | X | X | | X | | | |
| Suspended Solids - mg/l | | S.V. $\leq$ 25 | | | X | | | X | | | | | |
| Turbidity - NTU | | S.V. $\leq$ 10 | | | X | | | X | | | | | |
| Total Dissolved Solids - mg/l | S.V. $\leq$ 250 | S.V. $\leq$ 500 | X | X | | | | X | | | | | |
| Chlorides - mg/l | S.V. $\leq$ 8.0 | S.V. <250 | X | X | | | | X | | X | | | |
| Sulfate - mg/l | S.V. $\leq$ 250 | | | | | | | X | | | | | |
| Alkalinity (as CO3) - mg/l | | <25% change from natural conditions | | | X | | | | | X | | | |
| E. coli - No./100 ml | | AGM $\leq$ 126<br>S.V. $\leq$ 410 | | | | X | X | | | | | | |
| Fecal Coliform - No./100ml | | S.V. $\leq$ 1000 | X | X | | | X | X | | X | | | |
| Color - PCU | | S.V. $\leq$ 75 | | | | | | X | | | | | |
| | | | Livestock | Irrigation | Aquatic | Contact | Noncontact | Municipal | Industrial | Wildlife | Aesthetic | Enhance | Marsh |

Table F.4. Nevada TMDL for the South Fork Owyhee River from its origin to the Nevada-Idaho state line.

| Parameter | Requirements to maintain existing higher quality | Water quality standards for beneficial uses | Livestock | Irrigation | Aquatic | Contact | Noncontact | Municipal | Industrial | Wildlife | Aesthetic | Enhance | Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature - °C Maximum | $\triangle$ T=0 | S.V. May-Oct. <21°<br>S.V. Nov.-Apr. <7°<br>$\triangle$ T<1 | | | X | X | | | | | | | |
| pH - Units | $\triangle$ pH ±0.5 | 6.5 - 9.0 | | | X | X | | X | | | | | |
| Total Phosphorous (as P) - mg/l | | $\leq$ 0.1 | | | X | X | X | X | | | | | |
| Nitrogen Species (as N) - mg/l | Nitrate S.V. <1.0 | Nitrate S.V. $\leq$ 10<br>Nitrite S.V. $\leq$ 0.06 | | | X | X | X | X | | | | | |
| Total Ammonia (as N )- mg/l | | See formulas below | | | X | | | | | | | | |
| Dissolved Oxygen - mg/l | | $\geq$ 6.0 | X | | X | X | X | X | | X | | | |
| Suspended Solids - mg/l | | S.V. $\leq$ 25 | | | X | | | X | | | | | |
| Turbidity - NTU | | S.V. $\leq$ 10 | | | X | | | X | | | | | |
| Total Dissolved Solids - mg/l | S.V. $\leq$ 280 | S.V. $\leq$ 500 | X | X | | | | X | | | | | |
| Chlorides - mg/l | S.V. $\leq$ 15.0 | S.V. <250 | X | X | | | | X | | X | | | |
| Sulfate - mg/l | S.V. $\leq$ 250 | | | | | | | X | | | | | |
| Alkalinity (as CO3) - mg/l | | <25% change from natural conditions | | | X | | | | | X | | | |
| E. coli - No./100 ml | | AGM $\leq$ 126<br>S.V. $\leq$ 410 | | | | X | X | | | | | | |
| Fecal Coliform - No./100ml | | S.V. $\leq$ 1000 | X | X | | | X | X | | X | | | |
| Color - PCU | | S.V. $\leq$ 75 | | | | | | X | | | | | |
| | | | Livestock | Irrigation | Aquatic | Contact | Noncontact | Municipal | Industrial | Wildlife | Aesthetic | Enhance | Marsh |

Table F.5. Nevada TMDL for Taylor Canyon Creek from its origin to its confluence with the South Fork of the Owyhee River.

| Parameter | Water quality standards for beneficial uses | Livestock | Irrigation | Aquatic | Contact | Noncontact | Municipal | Industrial | Wildlife | Aesthetic | Enhance | Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature - °C Maximum | S.V. May-Oct < 21<br>S.V. Nov-Apr < 13 | | | X | X | | | | | | | |
| pH - SU | S.V. 6.5 - 9.0 | | | X | X | | X | | | | | |
| Total Phosphorous (as P) - mg/l | S.V. $\leq$ 0.1 | | | X | X | X | X | | | | | |
| Nitrogen Species (as N) - mg/l | Nitrate S.V. $\leq$ 10<br>Nitrite S.V. $\leq$ 0.06 | | | X | | | X | | | | | |
| Total Ammonia (as N )- mg/l | See formulas below | | | X | | | | | | | | |
| Dissolved Oxygen - mg/l | S.V. $\geq$ 6.0 | X | | X | X | X | X | | X | | | |
| Suspended Solids - mg/l | S.V. $\leq$ 25 | | | X | | | X | | | | | |
| Turbidity - NTU | S.V. $\leq$ 10 | | | X | | | X | | | | | |
| Total Dissolved Solids - mg/l | S.V. $\leq$ 500 | X | X | | | | X | | | | | |
| Chlorides - mg/l | S.V. $\leq$ 250 | X | X | | | | X | | X | | | |
| Sulfate - mg/l | S.V. $\leq$ 250 | | | | | | X | | | | | |
| E. coli - No./100 ml | A.G.M. $\leq$ 126<br>S.V. $\leq$ 410 | | | | X | X | | | | | | |
| Fecal Coliform - No./100 ml | S.V. $\leq$ 1,000 | X | X | | | X | X | | X | | | |
| Color - PCU | S.V. $\leq$ 75 | | | | | | X | | | | | |
| | | Livestock | Irrigation | Aquatic | Contact | Noncontact | Municipal | Industrial | Wildlife | Aesthetic | Enhance | Marsh |

## Ammonia criteria for Nevada

### 1. Acute water quality criteria

For cold-water fisheries, the 1-hour average concentration of total ammonia, in milligrams of nitrogen per liter, must not exceed the applicable acute criterion for "Cold-Water Fisheries" more than once every 3 years on average.

$$\text{Acute water quality criteria for ammonia (cold-water fisheries)} = \left[\frac{0.275}{1+10^{7.204-pH}}\right]+\left[\frac{39.0}{1+10^{pH-7.204}}\right]$$

For warm-water fisheries, the 1-hour average concentration of total ammonia, in milligrams of nitrogen per liter, must not exceed the applicable acute criterion for "Warm-Water Fisheries" more than once every 3 years on average.

$$\text{Acute water quality criteria for ammonia (warm-water fisheries)} = \left[\frac{0.411}{1+10^{7.204-pH}}\right]+\left[\frac{58.4}{1+10^{pH-7.204}}\right]$$

### 2. Chronic water quality criteria

The chronic criteria of water quality with regard to the concentration of total ammonia are subject to the following:

The concentration of total ammonia, in milligrams of nitrogen per liter, expressed as a 30-day average must not exceed the applicable chronic criterion more than once every 3 years on average, and the highest 4-day average within the 30-day period must not exceed 2.5 times the applicable chronic criterion.

$$\text{Chronic water quality criteria for total ammonia} = \left[\frac{0.0577}{1+10^{7.204-pH}}\right]+\left[\frac{2.487}{1+10^{pH-7.204}}\right] \mathbf{x}\, MIN\left[2.85, 1.45 \mathbf{\ x\ } 10^{0.028\mathbf{x}(25-T°)}\right]$$

A different criterion may be used only where documentation has been accepted showing the absence of freshwater fish in early life stages.

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# Upper Owyhee Watershed Assessment

## Appendix G. TMDLs in Idaho



### Current Idaho

The Idaho Department of Environmental Quality (DEQ) has conducted assessments and developed Total Maximum Daily Loads (TMDLs) for the Upper Owyhee Watershed subbasin and the South Fork Owyhee River subbasin.

Idaho's water quality standards establish the potential beneficial uses of a waterbody to be habitat for aquatic life, recreation, water supply, wildlife habitat, and aesthetics. The first three uses are further divided. Aquatic life includes cold water, salmonid spawning, seasonsal cold water where coldwater aquatic life may be absent or tolerate seasonally warm termperatures, warm water, and modified "with aquatic life limited by one or more conditions that preclude attainment of reference streams or conditions."[Idaho 2010a] Recreational uses are divided into primary contact recreation in the water with a chance of swallowing water and secondary contact recreation with possible occasional ingestion of water. Water supply is further broken down to providing domestic drinking water, providing agricultural water for irrigation or drinking water for livestock, and industrial. Industrial use as well as wildlife habitat and aesthetics are considered to be beneficial uses that apply to all of the surface waters of the state.

### A. Upper Owyhee Watershed

The DEQ's *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load, Owyhee, County, Idaho* is a 151 page document. The information in the document is found in a number of different places and sometimes it is difficult to distinguish between existing and recommended designations. An effort has been made to ensure that the data presented here in table format accurately represents the information. There seem to be some discrepancies between these summaries and the summary information of the same document included in the *Upper Owyhee River five year review*.

In the assessment of the Upper Owyhee Watershed, there were no waterbodies with a designated or presumed beneficial use of domestic drinking water. The agricultural and industrial uses were combined under "water supply".

## 1. 303(d) waterbodies

Table G.1. Beneficial uses of waterbodies identified or recommended as 303(d) in the Upper Owyhee HUC of Idaho as included in the *Upper Owyhee Watershed Subbasin Assessment*. Only Red Canyon Creek has designated uses. The others are presumed beneficial uses.

e = existing use
x = beneficial use
f = beneficial use fully supported
s = beneficial use no evidence not supported
n = beneficial use not fully supported
i = recommended listing as impaired beneficial use
r = recommended beneficial use

| 303(d) waterbody* | Cold water aquatic | Salmonid spawning | Modified aquatic | Primary recreation | Secondary recreation | Water supply | Wildlife | Aesthetics |
|---|---|---|---|---|---|---|---|---|
| Included in Idaho 2003 assessment | | | | | ✵ | | | |
| Blue Creek Reservoir | e, n,i | i | | e,f | e,f | f | f | f |
| Juniper Basin Reservoir | i | i | r | e,f | e,f | s | s | s |
| Red Canyon Creek | e, n, i | e, n, i | | x | | x | x | x |
| Deep Creek | e, n, i | e, n, i | | r | | s | s | s |
| Pole Creek | e, n, i | e, n, i | | r | | s | s | s |
| Castle Creek | e, n, i | e, n, i | | s | s | s | s | s |
| Battle Creek | e,n | e,n | | e,f,i | e,f,i | s | s | s |
| Shoofly Creek | | r | | e,f,i | e,f,i | s | s | s |
| Nickel Creek | e, n, i | e, n, i | | e | e | s | s | s |
| Proposed for next 303(d) list | | | | | | | | |
| Camas Creek | i | i | | | | | | |
| Battle Creek | i | i | | | | | | |
| Camel Creek | i | i | | | | | | |
| Dry Creek | i | i | | | | | | |
| Beaver Creek | i | i | | | | | | |
| | Cold water aquatic | Salmonid spawning | Modified aquatic | Primary recreation | Secondary recreation | Water supply | Wildlife | Aesthetics |

Changes to the TMDL noted in the 2009 Five Year Review

✵ Most streams receive some recreational use by hikers, hunters, and anglers. Secondary contact recreation use should apply to all of these streams.

* Thomas and Smith Creeks are also mentioned as being included in the original TMDL.

## 2. DEQ identified pollutants

In the past each state submitted two documents to the EPA: a list of impaired waters in the state (303(d)) and a report summarizing the status of all the waters of a state (305(b)). Now the two documents are combined into one document called an Integrated Report.

Table G.2. DEQ identified pollutants of waterbodies in the Upper Owyhee HUC of Idaho. Pollutants were identified in the 2003 TMDL or in the 2010 integrated report.

| 303(d) waterbody | Temperature 2003 TMDL | Temperature 2010 integrated report | Sedimentation/ siltation*† | Flow regime alterations* | Escherichia coli* | Mercury* | Metals | Aquatic plant bioassessments* | Organic enrichment | Dissolved oxygen | Combined biota/ habitat bioassessments* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Included in Idaho 2003 assessment | | | | | | | | | | | |
| Blue Creek Reservoir | | | | | | | | | | | |
| Juniper Basin Reservoir | | | | | x | | | | | | |
| Red Canyon Creek | x | x | | x | | | | | | | |
| Deep Creek | x | | | | | | | | x | x | |
| Pole Creek | x | x | | x | | | | | | | |
| Castle Creek | x | x | x | | | | | | | | |
| Battle Creek | | | | | | | | | | | |
| Shoofly Creek - delist | | | | | | | | | | | |
| Nickel Creek | x | x | x | | | | x | x | | | |
| Proposed for next 303(d) list | | | | | | | | | | | |
| Camas Creek | | x | | | | | | | | | |
| Battle Creek | | | | | | | | | | | |
| Camel Creek | | x | | | | | | | | | |
| Dry Creek | | | | | | | | | | | x |
| Beaver Creek | | | | | | | | | | | |
| Included in 2010 combined report | | | | | | | | | | | |
| Thomas Creek | | x | x | | | | | x | | | |
| Smith Creek | | x | x | | | | | x | | | |
| Little Blue Creek | | | | | | | | | | | x |
| Shoofly Reservoir | | | | | | x | | | | | |
| Dry Creek | | | | | | | | | | | x |
| Big Springs Creek | | | | | | | | | | | x |

† This includes waterbodies listed for sedimentation in either the TMDL or the 2010 combined report.

* From the 2010 303(d) 305(b) combined report.

### 3. Temperature impaired waterbodies.

In the 2003 TMDL, the DEQ judged Deep Creek, Pole Creek, Castle Creek, and Red Canyon Creek as being water quality limited due to temperature.

Table G.3. The target temperatures for Deep Creek, Pole Creek, Castle Creek, and Red Canyon Creek in the 2003 TMDL for the Upper Owyhee HUC from the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load,*.

| Beneficial use | Selected targets |
|---|---|
| Salmonid spawning | Temperature ≤ 13 °C (55 °F)<br>Maximum daily average ≤ 9°C (48 °F) |
| Cold water aquatic life | Temperature ≤ 22 °C (72 °F)<br>Maximum daily average ≤ 19°C (66 °F) |
| Shade component | Shade required to meet targets as determined through the use of the SSTEMP model |

The Idaho TMDL for the Upper Owyhee HUC identified temperature impairment as a nonpoint source. The TMDL attempts to assign part of the responsiblity for improving the condition to different contributing factors. These contibuting "loads" are considered to be the different streams and the amount of change which is required in each one, therefore some streams which are not listed as 303(d) have recommended shading requirements.

Table G.4. Shade requirements to achieve load capacity for stream segments in the Upper Owyhee HUC. The stream segment temperature model was used to develop these estimates, from the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load*

| | June | July | August |
|---|---|---|---|
| | Criteria | | |
| | Salmonid spawning - 9°C % shade | Cold water aquatic life - 22 °C % shade | Cold water aquatic life - 22 °C % shade |
| Upper Deep Creek | 100 | 52 | 59 |
| Middle Deep Creek | 100 | 57 | 57 |
| Lower Deep Creek | 100 | 66 | 67 |
| Deep Creek below Nickel Creek to Pole Creek | 100 | 58 | 57 |
| Upper Pole Creek | 96 | 96 | 58 |
| Lower Pole Creek | 100 | 65 | 60 |
| Castle Creek | 95 | 95 | 58 |

| | | | |
|---|---|---|---|
| Red Canyon Creek | 94 | 94 | 57 |
| Nickel Creek | 88 | 88 | 56 |
| Hurry Back Creek | 92 | 95 | 54 |
| Nip & Tuck Creek | 87 | 87 | 54 |
| Current Creek | 91 | 91 | 53 |
| Camas Creek | 98 | 98 | 61 |
| Camel Creek | 97 | 97 | 62 |
| Bull Gulch | 98 | 98 | 62 |
| Beaver Creek | 97 | 97 | 59 |
| Upper Dickshooter Creek | 100 | 100 | 62 |
| Lower Dickshooter Creek | 94 | 65 | 67 |

The table above from the *Upper Owyhee Watershed Subbasin Assessment* describes "the required load allocation to address . . . temperature . . . issues in the Upper Owyhee Watershed.  All allocations are gross estimates with the belief that once more data is collected by the appropriate land management agencies, and other interested parties, refinements to these allocations can be made."[Idaho 2003]

## B.  South Fork

The conclusion of the *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load* is that only temperature is impairing beneficial uses.  In the assessment, there were no waterbodies with a designated or presumed beneficial use of domestic drinking water.  The agricultural and industrial uses were combined under "water supply".

Table G.5.  Beneficial uses of waterbodies identified or recommended as 303(d) in the South Fork Owyhee HUC and Idaho DEQ identified pollutants, from the *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load*.

| 303(d) waterbody* | Cold water aquatic | Salmonid spawning | Modified aquatic | Primary recreation | Secondary recreation | Water supply | Wildlife | Aesthetics |
|---|---|---|---|---|---|---|---|---|
| South Fork Owyhee River | x | x | | x | x | x | x | x |
| Impaired by temperature | x | x | | | | | | |

Table G.6. Target overall maximum and average temperature reductions necessary at the Nevada - Idaho state line for the South Fork Owyhee River in Idaho to achieve State of Idaho water quality standards.

| Beneficial use | Maximum temperature load capacity | Daily average temperature load capacity |
|---|---|---|
| Salmonid spawning | 13 °C (55 °F) | 9°C (48 °F) |
| Reduction needed from current temperature | 78% | 97% |
| Cold water biota | 22 °C (72 °F) | 19°C (66 °F) |
| Reduction needed from current temperature | 27% | 28% |

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# Upper Owyhee Watershed Assessment

## Appendix H.  Oregon integrated report



Oregon’s integrated report lists waterbodies where not all standards are met.  The criteria used for considering the inclusion of a pollutant in the Oregon integrated report that apply to the Owyhee River at the Idaho state line are:

Category 2: Attaining - Some of the pollutant standards are met.
Category 3: Insufficient data to determine whether a standard is met.
3B: Potential concern - Some data indicate non-attainment of a criterion, but data are insufficient to assign another category.
Category 5: The waterbody is water quality limited and a TMDL is needed, Section 303(d) list.

Oregon’s integrated report includes data which may support either a stream’s impaired condition or properly functioning condition.  These data are not differentiated in the table below (e.g. none of the collected samples for alkalinity or ammonia are outside of the accepted standard).

Table H.1.  Pollutants included in Oregon’s 2010 integrated report for the Owyhee River at mile 200.4, the Idaho state line.

| Pollutant | Season | Criteria | Beneficial Uses | Status | Data Source, Supporting Data |
|---|---|---|---|---|---|
| Temperature | Year Around (Non-spawning) | Redband or Lahontan cutthroat trout: 20.0 degrees Celsius 7-day-average maximum | Redband or Lahontan cutthroat trout | Water quality limited, 303(d) list, TMDL needed | Previous Data: [DEQ] LASAR 12258 River Mile 109.8: From 6/30/2000 to 10/5/2001, 156 days with 7-day-average maximum > 20 degrees Celsius.<br>DEQ] LASAR 12260 River Mile 130.7: From 7/17/1999 to 9/29/2000, 134 days with 7-day-average maximum > 20 degrees Celsius.<br>[DEQ] LASAR 12262 River Mile 167.7: From 7/17/1999 to 10/5/2001, 217 days with 7-day-average maximum > 20 degrees Celsius. |
| Arsenic | Year around | Table 20 Toxic | Aquatic life; Human health | Water quality limited, 303(d) | Previous Data: 2004 Data [USGS] Site 13177900 River Mile 165: |

| | | | | | |
|---|---|---|---|---|---|
| | | Substances, see below | | list, TMDL needed | From 4/17/2001 to 6/25/2001, 2 out of 2 samples > applicable Table 20 criterion |
| Phosphate Phosphorus | Summer | Total phosphates as phosphorus (P): Benchmark 50 ug/L | Aquatic life | Potential concern, category 3b | Previous Data: [DEQ] LASAR 12262 River Mile 167.7: From 9/11/1996 to 9/9/2003, 2 out of 10 samples > 50 ug/L benchmark criterion in streams to control excessive aquatic growths. |
| Alkalinity | Year Around | < 20 mg/L (Table 20 criterion). | Aquatic life | Attaining some criteria/uses, category 2 | Previous Data: [DEQ/ODA - Salem] LASAR 10729 River Mile 2.8: From 10/15/1996 to 12/10/2003, 0 out of 50 samples < 20 mg/L (Table 20 criterion).<br>[DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 5/21/1996 to 7/13/1999, 0 out of 3 samples < 20 mg/L (Table 20 criterion).<br>[DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 5/24/1994 to 9/9/2003, 0 out of 11 samples < 20 mg/L (Table 20 criterion).<br>[DEQ] LASAR 12260 River Mile 130.7: From 5/25/1994 to 9/9/2003, 0 out of 8 samples < 20 mg/L (Table 20 criterion).<br>[DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 5/25/1994 to 9/9/2003, 0 out of 11 samples < 20 mg/L (Table 20 criterion). |
| Ammonia | Year Around | Table 20 Toxic Substances, see below | Aquatic life | Attaining some criteria/uses, category 2 | [DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 5/25/1994 to 9/9/2003, 0 out of 22 samples > applicable Table 20 criterion.<br>[DEQ/ODA - Salem] LASAR 10729 River Mile 2.8: From 10/15/1996 to 12/10/2003, 0 out of 54 samples > applicable Table 20 criterion.<br>[DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 5/21/1996 to 7/13/1999, 0 out of 8 samples > applicable Table 20 criterion.<br>[DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 5/24/1994 to 9/9/2003, 0 out of 21 samples > applicable Table 20 criterion.<br>[DEQ/ODA - Salem] LASAR 12260 River Mile 130.7: From 5/25/1994 to 9/9/2003, 0 out of 14 samples > applicable Table 20 criterion. |
| Chloride | Year Around | Table 20 Toxic Substances, see below | Aquatic life | Insufficient data, category 3 | Previous Data: [DEQ] LASAR 10730 River Mile 127.7: From 9/30/1998 to 7/13/1999, 0 out of 2 samples > applicable Table 20 criterion.<br>[DEQ] LASAR 12258 River Mile 109.8: From 9/29/1998 to 9/10/2002, 0 out of 3 samples > applicable Table 20 criterion. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | [DEQ] LASAR 12260 River Mile 130.7: From 9/10/2002 to 9/10/2002, 0 out of 1 samples > applicable Table 20 criterion.<br>[DEQ] LASAR 12262 River Mile 167.7: From 9/29/1998 to 9/10/2002, 0 out of 3 samples > applicable Table 20 criterion. |
| Dissolved Oxygen | Year Around (Non-spawning) | Cool water: Not less than 6.5 mg/l | Cool-water aquatic life | Attaining some criteria/uses, category 2 | Previous Data: [DEQ/ODA - Salem] LASAR 12260 River Mile 130.7: From 5/25/1994 to 9/9/2003, 0 out of 11 samples (0%) < 6.5 mg/l and applicable % saturation.<br>[DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 5/21/1996 to 7/13/1999, 0 out of 5 samples (0%) < 6.5 mg/l and applicable % saturation.<br>[DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 5/25/1994 to 9/9/2003, 0 out of 16 samples (0%) < 6.5 mg/l and applicable % saturation.<br>[DEQ/ODA - Salem] LASAR 10729 River Mile 2.8: From 6/11/1997 to 8/20/2003, 1 out of 14 samples (7%) < 6.5 mg/l and applicable % saturation.<br>[DEQ/ODA - Salem] LASAR 10729 River Mile 2.8: From 10/15/1996 to 12/10/2003, 0 out of 30 samples (0%) < 6.5 mg/l and applicable % saturation.<br>[DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 5/24/1994 to 9/9/2003, 0 out of 16 samples (0%) < 6.5 mg/l and applicable % saturation. |
| pH | Fall, winter, spring | pH 7.0 to 9.0 | Water contact recreation; Resident fish and aquatic life | Attaining some criteria/uses, category 2 | Previous Data: [DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 5/25/1994 to 10/9/2001, 1 out of 8 samples (12%) outside pH criteria range 7 to 9.<br>[DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 5/21/1996 to 5/21/1996, 0 out of 1 samples (0%) outside pH criteria range 7 to 9.<br>[DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 5/24/1994 to 10/9/2001, 0 out of 7 samples (0%) outside pH criteria range 7 to 9.<br>[DEQ/ODA - Salem] LASAR 12260 River Mile 130.7: From 5/25/1994 to 10/9/2001, 0 out of 6 samples (0%) outside pH criteria range 7 to 9. |
| pH | Summer | pH 7.0 to 9.0 | Water contact recreation; Resident fish and aquatic life | Attaining some criteria/uses, category 2 | Previous Data: [DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 9/10/1996 to 9/9/2003, 0 out of 11 s amples (0%) outside pH criteria range 7 to 9. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | [DEQ/ODA - Salem] LASAR 12260 River Mile 130.7: From 9/15/1997 to 9/9/2003, 1 out of 6 samples (17%) outside pH criteria range 7 to 9.<br>[DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 9/11/1996 to 9/9/2003, 1 out of 11 samples (9%) outside pH criteria range 7 to 9.<br>[DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 9/10/1996 to 7/13/1999, 0 out of 5 samples (0%) outside pH criteria range 7 to 9. |

Table H.2.  Criteria not to be exceeded in waters of the state of Oregon in order to protect aquatic life and human health. The acute criteria refer to the average concentration for one hour and the chronic criteria refer to the average concentration for 96 hours (4 days) and these criteria should not be exceeded more than once every three years.

| | Concentration for protection of aquatic life | | |
|---|---|---|---|
| | Fresh acute criteria | Fresh chronic criteria | |
| Alkalinity | | 20,000 micrograms/liter | |
| Ammonia | Criteria are pH and temperature dependent.  They are established by the EPA .  See example below (Table H.3) | | |
| Arsenic | 360 micrograms/liter | 190 micrograms/liter | |
| Chloride | 860 mg/L | 230 mg/L | |

Table H.3. An example of the interaction of pH with temperature in the determination of ammonia criteria. Values of the acute criterion with mussels absent.

| CMC: Mussels Absent, mg N/L | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| pH | Temperature, C | | | | | | | | | |
| | 0 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 |
| 6.5 | 58.0 | 58.0 | 58.0 | 58.0 | 43.7 | 37.0 | 31.4 | 26.6 | 22.5 | 19.1 |
| 6.6 | 55.7 | 55.7 | 55.7 | 55.7 | 41.9 | 35.5 | 30.1 | 25.5 | 21.6 | 18.3 |
| 6.7 | 53.0 | 53.0 | 53.0 | 53.0 | 39.9 | 33.8 | 28.6 | 24.3 | 20.6 | 17.4 |
| 6.8 | 49.9 | 49.9 | 49.9 | 49.9 | 37.6 | 31.9 | 27.0 | 22.9 | 19.4 | 16.4 |
| 6.9 | 46.5 | 46.5 | 46.5 | 46.5 | 35.1 | 29.7 | 25.2 | 21.3 | 18.1 | 15.3 |
| 7.0 | 42.9 | 42.9 | 42.9 | 42.9 | 32.3 | 27.4 | 23.2 | 19.7 | 16.7 | 14.1 |
| 7.1 | 39.1 | 39.1 | 39.1 | 39.1 | 29.4 | 24.9 | 21.1 | 17.9 | 15.2 | 12.8 |
| 7.2 | 35.1 | 35.1 | 35.1 | 35.1 | 26.4 | 22.4 | 19.0 | 16.1 | 13.6 | 11.5 |
| 7.3 | 31.2 | 31.2 | 31.2 | 31.2 | 23.5 | 19.9 | 16.8 | 14.3 | 12.1 | 10.2 |
| 7.4 | 27.3 | 27.3 | 27.3 | 27.3 | 20.6 | 17.4 | 14.8 | 12.5 | 10.6 | 8.98 |
| 7.5 | 23.6 | 23.6 | 23.6 | 23.6 | 17.8 | 15.1 | 12.8 | 10.8 | 9.18 | 7.77 |
| 7.6 | 20.2 | 20.2 | 20.2 | 20.2 | 15.3 | 12.9 | 10.9 | 9.27 | 7.86 | 6.66 |
| 7.7 | 17.2 | 17.2 | 17.2 | 17.2 | 12.9 | 11.0 | 9.28 | 7.86 | 6.66 | 5.64 |
| 7.8 | 14.4 | 14.4 | 14.4 | 14.4 | 10.9 | 9.21 | 7.80 | 6.61 | 5.60 | 4.74 |
| 7.9 | 12.0 | 12.0 | 12.0 | 12.0 | 9.07 | 7.69 | 6.51 | 5.52 | 4.67 | 3.96 |
| 8.0 | 9.99 | 9.99 | 9.99 | 9.99 | 7.53 | 6.38 | 5.40 | 4.58 | 3.88 | 3.29 |
| 8.1 | 8.26 | 8.26 | 8.26 | 8.26 | 6.22 | 5.27 | 4.47 | 3.78 | 3.21 | 2.72 |
| 8.2 | 6.81 | 6.81 | 6.81 | 6.81 | 5.13 | 4.34 | 3.68 | 3.12 | 2.64 | 2.24 |
| 8.3 | 5.60 | 5.60 | 5.60 | 5.60 | 4.22 | 3.58 | 3.03 | 2.57 | 2.18 | 1.84 |
| 8.4 | 4.61 | 4.61 | 4.61 | 4.61 | 3.48 | 2.95 | 2.50 | 2.11 | 1.79 | 1.52 |
| 8.5 | 3.81 | 3.81 | 3.81 | 3.81 | 2.87 | 2.43 | 2.06 | 1.74 | 1.48 | 1.25 |
| 8.6 | 3.15 | 3.15 | 3.15 | 3.15 | 2.37 | 2.01 | 1.70 | 1.44 | 1.22 | 1.04 |
| 8.7 | 2.62 | 2.62 | 2.62 | 2.62 | 1.97 | 1.67 | 1.42 | 1.20 | 1.02 | 0.862 |
| 8.8 | 2.19 | 2.19 | 2.19 | 2.19 | 1.65 | 1.40 | 1.19 | 1.00 | 0.851 | 0.721 |
| 8.9 | 1.85 | 1.85 | 1.85 | 1.85 | 1.39 | 1.18 | 1.00 | 0.847 | 0.718 | 0.608 |
| 9.0 | 1.57 | 1.57 | 1.57 | 1.57 | 1.19 | 1.00 | 0.851 | 0.721 | 0.611 | 0.517 |

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# Upper Owyhee Watershed Assessment

## Appendix J. Riparian plant associations



### Contents



### Riparian plant associations

#### Inter-mountain basins semi-desert grassland.

This widespread ecological system occurs throughout the Intermountain western U.S. on dry plains and mesas, at approximately 1450 to 2320 m (4750-7610 feet) in elevation. These grasslands occur in lowland and upland areas and may occupy swales, playas, mesa tops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are often well-drained sandy- or loamy-textured soils derived from sedimentary parent materials, but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. When they occur near foothills grasslands they will be at lower elevations. The dominant perennial bunch grasses and shrubs within this system are all very drought-resistant plants. These grasslands are typically dominated or codominated by *Achnatherum hymenoides, Aristida* spp., *Bouteloua gracilis, Hesperostipa comata, Muhlenbergia torreyana, or Pleuraphis jamesii,* and may include scattered shrubs and dwarf-shrubs of species of *Artemisia, Atriplex, Coleogyne, Ephedra, Gutierrezia,* or *Krascheninnikovia lanata*.

#### Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland

This system occurs in mountain ranges of the Great Basin and along the eastern slope of the Sierra Nevada within a broad elevation range from about 1220 m (4000 feet) to over 2135 m (7000 feet). This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. The variety of plant associations connected to this system reflects elevation, stream gradient, floodplain width, and flooding events. Dominant trees may include *Abies concolor, Alnus incana, Betula occidentalis, Populus angustifolia, Populus balsamifera* ssp. trichocarpa*, Populus fremontii, Salix laevigata, Salix gooddingii, and Pseudotsuga menziesii*. Dominant shrubs include *Artemisia cana, Cornus sericea, Salix exigua, Salix lasiolepis, Salix lemmonii*, or *Salix lutea*. Herbaceous layers are often dominated by species of *Carex* and *Juncus*, and perennial grasses and mesic forbs such *Deschampsia caespitosa, Elymus trachycaulus, Glyceria striata, Iris missouriensis, Maianthemum stellatum*, or *Thalictrum fendleri*. Introduced forage species such as *Agrostis stolonifera, Poa pratensis, Phleum pratense*, and the weedy annual *Bromus tectorum* are often present in disturbed stands. These are disturbance-driven systems that require flooding, scour and deposition for germination and maintenance. Livestock grazing is a major influence in altering structure, composition, and function of the community.

## Columbia Basin Foothill Riparian Woodland and Shrubland

This is a low-elevation riparian system found on the periphery of the mountains surrounding the Columbia River Basin, along major tributaries and the main stem of the Columbia at relatively low elevations. This is the riparian system associated with all streams at and below lower treeline, including permanent, intermittent and ephemeral streams with woody riparian vegetation. These forests and woodlands require flooding and some gravels for reestablishment. They are found in low-elevation canyons and draws, on floodplains, or in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff. Underlying gravels may keep the water table just below the ground surface and are favored substrates for cottonwood. Large bottomlands may have large occurrences, but most have been cut over or cleared for agriculture. Rafted ice and logs in freshets may cause considerable damage to tree boles. Beavers crop younger cottonwood and willows and frequently dam side channels occurring in these stands. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Important and diagnostic trees include *Populus balsamifera* ssp. trichocarpa, *Alnus rhombifolia, Populus tremuloides, Celtis laevigata* var. reticulata, *Betula occidentalis*, or *Pinus ponderosa*. Important shrubs include *Crataegus douglasii, Philadelphus lewisii, Cornus sericea, Salix lucida* ssp. lasiandra, *Salix eriocephala, Rosa nutkana, Rosa woodsii, Amelanchier alnifolia, Prunus virginiana*, and *Symphoricarpos albus*. Grazing is a major influence in altering structure, composition, and function of the community.

## Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

This ecological system is found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevational range from approximately 900 to 2800 m. This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. It is dependent on a natural hydrologic regime, especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. It can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. In some locations, occurrences extend into moderately high intermountain basins where the adjacent vegetation is sage steppe. Dominant trees may include *Acer negundo, Populus angustifolia, Populus deltoides, Populus fremontii, Pseudotsuga menziesii, Picea pungens, Salix amygdaloides*, or *Juniperus scopulorum*. Dominant shrubs include *Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, Salix drummondiana, Salix exigua, Salix irrorata, Salix lucida, Shepherdia argentea*, or *Symphoricarpos* spp. Exotic trees of *Elaeagnus angustifolia* and *Tamarix* spp. are common in some stands. Generally, the upland vegetation surrounding this riparian system is different and ranges from grasslands to forests. In the Wyoming Basins, the high-elevation *Populus angustifolia*-dominated rivers are included here, including along the North Platte, Sweetwater, and Laramie rivers. In these situations, *Populus angustifolia* is extending down into the sage steppe zone of the basins.

## Rocky Mountain Subalpine-Montane Riparian Shrubland

This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana, and also occurs in mountainous areas of the Intermountain region and Colorado Plateau. These are montane to subalpine riparian shrublands occurring as narrow bands of shrubs lining streambanks and alluvial terraces in narrow to wide, low-gradient valley bottoms and floodplains with sinuous stream channels. Generally it is found at higher elevations, but can be found anywhere from 1700-3475 m. Occurrences can also be found around seeps, fens, and isolated springs on hillslopes away from valley bottoms. Many of the plant associations found within this system are associated with beaver activity. This system often occurs as a mosaic of multiple communities that are shrub- and herb-dominated and includes above-treeline, willow-dominated, snowmelt-fed basins that feed into streams. The dominant shrubs reflect the large elevational gradient and include *Alnus incana, Betula nana, Betula occidentalis, Cornus sericea, Salix bebbiana, Salix boothii, Salix brachycarpa, Salix drummondiana, Salix eriocephala, Salix geyeriana, Salix monticola, Salix planifolia*, and *Salix wolfii*. Generally the upland vegetation surrounding these riparian systems are of either conifer or aspen forests.

## Rocky Mountain Subalpine-Montane Riparian Woodland

This riparian woodland system is comprised of seasonally flooded forests and woodlands found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Mountains. This system contains the conifer and aspen woodlands that line montane streams. These are communities tolerant of periodic flooding and high water tables. Snowmelt moisture in this system may create shallow water tables or seeps for a portion of the growing season. Stands typically occur at elevations between 1500 and 3300 m (4920-10,830 feet), farther north elevation ranges between 900 and 2000 m. This is confined to specific riparian environments occurring on floodplains or terraces of rivers and streams, in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, and on pond or lake margins. Dominant tree species vary across the latitudinal range, although it usually includes *Abies lasiocarpa* and/or *Picea engelmannii*; other important species include *Pseudotsuga menziesii, Picea pungens, Picea engelmannii X glauca, Populus tremuloides*, and *Juniperus scopulorum*. Other trees possibly present but not usually dominant include *Alnus incana, Abies concolor, Abies grandis, Pinus contorta, Populus angustifolia, Populus balsamifera* ssp. trichocarpa, and *Juniperus osteosperma*.

## Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe

This ecological system includes sagebrush communities occurring at lowland and montane elevations in the Columbia Plateau-northern Great Basin region, east almost to the Great Plains. These are generally depressional wetlands or non-alkaline playas, occurring as small- or occasionally large-patch communities, in a sagebrush or montane forest matrix. Climate is generally semi-arid, although it can be cool in montane areas. This system occurs in poorly drained depressional wetlands, the largest characterized as playas, the smaller as vernal pools, or along seasonal stream channels in valley bottoms or mountain meadows. *Artemisia cana* ssp. bolanderi or *Artemisia cana* ssp. viscidula are dominant, with *Artemisia tridentata* ssp. tridentata, *Artemisia tridentata* ssp. wyomingensis, or *Artemisia tridentata* ssp. vaseyana occasionally codominant. Understory graminoids and forbs are characteristic, *with Poa secunda* (= *Poa nevadensis*), *Poa cusickii, Muhlenbergia filiformis, Muhlenbergia richardsonis*, and *Leymus cinereus* dominant at the drier sites; *Eleocharis palustris, Deschampsia caespitosa*, and *Carex* species dominate at wetter or higher-elevation sites.

## North American Arid West Emergent Marsh

This widespread ecological system occurs throughout much of the arid and semi-arid regions of western North America, typically surrounded by savanna, shrub steppe, steppe, or desert vegetation. Natural marshes may occur in depressions in the landscape (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Water chemistry may include some alkaline or semi-alkaline situations, but the alkalinity is highly variable even within the same complex of wetlands. Marshes have distinctive soils that are typically mineral, but can also accumulate organic material. Soils have characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of *Scirpus* and/or *Schoenoplectus, Typha, Juncus, Potamogeton, Polygonum, Nuphar*, and *Phalaris*. This system may also include areas of relatively deep water with floating-leaved plants

(*Lemna, Potamogeton*, and *Brasenia*) and submergent and floating plants (*Myriophyllum, Ceratophyllum, and Elodea*).

## Rocky Mountain Subalpine-Montane Mesic Meadow

This Rocky Mountain ecological system is restricted to sites from lower montane to subalpine where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. It is found typically above 2000 m in elevation in the southern part of its range and above 600 m in the northern part. These upland communities occur on gentle to moderate-gradient slopes. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as those found in Rocky Mountain Alpine-Montane Wet Meadow (CES306.812). Vegetation is typically forb-rich, with forbs contributing more to overall herbaceous cover than graminoids. Important taxa include *Erigeron* spp., *Asteraceae* spp., *Mertensia* spp., *Penstemon* spp., *Campanula* spp., *Lupinus* spp., *Solidago* spp., *Ligusticum* spp., *Thalictrum occidentale, Valeriana sitchensis, Rudbeckia occidentalis, Balsamorhiza sagittata, Wyethia* spp., *Deschampsia caespitosa, Koeleria macrantha*, and *Dasiphora fruticosa*. Burrowing mammals can increase the forb diversity.

## Rocky Mountain Subalpine Mesic Meadow

This Rocky Mountain ecological system is restricted to sites in the subalpine zone where finely textured soils, snow deposition, or wind-swept dry conditions limit tree establishment. It is found typically above 3000 m in elevation in the southern part of its range and above 1500 m in the northern part. These upland communities occur on gentle to moderate-gradient slopes. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as found in Rocky Mountain Alpine-Montane Wet Meadow (CES306.812). Vegetation is typically forb-rich, with forbs contributing more to overall herbaceous cover than graminoids. Important taxa include *Erigeron* spp., *Asteraceae* spp., *Mertensia* spp., *Penstemon* spp., *Campanula* spp., *Lupinus* spp., *Solidago* spp., *Ligusticum* spp., *Thalictrum occidentale, Valeriana sitchensis, Balsamorhiza sagittata, Wyethia* spp., *Deschampsia caespitosa, Koeleria macrantha*, and *Dasiphora fruticosa*. Burrowing mammals can increase the forb diversity.

## Rocky Mountain Alpine-Montane Wet Meadow

These are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from montane to alpine (1000-3600 m). These types occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toeslope seeps. They are typically found on flat areas or gentle slopes, but may also occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late-melting snow patches or on snowbeds. Soils of this system may be mineral or organic. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations, often dominated by graminoids, including *Calamagrostis stricta, Caltha leptosepala, Cardamine cordifolia, Carex illota, Carex microptera, Carex nigricans, Carex scopulorum, Carex utriculata, Carex vernacula, Deschampsia caespitosa, Eleocharis quinqueflora, Juncus drummondii, Phippsia algida, Rorippa alpina, Senecio triangularis, Trifolium parryi*, and *Trollius laxus*. Often alpine dwarfshrublands, especially those dominated by *Salix*, are immediately adjacent to the wet meadows. Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding.

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