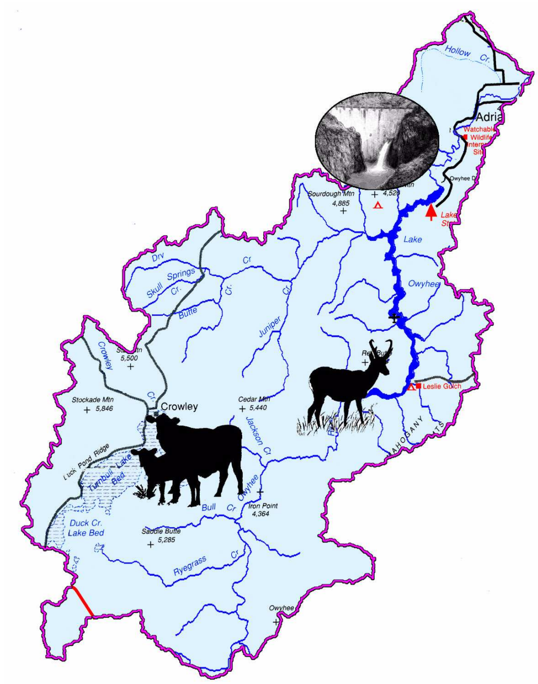


Lower Owyhee Watershed Assessment

I. Overview

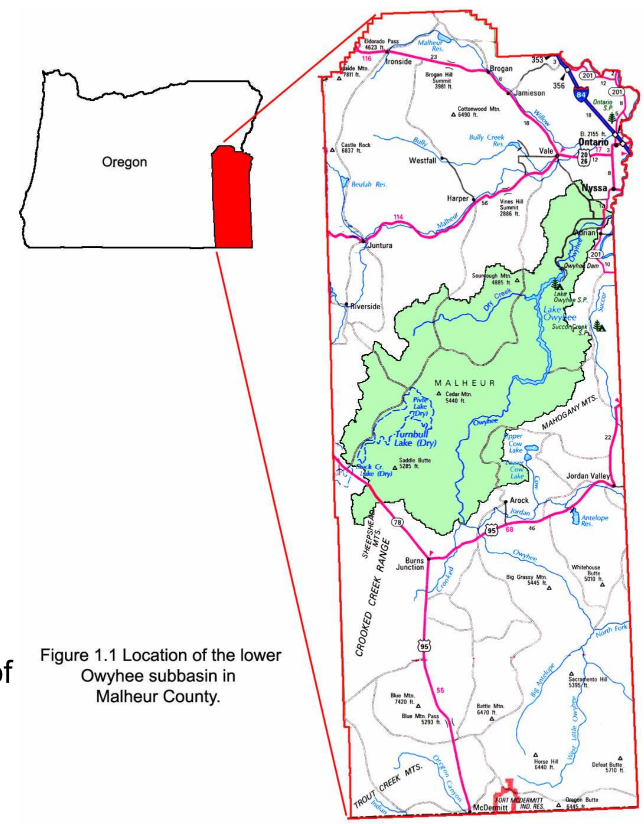


Figure 1.1 Location of the lower Owyhee subbasin in Malheur County.

I. Overview

The lower Owyhee subbasin is located in the southeastern-most corner of Oregon in Malheur county (Figure 1.1). It covers 1,268,900 acres (1,983 square miles), larger than the state of Delaware.

A. Climate

The identification of natural variables is an important facet in describing a watershed. The lower Owyhee subbasin is a semiarid desert. At the Rome weather station slightly south of the subbasin, the thirty year average annual rainfall is 8.28

inches. At the Malheur Experiment Station slightly north of the subbasin, the sixty year average annual rainfall in 10.19 inches. This scarcity of precipitation is a major determining factor in the functioning of the subbasin. The least rainfall falls in the months of July and August. The greatest precipitation is during the winter and early spring months.

The months of July and August are also the hottest. Over sixty years, the average maximum temperature at the Malheur Experiment Station in July was 92 degrees and in August 91 degrees. Rome is at a slightly higher elevation, so the average maximum temperatures there were slightly lower, 90 degrees in July, 89 degrees in August.

B. Geography

The construction of the Owyhee Dam has led to two distinct parts to the lower Owyhee subbasin. Below the dam the use of the land has been transformed to irrigated agriculture. Most of the unirrigated portion of the Lower Owyhee subbasin is part of the Owyhee uplands.

1 Snake River plain

The northern end of the lower Owyhee subbasin lies within the Snake River plain. This broad, relatively flat plain is though to have originally formed by subsidence after the Yellowstone hot spot passed by the area to the south. Subsequent flooding events of the Snake, Owyhee, and other rivers have resulted in depositing layers of gravel and soil. The lower Owyhee river valley has now been substantially converted into irrigated agriculture (Figure 1.2) although previously the vegetation was largely sagebrush steppe. Much of the soil is alkaline and overlies a caliche hardpan. Most of the caliche hardpans in cultivated soils have been intentionally shattered by deep cultivation.

Figure 1.2 Irrigated agriculture in NE Malheur County, 2005.

2 Owyhee Uplands

Most of the lower Owyhee subbasin lies within the Owyhee uplands. The Owyhee uplands geography is distinct from the geography of the Great Basin or the geography of the Snake River plains, sharing characteristics of both. Although the vegetation and animals of the Owyhee uplands are similar to those found in the Great Basin, the area has fewer mountains running north and south which characterize the Basin and Range topography and the Owyhee uplands has had more volcanic activity.

a. Geology

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 soils of the mesas are generally shallow and in some areas are stripped to bare rock by wind and water. 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.

Where the layers beneath a hard cap rock of basalt or rhyolite are softer tuffs (consolidated volcanic ash), they were easily removed by moving waters and in some cases wind erosion. These geologic processes have resulted in fantastic formations of different colors in dry canyons as can be seen in Leslie Gulch (Figure 1.3), Carlton Canyon, Three Fingers Gulch, the Honeycombs, and elsewhere. These tuffaceous outcroppings can also be riddled with shallow caves. 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. Larger numbers of recreationists view the lower part of the Owyhee River and canyon lands from Owyhee Reservoir while fishing and boating.

Figure 1.3. Volcanic tuff formations in Leslie Gulch

Although most of the lower Owyhee subbasin in the Owyhee uplands drains into the Owyhee River and hence into the Columbia River system, in the southeastern corner of the subbasin there are several small playas, lakes with no external drainage. These tend to be dry lakes except in exceptionally wet years.

b. Hydrology

Since the Owyhee uplands are a semiarid desert with very few sources of perennial water, the landscape is primarily dissected by intermittent drainages and ephemeral streams which flow only following rainstorms or snow melt. The erosional processes which are forming the landscape follow major storm or storm on snow events. Runoff events are aggravated when the soil is frozen. Surface water availability for 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 some springs in the area. Surface water has been enhanced by stock ponds, pipelines and reservoirs.

c. Vegetation

Vegetative communities are shaped by the low quantities and infrequent nature of water availability. The rolling 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.

d. Animals

The limited 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 Owyhee uplands today include pronghorn, mule deer, white-tailed deer, elk, and cougar. Bighorn sheep have been reintroduced to the rugged canyons. Wild horses are abundant.

e. Native Americans

The Owyhee uplands were home to the Tagötöka band of the Northern Paiute at European contact. This group's territory largely coincided with the Owyhee watershed. They were surrounded by other Northern Paiute and Shoshone bands in Oregon, Nevada and Idaho. Prior to the Northern Paiute, other groups have inhabited the Owyhees since at least 12,000 BP (years before the present).

C. Owyhee Dam

The Owyhee dam is in the lower Owyhee subbasin. The Owyhee River system drains an enormous area of land, approximately 7 million acres or 11,337 square miles. Most of the precipitation falls during the winter and spring months. The runoff from this area is captured in the Owyhee Reservoir. The reservoir covers 13,900 acres and holds 715,000 acre feet of water above the minimum pool. This water is used to irrigate 110,000 acres of land and partially supply water to another 13,000 acres. Most of the water from the lower Owyhee subbasin is utilized outside the subbasin to the north in Malheur County and to the east in Idaho. About 22,000 acres in the lower Owyhee subbasin are irrigated mostly from the Owyhee project.

D. Population

In the 2002 census of population, 4,187 people were shown as living in the lower Owyhee subbasin. Most of the population was concentrated on the small area below the Owyhee Dam that receives irrigation water from the dam. There are no towns in the subbasin.

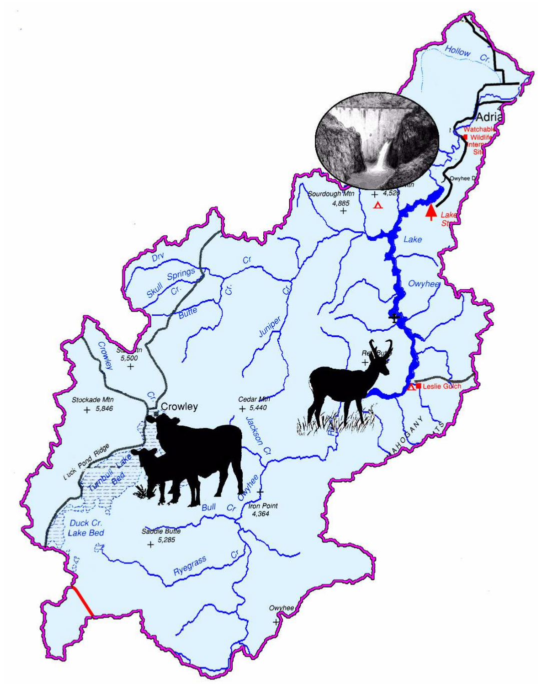
E. Use of the subbasin

Ninety percent of the subbasin is publicly owned land. Eighty-three percent of all land in the subbasin is rangeland and fourteen percent is hayland and pastureland. There are small areas of wetland. Three percent of the land is irrigated; two-thirds of the irrigated land is in row crops. In 2005 the NRCS recorded about 175 operations with 103 full time farmers or ranchers and 184 part-time farmers or ranchers in the subbasin.

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

F. Conclusion

In the lower Owyhee subbasin, during the summer months the temperatures are high and the rainfall very low. The area of the lower Owyhee subbasin is mostly uninhabited rangeland. There are creeks and the Owyhee River in deep canyons and little water access on the mesas. Crops are grown on irrigated land below the Owyhee dam utilizing water captured during spring runoff. The lower Owyhee has areas with great natural beauty, geological complexity, and diverse uses.



Lower Owyhee Watershed Assessment

II. Background

Contents

II. Background

A. The lower Owyhee subbasin

1 Location

The lower Owyhee subbasin is located in the southeastern corner of Oregon (Figure 2.1) in Malheur county. It covers 1,268,900 acres[64] (1,983 square miles), larger than the state of Delaware.

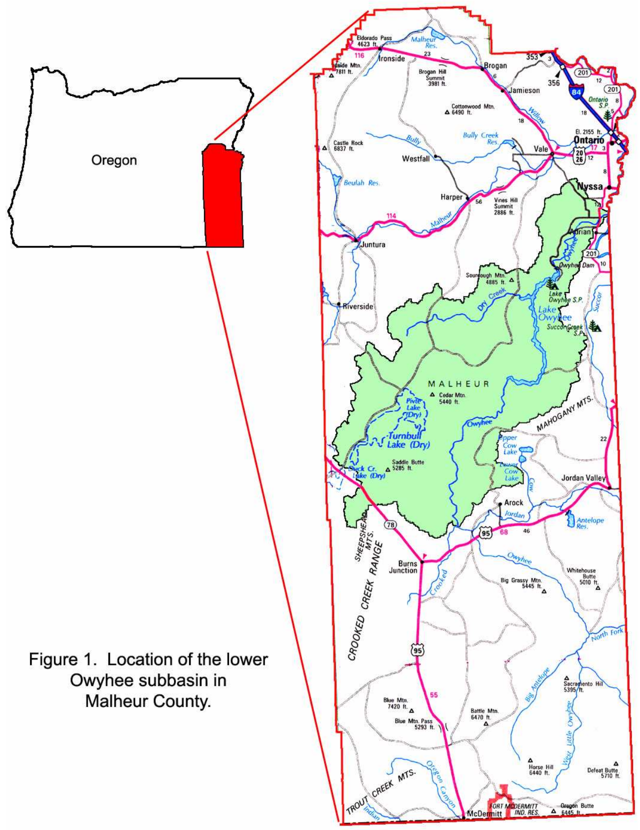


Figure 1. Location of the lower Owyhee subbasin in Malheur County.

2 What is the lower Owyhee subbasin?

The lower Owyhee subbasin is a geographic region designated by the United States Geological Survey (USGS). The United States is divided into geographic units called hydrologic units based on drainage areas of rivers. The largest units, given first order hydrologic unit codes (HUC), are drained by a major river or series of rivers. These regions are further subdivided into areas drained by a river system. These areas in turn are split into smaller units.[98]

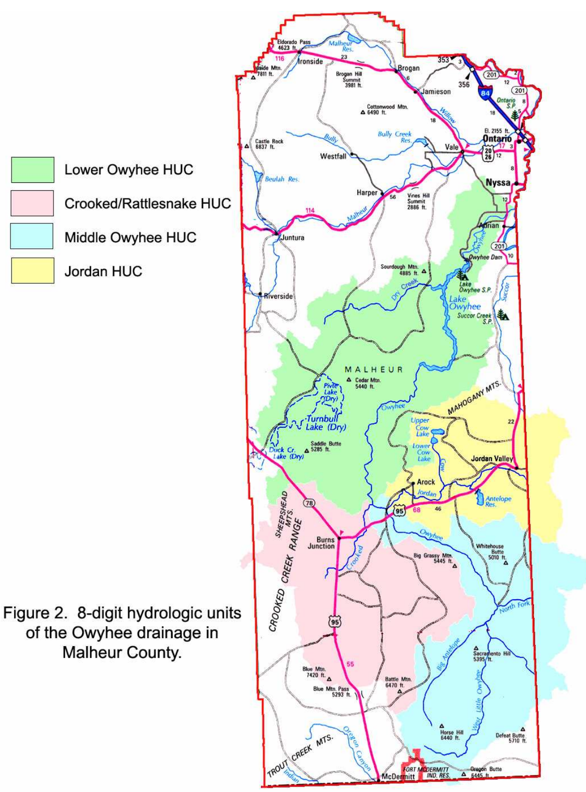


Figure 2. 8-digit hydrologic units of the Owyhee drainage in Malheur County.

The lower Owyhee subbasin is a 4th order or 8-digit hydrologic unit. It is part of the Columbia River, Snake River, and Owyhee River drainages. Within the Owyhee River drainage, there are several tributary rivers which have been designated as 4th order HUCs. Immediately south (upstream) of the lower Owyhee subbasin, the drainage areas of Crooked Creek and Rattlesnake Creek form one HUC, Jordan Creek drains another HUC, and the middle fork of the Owyhee River drains a third HUC (Figure 2.2). Upstream from the middle fork are three additional 4th order HUCs. The lower Owyhee subbasin includes everything downstream from these HUCs that drains into the Owyhee River. The lower Owyhee subbasin also includes land that does not drain into the Owyhee river, but has the potential to become part of the drainage over a geological time scale. This region is the Paiute, Turnbull, and Duck Creek playa lake beds.

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 to have some way to monitor, inventory, assess and manage resources.[69] The use of HUCs or watersheds was developed because water is a major resource and concern. It is also fairly easy to delineate the boundaries of most watersheds. However, the area within the boundaries of a watershed is not necessarily homogeneous in other ways. For example, the lower Owyhee subbasin includes forested areas on Mahogany Mountain and barren playa lakes, steep pinnacles in Leslie Gulch and leveled irrigated row 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 approach to assessing an area recognizes that the different components of a region interact and exist in association with one another.[69] There is a potential to misunderstand how watersheds can be used to structure ecological management.[70]

James Omernik points out the 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.[69] However, determining the capacity and potential of a watershed depends on the characteristics of the ecoregions within it. Each of these is a mosaic of abiotic and biotic factors including climate, geology, soils, land cover including vegetation, human use, wildlife, water chemistry, and topography.[69]

In assessing the lower Owyhee subbasin, the existence of different ecosystems needs to be taken into consideration.

3 Ecoregions within the lower Owyhee subbasin

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.[69] In general an ecoregion is defined as an area with relative homogeneity of biotic and abiotic components which are distinct from adjacent areas.[69,82] Many of the classification systems for ecoregions give preference to specific factors for separating areas. Below we discuss four approaches to describing ecoregions within the lower Owyhee subbasin.

a. NRCS

A common resource area map is included in the Natural Resources Conservation Service (NRCS) profile of the lower Owyhee subbasin.[64] The NRCS has developed a land classification system as a resource for farming, ranching, forestry, engineering, recreation, land management, conservation programs, and other uses.[66] This classification divides the United States into land resource units, major land resource areas (MLRA), and common resource areas (CRA).[65,66] The major land resource areas

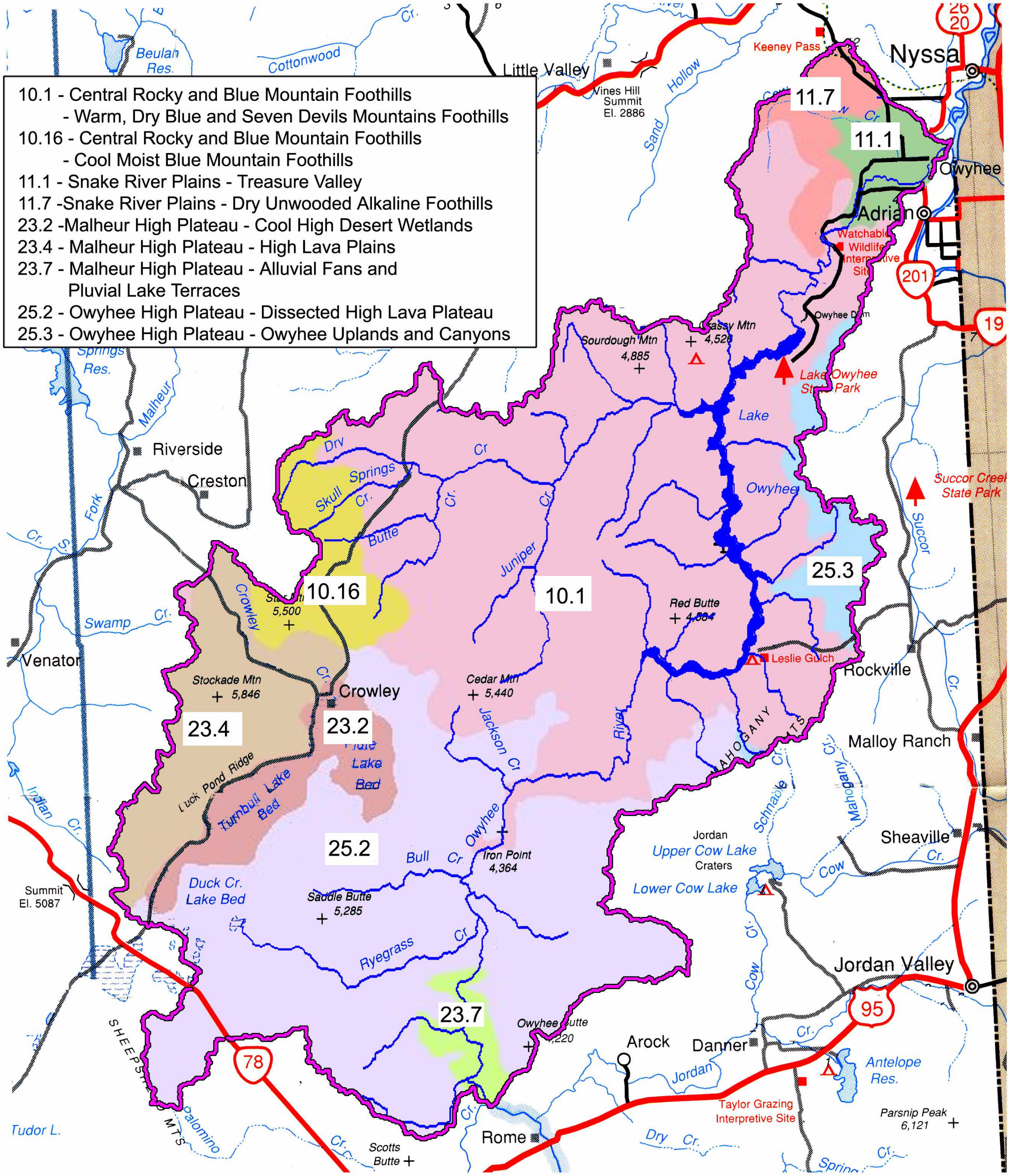


Figure 2.3. Common Resource Areas in the lower Owyhee subbasin.[68] Descriptions in Appendix B.

are one continuous area or several separate areas near each other without consideration of 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.[65,66] The NRCS has identified 278 major land resource areas in the US[65] and the lower Owyhee subbasin includes parts of four of these areas.[64,66,68]

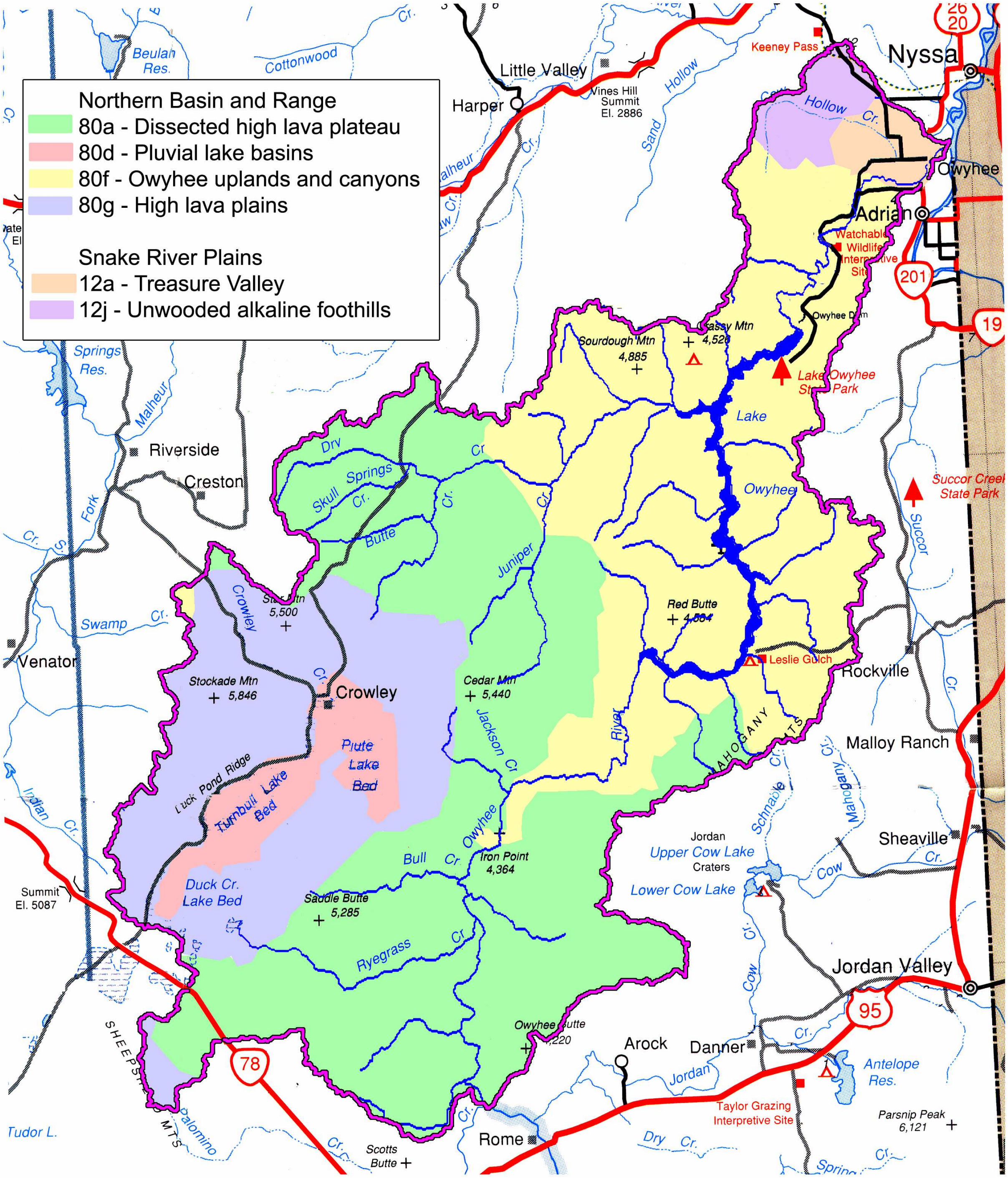


Figure 2.4. Northern basin and range ecoregion subregions and Snake River plains ecoregion subregions in the lower Owyhee subbasin from the Oregon Natural Heritage Plan.[72] Descriptions in Appendix B.

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."[67] They are created by subdividing MLRAs by topography, other landscape features, resource concerns, resource uses and conservation needs.[66] There are parts of nine common resource areas in the lower Owyhee subbasin (Figure 2.3) (Appendix B).[64,68]

b. Oregon Natural Heritage plan

One of the goals of the Oregon Natural Heritage (ORNH) program established by the Oregon legislature was to identify the "full range of Oregon's natural heritage resources."[62] To do this they identified ecoregions that support different terrestrial, wetland and aquatic ecosystems.[62] Part of the purpose of describing the ecoregions is to identify natural areas of exceptional value for conservation. The lower Owyhee subbasin includes two of the ORNH ecoregions and six subregions (Figure 2.4) (Appendix B).[62] These ecoregions are the ones used by the Oregon Department of Fish and Wildlife.

Although the original purpose of the NRCS and ORNH delineations is different, a comparison of the maps of the NRCS common resource areas (Figure 2.3) and the ORNH subregions (Figure 2.4) shows some overlap between the identified distinctive areas.

c. Ecological Provinces of Oregon

Anderson, Borman, and Krueger[6] recognize that much planning and management is done on different scales and that it is important to understand the relative similarity in quality and quantity of resource types on different scales. They define an ecological site as an area with certain soils, climate, topography, and vegetation. These factors influence management decisions.

On a broader scale they define an ecological province as an area in which the difference in vegetation among ecological sites can be related to underlying geology, climate, and the characteristics, configuration, and evolution of rocks and land forms. An ecological province therefore contains a number of ecological sites.

Ecological provinces can be used for considering broader scale responses to management decisions. The ecological province has grouped ecological sites with similar types, quality, and quantity of environmental resources. Ecological provinces are not homogeneous. They have unifying characteristics that impact the local environment. The local environment is created by an interaction among factors including soil, aspect, slope, elevation, moisture, and temperature. The distinguishing feature between ecological provinces is that within a province, vegetation in similar local environments, for example on north-facing slopes, is similar.[6]

Anderson, Borman, and Krueger have described 15 ecological provinces in Oregon. The lower Owyhee subbasin contains parts of four of these provinces (Figure 2.5) (Appendix B).[6]

d. Owyhee Uplands ecoregion

On a different scale, the Bureau of Land Management (BLM) 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

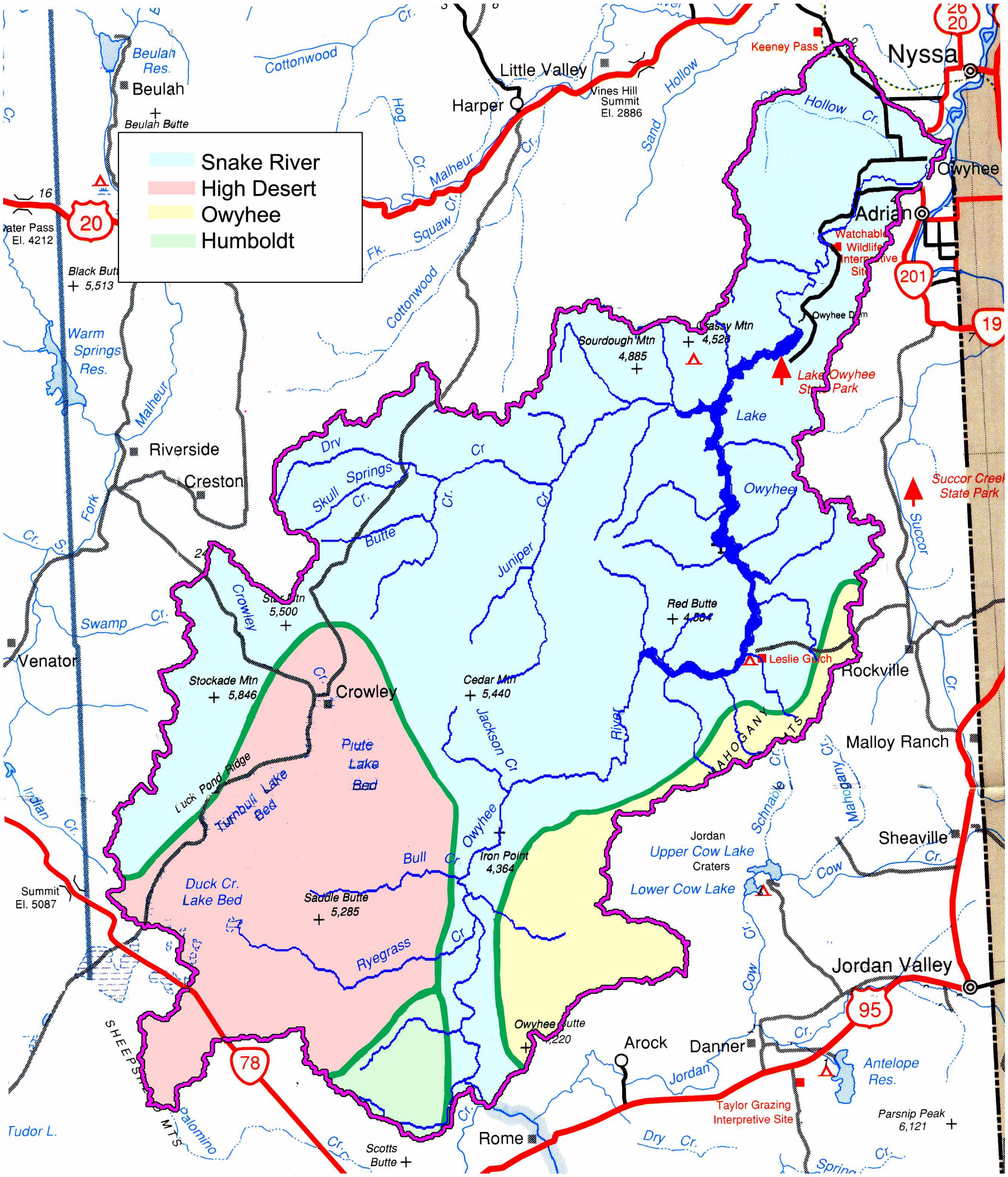


Figure 2.5. Ecological provinces in the lower Owyhee subbasin from Anderson, Borman, and Krueger.[6] Descriptions in Appendix B..

are trying to distinguish the Owyhee Upland ecoregion at the regional and national level of ecoregions from the Great Basin and the Snake River Plain. This is more along the lines of a first order HUC or a land resource unit. The discussion of the characteristics of the Owyhee Upland ecoregion is broad and general.[82]

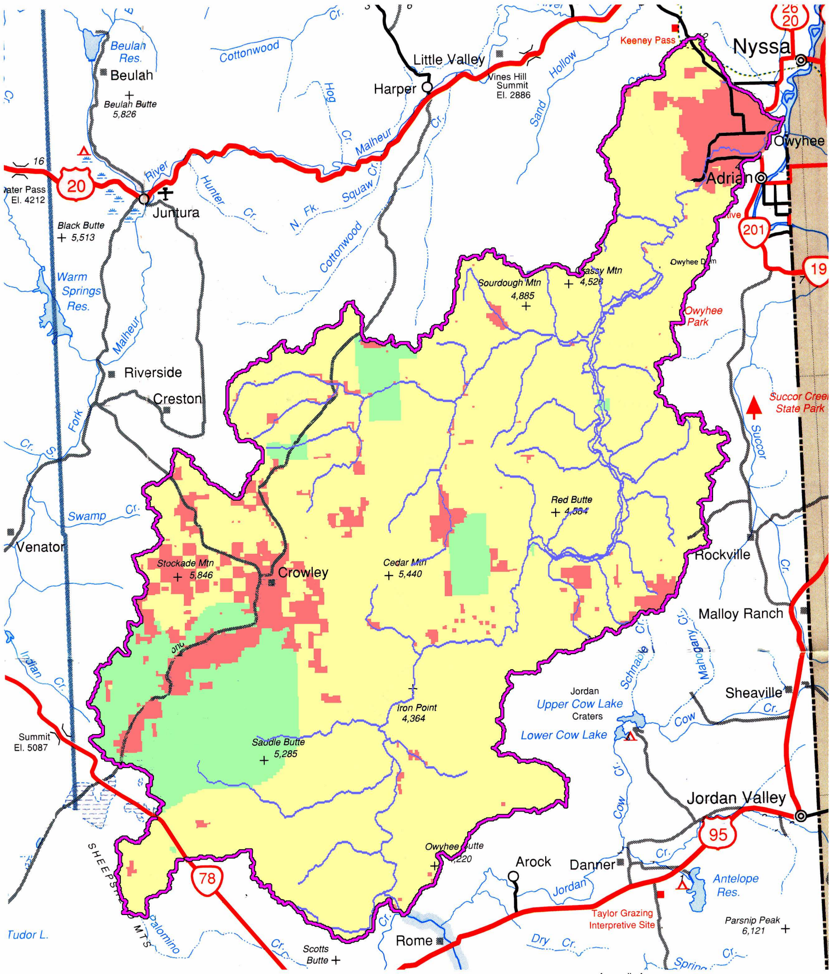


Figure 2.6. Land Ownership in the lower Owyhee subbasin. Appendix A

Federal State Private

e. *Discussion*

It is apparent from all of the above approaches to describing ecoregions within the lower Owyhee subbasin that there is 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 ecological factors needs to be taken into consideration rather than using a predetermined scheme.

4 Ownership of land

Within the lower Owyhee subbasin 79% of the land is federal, 11½% is state land, and 9½% is private (Figure 2.6). BLM manages most of the federal land. The majority of the private land is located on the irrigated lands along the Owyhee River below the Owyhee Dam and in the internally drained subbasin south of Crowley in the southwest corner of the lower Owyhee subbasin.

The corridor along the Owyhee River from the south end of the lower Owyhee subbasin to where the river enters Lake Owyhee is designated as a wild and scenic river. On the federal land, there are a series of wilderness study areas along both sides of the Owyhee River corridor. BLM wilderness study areas constitute 30% of the lower Owyhee subbasin (Figure 2.7).[16] A number of these wilderness study areas have been recommended as suitable for wilderness designation by the BLM (Figure 2.8).

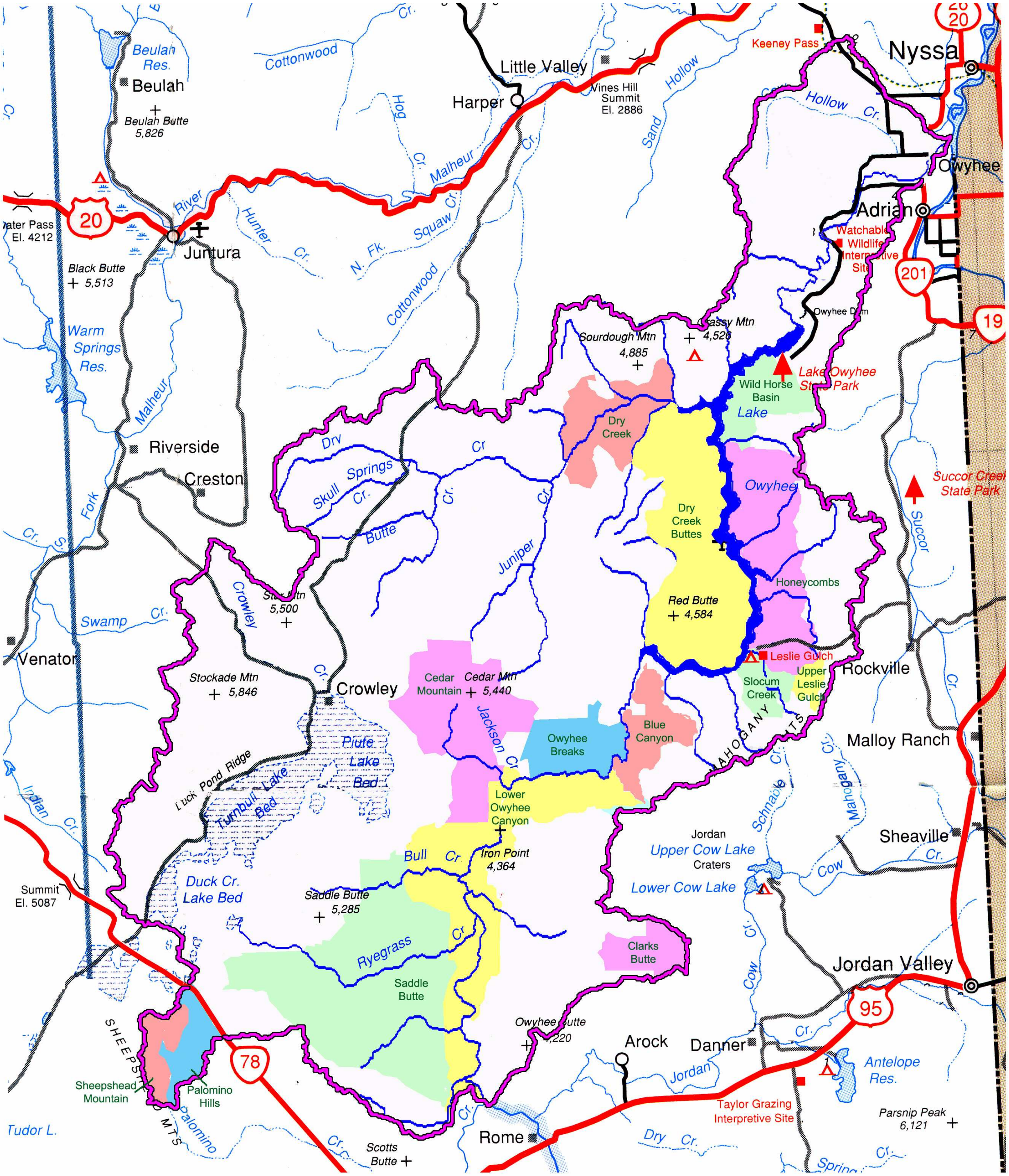


Figure 2.7. Bureau of Land Management wilderness study areas.[16]
BLM names

There is one national historic district in the lower Owyhee subbasin. The Birch Creek Ranch Historic Rural Landscape is on federal land at the junction of the Owyhee River with Birch Creek. There are 4,540 acres including 12 buildings and 7 structures.[61]

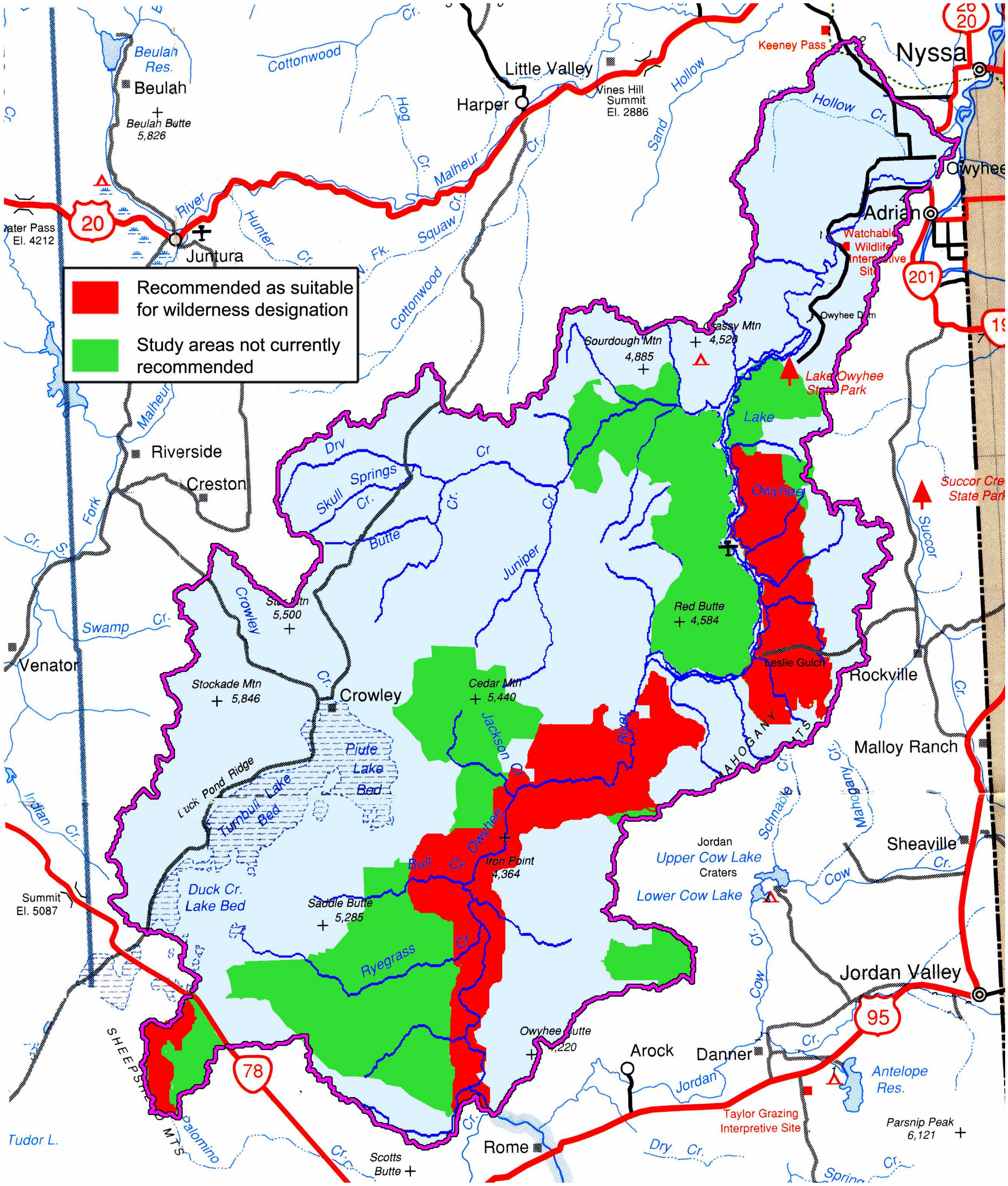


Figure 8. Bureau of Land Management wilderness study areas recommended as suitable for wilderness designation by the BLM.[16]

5 Population

The US census doesn't use hydrologic units as the basis for the data which it analyses. The data is tabulated both by census tract and by zip code. For the lower Owyhee subbasin the zip codes more accurately reflect the area than census tract. The

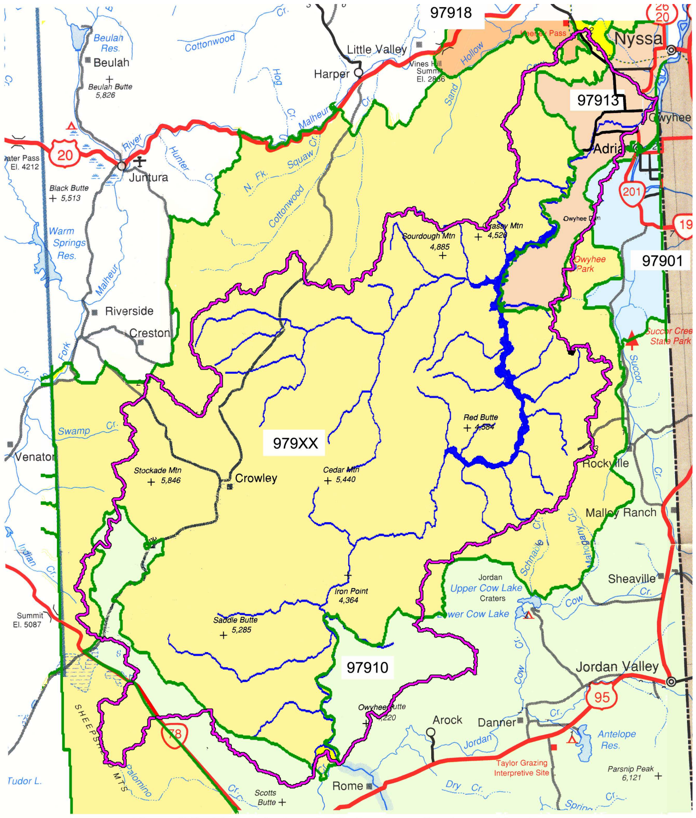


Figure 2.9. Five digit zipcodes in the lower Owyhee subbasin used for US Census data.[Appendix A]

lower Owyhee subbasin contains parts of five different zip codes: 97901 (Adrian), 97910 (Jordan Valley), 97913 (Nyssa), 97918 (Vale), and 979XX (Figure 2.9).

Since none of the zip codes is exclusively in the subbasin, it is difficult to accurately estimate how they represent the area. Zip code 979XX represents the majority of the land area as well as much of the remaining area of Malheur County south to the border with Nevada. However, in the entire zip code there were only 105 residents in 2000.[95] The NRCS, using the percentage of area of each segment in the lower Owyhee subbasin, estimates that there are 4,187 people living in the subbasin.[64]

Combining the information from the 979XX and 97910 zip codes to approximate the upland area and the information from the 97901 and 97913 zip codes to approximate the area below the dam, there are some characteristics which seem to set the upland area apart from Malheur County as a whole. The median age in the upland area is 41 years old as compared to 34 years old for the county. The average family size is smaller, 2.9 people per family as compared to 3.28 for the county.[95] This may be partially accounted for by the fact that a greater percentage of the population is over 65 (Figure 2.10). There are also two and a half times as many vacant houses in the uplands. And, although there is no greater percentage of families with incomes below the poverty level, a greater percentage of the individuals are below the poverty level when compared to county wide percentages. In general the area below the dam differs less from the county wide averages (Figure 2.10).[95]

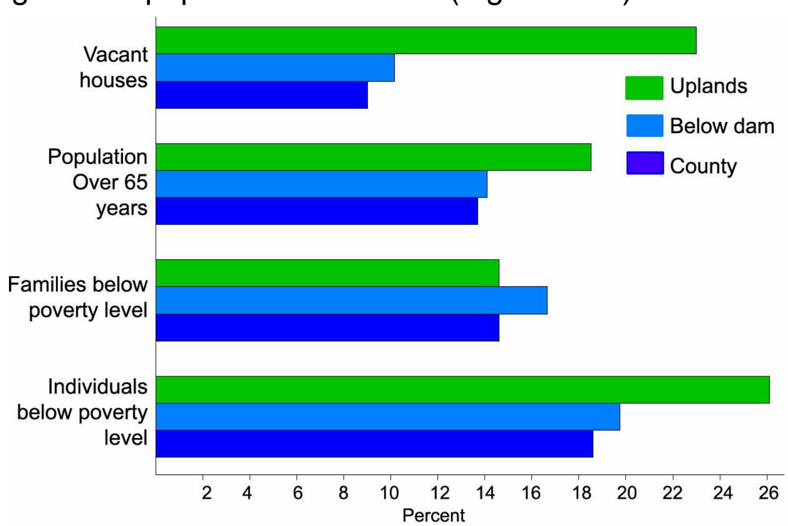


Figure 2.10. Comparison of selected socio-economic factors between the uplands (zip codes 979XX and 97910) and the below dam (zip codes 97901 and 97913) sections of the lower Owyhee subbasin.[95]

B. Climate

1 Historical data

The earliest recorded weather data from near the lower Owyhee subbasin is US army data from Vale, Oregon to the north of the lower Owyhee subbasin. Temperature and precipitation there were measured for nine years from December 1891 to December 1900. A nine year period of weather data is probably too short to be considered to be representative.

Weather records from regions around the lower Owyhee subbasin are available starting in 1922 for Parma, Idaho,[107] in 1928 for Vale[109] and Adrian,[102] in 1931 for Danner[104] and Warm Springs,[110] in 1943 for the Malheur Experiment Station,[105] in 1948 for Beulah Reservoir[103] and Owyhee Dam,[106] and in 1950 for Rome.[108]

2 Precipitation

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 2.11 shows the approximate annual rainfall across the lower Owyhee subbasin developed using PRISM.[64]

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 further 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."[24]

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.[24] Other factors which affect climate include slope and aspect, riparian zones, and land use/landcover. These are not accounted for in PRISM or other statistically interpolated data sets. Slope and aspect may play a role in determining local precipitation and near-surface temperatures.[24]

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.[24]

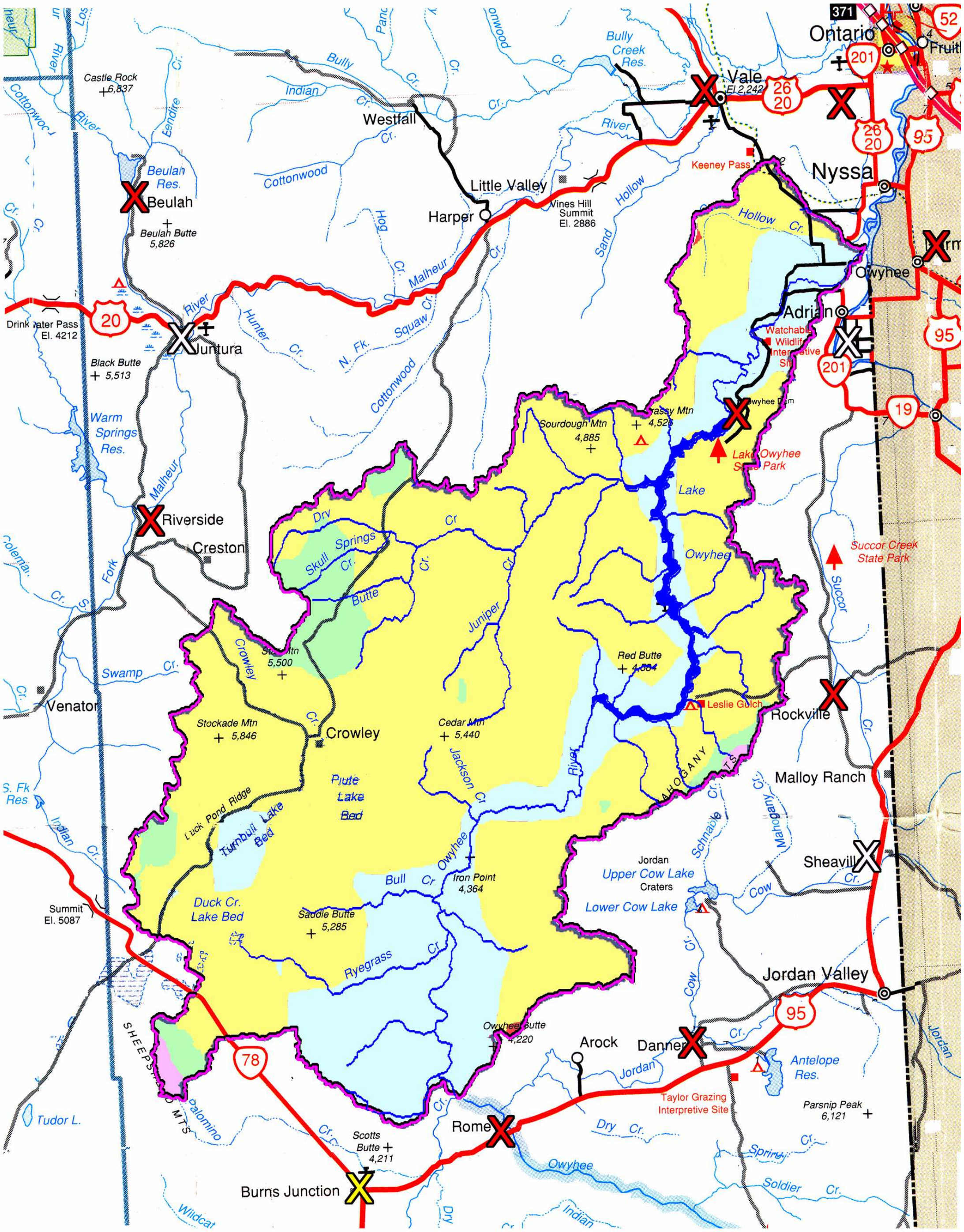


Figure 2.11. Annual precipitation in the lower Owyhee subbasin from PRISM modeling.[64]

Less than 9"
13" - 17"
9" - 13"
17" - 21"

Current recording stations with over 30 years data
Discontinued stations with over 30 years data - probably used in the modelling
Discontinued stations with less than 30 years data

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."[24] The limitations of the annual precipitation map (Figure 2.11) are that it uses data from sparsely located meteorological stations. Local aspects that might affect climate in one 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 map of average annual precipitation (Figure 2.11), most of the area of the lower Owyhee subbasin averages less than 13 inches of rain per year. Small areas in the Sheepshead Mountains, Mahogany Mountain, near Duck Butte, and north of Star Mountain receive average annual precipitation between 13 an 21 inches of rain.

Only an area which generally receives less than 10 inches of precipitation a year is defined by some sources as a desert.[25,65] Other sources define a desert as only areas receiving less than 12 inches of precipitation a year.[94] Many ecologists studying ecosystems classify an area receiving less than 10 inches of precipitation as an "arid" deserts, whereas those areas receiving 10 to 20 inches are classified as "semi-arid deserts. [45,63]

Within a desert there is a random spatial variation in rainfall 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.[63] The random variation in where rain falls is greater for summer thunderstorms than for general winter storms. Daily rainfall may be localized to areas 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."[63]

3 Meteorological stations

Owyhee Dam is the only meteorological station within the lower Owyhee subbasin (Figure 2.11). There are other stations around the perimeter of the subbasin. The station at Rome, Oregon is slightly south of the southern boundary of the subbasin and upstream along the Owyhee River. The station at Danner is at a higher elevation on the plateau to the east of Rome. The Malheur Experiment Station (MES) station is to the north of the lower Owyhee subbasin within the Owyhee Irrigation District. These four stations have been chosen as fairly representative of the main climates in the lower Owyhee subbasin even though three of them are outside the boundaries of the subbasin.

4 Temperature

The average maximum temperatures at the four meteorological stations mentioned above closely track each other (Figure 2.12). Average temperatures begin to rise from January to February, peak during July, and fall between August and January. Danner, at a higher elevation, has average maximum temperatures that are slightly lower than the other three stations except during the fall. Only Danner doesn't average over 90^0F in July reaching only 89.3 degrees on average.[104,105,106,108]

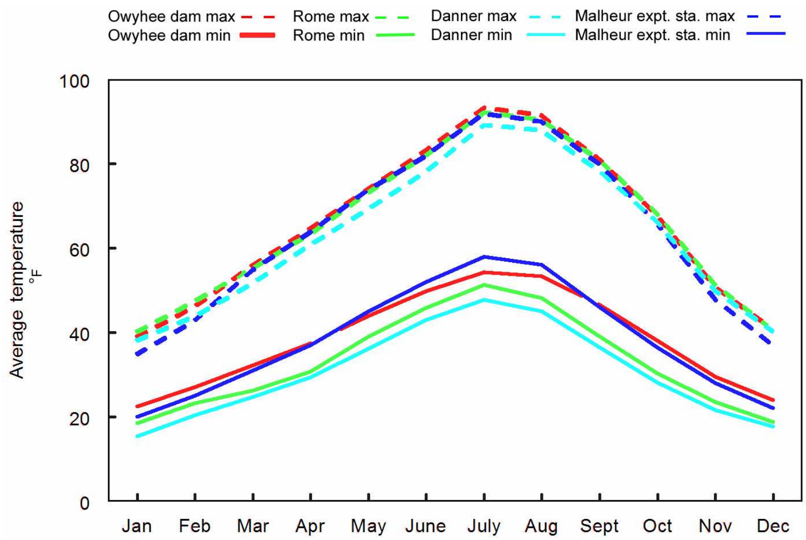


Figure 2.12. Average maximum and minimum temperatures at four weather stations around the lower Owyhee subbasin.

The average minimum temperatures rise and fall in a similar manner at the four stations (Figure 2.12). Although the average minimum temperatures from the different stations parallel each other, they show a difference roughly corresponding to their elevations. The average minimum temperature in every month is lowest at Danner, at the highest elevation, followed by Rome at a slightly lower elevation. Factors other than elevation are affecting the average minimum temperatures at the Owyhee Dam and MES since MES has lower temperatures than at Owyhee Dam except during the late spring and summer months.[104,105,106,108]

Average monthly maximum temperatures over 90^0F 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 90^0F? Figure 2.13 shows the average number of days each month when the maximum temperatures are 90^0 or greater. In every month from June to September, Owyhee Dam has the most days above 90^0, followed by Rome, MES, and Danner with the fewest days over 90^0.[104,105,106,108]

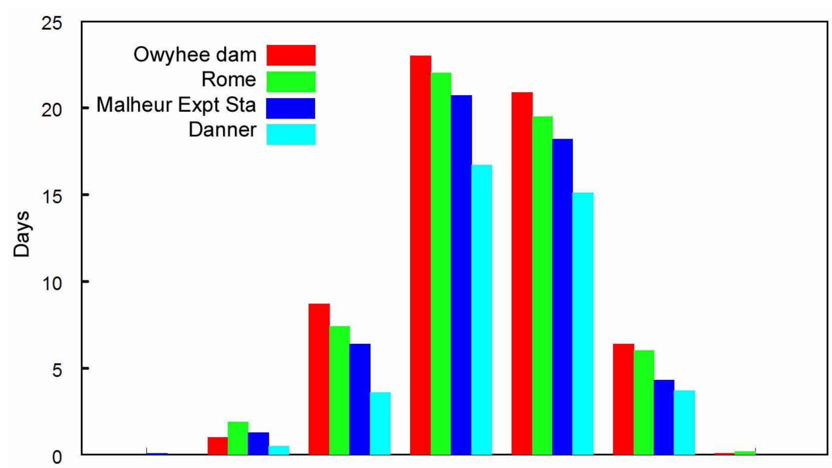


Figure 2.13. Average number of days each month with maximum temperatures greater than or equal to 90 °F.

Although all four of the meteorological stations show average minimum temperatures below 32^0F from November to February, how many days on average each month does the minimum temperature fall to 32^0 or lower? In every month, the Owyhee Dam site averaged the fewest days with minimum temperatures below 32^0 (Figure 2.14). Except for December and January when all of the stations had similar numbers, Danner had the most days that fell below 32^0F, followed by Rome and MES. The greatest difference in the number of freezing nights was in the fall and spring months: September, October, March, April, and May.[104,105,106,108] These are the months when the difference in low temperatures is most likely to affect the growth of vegetation in a different fashion at the different elevations.

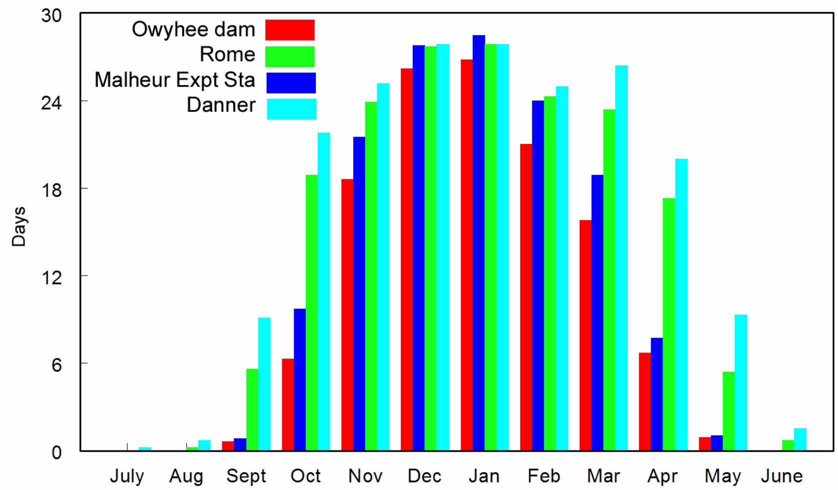


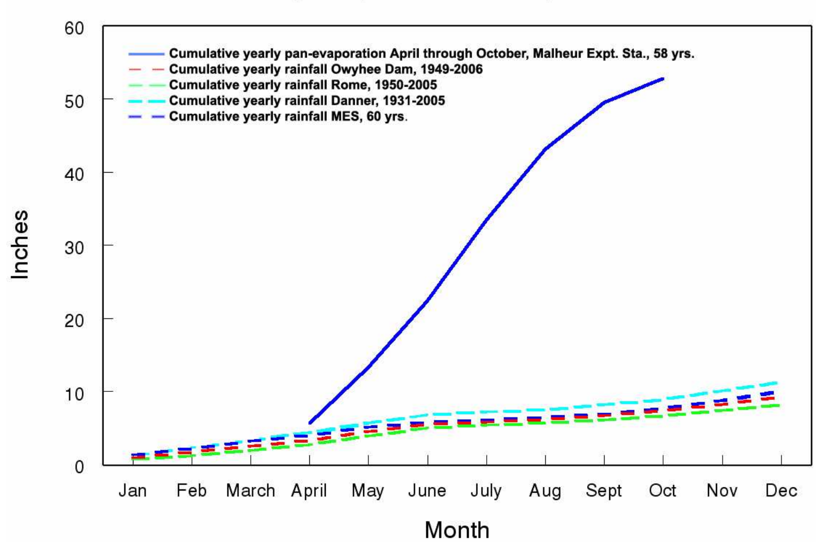
Figure 2.14. Average number of days each month with minimum temperatures less than or equal to 32 °F.

Because the temperatures in the winter in the lower Owyhee subbasin drop as low as they do, the area is also classified as a cold-winter desert.[45,101] The lower Owyhee subbasin is a semi-arid, cold-winter desert.

5 Potential evaporation.

One other way to define a desert is a region where the potential evaporation is significantly larger than the precipitation.[45,63,101] The Malheur Experiment Station measures the pan-evaporation, the amount of water which evaporates from a flat pan, from April to October. When the cumulative amount of pan-evaporation at MES is compared to the cumulative amount of precipitation at the different meteorological stations (Figure 2.15), it is apparent that the evaporative potential far exceeds the cumulative rainfall.[28,104,106,108] By October it is about five to six times as great.

Figure 15. Cumulative rainfall at four meterological stations in the lower Owyhee subbasin and cumulative pan-evaporation at Malheur Experiment Station.



The deficiency of rainfall received relative to the potential evaporative water loss tends to create a landscape with sparse vegetation.[45] Life in these regions is limited by the constant struggle to obtain water. The availability of water controls much of the ecosystem.[63,101] When annual water gained by precipitation is far less than annual water lost by evaporation, there are few permanent surface water streams that originate in a region.[25] Perennial surface water streams in the lower Owyhee subbasin largely originate elsewhere.

C. Vegetation

The vegetative distributions in the lower Owyhee subbasin are shaped by the geology, soils, and the low quantities and infrequent nature of water availability. The primary plant community is steppe vegetation dominated by sagebrush scrub and perennial bunchgrass.[87] Other plant communities are those consisting of 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.[6,87] Paleobotanical research reflects an environment which has supported *Artemisia* steppe / desert scrub communities for the last 8000 years.[87]

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.[87] 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 lower Owyhee subbasin is covered in more detail in the rangeland section below.

D. Wildlife

There is limited access to perennial water in the lower Owyhee subbasin due to steep canyon walls along much of the Owyhee River. Just like the vegetative distributions, the animal distributions are shaped by the low quantities and infrequent nature of water availability. The species present are similar to those found in surrounding regions. Large mammals of the Owyhee uplands today include pronghorn, mule deer, white-tailed deer, elk, feral horses and cougar. Bighorn sheep have been reintroduced to the rugged canyons. Wild horses are abundant. Some small animals are cottontails, jackrabbits, badgers, rattlesnakes, gopher snakes, chipmunks, sagebrush voles and coyotes. Birds like sage grouse, hawks, chukars, and migratory ducks and geese are fairly common.[82,92] Wildlife in the lower Owyhee subbasin is discussed in more detail in the wildlife section below.

E. Geology

The geological history of the lower Owyhee subbasin describes how the rock formations got to be where and what they are today. The rocks found within the lower Owyhee River subbasin can be the source for ores and minerals sought by rock hounds. The bedrock has also weathered to form the soils found within the subbasin. An overview of the chemical composition of rocks within the whole Owyhee River drainage explains the source of minerals such as uranium and mercury which, if they naturally occur within a rock, can be leached to the streams as the rock weathers. Once in the streams, these become part of the mineral load the river is carrying when it enters the subbasin.

The discussion will show that the rocks in the lower Owyhee subbasin were formed relatively recently from a geological perspective. The soils discussion will show that for the Owyhee Uplands the recent geological origin has resulted in soils that are very shallow.

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 like Leslie Gulch (Figure 2.16), the source of precious metals, and the source of sediments within the watershed.

Figure 2.16. Intricate rock formations in volcanic tuff in Leslie Gulch.

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 minerals are mixed together to form rocks.

Rocks are named on the basis of texture, mineral composition and formation process. Common rocks are basalt and sandstone. Two sandstones may have the same basic mineral composition and similar texture, but they will often 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."[49:3] 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 cooling more slowly within a mountain.

Sedimentary rocks are those formed by the accumulation of sediment in layers. Sediment most frequently accumulates on the bottom of the ocean, but it can also accumulate in lake beds or be layered ash.

Metamorphic rocks are those formed by placing existing rocks or sediments under extreme pressure and heat, usually deep within the earth's mantle.

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

c. Weathering of rocks

Weathering is the process by which rocks are turned into smaller rocks and eventually 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 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, which makes it rapid in the tropics.

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 the forms weathering takes as well as the original bedrock it, is possible to predict the effects of natural weathering processes on a region's rock features.

2 Rocks common in the lower Owyhee subbasin

A variety of igneous rocks are found in the lower Owyhee subbasin because of the active volcanism in the recent past. **Basalt** is a common rock of lava flows. It is generally black or dark-grey. Basalt pours out of cracks (vents) 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 (Figure 2.17).[9] 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.[77] 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.

Figure 2.17. Basalt columns in the Owyhee watershed

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 it moves so slowly that the surface cools and then breaks into chunks that get moved within the flow so the surface is not as flat as a basalt lava flow.

Within the Owyhee uplands some of the volcanic activity was bimodal, indicating that both rhyolite and basalt erupted 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 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 (Figure 2.18). Then basalt lava flows broke through one wall of the cinder cone, flowing downhill, leaving the earlier phase of explosive rhyolite exposed.[11,75,79]


Figure 2.18. Coffeepot Crater at Jordan Craters.

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**.[26] Sometimes the lava in cracks will never reach the surface, but it may form a dike underground that is later exposed by erosion. One example of a dike in the Owyhee uplands is Three Fingers Rock. When the Three Fingers caldera stopped its activity, this is the rock that cooled and plugged the vent.[74] Other impressive dikes of basalt are visible along the road through Leslie Gulch (Figure 2.19).


Figure 2.19. Basalt dike in Leslie Gulch.

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.[93] 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** (Figures 1.3 and 2.16). The heat of the ash particles was sufficient for them to stick, or weld, to each other.[93] 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.

Faulting is the process where pieces of the earth's surface change position in relationship to one another. This 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 dropping piece of land that forms the basin is also called a **graben.**[39] The Snake River plain is a graben between the Owyhee uplands and the central mountains of Idaho.

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 type of minerals within lake deposits depends upon the rocks eroding around the lake. As the Owyhee uplands had active volcanism the sediments should be derived from those raw materials. In addition ash within the air will settle on the top of lakes and slowly reach the bottom. It is within ash or fine silt deposits of lakes that fish and leaf fossils are often found. Prominent lacustrine deposits in the lower Owyhee subbasin occur north of Rome along the Owyhee River at Chalk Basin, the playa lakes, and the lower Treasure Valley. **Alluvial** sediments are those deposited by running water, generally rivers. 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 flood plains or on lake bottoms where rivers enter lakes.[2] Like lake deposits, the rock materials found in alluvium are derived from other rocks in the area. But in many cases these deposits will contain larger chunks, namely gravel and boulders.

a. Weathering of common rocks

Ash tuffs are soft rocks easily sculpted by wind and water (Figure 2.16).[11] Basalt lava flows are significantly harder but can be broken down more easily than rhyolitic lava which is mainly silica. Rocks exposed in the Owyhee uplands are susceptible to weathering. 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.

b. 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, but there continue to be many claims to this day. In 1988 there were 10 active mines in Oregon and 36 exploration sites recorded by the Oregon Department of Geology and Mineral Industries.[29] Most gold originates in volcanic rocks, but the history of the landscape determines where it can be found.

Gold occurs in many types of geological deposits.[8,37] Gold veins are generally in metamorphic rocks where the gold has accumulated in conjunction with quartz following the intense heating of the rock. 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 by chemical interactions at hot springs around volcanically active areas.[78] This concentrated gold may be located in veins or disseminated. "The term 'disseminated' is now commonly applied to gold deposits in which very fine-grained gold is dispersed though a relatively large volume of rock."[8:11] It is the disseminated type of gold deposits that are most common in Malheur County, as exemplified by Grassy Mountain in the lower Owyhee subbasin.[29,73]

ii. Fossils

"Fossils are the mineralized or otherwise preserved remains or traces (such as footprints) of animals, plants, and other organisms."[31] "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."[31] Fossilized remains of plants and animals can tell us about the type of environments that existed in the past and the changes they have undergone.[11] Petrified wood is commonly found in the lower Owyhee subbasin.

iii. Thundereggs

"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."[91] The thunderegg starts as a cavity in the rock where over time the passage of geothermal water allows for the deposition of minerals as crystals.[34] "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 can have agate, chalcedony, or jasper crystals. There is no way of telling what the inside of a geode holds until it is cut open or broken apart."[34]

c. Bentonite

Bentonite is a naturally occurring clay that is mined commercially. Bentonite is used in various ways including as a mud lubricant in oil and gas drilling projects and as an absorvant.[12,40] The production of bentonite requires the deposition of ash in a lake environment followed by heating from hydrothermal activity. These conditions have produced bentonite in the lower Owyhee watershed.

d. Zeolite

Zeolites are rocks with porous structures. "Natural zeolites form where volcanic rocks and ash layers react with alkaline groundwater."[113] Zeolites are used as cat litter, as a concrete additive, in water purification, in agriculture as a source of potassium, in laundry detergent, and for heat absorption in solar thermal collectors. The use of the zeolite is frequently based on the trace chemicals it contains; there are 48 naturally occurring types of zeolite.[113]

e. Mercury

Mercury is a commercially valuable metal that is used in batteries, paints and electrical devices.[112] Mercury deposits are formed at shallow depths and at temperatures of 50°C to 200°C. Mercury generally fills in pores and fissures where it was carried by heated water. Mercury is often found in association with gold and silver.[112] "The major producer, and only operating mercury mine, in the United States in 1984 was at McDermitt, Nevada. The ore is in . . . volcanic ash and lake beds, and is 70 percent cinnabar [mercury sulfide] and 30 percent corderoite [mercury sulfide chloride]. Grade is about 4 kg of mercury per ton of ore,"[112:146] or 0.4%. Between 1976 and 1983 the McDermitt mine produced mercury accounting for 46 percent of the US consumption.[112]

"Elevated concentrations of mercury in surface water can be derived from many sources, including natural processes and anthropogenic 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."[1:1] 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. "While mercury most frequently occurs as deposits in rock fractures and veins, it may also be found in low concentrations in other geological formations. In the Owyhee River area, mercury is commonly found as an anomaly, present in 12 of 23 random outcrop rock-chip samples."[1:4]

3 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 they start with the principle of **stratigraphy**, that newer layers accumulate on top of older layers of rocks. This means that in a canyon like that 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 or relative inactivity. This can be seen when a group of tilted rocks get covered by new flat deposits (Figure 2.20). Past erosional surfaces can also be flat and hard to identify. Geologists call the gaps of time caused by erosional events **unconformities**.

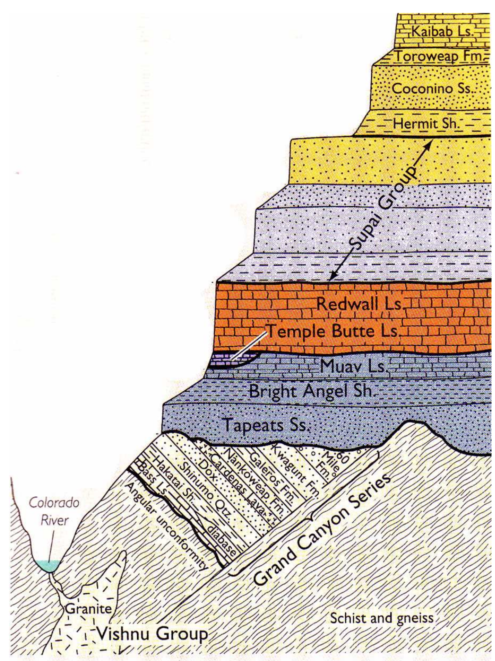


Figure 2.20. Geological series of the Grand Canyon is broken by erosional events (unconformities) seen as darker black lines. (Adapted from 114:198)

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 where the two pieces of the crust are moving past 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.

a. Geological time scale

To compare historical events like the formation of the Grand Canyon or the Owyhee Canyon and the building of the Rocky Mountains or 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**.[97] These divisions are marked by major changes in the earth's environment or animal extinctions.[99] In Figure 2.21 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.

After documenting major change in climate and fossils within the rocks, geologists date the divisions using radioactive decay of naturally occurring minerals within the rocks. Radiocarbon, or C^{14}, is often used to date charcoal from human fires because the rate of radioactive decay is predictable. For example, this is

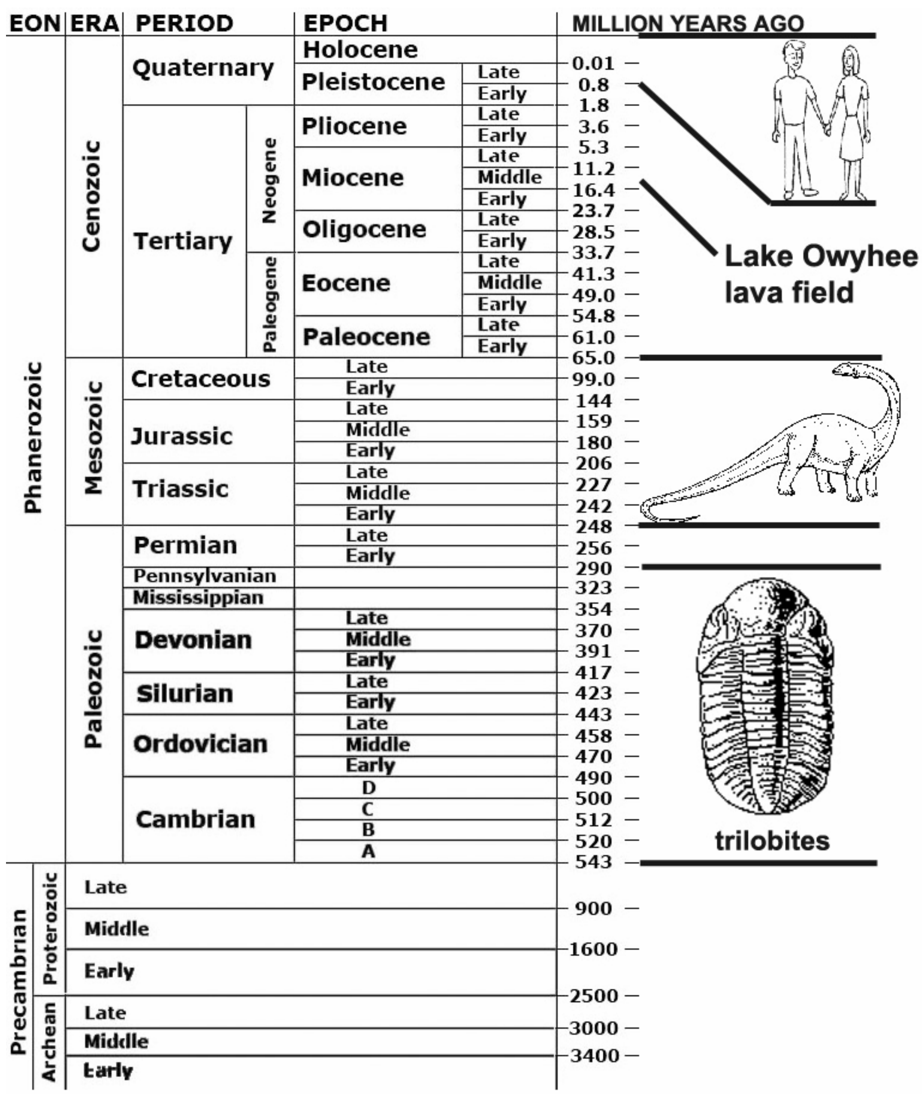


Figure 2.21. Geologic time scale.
(Adapted from 97)

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.[38,99]

Based on radioactive mineral data, the Owyhee uplands are very young on the geological time scale. After the dinosaurs died out 65 million years ago it was another 48 million years until the Steens and Sheepshead mountains were formed. This was followed only 15 million years ago by activity in the Lake Owyhee volcanic field.

4 Location of the Owyhee uplands in regional geology

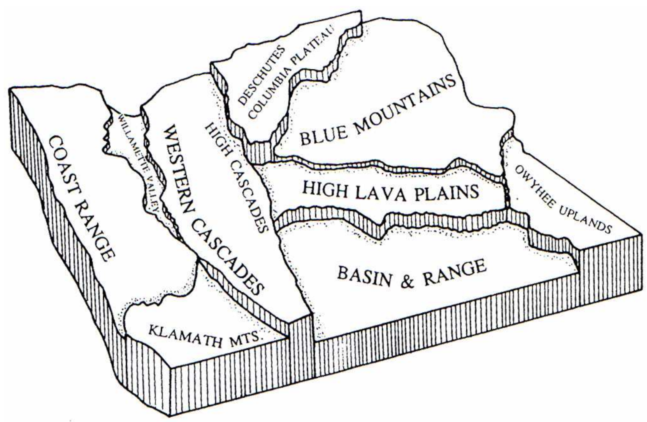


Figure 2.22. Geological areas of Oregon.
(Adapted from 74:1)

Eastern Oregon as we see it today began forming 20 to 25 million years ago. The region began extending east to west. Faulting like that of the Great Basin extended into Oregon. The stretching and cracking of the crust also provided a way for lava to reach the surface. The faulting was accompanied by volcanic eruptions on the Columbia River plateau, in the Steens Mountains, at Glass Mountain, and in the Strawberry Mountains.[11,74] This volcanism formed the High Lava Plains in central Oregon and the Columbia Plateau in northern Oregon (Figure 2.22).[96] In southeastern Oregon the Steens Mountain volcano sent basalt and ash into Idaho on the east, Lakeview County on the west, and up to Saddle Butte in the North (Figure 2.23).[74]

The Steens Mountain volcano was followed in Malheur County by the formation of a large number of calderas, also shown in Figure 2.23. These calderas were responsible for thick ash deposits such as those in Leslie Gulch (Figure 2.24).

North-south faulting with east-west expansion continued across southern Oregon, after the caldera eruptions, forming the basins of the Alvord desert and Warner Valley and ridges like the Steens Mountains (Figure 2.25).[96] Hot spring groups formed in north-south lines running along faults where groundwater could more easily flow down to the hot magma and back up to the earth's surface.

During the Pliocene large lakes formed in the basins because of higher rainfall. Alluvial sediments accumulated in the lake basins and along the stream courses feeding the lakes.[96] One of the largest lakes, Lake Idaho, occupied the area we now call the Treasure Valley. Lake Idaho (also known as Lake Payette) was very deep and covered areas into the northernmost reaches of the Owyhee uplands. It was only after Lake Idaho drained that the Owyhee River eroded its current path into southeastern Oregon. So the canyon lands we see today around the Owyhee River began forming between six and two million years ago.[47]

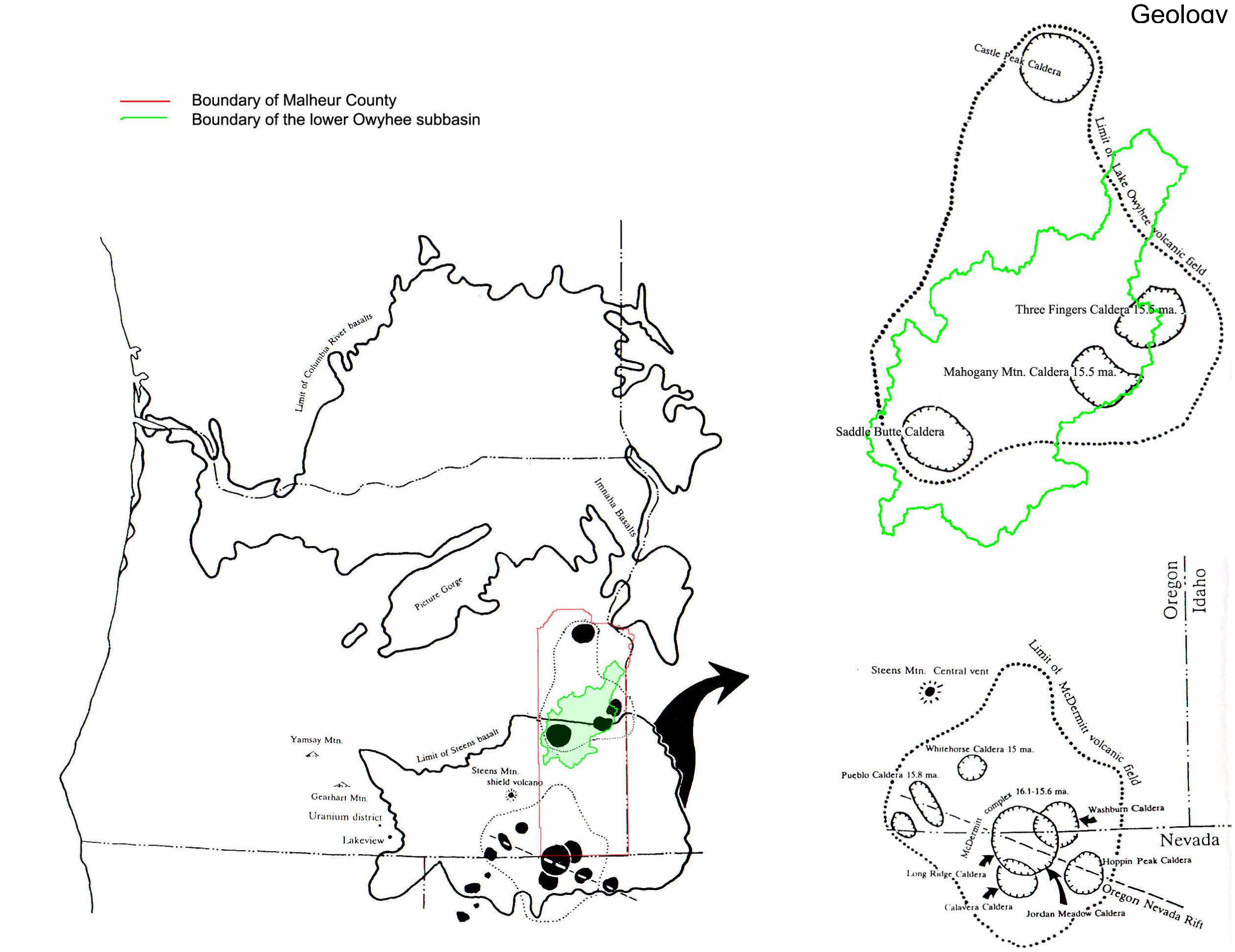


Figure 2.23. The Lake Owyhee and McDermitt volcanic fields are located in the Owyhee uplands of southeastern Oregon and northwestern Nevada.
(Compiled from 74:83 and 121:641)

Meanwhile in the western Snake River Plain, the crust was thinning and dropping. The exact process that accounted for the dropping of what we now call the Treasure Valley is debated, but involved graben faulting as well as possible formation of a rift.[55] "A well drilled by El Paso Natural Gas Co., 10 miles south of Vale, penetrated about 4,500 feet of Pliocene sedimentary rocks and lavas before encountering rocks considered to be ... older"[96:82] Drilling in other parts of the western Snake River plain has passed through basalt flows and sediments to depths of 2 to 3.4 kilometers.[55] This suggests a history where volcanism from the Owyhee River region and Bruneau area filled the Snake River Plain with new sediments and then the area began subsiding under the weight of it all.[47,55]

Volcanism, lakes, and faulting all played important roles in shaping the Owyhee uplands. The specific events that have affected the watershed are discussed below.

a. How did all the volcanism begin?

The Snake River plain is a huge, wide arc of croplands and arid unirrigated plains running from the Oregon-Idaho border to central Idaho where the valley continues to the Yellowstone National Park. The Treasure Valley western end of this valley. It is commonly considered that the movement of the Yellowstone "hot spot" caused the

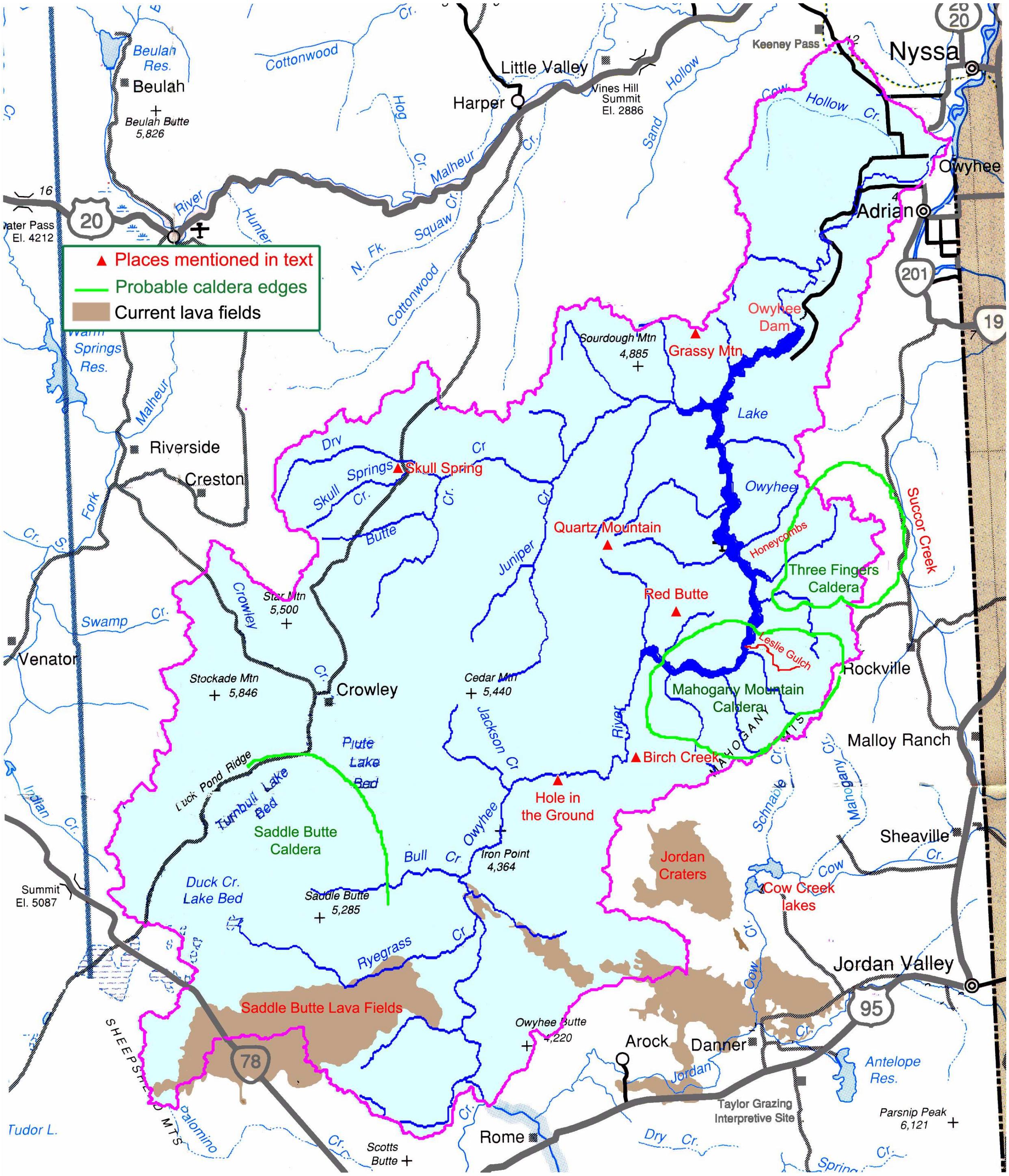


Figure 2.24. Locations of geological phenomena in the lower Owyhee subbasin. Places mentioned in the text are labeled in red.

creation of the west to east extension of the wide Snake River Plain. 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. The Yellowstone hot spot actually followed a straight course out of somewhere

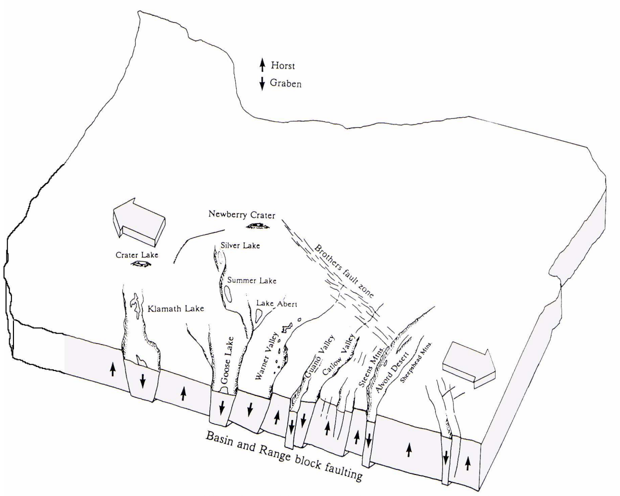


Figure 2.25. Faulting of the Great Basin extended into southern Oregon and stretched the earth's crust creating large valleys and the Steens Mountains. (Adapted from 74:81)

in southeastern Oregon or southwestern Idaho (Figure 2.26). The fertile Treasure Valley was formed by faulting followed by alluvial sediments being deposited from Lake Idaho and from the water which drained across the Snake River plain after Lake Bonneville in Utah burst.[5,47]

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.[11,44,74] It has also been suggested that faulting stretched the crustal sediments in southeastern Oregon thin allowing for an outpouring of lava.[55] And yet others see the volcanism starting with a meteor impact.[3,4,5] Regardless of the cause of volcanism, authors agree that volcanic activity began 17 to 18 million years ago and radiated east and west. Volcanism, starting in the vicinity of the McDermitt caldera follows the Yellowstone hot spot to the east (Figure 2.26).[55] And to the west, volcanic calderas spread from Malheur county west across the High Lava Plains to Newberry crater in central Oregon, a recent caldera eruption (1.7 million years ago).[46,58]

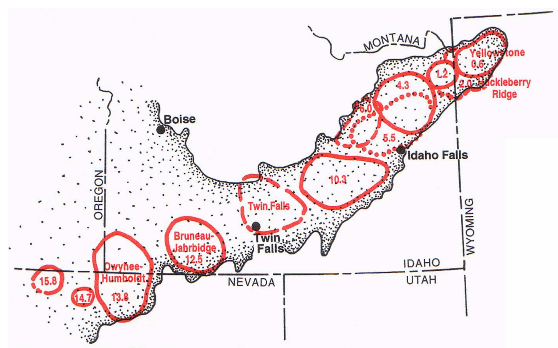


Figure 2.26. Calderas left across Idaho mark the movement of the Yellowstone hot spot from its origin at the Idaho, Oregon, Nevada border to its current location in Wyoming. (adapted from 5:270)

b. *Geological history of the Owyhee uplands*

The lava flows and lake sediments found within the lower Owyhee subbasin average 14 to 15 million years old. And yet these changes are relatively recent from a geological perspective. Recall that the dinosaurs died out 65 million years ago.

The Lake Owyhee volcanic field is composed of four caldera volcanoes that were active 14 to 16 million years ago (Figure 2.23). The names given these calderas are Castle Peak, Three Fingers, Mahogany Mountain, and Saddle Butte. These calderas produced rhyolitic lava and ash. This activity as been dated to approximately 15.5 million years ago.[74] The ash from these calderas produced extensive beds of welded tuff exposed today in Succor Creek and Leslie Gulch (Figure 2.24). The activity of the calderas was followed by faulting and some erosion of the ash tuffs into stream courses and basin lakes. Fossils preserved in Succor creek ash and ash derived sediment deposits in a lake environment record Miocene plants and animals.

During the period that the calderas were active, the Owyhee Basalts blanketed more than 1000 square miles. The sources of these basalt flows were dikes that cut through the ash flows near Hole in the Ground around 15 million years ago. These basalts are often overlain by additional ash deposits from the calderas.

While the exact processes that caused volcanism to start and stop on the Owyhee uplands are debated, by 14 million years ago the area's surface was made up almost entirely of volcanic rocks. The next 14 million years are a convoluted sequence of faulting, lake beds filling, formation of sediments, small scale volcanism, and erosion.

The volcanic sediments of the Owyhee uplands have been broken by faulting, but the faults are shorter and more broken up than those in other parts of the Great Basin.[3] So while faulting created many hills and valleys the result is difficult to see and more recent smaller volcanism episodes have filled many of the troughs.[96]

The most recent geological activity dates to the Quaternary period, from 1.8 million years ago up through the present. During this period the surface of the Owyhee plateau has been covered by basalt lava flows. These flows are relatively intact as faulting has transformed the landscape less. The youngest of the lava flows are Jordan Craters (Figure 2.18), 3200 years or younger, and Diamond Craters (Saddle Butte lava field) which dates to approximately 17,000 years ago (Figure 2.24).[18] Jordan Craters is actually part of a larger group of four lava flows that were first described by Russell in 1903.[79] The rest of this lava field is composed of the Rocky Butte flow (30,000 to 90,000 years ago), the Clarks Butte flow (250,000 years ago) and the Three Mile Hill flow (1.9 million years ago).[42] For those familiar with the area, these flows progress from the oldest, Three Mill Hill, just north of Jordan Creek in a northward trend to Jordan Craters. The date of these flows has been estimated by potassium - argon dating, but the relative chronology was apparent in 1903 on the basis of the development of vegetation and soils atop the lava.[42,79]

5 Lower Owyhee subbasin geological features

a. Succor Creek and Owyhee River stratigraphy

While Succor Creek lies outside of the lower Owyhee subbasin, most of the geological studies in the Owyhee uplands have focused on this area and the Owyhee River (Figure 2.24). Since Succor Creek and the Owyhee River have cut canyons, the exposed canyon walls show the sequence in which the rocks were laid down.[13,48,50,53]

In Succor Creek, Lawrence mapped and described the portion between Sage and Camp Kettle creeks which is on the southeast portion of the Owyhee Ridge quad and the southwest portion of the Graveyard Point quad.[52,53] The rocks exposed in Succor creek show that it was part of a south to north trending lake basin in the late Miocene. This lake basin filled with sediments eroded from the volcanic ash and rhyolite to the south.

Kittleman described the formations making up a typical sequence in the eastern portion of the Owyhee region (Figure 2.27).[48,49,50] Starting at the bottom of the sequence, the Succor Creek Formation and Owyhee Basalt are rocks deposited during the caldera activity within the lake Owyhee volcanic field and from basalt vents in the area of Hole in the Ground southwest of the Birch Creek Ranch (Figure 2.24). The Deer Butte Formation is separated from deposits below and above by unconformaties, which can be interpreted as periods of erosion. The Deer Butte Formation has been dated as being from the end of the Miocene using mammal fossils in Idaho.[50] The Deer Butte Formation is a mix of sedimentary material, basalt flows and rocks made of cobbles.[50] The Deer Butte Formation reflects deposition in north trending basins which was controlled by faulting.[21,22] The Grassy Mountain Formation takes its name from basalts and ash layers found on Grassy Mountain that date to the beginning of the Pliocene.[22,50] The formation can be observed as a prominent, former mesa to the west of the Owyhee River. The stratigraphic sequence in Succor Creek ends here, but in other parts of the Owyhee uplands it is topped by younger basalt flows. Younger basalt flows at Cow Creek Lakes are individually 20 to 50 ft thick (Figure 2.24).[50] There are six or eight different flows, the youngest of which are nearly free of vegetation.

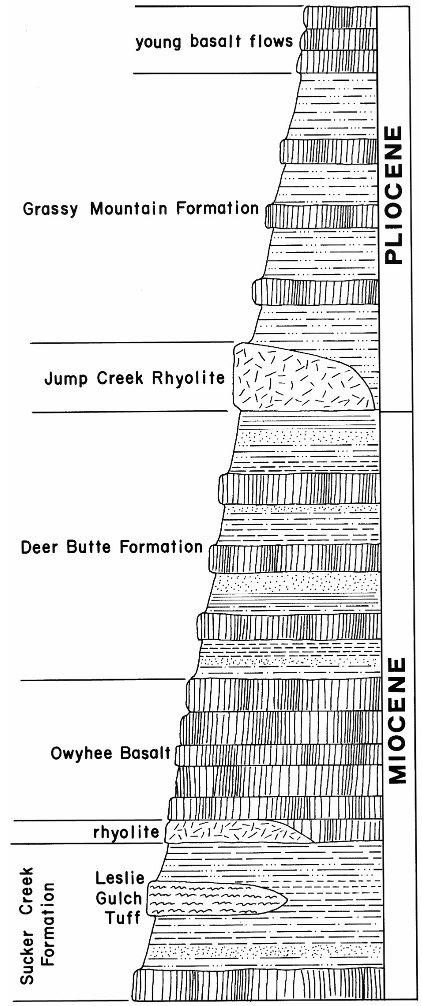


Figure 2.27: Sequence of layered rocks in the eastern Owyhee region,
(Adapted from 49: Figure1)

This is the geological work that has been done on the stratigraphy of rocks in the local area, although the research was done outside the boundaries of the lower Owyhee subbasin. Kittleman's basic research around the Owyhee dam shows that the sequence of rock formation exposed in the Owyhee River canyon is identical to the adjacent Succor Creek stratigraphy.[48]

b. Lake Owyhee volcanic field

The Lake Owyhee volcanic field is defined as "all middle Miocene vents that formed following eruption of the Steens Basalt,"[30:12] where the volcanic material has a high silica content, basically rhyolite.

The Lake Owyhee volcanic field is composed of four calderas and a mini-caldera. The calderas are Castle Peak, Three Fingers, Mahogany Mountain, and Saddle Butte and the mini-caldera is the Honeycombs (Figures 2.23 and 2.24). The large volume volcanic eruptions from the calderas are dated between 15 and 15.5 million years ago.[80]

The scale of volcanic activity in the Lake Owyhee volcanic field was tremendous as measured by depth of ash flow and caldera dimensions. The ash flow produced by the Mahogany Mountain caldera is over 1000 feet thick in Leslie Gulch.[11] The scale of these eruptions is also visible along the Owyhee River canyon where much ash is visible in the canyon walls and river downcutting has yet to reach older geological deposits. "Mahogany Mountain is the southeast rim of an ancient volcanic caldera 10 miles in diameter, whereas the Three Fingers caldera just to the northeast, is a circular collapsed depression 8 miles in diameter." [74:85] Saddle Butte caldera is 15 miles in diameter but has been obscured by the more recent activities at the Saddle Butte volcanic field.[74] For size comparison to current volcanoes in the Oregon Cascades, Crater Lake is a caldera 6 miles in diameter and Newberry crater measures 5 miles in diameter.[5]

c. Leslie Gulch

The cliffs of Leslie Gulch are welded tuff from the Mahogany Mountain caldera. The flow in this location is more than 1000 feet thick.[11] "The rocks are soft, sculpted by water and pock marked by the escaping gases of their eruption. Larger holes reveal that sometimes chunks of solid rock are torn from the caldera's throat during eruption . . . and held closely in the ash flow."[11:159]

Figure 2.28 The Honeycombs, lower Owyhee subbasin.

d. The Honeycombs

"The Honeycombs ... represent a minicaldera that produced tuffs and rhyolite flows too viscous to be blown away. Instead, the gas-charged lava froze above its conduit, piling up in a mass of soft, cavity-ridden stone like a giant sponge. Fifteen million years of unceasing labor by wind and water eroded the softer stone, leaving rocks that look as though a shotgun-toting, Paul Bunyan-sized cowboy thought they were local road signs" (Figure 2.28).[11:159]

e. Oregon-Idaho graben

i. Hot springs

"The Owyhee caldera eruptions pumped a lot of magma and molten rock from beneath the surrounding landscape. About 14.5 million years ago, the crust just west of the main calderas began to subside along shallow faults. The resulting down-faulted basin is called the Oregon-Idaho graben. Lakes developed on the valley floor."[11:159] The faults of the Oregon-Idaho graben provided a path for surface water to interact with the magma still below the ground.[86] These super heated waters carried precious metals to surface hot springs where gold, silver, and mercury were deposited in tiny cracks within the rocks. These hot springs created large gold deposits in the lower Owyhee subbasin, but all the flecks of gold are extremely small.[11] Hot springs areas provided heat over long periods of time and altered existing deposits to create “picture rock” (silicified tuff) and zeolite.[30,127]

The fault activity along the Oregon-Idaho graben is dated on the basis of geological layers that were shifted around and geological deposition accompanying the faulting. The suggested onset of mineralization of hot-spring deposits is 14.5 million years ago according to Cummings or 13 million years ago according to Peter et al.[22:131,86:B7] Both of these sources agree that the end of hot-spring deposition was at 10 million years ago. Rytuba and Vander Meulen place the development of hot-spring systems between 14 and 8 million years ago.[80] The real agreement here is that faulting in the Oregon-Idaho graben and its accompanying highly active hot-spring depositions followed volcanism of the calderas and largely ended between 8 and 10 million years ago.

ii. Hot-spring gold deposits

The hot-spring gold deposits were formed in association with the faulting of the Oregon-Idaho graben. Gold carried in the water of the hot springs was deposited in spaces within volcanic rocks and tuff.[23] "Grassy Mountain, Red Butte, and Quartz Mountain, a series of peaks just west of the Owyhee River near Leslie Gulch, all sit atop large deposits of gold so finely divided that the metal can barely be seen in an electron microscope (Figure 2.24). The deposit at Grassy Mountain has been mapped out as 1.05 million ounces of gold contained in 17.2 million tons of rock ."[11:159] Gersic et al. tell us that most of these gold deposits are within the Deer Butte Formation.[35] This suggests that the faulting along Dry Creek, which is discussed below, may be a specific set of the faults associated with the Oregon-Idaho graben, but no references were found.

f. The Deer Butte Formation and the Dry Creek fault system

Following the outpouring of volcanic ash from the Lake Owyhee volcanic field, the deposits were moved by faulting. "Two zones are recognized: the western zone is the Wall Rock Ridge fault zone . . .; the eastern zone is the Dry Creek Buttes fault zone."[21:347] Both of these areas of faulting are within the lower Owyhee subbasin on the western side of Lake Owyhee. The Dry Creek Buttes fault zone has been "estimated at 8-12 km [5-7.5 miles] wide . . . The greatest displacement is near the west edge of Lake Owyhee where minimum throw [or vertical movement] is at least 240 m."[21:347] This fault zone, immediately to the west of Lake Owyhee, is important to the geology of the subbasin because these faults are long, running at least 50 km north to south, and because they moved geological strata up and down, moving volcanic deposits into different positions in adjacent areas. This faulting created north trending basins and ridges. Faulting is estimated to date between 15 and 12.6 million years ago.[22] Later in geological history these basins were home to lakes. Subsequent to the north-south trending lake basins, Dry Creek cut its path across east to west. Very little is known about the Wall Rock Ridge fault zone which is located further to the west and cuts across the higher headwater of the modern day Dry Creek drainage.

Since the fault under the Owyhee Dam runs parallel to faults of the Dry Creek system, it may date from the same geological era.

Since the dates for this fault activity overlap for dating of the Oregon-Idaho graben, it is possible that the two are connected processes, however none of the references mention this or tell us how these two sets of faulting are differentiated.

The north trending basins created by faulting in the Dry Creek and Lake Owyhee area are the setting in which geological layers named the Deer Butte Formation were deposited. These deposits are a mix of volcanic rocks from basalt flows, deposits from hot spring activity along the faults, and sedimentary rocks from river transported sand and ash and airborne ash.[21,22,23] Sediments of these types accumulated in five basins that changed in location on the basis of faulting and were each stable for approximately half a million years. Most of the sand that is part of these formations has its origin in geological formations of Idaho, indicating flow into the basins from the east. [50,80]

g. Grassy Mountain Basalt

The basalt flows that cap Grassy Mountain are called the Grassy Mountain Basalt. These flows are dated to 10 million years ago and are the last Miocene volcanic activity documented along the Owyhee River.[22]

h. Lakes of the Snake River Plain

The northern portion of the lower Owyhee subbasin below the dam is largely in the western end of the Snake River plain. The western Snake River plain appears to have developed from the middle of the Miocene to present times. The "western segment [of the Snake River plain] is bounded by prominent NW-trending faults."[55:4,59,60] The western Snake River plain is filled with sediments and Pliocene and Miocene volcanic rocks to depths of 2 to 3 kilometers.[55,59,96] These observations are consistent with the geological structure known as a graben. The area was covered by lava and ash flows of the Miocene, but when faulting began these geological layers were dropped down great distances relative to where they were originally laid down. Once lower than the surrounding land the western Snake River plain became a lake bed.

The large lake that filled the Snake River Plain has often been called Lake Idaho. Within the lake, water moved slowly allowing for particles to settle on the bottom of the lake and form sedimentary deposits (Chalk Hills and Glens Ferry Formations). As much of the run-off feeding Lake Idaho came from volcanic regions, the sediments deposited in the lake were primarily ashes.[47,58] The high lake levels also produced gradual stream courses in the surrounding hills and mountains. The alluvial sediments deposited in these stream courses are at levels much higher than where creeks and rivers run today within the Owyhee uplands.

The exact time frames within which Lake Idaho was full of water are in debate among geologists. Kimmel discusses how Lake Idaho actually filled at two separate times. [47] Once at the Late Miocene-Pliocene boundary (6.5 - 9 million years ago) and again during the Pliocene (approximately 2.5 - 3.3 million years ago). Hart comments that significant lake deposits date from 4.1 to 4.5 million years ago, in contrast to 6.5 to 9 million years ago. Either way, the western Snake River plain filled with water twice during the Pliocene and the geological markers of this are the Chalk Hills and Glenns Ferry formations, lake sediments named for where they were identified.[47,90]

With the western Snake River plain full of water, eventually the water needs somewhere to go. Geologists discuss two possible outlets for Lake Idaho. The first is the current path through Hells Canyon. The second is an outlet to the southwest. This is postulated as a possible outlet based on fossil fish and snails that suggest Lake Idaho may have been linked to the California coast.[5,60] It has also been suggested that the southwestern route was the outlet for the earlier lake and the route through Hells Canyon was carved the second time the lake reached a high stand, around 2 million years ago.[47,60] Glenns Ferry sediments are little more than 2 million years old and these are the best marker of the second lake high.[60] Volcanism may have caused the lake outlets to be blocked in both instances when the lake was full.[47] The height of these blocking flows determined the lake level. A major topographic break at 3800 feet above sea level may mark one of the shorelines.[5]

The lake that began forming in the Late Miocene left its mark on the land in fine sediments, sometimes including fish fossils. Faulting after the deposition of lake sediments means that today they can be found at a higher level on the edges of the Snake River Plain (such as at Chalk Hills) because faulting continued to drop the plain to its present level. The exception to this occurs around Adrian where the sediments do not show a clear history of deposition. Kimmel suggests that faulting and subsidence could account for the jumbled arrangement of these sediments. Both Chalk Hills and Glenns Ferry sediments are found in the Adrian area.[47]

A final note on the western Snake River plain is that at the end of the Pleistocene, approximately 15,000 years ago, a lake briefly formed once again. This time the lake was the result of the Bonneville flood.[4,5,60] The various sediments deposited on the floor of the lake in what is now the Treasure Valley have contributed to the type of soils found there and to the difference in soils between the plains and areas above the plains.

6 Lower Owyhee subbasin mineral deposits and mining

"The deposit types considered most important for metallic minerals in the MJARA [Malheur-Jordan-Andrews resource areas] are shallow, hot-spring-related, hydrothermal deposits of mercury, gold and silver. Uranium deposits ... are associated with some of the mercury and precious-metal deposits. ... The hot-spring deposits are shallow and disseminated."[86:B5] Smith ed. and Peters et al. modeled the probable occurrence and quantities of gold, silver, copper, uranium and mercury within the Malheur-Jordan resources areas of the BLM.[76,86] There are no known occurrences of oil or gas within the Owyhee uplands, nor would oil and gas be likely on the basis of the geological deposits.[86]

a. Gold

The known gold deposits within the lower Owyhee subbasin are disseminated gold deposits. The hot springs that formed along the faults of the Oregon-Idaho graben all produced disseminated deposits of gold.[29,73,81] As mentioned above, Grassy Mountain, Red Butte and Quartz Mountain all sit above gold deposits. This gold is very small flecks distributed through large quantities of rock. For example, the Quartz Mountain prospect has 0.04 ounces of gold in each ton of rock.[29] The only commercial method currently known for extraction of disseminated gold is a large open pit mine using heap-leach methods to remove the gold.[8,11] “The gold is extracted from millions of tons of crushed rock by spraying or injecting a cyanide solution onto or into heaps of it and leaching the gold out. Known as cyanide heap-leach mining, the technique uses the cyanide to dissolve gold from the stone, then recovers both cyanide and gold."[11:159]

In 1988 there were 14 commercial exploration sites for hot-spring gold deposits within the subbasin. This exploration followed the announcement made the same year by Atlas Corporation of their discovery of gold at Grassy Mountain.[29] This boom in commercial gold exploration was followed by a downturn by 1991 when most commercial companies had abandoned their prospects,[43] probably due to environmental concerns and Oregon’s extremely stringent regulations on heap-leach mining. Ellen Bishop explains that the “technique of extracting the gold calls for large-scale open-pit mining . . . [and the] process requires holding ponds of cyanide laced waters. While an economical method of mining gold, cyanide heap-leach mining carries grave risks and leaves deep scars on fragile arid landscapes."[11:159] Grassy mountain deposits are still of commercial interest.[35]

b. Thundereggs

Thundereggs are well known from the area of Succor Creek. While not a precious stone, thundereggs are collected and sold.[54] "Succor Creek Thundereggs: This deposit is in the far eastern part of Oregon almost on the border with Idaho. This was and is a very large deposit of Thundereggs."[71] "Thundereggs from Succor Creek are from Oregon. The centers are mostly blue agate with white bands. Thunderegg rough sizes are from 1-4 pounds each."[89]

Because thundereggs form in cavities within the ash flows, the type of minerals they will contain is based on the solution which filled the cavities. Thundereggs are sought for agate in particular. "One of the more important nonmetallic minerals in the Owyhee country is gem-quality chalcedony (agate) that is much prized by 'rockhounds' throughout the country. Some of the well known areas where agatized material has been found are along Succor Creek and the Owyhee Reservoir (moss agate and thunder eggs), in Stinkingwater Mountain (petrified wood and agate), and in the Buchanan area (thunder eggs)."[96:83]

The extent of thunderegg deposits within the lower Owyhee subbasin is unknown. Southeast of Skull Springs there is an area where thundereggs have been collected (Figure 2.23).[10] Both moss agate and jasper can be found in Leslie Gulch north of the road and near the Owyhee Reservoir.[10] There is an old jasper mine above the historic Birch Creek Ranch (Figure 2.24).[15]

c. Bentonite and Zeolite

The Teague Mineral Products mill, one mile to the south of Adrian, Oregon, began mining bentonite and zeolite in 1974. "The bentonine deposits are located 20 mi south and east on Succor Creek."[40:7] The main mining occurs in a deposit 20 feet thick that is within the Miocene age ash-tuff beds called the Sucker Creek Formation. This bentonite bed is at or near the surface in various areas within the Succor creek basin and in basins to the east. This main mining bed exceeds 8 miles in length. The Teague Mineral Products mill has also mined a more recent bentonite bed within Succor Creek, but it is unknown if this bed continues to the west to enter the subbasin. The mining is open pit mining.[40]

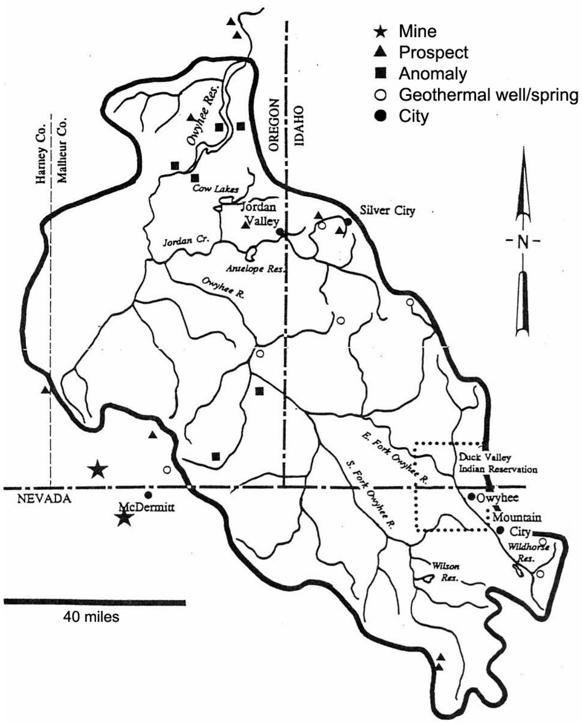


Figure 2.29. Occurrences of mercury prospects and known mercury anomalies in the Owyhee River drainage.
(Adapted from 51)

d. Mercury

Mercury is reported from within the subbasin on the western side of the Owyhee reservoir (Figure 2.29).[1] The occurrence of anomalous high mercury concentrations (>0.2ppm) is also recorded in rock samples taken by the BLM within wilderness study areas. "The study found 10 sample locations with high mercury concentrations in rock chip samples along the west side of Owyhee Reservoir and two locations with high values on the east side of the reservoir."[51]

e. Uranium

The uranium potential within the Oregon-Idaho graben (OIG) was judged to be low. However, "One uranium prospect is known in the OIG at Valley View."[86:B11]

7 Geologic maps of the subbasin

The Oregon Department of Geology and Mineral Resources has released geologic maps or partial geological maps for some of the USGS 7.5" quadrangles within the subbasin. These are: Owyhee Dam, Owyhee Ridge, Mahogany Mountain, Double Mountain, Mitchell Butte, Keeny Ridge, and Grassy Mountain.[86] Within the Twin Springs quadrangle the area of Red Butte has been mapped at a scale of 1:7500.[22] The rest of the subbasin geology remains unmapped at a fine scale.

8 Erosion of geological deposits within the subbasin

Because lava and ash flows carpeted the Owyhee uplands during the middle to late Miocene, all of the soil that used to exist in the area was buried under these flows. Also the existing stream channels were blocked and covered. All of the sediments and stream locations we see today formed in recent geological history. Since ash and tuff are more susceptible to chemical and physical weathering than basalt and rhyolitic lava, the majority of the sediments are derived from ash and tuff.

Ash flow deposits erode quickly into sediment from both the action of wind and water.[93] These sediments are carried down slope in runoff and by gravity (through rock fall and avalanche). Steep slopes do not hold any of the eroding sediments. As sediments are carried from steep slopes and deposited on lower slopes and along stream courses, we can expect the soils found within the subbasin will differ based on their slope. Ash also settled out on the bottoms of lake beds formed during the Pliocene. As Adrian and the Snake River plain were under water from Lake Idaho, settling ash helped to form the soils.

Lava flow surfaces erode and breakdown very slowly into soil. Young lava flows are covered by soil brought in by the wind or by sediments washing in from higher land. This soil is important for vegetation. In the Owyhee uplands there are many locations where the lava flows are the uppermost geological strata. In these locations soil develops very slowly. If a lava flow is the highest feature in the landscape the only sediment input for soils will come from the wind. Softer, sand-like rock layers that are found below the lava may erode but due to their lower position do not provide sediment for the soil. The various lava flows associated with volcanism around Jordan Craters give us an idea of the time scale required for soil formation. What we map as Jordan Craters is the most recent in a series of lava flows. The three older components are less visible today because they have some vegetation growing on them. However the amount of vegetation is controlled by the amount of windblown dirt that has accumulated. The three areas discussed above have progressively more vegetation the older they are because they have collected a greater amount of windblown soil.[79]

There are still several lava fields that haven't been reclaimed by vegetation along the southern edge of the lower Owyhee subbasin, including the Saddle Butte lava field (Figure 2.24).

9 Mineral deposits and mining in the headwaters of the Owyhee River drainage

As the rocks within the subbasin erode to form the soils, some of the minerals within the rocks and soils will be carried in the water flowing off of the hills for great distances. Rocks and minerals being carried by the Owyhee River when it enters the subbasin come from geological deposits up stream.

a. Gold and Silver

Gold and silver are known from other hot spring deposits within the Owyhee watershed. The most notable are the vein deposits of silver and gold near Silver City, Idaho.[36] Gold and silver washing out of these deposits have been carried downstream.

b. 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.[8] If any cyanide heap-leach mining has been used for hot-spring deposits within the headwaters of the Owyhee River, cyanide could be introduced to the water. No record has been found of such activity.

c. Mercury

Mercury has been used in the extraction of gold. This is an anthropogenic addition of mercury to the environment. "The Delmar-Silver City area in Idaho is the only area of mining activity that has been positively identified as a source of environmental mercury in the [Owyhee River] Basin. The Silver City area is suspected as a mercury source because of the use of mercury to recover gold and silver from ores".[51] 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.

Koerber also reports natural mercury deposits within the Owyhee river drainage in the headwaters of Jordan Creek and far to the south in Nevada in the headwaters of the south fork of the Owyhee River.[51] Allen and Curtis record the mercury in the same region of the headwaters of the Owyhee River as mercury deposits (Figure 2.29).[1] Aside from formal deposits, the Owyhee River area has anomalous mercury occurrences recorded from random rock-chip samples. These samples have an average mercury concentration of 0.3 parts per million (ppm) of mercury.[1] The anomalous locations include the Owyhee Breaks area and Three Forks area where BLM rock chip sampling found high mercury concentrations in four and two locations, respectively.[51]

d. Uranium and Mercury deposits

Uranium and mercury are found together in the McDermitt volcanic field (Figure 2.23).[85] Both of these heavy metals were concentrated by the volcanism of rhyolitic calderas and subsequent hot spring activity.[17] "The mercury minerals are deposited from ascending hot waters".[96:26] The Bretz mine, Opalite mine, Cordero mine, McDermitt mine, and Moonlight mine are all commercial mining operations that have worked in the McDermitt volcanic field.[51,85,86] The mercury deposit that has been exploited by the Bretz Mine is the largest mercury deposit in North America.[51,112] These deposits are also associated with arsenic, barium, molybdenum, antimony, and copper.[86] In addition to rich uranium deposits, the rhyolite of the McDermitt volcanic field contains greater quantities of uranium (12 ppm) and thorium (another radioactive metal, 19 ppm) than is standard (6.5 ppm).[17] It is probable that runoff from the McDermitt region will naturally carry some uranium and mercury.

Sediments washed downstream which contain mercury may come from natural deposits or be a legacy of anthropogenic gold mining and processing activities.

e. Potassium

About five miles southwest of Rome, Oregon, one of the ash deposits has a bed one foot thick of high-grade potassium feldspar. "The size and purity of these potentially valuable feldspar deposits are not adequately know [sic] for a meaningful appraisal; however, large volumes of vitric tuffs have obviously been replaced by potassium feldspar. Deposits of similar or higher grade may occur in the tuffaceous rocks of other Cenozoic basins of southeastern Oregon. Some of these deposits may have commercial potential for use by the glass and ceramic industries or perhaps as a source of potash for fertilizer."[96:229]

10 Summary

The beauty of the lower Owyhee subbasin is due to the geology of the area. The rock formations, lava flows and ash deposits within the subbasin are of very recent geological origin. The erosion of these rock formations and of formations upstream in the rest of the Owyhee basin creates the sediments within the region. These sediments may carry minerals from naturally occurring deposits. There are no geologic maps for most of the quadrangles in the subbasin.

F. Soils

Soils are very important to ecosystems. They hold water and nutrients that plants need to grow. In turn, plants contribute organic matter to the soil and help break down bedrock. This section will discuss the basic characteristics of soils from desert climates and what we know about the soils from the lower Owyhee subbasin. In general these soils are composed of material derived from the volcanic and sedimentary rocks and soil depths are shallow. There has been no systematic soil mapping of the Owyhee uplands although mapping is currently underway.

1 Basics of soil

Soil can be defined as the product of weathering processes. Physical weathering breaks a rock down into minerals, but does not change the composition of the original rock. The amount of physical weathering generally effects 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. The **vegetation** growing on any spot of soil can change the soil chemistry by taking up nutrients, by providing organic matter from fallen leaves or dead plants, 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 that surface. Steep slopes that are prone to landslides 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 the 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 and urbanization, for example some soils in Europe have experienced so many years of mulching that their present composition is almost entirely based on this 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.[32] Researchers dig multiple holes across the landscape to map out the 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 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." [19:16] While semiarid climates have a slightly higher quantity of precipitation than arid lands, chemical weathering is less important than physical weathering. One of the results of less chemical weathering is that, "soils inherit many of their characteristics from the parent material"[19:17] With physical weathering, the bedrock is broken down into smaller and smaller pieces, but it is not transformed chemically into another type of mineral.[33] Physical weathering in the form of extreme rainfall is recognized as one factor driving erosion and creating differing soils on slopes and flood plains.[41]

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."[19:17] At times these salt layers become so cemented that they inhibit the growth of plant roots. The development of salt concentrations is normally a factor of age.[19] Layers of sodium chloride and calcium carbonate (know locally as caliche) were commonplace in low lying parts of the lower Owyhee subbasin that have been converted to irrigated agriculture. These salt and calcium carbonate layers had to be broken and dispersed by deep plowing to allow crop production.

a. Factors in desert soil formation

Soil formation does not occur in isolation from other parts of the ecosystem. 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."[33:40] In addition, temperature controls the rate of decomposition of organic mater. In warm wet climates, decomposition takes place year round, in colder climates decomposition only occurs in the warmer months when moisture is present. The cycling of organic material is dependent upon microorganisms in the soil that break leaf litter and branches into their component parts.[27,33]

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."[33:40] "The consequences of the high-intensity rain are rapid runoff and accelerated erosion."[27:208] Low topographic areas accumulate soil while the slopes lose soil to erosion.[100]

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"[27:208] 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.

Soil moisture is controlled by infiltration rates, the rate at which soil can absorb rainfall, and 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."[27:208] 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."[27:211] This means that the flow of water between pores in the soil does not 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 to prevent deep moisture movement. A coarse-textured surface soil not only permits rapid infiltration of water but also dries rapidly and protects subsoil water from evaporation losses."[27:212]

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."[33:40-41] The salt cedar that is becoming established as a weed in the lower Owyhee subbasin is know to concentrate salt in surface soils.

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.[100] Plants need nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and micronutrients.[32] 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 usually insufficient for maximum growth.[32]

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.[83,84] 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.[84] The processes that lead to the development of shrub patches with high quantities of nutrients are still unknown.[84] 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.[83] 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.[83]

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.[14,88]

Most soils in the lower Owyhee subbasin fall into the order of Aridisols or Entisols.

"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."[27:42] 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 through 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"[27:49]

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 eroding away of the previous surface."[27:43] A basic example of an entisol would be a sand dune, where there 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.[27] Shallow stony soils over bedrock also fall in this category.

4 Data on soils in the lower Owyhee subbasin

The above discussion of desert soils lets us know what type of soils we should expect in the subbasin, but this does not describe the variability in soils or their current attributes and distribution.

There is almost no data on soils in the lower Owyhee subbasin. The only soil surveys are below the dam on agricultural soils and in archaeological excavations at Birch Creek along the Owyhee River. In addition we have data from work with vegetation on the Owyhee plateau to the south of the subbasin.

a. Agricultural soils

The agricultural portion of northeastern Malheur County has an intensive soil survey.[57] This 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.[57] The agricultural soils within the lower Owyhee subbasin are classified into 9 series along the Owyhee River and its previous meanders and an additional 11 series for the slopes and plains around the river.

The basic characteristics of these soils, despite the 20 series names are very similar. From the region's geology we know that these soils have their origin in the sediments deposited on a lake bed and flood plain deposits of the Owyhee River. The soil textures are silty loam and sandy loam.[57] The depth to bedrock is always greater than 60 inches, however many soils have a cemented layer, or pan of calcium carbonate, between 20 and 40 inches depth. This is an accumulation of salts that is common in desert soils and which farmers have broken with ripping or deep plowing. All of the soils classify as either Entisols or Aridisols. Risk of flooding and a high water table also characterize the soils adjacent to the Owyhee River.[57]

b. Soils at Birch Creek on the Owyhee River

During archaeological investigations at the location of Birch Creek Ranch on the Owyhee River the soils of the Owyhee River flood plain were described.[7] The sample location is on the east side of the river and in what used to be a farmed field. There are three terraces, each of which represents the flood plain of the river at a different period in time. The highest terrace is the oldest and furthest away from the current river. The lowest terrace is the youngest and closest to the river. The soils on all three terraces are Entisols.[7]

"The highest terrace is believed to be late Pleistocene in age"[7:82] meaning that it would be between 15,000 and 10,000 years old. This terrace is made up of gravels that rolled down from the canyon slope above it and sand and gravel deposited by the Owyhee river. This soil also has the formation of lime (calcium carbonate) concentrations where the lime has been washed by rainfall but not leached from the soil. [7] In addition, there are clays in the soil. Clay likely formed when the climate was wetter. The highest terrace also preserves, in places, evidence of large scale flooding that carried much of the gravel away and predates the formation of the middle terrace.[7]

The middle terrace is quite different from the one above it. The material is primarily Owyhee River sands. These sands were deposited on top of flood gravel and the Mazama volcanic ash which dates to 6,700 years before present.[7] This means that the middle terrace has formed over at least the last 7,000 years. Rainfall has transported some lime down in this soil, but the concentration is lower than that of the higher terrace.[7]

The lowest terrace "contains a very young soil with minor indications of soil development."[7:82] The parent material is sands and some silts deposited by the Owyhee River during flood stages.

c. Soils south of the subbasin on the Owyhee plateau

To the north of Jordan Creek, but south of the lower Owyhee subbasin Culver studied vegetation.[20] Part of this study was an exploration of the soils that were found in association with each vegetation type. He describes ten different soil profiles from holes he dug in the region. In two of his pits he hit volcanic rock at less than 20 inches. In six of the other samples he hit a hard layer of lime or basalt between 20 and 35 inches. Only two of the samples have soil extending deeper than 37 inches.[20] The depth at which root growth is inhibited is a major factor in determining the vegetation that can grow in a soil.[56] The soil classification terminology used by Culver is no longer in use.[7]

5 Conclusions

Very little is known about soils within the lower Owyhee subbasin. From geology, topography, and the semiarid environment we expect that many of the soils are recent in origin and will reflect the chemical composition of the volcanic parent material. Known soils fall within the Aridisol and Entisol orders of the U.S. soil classification scheme, as expected. On going soil survey work will greatly enhance knowledge of local soils in the near future.

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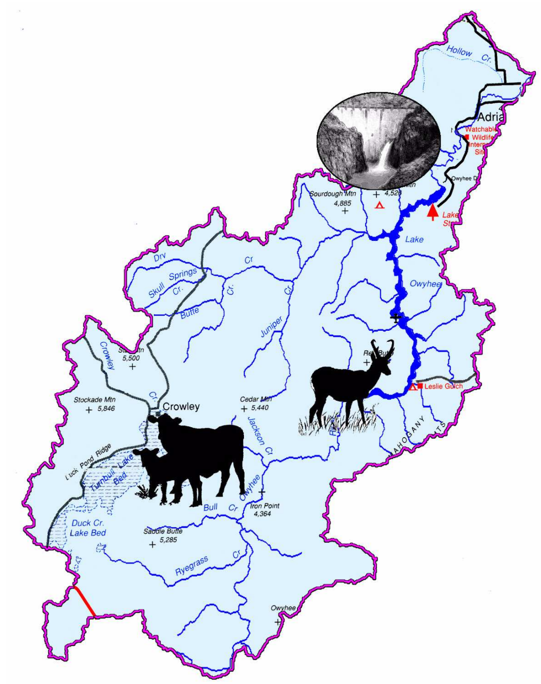


Lower Owyhee Watershed Assessment

III. Identification of Issues

III. Identification of 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 lower 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 or 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 their environment. A major concern for them 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 lower 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 lower Owyhee subbasin, the evaluations of either current or historical conditions need to take 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 problem areas.

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 a publicly advertised meeting. Members of the advisory board of the Malheur Agricultural Experiment Station of Oregon State University developed a list of issues. Many agency concerns are a matter of public record. Interested individuals expressed their concerns in informal conversations.

The stakeholders who provided input included ranchers with both private land and public grazing allotments and growers with irrigated land in the section of the lower Owyhee subbasin below the dam. Also present at meetings or providing input were recreational users of the Owyhee Reservoir, the Malheur County weeds specialist, the Nyssa mayor, and representatives of the Owyhee Irrigation District, the Nyssa highway district, the Bureau of Land Management (BLM), Oregon State University, the Ontario Chamber of Commerce, and the Bureau of Reclamation (BOR).

C. Specific issues

The general issues identified as areas where information either needs to be synthesized or needs to be identified as "not currently available" fall into several broad categories. Some of these issues were raised repeatedly, some of them emerged out of the discussion at one of the meetings. Some of the concerns stated as fact in the following discussion may only represent the opinion of one of more of the participants at the meeting.

1 Weeds

Noxious weeds and invasive species are spreading in the lower Owyhee subbasin, both on the rangelands and in fields. Medusahead rye is singled out as possibly the biggest threat since neither domestic animals nor wildlife will eat it and it is taking over huge sections of ground. Besides medusahead rye, white top and perennial pepperweed were mentioned as being really out of control on rangeland. Yellow nutsedge is becoming a major problem in irrigated fields. Other species identified as problems and potentially detrimental to the watershed include scotch thistle, yellow star thistle, Canada thistle, bull thistle, hemp dogbane, Japanese knotweed (now near the subbasin), leafy spurge (which may not be in the lower Owyhee hydrologic unit but is above it in the watershed), tamarisk, juniper, rush skeletonweed, halogeton, yellow flag iris, puncture vine, poison hemlock, and knapweed species including Russian knapweed. Cheatgrass is also invasive but now is almost everywhere. Noxious weeds are also seen as a problem on farm ground. Button weed (common mallow) and dodder continue to be problems for alfalfa seed production.

Concerns were expressed about who or what agencies are responsible for weed control and where they are responsible. What are the economic costs of controlling weeds?

Cheatgrass burns easily and it would be desirable to convert the range back to native species. Cheatgrass does grow where other grasses won't.

Among other problems presented by rangeland weeds, some weeds aggravate soil loss. There was a question raised as to whether the BLM would help fund weed research. Good range weed control requires competitive range plants. We need both biological control and competitive range plants. We need more vigorous grasses that are fire resistant and still palatable.

Since most of the land is federally owned and managed by the BLM, cattlemen are concerned with the BLM lack of control of noxious weeds and invasive species which are spreading on BLM land. Would a burning strategy eliminate medusahead rye? Medusahead rye is a particular concern because it seems to replace nearly all other plant species on large tracts of land, breaking food chains for many native animal species.

Tamarisk has the potential to replace riparian vegetation in the lower Owyhee watershed and is poised to do great harm to water availability in the few intermittent streams in BLM's areas of critical environmental concern within the watershed.

What is the effect of the spread of juniper on the availability of water? Is there an effective way to halt juniper invasion other than burning?

2 Identification of phenomena not open to remediation

One concern is that the effects of naturally occurring phenomena be separated from the effects of people. Naturally occurring phenomena are not open to remediation. There are some topics where there has to be a distinction made between the contributions of human use and those of nature or of historical use.

a. Mercury

Outside the Owyhee watershed, the Bretz and Opalite mercury mines operated through the 1940s. Possibly strata similar to that in which they are located is also contributing mercury to the Owyhee. Is there mercury at Cinnabar Mountain and in Slaughter House Gulch which could be washing down into the Owyhee River?

Mercury was used historically near Silver City to purify gold up until about 1920. Although this mercury was added to the environment by people, now that it is there, if it washes downstream there is nothing that the individuals along the river can do to ameliorate the situation. Locally, it is known that in 1909 a big flood washed out cyanide vats at the Delamar mine and killed willows along Jordan Creek. Jordan Creek drains into the lower Owyhee hydrologic unit. What are the current impacts of historic mining practices at the Delamar and other mines? What conditions in the watershed arise from past mining practices?

b. Ephemeral streams

The bottom of a gulch may only carry water infrequently following an unusual weather event. These are really "ephemeral" streams, although they are frequently and incorrectly referred to as "intermittent." Both historical accounts of how often a gulch carries water and a hydrological survey of the functioning of the creeks and streams is necessary to identify which streams have water resources. What identified waterways within the lower Owyhee subbasin are really "perennial" streams, which are "intermittent", and which are "ephemeral"? Which streams have the potential for remediation?

Accurate classifications of the different drainages do not exist.

c. Water temperature and quality

Given the high summer temperatures and low rainfall, individuals expressed concern that an effort be made to identify the conditions which really exist in the streams under natural conditions. What water temperatures can be expected? How do these differ between surface temperature, shallow reaches of streams, and deeper pools. Deep pools and refuges may be the reason fish survive, not the general, natural river conditions. What are the contributions made by hot springs? Possibly areas could be identified where different species of fish would find appropriate habitats.

The water quality issue is a huge problem. The water quality standards are unrealistic and unachievable. Realistic water temperature standards need to be developed and incorporated in DEQ and EPA documents. The water temperature issue is already impacting the ranches and it is going to impact the growers. There is a need for water quality research in the Owyhee basin on what is achievable.

d. River function

What was the actual frequency of droughts prior to the construction of Antelope Reservoir and the Owyhee dam? Were there droughts every year? That is to say, did the Owyhee River drop to very low flows after the spring runoff was finished? There are some indications that it went almost dry every summer.

e. Rare species

There is a concern that groups and public agencies sometimes champion the use of natural resources in the watershed for the benefit of a species that may never have been present in the watershed or for the benefit of a species that has always been less numerous due to the environment only being marginal for that species.

Other species identified by special interest groups or the BLM as threatened or endangered may really exist in greater numbers or in adjoining areas.

What species really are endangered or threatened?

3 Maintenance of water rights

There is a concern that current water rights throughout the lower Owyhee subbasin be protected. Water should be available for permittees. The Owyhee irrigation district wants to maintain facilities and operate as it has historically. The dam was built for irrigation and is designated for irrigation use.

For growers and ranchers below the Owyhee dam, the dam is their bank; it is their capital. There are lots of people who would like to raid the bank and use the water for their own priorities. There is concern that water rights will be taken away to augment the flow for salmon. Drift boaters, fly fishermen, motor boaters, and bait fishermen all have different priorities.

4 Interaction of wild and domestic animal species

Many of the stakeholders in the hydrologic unit are ranchers. Ranchers are concerned about range conditions and the effects of range conditions on stock. There is a feeling that stock water ponds beneficially affect hydrology and wildlife. The impression is that stock ponds and other water developments provide water for wildlife as well as cattle.

Since cattle are one of many species that might affect the watershed, they would like some evaluation of how different species affect the watershed. There is concern that the BLM has allowed the stocking rate for wild horses to exceed BLM's own guidelines. What are the impacts of grazing by wild horses? How do cattle and wild horses interact? The actual relationship between cattle grazing and fish needs to be explored. There is an increase in the elk population on South Mountain. What impact does this have? What are the effects of the lack of cougar control or other predator control?

5 Protection of wildlife and fish

Wildlife and fish populations need to be protected. Fish and wildlife populations are complex due to their dynamic nature and interactions between species. Wildlife populations are affected by public policies that control predators. For example public policies toward predator species and toward hunting affect sage grouse and other wildlife populations.

The actual geographic distribution of species needs to be considered. Redband trout are a part of the ecology of the Owyhee watershed, but they live in restricted river reaches upstream. Were they ever historically present in other areas?

Agricultural and rangeland management practices may benefit wildlife. Pheasants and quail are found around farmland. Stock ponds developed for cattle also provide water for wildlife. Are there other benefits for wildlife?

If there is enough human pressure, it will have adverse effects on the deer, antelope, lizards, and other wildlife. There is an amazing diversity of life even in a small plot of desert land. What areas are being impacted the most by people and possibly affecting the wildlife?

6 Grazing

Different agricultural management practices, including grazing practices, need to be factored into the assessment.

The public needs to be aware of the reasons for the Vale Project and its outcome. What have been the impacts of the Vale project? Why was it initiated?

What are the effects on the watershed of grazing sheep and cattle? What is the relationship of fire to rangeland conditions and grazing?

An archaeologist who has worked in the Owyhee Uplands says that grazing does not affect the archaeological sites in the area.

Is past heavy historical use of the rangeland by horses and sheep responsible for the greater degradation of parts of the rangeland? Historically areas near the Snake and Malheur rivers were subject to greater grazing pressure. Sheep were run on the land for the last fifty years from the rivers to Crowley.

7 Grazing management and riparian vegetation

There were some who expressed the opinion that cattle need to be removed from at least some stretches of perennial and intermittent streams that provide riparian vegetation. Some believe grazing intensity and timing need to be managed. Ranchers would like to cooperate with the BLM in developing water sources away from the riparian stretches and in excluding cattle from some prime riparian areas. What grazing strategies are compatible with healthy riparian vegetation?

What was the actual historic presence of willows and other riparian species. Were there any areas that had trees? What is the appropriate vegetation in riparian areas?

8 Water quality

There was concern expressed that growers in the Owyhee Irrigation District needed to reduce the amount of silt which washes on down into the Snake River and Brownlee Reservoir. Water samples taken between November and March from the Owyhee, Malheur, Snake, Payette, and Boise rivers nine years ago showed none of them met potential water quality standards even at a time when there was no irrigation and no runoff.

Water quality standards need to take into account the natural causes of contamination. Water in the Mitchell Butte drain was basically clean until it reached the slow water in the tulles and stagnated. Good water quality may not coincide with fishing.

We need baseline water quality data. We need to be progressive, proactive, and quantify improvements. The Owyhee Irrigation District is working to establish baseline water quality data. We need to find water quality data from the past if it exists. Baseline data is needed to show improvements in the future. The Oregon Department of Environmental Quality has identified sediment, phosphorous, nitrate and nitrite in the groundwater, E. coli levels, algae and mercury as contaminants of concern.

Does the Owyhee Reservoir affect the forms and availability of mercury or phosphorus?

The stakeholders expressed the desire to fix their own problems with runoff before it is mandated. Sediment ponds and a switch from furrow to sprinkler irrigation were both mentioned as steps that have been and could be taken to reduce silt in runoff.

With a significant conversion to sprinkler irrigation, what effects will it have on surface water quality and groundwater availability?

Very little agricultural ground drains back into the Owyhee River.

Gophers are a real problem and possibly cause more erosion than anything else. A bounty on gophers is needed.

9 Management of infrastructure and vegetation

Existing roads need to be maintained. There is almost no road maintenance on many of the roads on BLM property. Poor road access compromises the ability of the BLM to respond quickly to a fire or effectively reach areas contaminated by invasive weeds.

How are prescribed burns or lack of prescribed burns affecting the watershed? What was the pre-contact and historic fire frequency? Has this changed?

There is concern for the lack of interest and investment by BLM in maintaining range improvements such as the Vale Project.

Are areas that have burnt or that burn being managed in such a fashion that they will be returned to productive rangeland and not become overrun with weeds?

10 Absentee landowners

Absentee owners are purchasing the irrigated land below the dam and there is concern that they do not have the same interest in stewardship of the land and resources. In other parts of Malheur County absentee landowners have purchased rangeland. They have taken the rangeland out of production to use it for private hunting. They see juniper expansion as positive. Land removed from production produces no employment. Juniper expansion may lead to the land drying up and the degradation of the water. Drier land would eliminate water to maintain riparian areas.

11 Recreational use

Recreation is one of the growing uses of the land and its effects on the watershed need to be separated from the effects of ranching or grazing. Problems caused by recreational use need to be addressed in some fashion other than laying the burden on local land owners or allotment holders. We need to identify who is using the area and how they affect it. Hikers and campers use the more scenic canyons. Hunters from across the US come to hunt chukar. What effect do out of state hunters and fishermen have? How do rafters impact the area? What types of damage are inflicted by four wheelers and snow mobilers? The council members are concerned that recreational vehicles place pressure on the landscape and wildlife year-round. The dam has created an artificial recreational fishery in the reservoir and an artificial recreational fishery below the dam on the Owyhee River. Since there are artificial fisheries, the assessment should not focus on them. However, the recreationists are having impacts on the lower Owyhee subbasin.

People unfamiliar with the area also affect the existing infrastructure. Search and rescue efforts cost the local sheriff both time and money. Local road districts and the county have no increasing revenue to provide all the road maintenance needed due to the increasing recreational impacts of road use. In spite of publicity to the contrary, recreational users spend little or no money within the local economy. Roads with particularly high traffic are those into Leslie Gulch, Three Forks, and towards Birch

Creek Ranch. Away from these more intensely managed and improved gravel roads mentioned above, how do deteriorating roads impact the rest of the watershed? Should there be restrictions prohibiting the use of roads when they are wet or during a specific season?

There is also an impact on the paved roads from recreational use both above and below the Owyhee dam. The Nyssa road district has to maintain the road, with only one of its patrons living in the area. Vehicles pulling boat trailers are driven too fast on the road and the amount of traffic has increased. A recent road district study showed 180 round trips per day during the week and 700-800 round trips per day on the weekends. Most of the cars have Idaho plates. There was some question of whether the road could be turned into a toll road.

There is already concern that recreational use of the Owyhee River below the dam is having a negative impact on the environment. Five years ago during the week there were two to three cars on the road, now there are about 50 cars every morning. There are beer cans, bottles, human waste, diapers, and other trash being left along the river corridor. The fly fishermen have tried to run off kids since they disturb the fly fishing. Families that used to use the river are going elsewhere.

Fires can be caused by cars trying to park off the road where the dry cheatgrass contacts the exhaust pipes.

Recreational use with four wheelers can also cause problems. They don't use established roads. They can spread weed seeds, start fires, and destroy native vegetation. They need to be confined to established roads, and the established roads need to be maintained.

As more people use the area, culturally sensitive sites are more affected. What types of archaeological sites might be impacted?

12 Wild and scenic river status below the dam

There are concerns centered around the BLM process for recommending a wild and scenic river status for the Owyhee River below the dam. A BLM representative explained that the recommendations for "protections for the river were based on certain values" and that the initial process was probably initiated because of the SE Oregon management plan. At the time that plan was written, the Owyhee River corridor was under BOR management. It is now under BLM management.

The stakeholders were concerned that the designation would be based on artificial factors since the cold water fishing below the dam is an artificial effect of the way water is stored and then released from the base of the dam. The vegetation below the dam is also not natural since a wild river would scour the channel and flood plain periodically as the flooding in 1952 did. In 1937, Donna Cleaver says there was not a tree on the river. Historically, the fish in this stretch of the Owyhee river were basically hot water fish: bass, crappie, and bluegill. The brown trout below the dam are a recently introduced specie (1990 through 1997).

With the flooding in 2006, the fish below the dam did not seem to have come through very well. What are the impacts of flooding on the fisheries?

Will pressure be put on the Owyhee Irrigation District to manage the flows for the benefit of the artificial fishery rather than for irrigation? Before the dam was built, the river almost dried up during the summer.

There is already a highway in the bottom of the canyon.

To maintain or repair Owyhee Dam, the Bureau of Reclamation and the Owyhee Irrigation District need to have the right to use, and if necessary improve or rebuild, the road along the side of the river to allow heavy transportation.

People hunt the river and the Owyhee Breaks. Would designation of the river as wild and scenic eliminate hunting?

The designation of the river as wild and scenic could have tremendous negative economic effects for the people who have traditionally used it. Ranchers who have grazing rights need to be able to continue using their grazing rights on public land, especially along the lower Owyhee River. Some of this has already been compromised by the transfer of the management of the land below the Owyhee Dam to BLM.

There is a concern that all the private ground along the river remain zoned agricultural and no property rights are taken away.

The desire to keep flows high might compromise irrigation water. Establishing minimum flows along the lower Owyhee River could also impact crossings of the river and have economic consequences for businesses and farmers.

Restrooms and other facilities need to be placed beyond the upper limit of flooding of the river.

13 Transfer of management of the land below the Owyhee Dam to BLM

Already the transfer of the land along the river below the dam from the Bureau of Reclamation to the BLM has been seen as having negative consequences for local residents. One stakeholder with land on both sides of the river had a fence across the river at his property line. When the water was low, the fence prevented the cattle from leaving his land and drifting onto other property. The BLM required him to remove the fence. Now to control his cattle, he will be required to build a fence along each side of the river or stop using his land as he has traditionally used it. It becomes an economic burden since the landowner is not able to use all the land he owns.

Landowners who can't use the water due to agency restrictions, can't use their AUM's. Will the BLM pay to graze off the river corridor with goats instead of being paid for cattle to graze it?

The BLM has restricted the time when cattle can be trailed up and down the river to reach other grazing areas. However, some of the BLM allotment lands are unfenced, allowing cows to get on the river.

There is a rock quarry that the BOR has traditionally used for as a rock source. It has also been used as a rock resource by the BLM, Malheur County, Owyhee Irrigation District, Big Bend irrigation district, the Nyssa road district, Ontario, and others. After the sudden change in management from BOR to BLM, the rock became unavailable, although there is some short term use being allowed to the BOR. There is no other easily accessible source of similar rock material. The rock quarry was supposed to be withheld from the transfer.

There is a value in the preservation of the western culture and heritage in the area, including cattle drives.

There is also concern that Cow Hollow Park has been transferred to the BLM and traditional uses and maintenance may not be maintained.

Tamarisk has a foot hold along the Owyhee River below the dam. Will this invasive weed be eradicated, or will BLM simply ignore it and allow it to compromise the vegetation in the Owyhee River corridor?

14 Channel silting below the dam, minimizing flood potential

The Owyhee River channel below Mitchell Butte has silted up. In 1952 after it flooded and tore out everything, including the bridge to Adrian, the army corps of engineers channelized some of the river bed. After the 1984 flood, there was some clearing of the channel. For the last 15 to 18 years there has been no high water, not enough to flush anything. Before the dam was built, it always flooded, even in dry years and everything was washed away.

Since 1984 lots of the river capacity below the dam has been lost due to encroachment of vegetation along the river. Damage from flood waters backing up into adjoining cropland and houses has become more probable. Land owners were supposed to clean and maintain the channel. Land has changed hands and different owners don't remember floods. New owners need to buy in to the need to keep the channel clean. Permits are needed to do the work necessary to keep the channel open. The Oregon Department of State Lands administers the permit process for anything in the river.

It is hard to avoid flooding on the lower Owyhee River below the dam. The glory hole (spillway) does not work until the Owyhee Reservoir is 80% full, so large amounts of water can not be released before that point. The primary purpose of the reservoir is irrigation.

15 Channel modifications

What past modification were made in the river channel below the Owyhee Dam and why were they made? Was it to preserve farm lands?

16 BOR leases

The BOR leases on the Owyhee Reservoir are all year-to-year leases. This means that people with cabins in Fisherman's Cove and Dry Creek, the only two areas authorized for long term use, have less incentive to make the investments in maintenance than they did with the old, long term leases.

For areas outside of Fisherman's Cove and Dry Creek, the BOR leases can not be renewed at all after the original lessee dies and the structures are being destroyed.

17 Cooperation with the BLM and other agencies

Since most of the land in the lower Owyhee subbasin is BLM land, how can the assessment be used to develop cooperative projects?

It is currently difficult to cooperate on projects with the BLM because the BLM is currently focusing on their GMA planning, waiting until the planning is completed before starting other projects.

There is also concern that the GMA process may cause problems for permittees. In other areas the GMA's have really complicated or tied things up.

18 Responsiveness of state and federal agencies

Comments provided for agency processes are not taken seriously. The agencies make plans or draft regulations internally. After they have solicited comments on these plans, they don't alter the plans to take into account the public input. The public input is "window dressing." Oregon Watershed Enhancement Board and BOR are the exceptions.

There does not seem to be consistency between the management practices of the different agencies like BLM, BOR, and Fish and Wildlife.

19 Economic concerns

The livestock industry is an important contributor to the local economy. The livestock industry should remain an important part of the local economy.

The federal land needs to be multi-use, not designated for one purpose only, such as fishing.

We need to maintain economic profitability and economic sustainability. Farming and ranching need to be affordable.

20 Other concerns

After public agencies burned cabins (at sites previously leased to the public) in the 1970s, they didn't clean up the refuse that didn't burn. There were old bed springs, stove pipes, and other non-burnables left at the sites and they are still there.

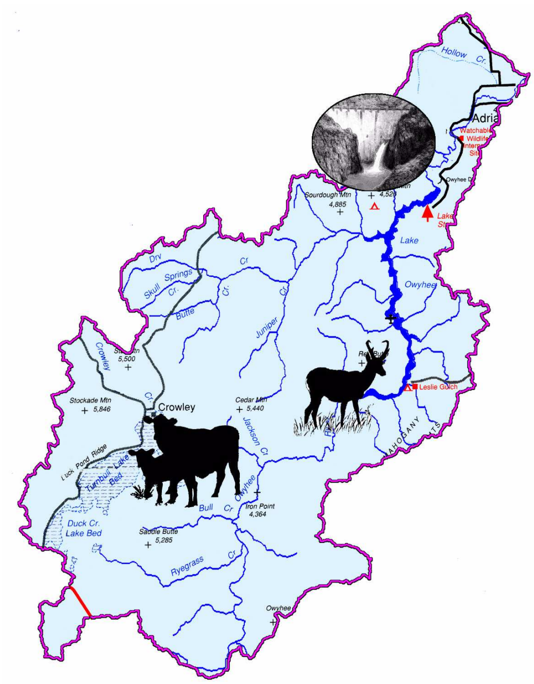
The Bureau of Reclamation tore down a very nice store on Cherry Creek that served a real need. A much "junkier" facility with fewer amenities now occupies the spot.

The BLM, which already has large tracts of land, is trying to force the few private land owners with land within the BLM area to sell to the BLM.

21 Use of the assessment

The lower Owyhee subbasin is a very special place to the people who live or work there. There have been many improvements in the management of activities in the subbasin and these need to be highlighted in the assessment. There are also real areas where further improvements are needed or where basic information about the subbasin is lacking. The assessment should provide a basis to assist in applying for grants.

The Owyhee Watershed Council has been positively involved with educating the public about the watershed with activities such as the 5th grade field day and the educational video. The accurate current portrayal of the state of the watershed developed by an assessment can aid the Owyhee Watershed Council's communication with the public.



Lower Owyhee Watershed Assessment

IV. Historical Conditions

Contents

IV. Historical conditions

This account relies on many sources. Ellipses, . . . , indicate a word, phrase, or short section has been omitted. Clarifying additions by the editor have been added in brackets, [ ]. Where trappers' or pioneers' words are quoted verbatim, some of the spelling and punctuation has been changed but the words and word order are the original.

A. Pre-contact

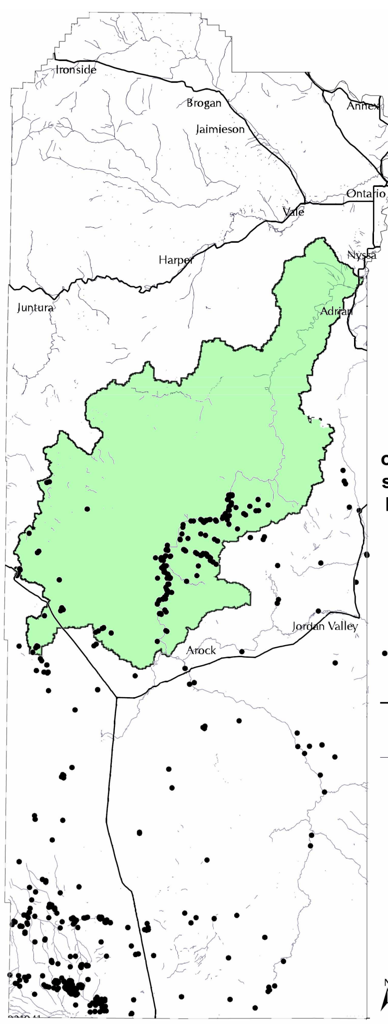


Figure. 4.1. Distribution of archaeological sites in Southern Malheur County.[78]

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 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 has been inhabited for more than 13,000 years.[1] Since the Owyhee uplands are currently semiarid and of recent geological formation, there is little soil formation. Collected or excavated artifacts from the 511[78] known sites in the Owyhee watershed within Malheur County include lithic scatters, projectile points from many time periods, ground stone, house pits, petroglyphs, rock alignments, and some pottery (Figure 4.1).[1,3,4,78] The excavations at Birch Creek have uncovered artifacts including shell beads, charred wood, animal bones, and stone, bone and shell tools.[4]

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.[79] 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."[47] Great Basin Native Americans are known to have taken massive rabbit populations, employed fish traps, nets, weirs and dams, and burnt range lands.[46,83,85] 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."[82] The plants that may have been propagated include, but are not limited to, great basin wild rye, sunflower, wild tobacco, camas, currant, biscuit root, bitter root, wild onion, sego lily, chokecherry, and wild rose. These plants currently grow in the lower Owyhee subbasin.

The Native American inhabitants of the Owyhee River drainage at the time of European contact were the Tagötöka (tuber eaters), a band of Northern Paiute.[84] As can be seen from Figure 4.2 the territory of the Tagötöka (Tagö) coincides with a large part of the Owyhee watershed and includes most of the lower Owyhee subbasin. Although interviews with two members of the Tagötöka, Dick Stanley, age 85, and his wife, age 80, were conducted in the late 1930's on the Duck Valley Reservation [85], some of the information gathered is important in understanding the pre-contact conditions of the Owyhee River drainage.

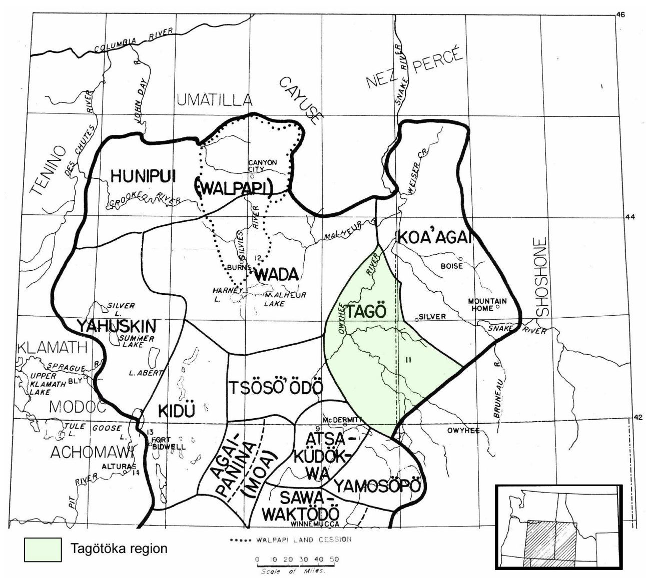


Figure 4.2. Northern Paiute bands in Oregon and Idaho

Taken from: Omar C. Stewart, 1939. The Northern Paiute Bands. Anthropological Records 2(3). University of California Press, Berkeley.

We do not know whether the fur trade that had 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 1700's, "a healthy 'ship based' fur trade flourished."[40] 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 Native Americans, 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."[86]

B. 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 lower Owyhee watershed.

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.[71]

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

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.[71] 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.

The other principal 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]

In the late 1770's, a group of trappers formed a third company, the North West Company or Nor'Westers. 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.[50]

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. However, 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.[50]

New competition for the Hudson's Bay Company came from Americans.

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."[51]

One of the Hudson's Bay Company's employees, Peter Skene Ogden kept diaries of trapping trips from 1825 to 1829.

1. The journals

The written records of the trappers and later of the early travelers on the Oregon Trail recorded what were 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 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. The information included here on the conditions at the time of contact is gleaned from bits and pieces in many different journals.

Some places are referred to names other than those we now know such as "South Fork", "Lewis River", and "Saptin" for the Snake River; "Sandwich Islands River" for the Owyhee River; and "Unfortunate River" for the Malheur River.

From these different observations of the landscape and conditions, mostly in areas around the edges of the watershed, we can extrapolate to conditions in the lower Owyhee watershed at the time of contact.

2. The effect of trapping on conditions

Already by 1826, Ogden is noticing a change in the condition of the countryside. There aren't as many beaver. In February of 1826 he notes changes on two rivers close to the Owyhee River. After sending trappers up the Malheur River he writes "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 finds a similar situation on the Payette River, "it was then [1819] rich in beaver but now destitute."

Later in the journey he lays the blame first on "American traders [who are]. . . 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."[71]

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

3. General description of the Owyhee countryside

There are virtually no early records specifically of the lower Owyhee subbasin. Although Ogden mentions sending trappers up the Owyhee River, they were not the ones keeping a journal. However, 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. And laying over the next day and going a short distance down the creek, we found Indians who had our future food, dried salmon."[5]

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. He writes that, "on the 20th [November], the rain, which had commenced to fall the previous night, gave us a little water. This alleviation was timely, as several Canadians had begun to drink their urine. It continued to rain all night."[37]

Throughout the trappers' journals there are several recurring themes. Food for the men and horses is mentioned, particularly when it is lacking. The lack of water is also mentioned when they are cutting across country since the rest of the time the trappers were following streams.

4. Vegetation

What was the vegetation in the lower Owyhee subbasin like prior to the advent of wagon trains of Euro-Americans crossing towards western Oregon? The trappers' descriptions are probably the best records we have. On many things, the different writers have made similar observations.

a. Few trees

Wilson Price Hunt records in his diary that "The country was devoid of wood".[37] Although this comment is made slightly east of Boise, this lack of trees in the immediate vicinity of the mouth of the Owyhee River is mentioned by both Captain Wyeth and Peter Skene Ogden 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 he] found none"[94] He was camped at a spot where the river referred to could be the Snake, the Owyhee or the Malheur.

Ogden says "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 reiterates this in another entry made along the Snake River about 26 miles east of the mouth of the Owyhee river. "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. At the mouth of the Owyhee, Wyeth comments that on the other side "in sight on what appears to be a river coming in from the N. side" is "the first timber we have seen since leaving the Mts."[94] Referring back to this river in writing a few days later, "it proves to be called Big Woody [Boise] on account of the timber on it"[94]

Going west the first time in 1811, Wilson Price Hunt writes, "at sunrise, we saw before us a river [Boise] which flowed westerly. Its shores were fringed with cottonwoods and willows."[37] Coming to the Owyhee, Stuart notes that "Opposite our present station a large river [Boise] comes in from the east, is well timbered, contains many beaver"[86]. Joseph Williams, an early traveler, writes "We reached Fort Bois. Some timber grows along the Bois, principally cottonwood. . . . We now started for Wallawalla, over hills and rough roads. We don't see any timber, scarcely"

Col. Fremont is more extravagant in his description of the atypical vegetation along the Boise River. "We came suddenly in sight of the broad green line of the valley of the Rivière Boisée, (wooded river), black near the gorge where it debauches into the plains. . . Descending the hills, after traveling a few miles along the high plain, the road brought us down upon the bottoms of the river, which is a beautiful, rapid stream, with clear mountain water, and, as the name indicates, well wooded with some varieties of timber — among which are handsome cottonwoods. Such a stream had become quite a novelty in this country, and we were delighted this afternoon to make a pleasant camp under fine old trees again."[80]

Beyond the Boise to the west, the landscape again lacks trees. The Burnt River does not conform to this generalization as Peter Skene Ogden notes that it "is without exception one of the finest streams for beaver in the Snake country, well lined with willows, birch, and poplar [cottonwood], the latter not very abundant. The soil sandy and banks hilly and rocky."[63]

b. Willows

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"[63] gives us some idea. Willows are mentioned when vegetation along the banks is discussed. Although he describes the "River au Malheure . . . [as] a fine stream about 1/16 mile in width and well lined with willows,"[63] most of Ogden's references to willows indicated that they were much sparser. "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."[63] 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."[63]

Coming to the Owyhee in 1812, Stuart described it as "a Creek 70 yards wide in everything resembling the one passed yesterday". The description of the creek passed the previous day was "numerous willows and beaver . . . the bottoms . . . were extensive, covered principally with saltwood [*Atriplex sp*. or greasewood] except near the river where there are some willows".[86]

The day that they crossed the Snake River at the Owyhee, Townsend records the use of willows as a building material by the Native Americans. "Towards noon, today, we fell in with a village, consisting of thirty willow lodges of Bannecks . . . Towards evening, we arrived on Snake river, crossed it at a ford, and encamped near a number of lodges along the shore."[88]

The willow which the trappers mention is not a tree (Figures 4.3 and 11.4). 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]

c. Other vegetation

John Townsend was an ornithologist who accompanied Wyeth on his trip west in 1834. He also wrote down some observations on the vegetation. Leaving the Owyhee River he says, "We passed, this morning, over a flat country . . . abounding in wormwood [sagebrush] bushes, the pulpy-leaved thorn [greasewood], and others, and deep with sand, and at noon stopped on a small stream called Malheur's creek."[88]

Figure 4.3. Willows growing along the banks of the lower Owyhee River, April 2005.

Peter Skene Ogden also notes the sagebrush near the mouth of the Owyhee river in February 1826. "Grass scarce in this quarter but wormwood in abundance. . . . Sandwich Island River . . . is from appearance a fine large river and from the upper parts not having been visited is worthy of examination."[63]

To the south of the lower Owyhee subbasin, north of McDermitt, John Work also notes lots of sagebrush, "The road good but in places stony & embarrassed with wormwood."[93]

Since Fremont was consciously taking measurements and making observations, he gives the best description of the vegetation at the mouth of the Owyhee River. "Here we found ourselves again surrounded by the sage; artemisia tridentata, and the different shrubs which during our voyage had always made their appearance abundantly on saline soils, being here the prevailing and almost the only plants. Among them the surface was covered with the usual saline efflorescences, which here consist almost entirely of carbonate of soda, with a small portion of chloride of sodium."[80] After they left the area, he states, "We resumed our journey; and directly leaving the river, and crossing the artemisia plain, in several ascents we reached the foot of a ridge, where the road entered a dry sandy hollow, up which it continued to the head; and, crossing a dividing ridge, entered a similar one. . . . In this hollow, the artemisia is partially displaced on the hill-sides by grass; arid descending . . ., about sunset we reached the Rivière aux Malheurs, (the unfortunate or unlucky river,) - a considerable stream, with an average breadth of 50 feet, and, at this time, 18 inches' depth of water. The bottom lands were generally one and a- half mile broad, covered principally with long dry grass; and we had difficulty to find sufficient good grass for the camp."[80]

Since their horses required grass, the condition of the grass in an area is important. For trappers or travelers with some knowledge of the area, the presence of grass could affect their plans. Peter Skene Ogden writes "We encamped an hour earlier than usual knowing well if we advanced farther our horses would be without grass."[63] Earlier, on June 17th, he had recorded his amazement at the small stature of the red clover "a strange sight to see red clover in abundance but not more than an inch in length . . . our horses being greatly fatigued and having been nearly two days without grass we encamped early on a small brook."[63]

5. Fires

Medorem Crawford thought that he had seen volcanic activity when he says that from Fort Boise he "saw a large smoke at a distance supposed to proceed from a volcanick mountain."[15] The smoke was more apt to come from fires. When Peter Skeen Ogden was staying near Ontario, he had noticed that it seemed like the "country on all sides is on fire."[64] Thomas Farnham had assumed that the fires had been deliberately set when he comments that "around our track thickly clothed with dry bunch grass. Some of them had been burned over by the Indians."[23]

6. Game

a. Lack of big game

Wyeth, Townsend, and Ogden all mention times of starvation. This 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."[41]

Both Townsend and Ogden have many entries devoted to the lack of game. Two days east of the Boise River at an abandoned Native American camp, Townsend writes there were "several white wolves lurking around in the hope of finding remnants of meat, but, as a Scotchman would say, 'I doubt they were mistaken,' for meat is scarce here, and the frugal Indians rarely leave enough behind them to excite even the famished stomach of the lank and hungry wolf."[88] Two days later, a colt came into camp. Although they were fairly certain that it had strayed from Native Americans, "every animal that comes near us is fair game, and we were hungry, not having eaten any thing of consequence since yesterday morning". So, "a bullet sealed the fate of the unfortunate visitor" and after cooking, "all pronounced it one of the most delicious meals they had ever assisted in demolishing. When our breakfast was concluded, but little of the colt remained."[88]

Townsend emphasizes the lack of large animals when he tells about inviting a Native American to eat a stew including the remains of the colt. Upon discerning horse meat in the mixture, the Native American spat it out and left in a huff. Townsend concludes his story "It would seem . . . that the Indians . . . are opposed to the eating of horse flesh, and yet, the natural supposition would be, that in the gameless country inhabited by them they would often be reduced to such shifts, and thus readily conquer any natural reluctance which they might feel to partake of such food."[88]

As Wyeth's party reaches the Powder river, Townsend remarks that, "Our men killed, in the afternoon, an antelope and a deer fawn, which were particularly acceptable to us; we had been on an allowance of one dried salmon per day, and we had begun to fear that even this poor pittance would fail before we could obtain other provision. Game has been exceedingly scarce, with the exception of a few Grouse, pigeons, etc. We have not seen a deer, antelope, or any other quadruped larger than a hare, since we left the confines of the buffalo country [east of the continental divide]."[88]

Ogden also mentions the lack of game when commenting on the Native-Americans' use of wild plants when salmon is scarce. "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] "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[44]] otherwise many would perish from want . . . those who unfortunately for them who have no horses pass their lives without ever tasting meat."[63]

Near the present day Ontario, Ogden was complaining of hunger and states that "two of the trappers who had been some distance in advance came in with nothing. Starving for the last three days, [they] have eat[en] nothing, but they have no encouragement by coming to the camp."[63] The trappers were not the only ones going hungry. "Three Snake Indians paid us visit. They came empty handed and returned in the same way. They complained of starvation. . . . It was some consolation to me to find we are not alone that starve."[63]

The following year after descending the Malheur River, Ogden records that "many in the camp are in a starving state. As for myself, I manage so far as to secure a meal per day. . . . From the sources of this river until this day we have not seen the track of a deer or antelope. This is strange as the country is most favorable for them and but few Indians to molest them. Still not one to be seen."[64]

Meek also concludes that "It may seem incredible to the reader that any country so poor as that in which our trappers starved could have native inhabitants. Yet such was the fact; and the people who lived in and who still inhabit this barren waste, were called Diggers, from their mode of obtaining their food--a few edible roots growing in low grounds, or marshy places. When these fail them they subsist as did our trappers, by hunting crickets and field mice."[41]

To supply food for their parties, both Wyeth and Ogden record trading with the Native-Americans for salmon, dried salmon, dogs, and colts. However, the extent to which they sometimes lacked game is shown by the sacrifice at times of their own animals although loath to do so. After a very stony descent east of the Owyhee River the horses had bloody feet and Ogden says, "I trust we will preserve them with the exception of those [which] should we not procure salmon will inevitably fall for the kettle and which I cannot prevent. A more wretched country was never seen."[63] Some do end up in the stew pot. Two days march east of the Owyhee River, Ogden writes that on "these barren plains" "when we last passed here a horse was then killed for food and the same [h]as again been acted here this day."[63]

Near McDermitt, Work comments that "The best hunters are out, but as usual did not see a single animal of any sort. 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."[93]

b. Antelope

However, the countryside was not entirely devoid of game. Antelope were occasionally mentioned by Ogden and although trained hunters accompanied the party, they weren't always successful. "Our hunters joined us as we reach'd the encampment. Only one antelope was seen by them and fortunately killed."[63] Later, near the mouth of the Owyhee River he records that, "2 beaver taken this day. Also, 1 antelope killed. Our hunters saw six but were unfortunate and could not kill."[63]

John Work, traveling North of McDermitt, notes on two successive days, "The hunters were out today but without success. Two antelopes were seen yesterday, which was a novelty." "The hunters were out, F. Payette had the good fortune to kill a male antelope. One of the men saw four sheep in the plain but did not kill any of them."[93]

"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. We must hope should we not find beaver ere we reach the South Branch [Snake River] that there we may find the natives who will give us a supply of salmon. Almost any thing would be preferable to the roots we now subsist on."[63]

c. Deer

Although Ogden's general description of the area talks about a lack of deer, there were apparently certain spots to the north west of the Owyhee River where they were to be found. On February 14, 1826 camped on the Malheur River he writes that "Gervaise killed two small deer . . . they are most abundant."[63] To the north, he finds deer between the Malheur and Burnt Rivers. ""One of our hunters succeeded in killing five fat deer. From being so many days on short allowance only one meal in 24 hours the sight of these deer was most pleasing."[63] Apparently near this same spot the following year he comments that, "The hunters kill'd five deer at this same place our hunters had the same success last year and it is strange they should be numerous here and in any other part of the river scarcely any are to be seen."[64]

d. Bison

Although the trappers find little game, there is no doubt that there were some deer and pronghorn. Comparing the area to the other side of the Rockies, Ogden does wonder about the lack of buffalo in certain areas and not in others. Since there are none, Ogden says "we must as we have done content ourselves with a dish of roots in lieu of buffalo or beaver."[63] Daniel Montgomery writes 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[36] says that the phenomena was first remarked by Zenas Leonard. In 1832 he "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.'"[16] Lyman and Wolverton[37] 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."[47]

e. Native consumption of game

The variety of game eaten by the Tagötöka is consistent with a general scarcity of game since the Tagötöka were willing to both hunt and consume small animals such as mice and chipmunks. In addition to eating deer, antelope, elk, buffalo, and mountain sheep, the Tagötöka were willing to consume mink, 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.[85] In addition a number of birds were taken as food.

7. Fish

As mentioned earlier, when he arrived on the lower Owyhee River, Ball is happy since "a short distance down the creek, we found Indians who had our future food, dried salmon."[5] This would indicate that salmon did run up the Owyhee River. However, there are many more comments of salmon in the Boise River. In 1812, Robert Stuart first mentions the Boise River as "where immense numbers of salmon are taken"[86] with the salmon "forming after the roots, the principal article of food which the natives of this barren tract possess."[86]

When Wyeth's party first reaches the Boise River on Aug. 19th, Townsend records that "It [the Boise River] is literally crowded with salmon, which are springing from the water almost constantly."[88] However, downstream on the Boise River they saw Native Americans fishing and tried to trade for fish. "Captain W. and his companions returned, bringing only three small salmon. The Indians had been unsuccessful in fishing, not having caught enough for themselves, and even the offer of exorbitant sums was not sufficient to induce them to part with more."[88]

Although there are many mentions of trading for salmon, the fish were not always in plentiful supply so there are some times like this one on June 22 when Ogden writes, "The natives are taking a few salmon, but not in sufficient numbers to supply their wants."[63]

One other dried fish is mentioned on the Malheur River shortly above the Snake River. "Here we found an Indian with a good stock of small dried carp. All were traded and will supply us food for three days."

The Tagötöka report catching trout, suckers and salmon within their territory.

8. The Owyhee River

When Wyeth is traveling west in 1832, he arrives on September 13th at "a creek [Owyhee River] about as large as Charles River at Watertown, where we found grass, salmon and Indians".[94] This description of the Owyhee as a broad river is reiterated by Ogden's observation in February 1826, that "Sandwich Island River . . . is from appearance a fine large river and from the upper parts not having been visited is worthy of examination. . . . Hunt this day 2 beaver altho 50 traps set."[63]

However, the trappers did not always find the water level high. On July 8, 1828 when Ogden "reached Sandwich Island River, [he] found the water remarkable low."[65]

Ogden also didn't record his trappers as having very great success on the Owyhee. On two successive days in July 1827, he wrote "I was glad to see the Owyhee River party make their appearance. At the same time, their success is miserable and report of the river very far from being flattering as regards beaver. And so far as they proceeded the bank of the river lined with rock, the stream wide and deep."[64] "At daylight I sent two men in quest of the three absent men . . . [they] succeeded in finding them in Owhyee [sic] River. . . .Their success most wretched during their absence 16 days only 20 beavers. It is however satisfactory to find them safe and all alive."[64]

9. River fluctuation

Ogden records 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 comments 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]

10. Land

John Ball mentions the plains with a shallow thin soil over the basaltic rock.[5] Several of the journals have references to the land between the Owyhee River and the Malheur River (at Vale) as sandy, "traveled briskly over a sandy country. Suffered considerable for water."[15]

C. Oregon trail travelers

The picture which emerges from the trapper's observations of an area with little game, changeable river flows, and treeless rivers is largely corroborated by the observations of the first emigrants. There were two principle routes along this stretch of the Oregon Trail. The southern route followed the south side of the Snake River passed Givens Hot Springs and crossed the Owyhee near present day Owyhee Junction. The northern route crossed the Snake River at Fort Boise (Figure 4.4).

In 1836, Narcissa and Marcus Whitman traveled along the Snake returning to their mission in Walla Walla. However, the first wagon train is considered to be the Peoria Party in 1839. In the Whitman journals, it is fairly easy to tell when these emigrants were near the lower Owyhee River since many of them stopped at Fort Boise. Although the emigrants only crossed a small stretch of the lower Owyhee subbasin, the observations which they made may be considered representative of a larger area, since they are the only existing historical accounts of the region.

The emigrants began their journeys planning to carry most of the supplies that they needed to reach the Oregon Coast so there are fewer references to the availability of game. However, they may have recorded more concerns with the availability of grass since they did not carry animal feed for the cattle or horses and frequently were taking stock with them.

1. General description

Before the emigrants set out, many of them may have read Lansford Hastings's *The Emigrants' Guide to Oregon and California* written in 1845. He presumably wrote it from his personal experience traveling on the Oregon Trail. He deals in generalities about the different areas, however his observations on the Eastern area probably reflect a general perception of the time. "There are also several very extensive plains and valleys, in the immediate vicinity of Fort Boisia, which are quite fertile, and capable of producing grain and vegetables, in great abundance; yet, the surrounding country, is generally, barren and mountainous."[35]

Not only does he consider the area barren and "as a general thing, [having] a very great deficiency of timber."[35] but when compared to the more humid climates of the east and Midwest he is amazed at the temperature swings. He warns travelers that "even in the same portion of the country, one day, you have the extreme heat of a southern summer, and the next, the excessive cold of a northern winter. There are other portions of this section where, in the short space of 24 hours, you experience four

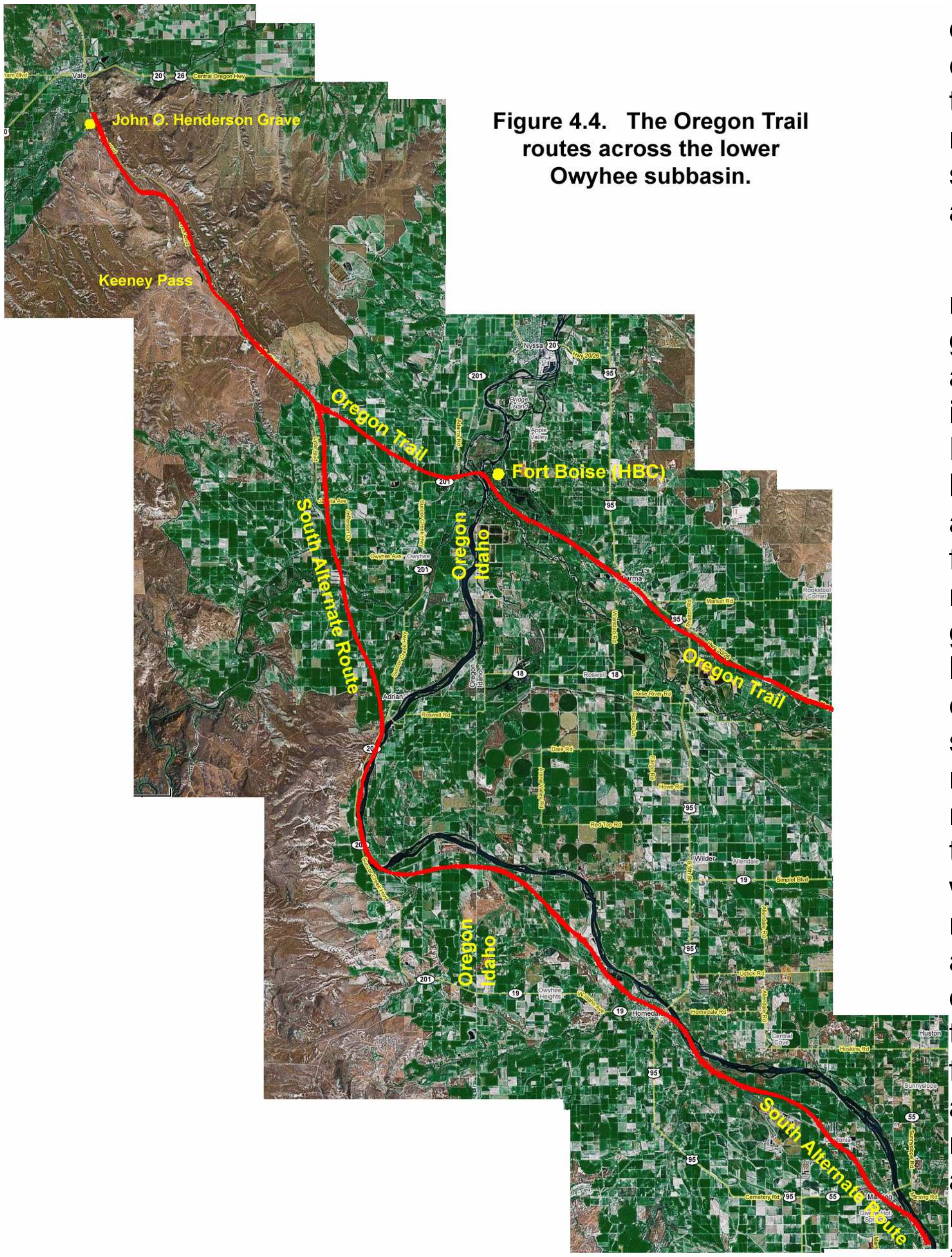


Figure 4.4. The Oregon Trail routes across the lower Owyhee subbasin.

distinct changes, corresponding in temperature, with a northern spring, summer, autumn and winter."[35]

He also reports that "the game of the Eastern and Middle sections, is not very abundant. It consists chiefly, of bear, wolves, elk, antelope, muskrats, foxes, beavers and martens. . . . No game, can be said to be very plentiful, in either of these sections. Persons may travel through many parts, of both these sections, for weeks together, and not see a wild animal of any kind, during the whole time. The fur-bearing animals are the most numerous, but they are much less numerous latterly, and they are constantly diminishing in numbers. . . . Water-fowls are very seldom met with"[35]

He doesn't see the barrenness, the lack of trees, the temperature changes, or the absence of much game as discouraging settlement but he sees the area as "better suited to the rearing of herds, than to farming purposes. Some experiments in this respect have been made, in all the different sections. In the Eastern section, at Forts Hall and Boisia, both horses and cattle are reared in large numbers, where they thrive most admirably. The Indians of this section also, rear horses in vast numbers, and of a very superior quality."[35]

Emigrants on the Oregon Trail frequently passed through the area around the Owyhee River in two or three days. Not all of them even made entries in journals during this time period. Others described Fort Boise and Mr. Payette who ran the fort. Later emigrants listed purchases made at the fort. All of the comments quoted below were written about the area approaching and leaving the Owyhee River unless otherwise noted.

2. Climate

The emigrants coming from the higher rainfall areas of the east or Midwest frequently remarked on the arid nature of the countryside near the Owyhee River along the Oregon Trail. Sidney Smith, coming across with one of the first emigrant groups, the Peoria Party, remarked upon the continuing lack of rain at Fort Boise. "15th SUNDAY . . . for the last 4 days the wind has been from the West and very Cold and dry changing to the No. West. no rain at this place for the 5 last months; everything is burnt up by the Drouth this fort Stands upon Snake River and a most butifull location."[28]

Thomas Farnham didn't think the lack of rain would ever allow farming in the area. After leaving Fort Boise, he says "Our packs and ourselves were sent across the Saptin [Snake River] in a canoe; and our horses having swam it . . . we left . . . Our course was down the west bank of the river. The soil was sand and clay mixed in nearly equal proportions. Its composition is such as to render it fruitful; but the absence of dews and rains forbids the expectation that it will ever be so."[23]

Evans McComas gives a less generous, vivid description of traveling across country where there is no rain. "The country all the way down the Snake River is one of the most desolate and dreary waste in the world. Light soft ground with no soil on top, looking like an ash heap, dust six inch deep and as light as flour. When a man travels all day in it he looks like a miller. You can see nothing but his eyes and them look red. The dust is here so light that it sometimes raises 300 feet above the train."[53]

3. Vegetation

a. Grass and shrubs

Grass and sagebrush (wormwood) are often mentioned together by the emigrants. Grass is a concern and mentioned frequently because not only the horses or oxen but also any stock being moved with the emigrants needed to feed on it. Coming west with one of the early pioneer parties in 1842, Medorem Crawford describes the countryside in three journal entries before reaching the Owyhee river. "Astonishingly barren country . . . found Indians plenty towards evening. Camped near their village [29 miles east of Fort Boise], poor grass." "Camped on the river [14 miles east of Fort Boise], poor grass." Almost across from Fort Boise "No alteration in the general appearance of the country . . . very poor grass. Camped in the evening on Warior River [Owyhee], a branch of the Snake."[15]

Members of several wagon trains commented on poor stands of grass. Abigail Scott says ". . the grass is miserable the dust very annoying & the sun oppressively hot we lost another ox to day from eating some poisnous herb."[76] Lafayette Spencer records a "Camp on Malaher River. Grass scearse."[81] Even at the Owyhee River, there are mentions of the scarcity of grass. Philemon Morriss writes that they "came to Oywhee river today. . . . Grass rather scears, warter plenty."[59] William Lieuallen says "We travel a round the bend and left Snake river a little & came to Owyhee river in

Oregon Baker Co. & campt on the same & lay over the rest of the day. Poor like grass."[29] Since there were few routes, the lack of grass along the Oregon Trail may have been partially due to previous groups passing along the same route so that between 1839 and when these journals were written in 1847, 1852, 1852, and 1864, respectively, the grass had been eaten repeatedly. However, even before the emigrant trains began coming, Ogden recorded areas within the region with poor grass or no grass.[63]

Worse than poor grass was the complete absence of grass. On a different day Abigail Scott writes, "We find, no grass, willows, or even sagebrush, nothing like vegetation is to be seen except the thorny Greasewood and a species of herb resembling the garden wormwood."[76] John McDowell complains "In camp for dinner 5 miles east of the Snake River where we cross. This is an awful dusty country. Dry and no grass but lots of sagebrush. In camp for the night on the Snake River close to the Ferry."[55] The night before reaching the Owyhee, Evans McComas records they "encamped without grass."[53] In almost the same spot, Philemon Morriss who complains of the poor grass at the Owyhee river writes, "Tollerable fore grass and fuel such as willows and wild sage and some dusty. I hope wee will soon get out of the cursed sage."[59]

In 1839, Robert Shortess noted some of the other vegetation, although his description makes it seem very sparse. "The natives had nearly all left their fisheries and there was scarcely any sign of life, either animal or vegetable, except sagebrush, dried grass and an occasional stunted cedar or pine clinging to the rocky bluffs, or a few dwarf willows on the river's margin. We arrived at Boise".[29] Near the Owyhee River, Evans McComas notes that "The ground is covered with two of the most detestable shrubs that grows, greasewood and artimecia or wild sage."[53] and Thomas Farnham describes the vegetation as "bunchgrass and wild wormwood."[23] Mrs. Joseph Myers' relative recalls vegetation near the mouth of the Owyhee River which helped feed the pioneer family. She says "a very poor emigrant cow came along, which we killed and ate. By mixing the beef with rosebuds and pusley, (purslane?) we made it last us two weeks."

b. No trees

Some emigrants remarked on the trees along the Boise river just as the trappers had done, because the trees were a novelty. Narcissa Whitman says they "Arrived at Snake Fort [Boise] about noon. It is situated on Bigwood river, so called because the timber is larger than any to be seen this side of the mountains. It consists chiefly of cottonwood and is small compared with timber in the states."[91] And Joseph Williams writes, *"September 1st.* We reached Fort Bois. Some timber grows along the Bois, principally cotton wood."[30] "Indians knew the Boise Valley as "cop-cop-he-bash -- or the 'much cottonwood feast valley,' [and there] the Indians found shade trees, luxuriant grass, hot springs, and salmon in abundance for food."[56]

Trees are such an unusual site that Abigail Scott comments upon some which they see. "The country around is barren in the extreme. We saw some trees this afternoon in a S. W. direction from us along the Snake river. We encamped upon the

Owyhee. This is a clear and rapid stream with a peply bottom; It is (about) twenty five yards in width. . . . The water is clear and palatable but is rather warm."[76]

Likewise, the absence of trees is indicated by the naming of a single tree which emigrants reached before arriving at the forested hillsides of the Blue Mountains. Hastings' describes this in his Emigrant's Guide. "In the midst of this valley, is a single pine tree, which is called l'arbour seuel, the lone tree, from which circumstance, the valley is called the 'Lone Tree valley.' There is not a sufficiency of timber in the immediate vicinity of this valley."[35]

Some emigrants record their arrival at such an obvious landmark. Medoram Crawford is within sight of the blue mountains when he writes that "At some distance we could discover a tree which we at once recognized as 'the lone tree' of which we had before heard. . . . I believe [it] is respected by every traveler through this almost treeless country."[15] Narcissa Whitman says they "came as far as the Lone Tree. The place called Lone Tree is a beautiful valley in the region of Powder river, in the center of which is a solitary tree, quite large, by the side of which travelers usually stop and refresh themselves."[91] Joseph Williams says they "nooned at the Lonely pine So Called from the fact that their is no other pine in Sight and this Rears its head in the prairie like a towering monument as a guide for the Lonly traveler of the Prairia"[28]

Narcissa Whitman gives us an idea of what grows along the waterways instead of trees when she described the construction of a canoe at Fort Boise on the Snake River (Figure 4.4). "This being a fishing post of the Indians, we easily found a canoe, made of rushes and willows [Figure 4.3], on which we placed ourselves and our saddles (Sister Spalding and myself), when two Indians on horseback, each with a rope attached to the canoe, towed us over. (O! if father and mother and the girls could have seen us in our snug little canoe, floating on the water.) We were favorites of the company. No one else was privileged with a ride on it. I wish I could give you a correct idea of this little bark. It is simply bunches of rushes tied together, and attached to a frame made of a few sticks of small willows. It was just large enough to hold us and our saddles."[91]

After escaping a Native American attack on their wagon, two families traveled about 60 miles on foot. Arriving at the Owyhee River, they felt they couldn't proceed further and constructed shelter from the available willows. We "were obliged to build wigwams, which we did as well as we could, with willows. Here we lay by entirely. This was on the Owyhee River, about three miles from Ft. Boise which was deserted."[95]

4. Wildlife

Mostly, wildlife in the area is not mentioned in the travelers' diaries. However, Franklin Owen is thankful for some wild fowl. "For three days I had eaten nothing. But that evning, Dave, Bruce & Will, Howard, went out killed, & brought to camp some Prairie Chickens, which were dressed, & prepared by one of our best women that ever lived, who made Soup for me that I have, & shall ever think was the panasea that Saved my life."[67]

5. Fish

Not only is fishing for salmon by the Native Americans mentioned, but two of the early travelers comment on the abundance of salmon. In 1839, reaching the confluence of the Boise and Snake Rivers, Sydney Smith says "the River abounds in Salmon."[28] When Joseph Williams stays at Fort Boise in 1841, he not only complains about the Native American noise at night but that "the salmon also kept a great noise, jumping and splashing about in the water."[92]

There was an abundance of salmon for food at the Boise River. The "Shahaptain-Shoshoni tribes spent the early summer here . . . Oral traditions tell of fishing and harvesting as late as the 1860's when white prospectors moved in."[56] Probably the abundance of salmon in the Boise River means that some salmon were also migrating up the Owyhee River.

6. Oregon Trail Roadside conditions Owyhee to the Malheur

Although the emigrants on the Oregon Trail made many observations pertinent to understanding the conditions in the lower Owyhee subbasin in the 1840s and 1850s, only a short section of the Oregon Trail was in the lower Owyhee subbasin. The South Alternate Route of the Oregon Trail entered the subbasin just beyond Adrian. The principal Oregon Trail crossed the Snake River at Fort Boise and entered the subbasin just before the two routes joined. The combined routes of the Oregon Trail exited the subbasin around Keeney Pass (Figure 4.4).

Joseph Williams, traveling in 1840, describes this section of the trail after leaving Fort Boise. "We now started for Wallawalla, over hills and rough roads. We don't see any timber, scarcely. . . We passed some more hot springs to-day, and traveled some very dangerous roads."[30]

By 1852, greater traffic along the Oregon trail had resulted in a somewhat improved "road". Philemon Morriss describes his travel over the same stretch on August 8th. "This morning wee struck out for Malhear river. 15 miles over a good road, some dusty. A long and a graguel [gradual] assend and then a long desend. Good grass 3/4 of a mile above the road and warter [maybe after arriving at the Malheur River]. Willows for fuel. It is warm today."[59]

In 1853, the more heavily traveled road is seen as not only dusty, but lacking water. D.B. Ward writes, "Our next camp after leaving the Snake River was fifteen miles away. . . . Between these two points we suffered more for want of water than at any other time of the road, because, being short of teams we did not fill -- as was our custom -- our water casks, and the day being exceedingly warm and the road dry and dusty, our suffering for water was intense."[89]

Evans McComas, in 1862, also comments on the lack of water. "Had to drive another long drive without water. . . . to the 'Malhue' River and encamped."[53]

By 1864, there are a couple of dwellings and a ferry where the southern route crosses the Owyhee River. Ameil Clude describes the day's journey, "Travel about 18 miles heavy dust without water or grass. We came by the ferry on Owyhee by 2 houses then up a sandy rise to the road that came by Boisee City then up a long cannun & over the hill & down another cannun to Malheigh river."[46]

7. Conclusions

The Oregon trail was in regular use from 1843 until the 1870s; by 1849 about 11,000 people had come through the area and by 1853 the number was well over 50,000.[11] The emigration of so many people inevitably changed the area and ended the era which we can characterize as "at contact". What sort of picture emerges from the writings of the trappers and emigrants who recorded what they observed while skirting around the lower Owyhee subbasin?

Predictably, the observed climate is very similar to what we would note today. The summer days are hot with almost no rain. Away from the main rivers, there are few easily accessible water sources in the summer.

The Owyhee River is observed as both a broad river and as having little water in it. Other water courses in the area are also noted as varying in width on different visits to the area. There are 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 present along the river banks today (Figure 4.3). Mostly, the area was treeless, so that the presence of trees was noted. The Boise River was known for the trees along it, and there is some mention of trees when travelers reached the Burnt River. Even the willows were not always abundant along river banks. The willow was used by the Native Americans as a building material. Mrs. Whitman[24] describes the construction of a canoe from willows and Fremont[14] describes the use of willow in the construction of Native American housing.

The barrenness of parts of the region is frequently mentioned. Combined with complaints about dust, it is obvious that it is not only lack of trees that is causing this observation but also poor ground cover. The vegetation in many of the areas is sagebrush and greasewood. Although the stands of bunch grass are sometimes described as good, they are at other times decried as poor.

Perhaps the most amazing observation, particularly from the trappers' diaries, is the almost complete lack of big game, game birds, and rabbits.

There are salmon in the rivers, including the lower Owyhee River. There are times of year when the rivers were teeming with salmon. Fremont[14] describes seines made out of willows which the Native Americans strung clear across the Snake River to harvest the salmon.

D. Early settlement

Even after the Union Pacific completed the railroad to the West Coast in 1869, there were still some wagon trains on the Oregon Trail clear into the 1880's. The End of the Oregon Trail Interpretive Center says that they've had visitors who recalled that, because their family couldn't afford the train fare, they traveled the trail by wagon as late as 1912.

Although many people passed through the Snake River Valley, "To those who had grown up in the environment of mixed meadowland, hardwood, and conifer forests of the eastern United States, the Snake Plains particularly seemed forbidding and beyond consideration by “civilized’ people".[8] The emigrants were headed to other areas.

Fort Boise contained a few residents. The Hudson's Bay Company tried to have its outposts self-sufficient and encouraged them to farm and raise stock, both to support the employees and to help the trappers working in the area. In 1846 "Fort Boise had two tilled acres, twenty-seven cattle, and seventeen horses".[8] James Gibson concludes that the efforts enabled Fort Boise "not only to feed their own personnel but also to succour American migrants on the Oregon Trail in the first half of the 1840s."[25] The Fort was built of adobe and was largely destroyed by the great flood of 1853. The rebuilding was only partially done when even this brief occupation of the valley ended. Fort Boise was abandoned in 1854 due to frequent Native American raids.[24]

"While the army was busy fighting the Snakes, civilians finally began to enter the vast interior of East Oregon for reasons other than travel or exploration. A military order issued in 1856 against settling east of the Cascades [was] revoked two years later."[12]

1. Discovery of gold

Henry Griffin had been on an unsuccessful expedition in search of the Lost Blue Bucket Mine when he struck gold just a few miles south of Baker City, Oregon in October 1861. By the summer of 1862, a tent city with a population of over four thousand had sprung up.[18] Gold was discovered in the Boise Basin in 1862 and the population of the area boomed. As areas were claimed, newcomers searched elsewhere.[38]

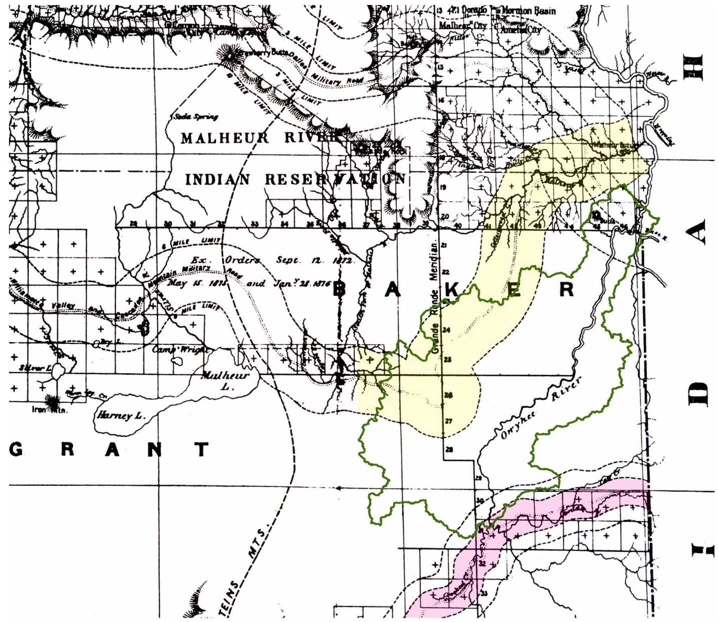
In 1863, a group of prospectors stopped by a stream in the Owyhee Mountains to camp. The first scoop of gravel one of the men tried panning had "about 100 colors". Within an hour, every member of the group had successfully panned some gold.[90] The rich placer deposits of gold along Jordan Creek led to the discovery of quartz ledges where hardrock mines were developed by the fall.[90] Not only did 2500 miners leave the Boise Basin and move to the Owyhees, but the gold seekers from elsewhere also came. With both placer and hard rock mining, there were "two hundred fifty mines recorded from 1863 to 1865."[32] The towns which grew up to supply the mines, Booneville, Ruby City, and Silver City, were the first permanent settlements in the Owyhee watershed.

2. Description of the environment

As with the trappers and emigrants, most of the descriptions of the environment during the 1860s are written about areas which surround the lower Owyhee subbasin or skirt through the edge of it.

During the 1850s the wagon roads west of the Cascades had been built by the U.S. Army. In 1864, Lieutenant Colonel Drew of the Oregon Calvalry explored a route which took him across southern Malheur County along roughly the route planned for the Oregon Central Military Wagon Road (Figure 4.5). The Oregon Central Wagon Road was suppose to start at Springfield, Oregon. After entering Malheur County it would run northeast to Crooked Creek, down Crooked Creek to the Owyhee River and present day Rome, and up Jordan Creek to Silver City, Idaho.[42,66]

Since Lieutenant Colonel C.S. Drew's journey took him across southern Malheur County, it provides a good description of the landscape in some of the Owyhee watershed directly to the south of the lower Owyhee subbasin. Since he refers to "the old route", it is possible that there was some sort of trail through the area.



The Oregon Central Wagon Road approximately followed the route explored by Lieutenant Colonel Drew.

Area around the Willamette Valley Cascade Mountain Wagon Road where the company received land grants

Approximate edge of the lower Owyhee subbasin - the old projection is difficult to duplicate.

Figure 4.5. An 1876 map from the General Land Office which shows the location of the three federal grant roads that came across Malheur County

His first record in the watershed is near the headwaters of Crooked Creek. He says they "continued eastward along the old route over a continuous sand and sage plain, with a few spots covered with fragments of lava, and two small, dry, hard bottomed, basins, to the large cluster of springs that are the source of Crooked creek."[20] At the springs he notices that "all but the largest are thoroughly shaded by manges of wild parsley. Between and around these springs there is perhaps two square miles of very good land, covered with a fair growth of grass. The usual sage and a little greasewood is all there is for fuel."[20]

Although the area around the springs has grass and some riparian vegetation, the vegetation disappears as they travel on down Crooked Creek toward the Owyhee River. It passes "through deep volcanic chasms that widen occasionally sufficient to allow a little inferior grass to grow along the waters edge at the bottom, and finally empties into the Owyhee a few miles below the crossing."[20] Above the gorge, the "country through which it passes is covered almost entirely with lava, sand and sage."[20]

At the Owyhee River, they cross it "by a gravely ford, smooth, and in the summer season, with but little depth of water. The river here is about sixty yards wide." On his first crossing on September 2nd and his return crossing on September 23rd he remarks that "the greatest depth of water on the ford was not to exceed fourteen inches."[20]

After climbing the eastern side of the Owyhee canyon, the four miles to the entry to the Jordan Creek Valley are described as a route that again goes "over lava and sand, and through sage and some greasewood."[20] Water was not running in Jordan Creek, but instead "Jordan Creek, through nearly the whole length of the valley, was in pools, and of course its waters are correspondingly poor. Some of these pools are deep and four or five miles long, and are somewhat abundant with fish. The line of the creek is heavily fringed with large willows."[20]

The vegetation along Jordan Creek in the valley is contrasted to the mountain vegetation near the headwaters of the creek. This Drew describes as "quite well timbered with fir, some pine, and a little of the cottonwood."[20] By the time he reaches Silver City he is describing the mountains as being "sparsely covered with fir, and some pine, that answers for the practical use for which it is required, but the quality is not good. The first lumber mill of that region went into operation in September."[20]

Even before the miners had discovered gold in the Owyhees, Lewis Scholl, a member of the Wallen expedition trying to locate a wagon route between Salt Lake in Utah and Dalles City, Oregon entered Jordan Valley in 1859.[74] He had come up the Owyhee River and he contrasts what he sees in the valley with the "somber color of the hills and bluffs, barren the entire distance I traversed to date."[96] Now the landscape "changed suddenly as by magic. . . . to a most cheerful green."[96] He too can see the distant mountains, "a high range covered with heavy timber, and a little scattered snow . . . towards the south."[96] After "crossing previously rich bottom land and a few small rivulets," he describes the encampment as "close to a small brook. Prairie chickens and sage hens were in abundance here . . ."[96]

Alexander Fuqua Canter recalls that when he came to Jordan Valley in 1864, "All that I found in this valley was an abundance of grass and prairie chickens. . . . I had to kill a couple of prairie chickens for each meal or go hungry while I mowed hay."[43]

The willows along Jordan Creek and the grass in the valley didn't offset the generally negative impression of the arid conditions for some other early travelers through the region. Arriving at Crooked Creek, Lieutenant Gates tells travelers going the other direction towards Boise to "expect nothing but more of the same -- sand, sage, alkali, and rocks."[32] Major Gorham Gates Kimball is even less flattering when he writes, "I was brought up and educated to believe there is a hell where all had to suffer for their sins. . . . I now think there was one once and the country over which I have just passed must have been the place where it was located. I have seen no boundary lines, but the marks of the heat are still there -- and I guess all the rocks that were not used were thrown into the devil's half acre."[32]

a. Willows

In the records of the early settlers, when willows are mentioned, they are along the streams. David Shirk recalls wondering if they should "make a break for the willows along Jordan Creek."[77] when attacked by Native Americans. J.W. Hill explains how he ended up in Jordan Valley with only "shirt tails". He had been at the Owyhee ferry and writes "it will be understood that often on the frontier clothing is scarce. I only had one pair of pantaloons, and in the morning previous to the Indian attack I had washed and hung them out to dry on the willows by the river."[31] Describing how in another instance the Native Americans lured vigilantes into a trap, Mike Hanley describes the place where they were camped as a "box canyon, a place known long to the Paiutes as *Sihwiyo*, 'Willows Growing all in a Row.' The stream running through the center was lined with willows."[32]

In 1864 Camp Henderson was established on Crooked Creek southwest of Jordan Valley. It was the closest cavalry camp to the Owyhee Crossing. A description of the time describes "the soldier-made huts as being constructed of material at hand, wild cane grass (rye grass) [great basin wild rye], sagebrush, and willows."[74]

Slightly to the north of the subbasin, at the Malheur ford where Vale now stands, in 1863 Jonathan Keeney took up a squatters right and built the Wayside Inn. Like the soldier's huts, the building was made of willows, but he plastered them with mud.[36]

3. Introduction of resource based industries

Following the discovery of gold, there was an influx of miners. Traders and some settlers began supplying the miners with the necessities of life.

Not only did the miners require food, but their horses required feed. The land with creeks from which water could easily be diverted was the first settled by men "who found they could make more money cutting hay and raising vegetables to sell to the miners. . . . Jordan Valley and its tributary, Pleasant Valley, were settled quickly from 1864 on as an adjunct to the mines in the Owyhee Mountains."[43]

Ruby City was requesting hay as early as 1864, but Alexander Canter recalls that "no one of us had a team, neither was there a road to haul hay over had we a team. But a few of us succeeded in trading hay for oxen and wagons, and went at building roads over the mountain side via Cow Creek, then we began delivering hay to the mining towns."[43] Although initially it was settlers closest to the mining towns who supplied the towns, as population grew some of the supplies were being produced in the lower Owyhee subbasin.

a. Livestock industry

Other entrepreneurs recognized the grazing potential of the land. In 1867 Con Shea brought in a herd of Texas long horns from Texas for the start of the cattle business in the Owyhee region[7] "and for years operated one of the largest stock ranches in the west."[27] Not only were cattle introduced to the region to feed the miners, but sheepmen realized that "gold-seekers would pay high prices for mutton, especially when beef was scarce."[32] Once the stock were run out onto the range from wintering grounds along the Snake River, many of them would have ended up grazing in the lower Owyhee subbasin.

Raising cattle and sheep to feed the miners was the beginning of the livestock industry in Jordan Valley,[43] but there was also a growing need for horses, mules, and oxen. These draft animals were needed to bring goods to Silver City, which depended completely on supplies brought in from outside.[31] David Shirk recalls that in "those days, feed for stock was everywhere abundant, and the few ranchers in Jordan Valley seldom or never put up hay for their stock."[77] The lure of free grass and the demand both for meat on the hoof and for draft animals brought more families to eastern Oregon to raise livestock.

In 1872, "Peter Keeney and Thomas Glenn were the first to begin ranching on the lower Owyhee River. They had cattle and there was some grass available, especially in the spring. There was a market for beef since Silver City had a sizeable population. The Owyhee River provided an adequate water supply for the cattle."[87]

b. Farming

The first farming in the county began to supply the livestock industry and was limited to raising hay and grain. Where water could be used, small pieces of ground were being planted. The Ruby City newspaper comments that although "many let their livestock rustle for themselves during the winter, there was a demand for winter feed"[43] and imported grain was expensive. Small patches of grain were planted. To the north of the lower Owyhee subbasin, in 1868, David Dunbar began a wild hay ranch about two miles southeast of present day Ontario.[43] By the 1870s settlers along the Owyhee River in the lower Owyhee subbasin grew wild hay.

c. Salmon

In July 1859 upstream from Jordan Creek, Louis Scholl describes the Owyhee River as "abounding with salmon."[74] An idea of what "abounding with salmon means comes from the story of four travelers in 1852 who "came to a small stream, presumably Burnt river, which they said was literally alive with salmon. So numerous were the fish that, with forked sticks, they caught all the fish they could eat"[27]

Although there may have been fish in the rivers at the time of the early settlements, fishing is not recorded as a local enterprise. About this time or a little later, there was an elderly Dutchman who put a salmon seine in the Snake river. Dan Purcell who worked for him recalls that a "day's catch would run maybe 52 or 53 salmon, weighing 8 to 18 pounds apiece." The salmon were sold to peddlers who peddled them to mining camps.[22]

d. Timber

The timber industry developed to supply wood to the mines and new towns. Wood was used by the miners as fuel both for cooking and heating during the cold Owyhee winter. When David Shirk first arrived in the area, he acquired a "wood ranch situated at the head of Blue Gulch, six miles from Ruby City, the main town at that time."[77] Timber was also used for building and to shore up the mines. Originally the timber that wasn't big enough for use in the mines was burnt in the smelters.[6] Later, the mines hired people to cut trees for the fires.[70] "The miners came to the Owyhees in 1863 and by 1867 most of the timber and brush was gone."[31]

The lack of timber around Silver City, probably meant that the timber on the Mahogany Mountain, in the lower Owyhee subbasin became attractive as a source of wood.

4. Water

Early in the spring 1866, the water in the Owyhee River below the mouth of Jordan Creek had been very high. Jean Baptiste Charbonneau, Sacajawea's son, became very wet crossing the River, contracted pneumonia and died.[45] The flow in the Owyhee varied throughout the year, being highest in the spring.

The spring floods could also be damaging. During the winters the Owyhee River froze and no water was visible. The snow melt flowing into the Owyhee River in the spring and the warmer temperatures would cause the ice to break up and form dams. When these ice dams broke, the water which was released carried the ice and rocks downstream. Many years the ice and rocks scoured out the river bed. Most years, the spring floods turned the Owyhee River into a torrent which uprooted everything within reach of the raging water. The rest of the year the flow in the Owyhee varied, dwindling to a small trickle in the hot summer time.[87]

Although there was plenty of water in the Owyhee River during part of the year and the land along the river was fertile, the early settlers were limited in their ability to remove water from the river and use it to raise hay and grain for their cattle.[87]

5. Roads

After the discovery of gold on Jordan Creek and the rapid growth of the mines, access was still only by foot. Pack strings could go where wagons couldn't, so supplies were carried in by pack trains. The quartz ledges which had been discovered required heavy machinery including stamp mills to break up the rock.[43,31] Some roads were built by the cooperative efforts of neighboring settlers, but frequently roads, ferries and bridges were built privately so that tolls could be charged.[43]

Three principal roads connected the mines to the rest of the country. Two roads went south, one to Chico, California and the other to Winnemucca. One road went northeast, through Murphy to the Boise Valley. None of these roads passed through the lower Owyhee subbasin.

a. Willamette Valley and Cascade Mountain Military Wagon Road

Although the military conducted some early surveys searching for easier transportation and communication routes, later the "military roads" were privately constructed. To encourage private construction, the Republican congress gave companies willing to construct roads large tracts of land. In Oregon, these privately constructed roads could ostensibly be used for military purposes so they were called "military wagon roads."

Since the roads were supposed to be toll free, the private companies received land grants in place of either payment for construction or future tolls. Land grants consisted of alternate sections of land within six miles on either sides of the road. To assure that the received lands had rich potential, the company's road surveyors, when possible, laid out routes along major stream courses through lush bottomlands.[42,43,57,66]

One of the military roads ran through the lower Owyhee subbasin. In Malheur County, the Willamette Valley and Cascade Mountain Military Wagon Road ran from the Crowley area northeast to the Malheur River near Little Valley (Figure 4.5).[52] However, it is doubtful whether the road building crew ever constructed anything in Malheur County. When J.B. McNamee was sent from Washington D.C. to examine the road in 1887, he wrote "From the South Fork of the Malheur to Barren Valley (Figure 4.6) no road was made by the company. It is possible the construction party drove through that country, as there is some testimony that wagon tracks have been seen there. At the head of Barren Valley the construction party came into a branch of the Fort McDermitt road and followed it for about 6 miles . . . From that locality to the mouth of Cottonwood Creek, a distance of about 50 miles, no road was ever built until within the past five years. Ranchmen who had come into the country made roads for their own convenience and then over only part of this line."[43] In return for building a road which would be public and toll free, the company received alternate odd numbered sections, three per mile of road, in a belt on each side of the road (Figure 4.5).[43]

The roads in other areas had an effect on where settlements were established. However, since this road was not built, there was not the increased access for people to the surrounding areas and the consequent impact of people upon those areas. The land grants for the military road may have done more for populating the area than the road itself, since the companies tried to sell the land which they had acquired.[43,52]

6. Settlements

In addition to communities being established along the early roads, mining, grazing and farming all led to settlements in the Owyhee watershed. Most of these early settlements were around the edges of the lower Owyhee subbasin. Each of these settlements had some effect on the area where it was located. Fuel was collected for cooking and heating. Naturally occurring edible vegetation and game was harvested. Canter recalls that he "had to kill a couple of prairie chickens for each meal or go hungry" and Frank Cable "actually dug camas, a root that grows here, and lived on it alone for weeks."

7. Effects of livestock

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. Not only were there herds in Malheur County, but even animals not raised in Malheur County were driven across to the new railroad terminus at Winnemucca.[34,43]

Although many of these observations were made in subbasins upstream from the lower Owyhee subbasin where the first settlements were located, they provide a glimpse of the conditions in the still largely uninhabited lower Owyhee subbasin.

8. Changes and constants

By the beginning of the 1870s, changes in the lower Owyhee subbasin included the introduction of cattle and sheep on the range. However, some things had not changed. Residents of the area recorded weather events that were unusual. Two winters were recorded as unusually severe. In 1865-66 the Snake river at Weiser was almost frozen over.[27] In 1867-1868 when the snow started falling in early November, the Snake River froze solid from bank to bank. That year, conditions changed dramatically overnight. David Shirk writes that when they "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."[77]

E. End of the nineteenth century, early twentieth century

The changes in the areas surrounding the lower Owyhee subbasin during the 1860s set the stage for trends which continued into the succeeding decades in the lower Owyhee subbasin. Some changes were recorded, but some were so gradual that they weren't even noted by the individuals involved. Many of the records consulted for this 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.

Despite the government's best attempts to give away government lands between 1862 and 1934, there were 13,000,000 acres in the high desert of Oregon that were not claimed. Of this, 1,137,800 acres is in the lower Owyhee subbasin and is now managed by the Bureau of Land Management.[39]

1. Mining

Mining upstream from the subbasin continued even after the panic which followed the repeal of the Silver Purchase Act in October of 1893 (endnote 1). The Owyhee mines didn't depend only on silver. There was also mining for gold, copper, lead, zinc, and manganese.[32] Some of the negative effects of the mining affected downstream communities. Locally, it is known that in 1909 a big flood washed out cyanide vats at the Delamar mine and killed willows down Jordan Creek and there could have been effects further downstream in the lower Owyhee subbasin.

2. Grazing Pressure

The cattlemen were the principal users of the range lands from 1870 to 1880.[32] As the mines began to fail in the 1880s, some of the miners started raising stock and ranching.[27] As the small mines played out and prices dropped, raising livestock became the principle industry of Malheur County. After the Native Americans on the midwestern prairies were forcibly evicted, there was a need for livestock to stock the prairie grasslands. Buyers came to southeastern Oregon to purchase both cattle and horses.[43]

Before the constant pressure from homesteading began, the big cattle outfits in the Owyhees had tacitly divided the land so that they wintered their cattle in different areas, and, after meeting at Dry Creek for branding in the spring, they headed their cattle in different directions for the summer. When "ranches began springing up on all sides"[32] the understood domains no longer worked.[32] The Desert Land Act of 1877 encouraged settlers to settle on arid and semiarid lands and develop privately managed irrigation developments. 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."[43] The increase in the number of cattlemen led to an increase in cattle numbers. By the 1880s the region from Jordan Valley west to Fort Harney and north through the lower Owyhee subbasin contained hundreds of thousands of cattle.[33]

The rivalry between cattlemen, sheepmen and small settlers didn't come to open violence in Malheur County, but these three main factions tried to control or divide the public lands. The competition led to overstocking the range.[43] The buildup on the range of large numbers of cattle, sheep, and horses meant that there was a need to find markets. The transportation to distant markets was greatly improved by the extension of the Oregon Short Line to Ontario in 1883.[12,43]

There were several years when range stock died from a lack of food due to winter conditions. In 1873-74 stockmen estimated they lost 10 percent of their range stock. In the winter of 1880-1881 livestock loss was estimated to be 15 percent. That year the Snake river froze over to a depth of three feet.

During the winter, cattle were moved to areas where they wintered on bunch grass and white sage and few of the ranchers thought about putting up hay.[33] This changed after the summer and winter of 1888-1889. There was a terrible drought in the spring and summer. Waterholes dried up and feed was scarce. Cows that survived were in poor condition. Before the long winter even began, there was as average of two feet of crusted snow on the winter ranges. Dave Shirk used rye grass from the roofing on his buildings to feed his milkcow and several calves. Ranchers who hadn't put up hay lost almost all their cattle. [32,33,77]

Many of the same ranchers who ran cattle also had sheep. In 1900 most of the Owyhee sheep and cattle operators respected each other's right to the range. Like the cattlemen, some of the sheepmen had their "traditional" grazing grounds. "We'd winter in the Owyhee, shear at Iron Cabin, then trail through the country to South Mountain where we'd summer the sheep."[58] Bud Baltazar recalls that there "wasn't any trouble between the sheepmen and cattlemen in those days as there was enough grass for everybody. When the bunch-grass turned white . . . it was as tall as the sheep."[6]

The established sheep and cattle operators had a base property. Many of these were developed to raise hay for wintering the stock.[61] "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."[32] Although they approached congress and charged that the range was being destroyed by indiscriminate use, nothing was done.

Besides cattle and sheep, horses ran in the area. Frank Dobie thinks that it was doubtful if there was even one wild horse in eastern Oregon in 1848.[19] The number of horses in the Oregon desert was not substantial until the end of the last of the Indian wars in 1878.[39]

Bud Baltazar writes that when his "dad first came to the Owyhee Country in 1881, there were a lot more horses on the range than cattle. The horsemen rode all summer branding and taking care of them. So there weren't any real wild horses at that time, although, I guess they would be called wild horses today as they were hard to catch.[6] The large horse operations were quitting the business around 1895. After they had sold most of the horses, the horses that were left in the Owyhee Breaks were the start of the wild horses. Sometimes a thoroughbred stallion or a draft stud got out onto the range and serviced some of the wild horses.[6]

Around 1900 the wild horses roamed the country between Rome, Oregon and the mouth of the Owyhee River. Bud and his father made a living catching and breaking wild horses. One of the hardest jobs they had was to keep the horses they raised from returning to the wild horse country. This area was known as the Owyhee Breaks. Several other settlers would run the wild mustangs to get their saddle horses -- good horses but hard to catch.[62] Bud remembers about 2000 head running in this area.[6]

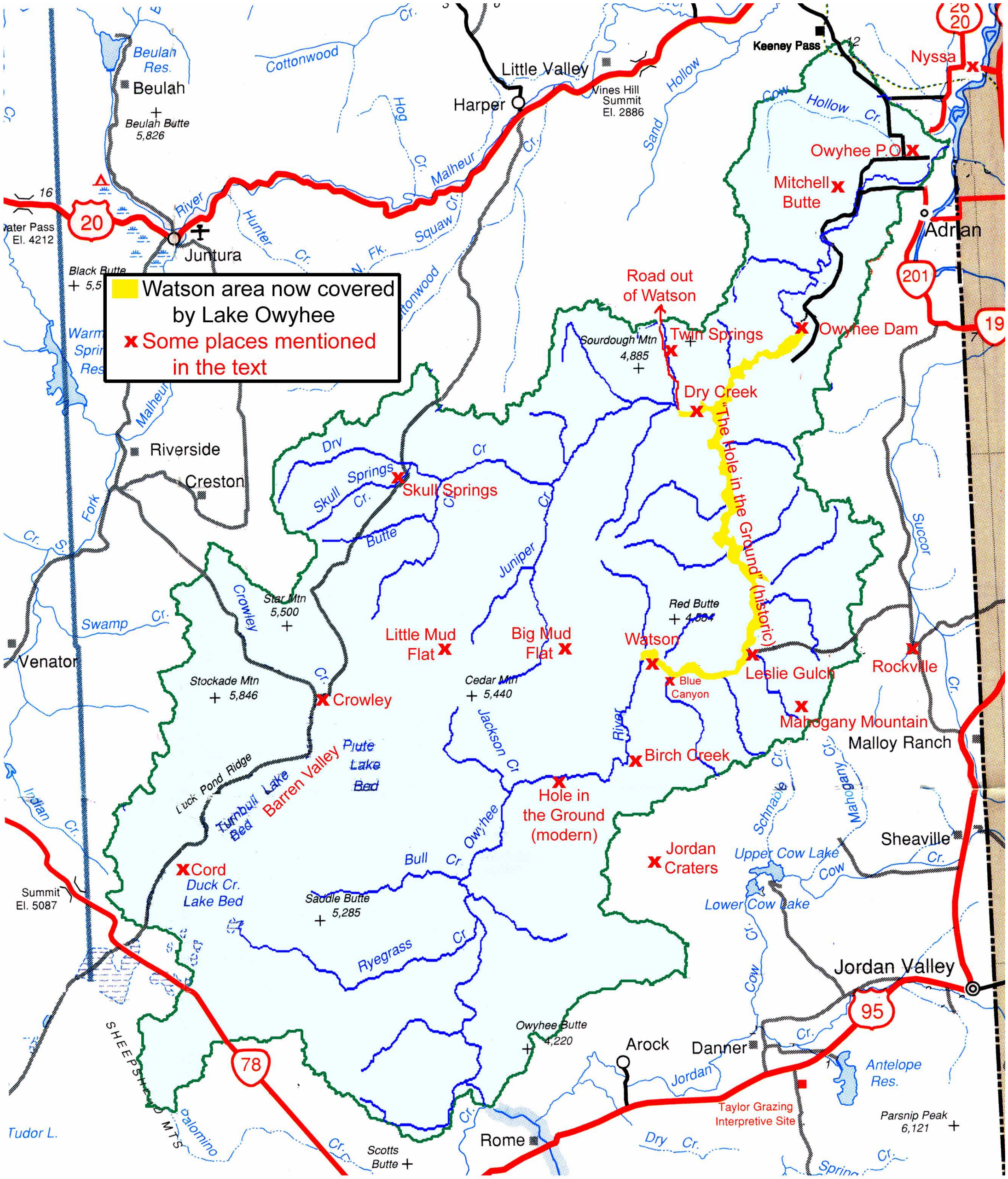


Figure 4.6. Historical locations in the lower Owyhee subbasin overlaid on a modern map.

There were so many wild horses in the Owyhee Breaks that the ranchers themselves decided the numbers had gotten out of control. In 1905 the Akins brothers were hired to thin out and bring down the number of wild horses. There were about 100 head left on the range when they finished. During the next decades, the individuals who ran the wild horses usually sold them to a packing house. By 1946 the herd of wild horses had grown to around 6000 head.[26]

Bill Murphy recalls that there were two bunches of wild horses in the early 1900s and that the wild and domestic horses ran in the same area. He writes that every "year in June the ranchers . . . would go out and round up these horses and separate the domestic mares and their colts from the wild horses."[61] Walter Perry says they would let their horses run wild on the range until they were three to five years old before breaking them.[72]

Since sheep were trailed back and forth, there were some areas with heavy grazing pressure from the sheep traffic. There were probably more than 100,000 sheep which crossed the Owyhee bridge each year on their way between the valley and Mud Flat.[10]

The number of animals on the range varied, but tended to increase. In 1890 there were 58,000 sheep, 21,000 cattle, and 14,000 horses on the range in Malheur County. During 1900-1910 the "remaining public lands were overstocked in this decade, with an incredible 360,000 sheep, 37,859 cattle and 15,000 horses."[43] During the 1920s an estimated 294,000 sheep and 53,000 cattle were still on the range.[43] By 1930 these numbers were estimated at 40,000 head of beef cattle and 366,000 head of sheep were on the range in Malheur County.[27]

3. Fauna

Bud Baltazar rode all over the area to catch the horses. He recalls that in "the early 1900's there were very few deer and antelope in the Owyhee Country. . . You could ride the range all day and never see a deer track so when you'd hear a rider say 'I saw a deer track on the mountain today', that was news."[6] However, he contrasts the scarcity of deer to the abundance of sage chickens. "They were everywhere you went."[6] They also provided good eating "better than chicken".[69]

Ray Nelson remembers lots of wild horses and rattlesnakes. He recalls only a few deer, antelope, and wild sheep. The wild sheep were domestic sheep which went wild and lived in the rimrock.[62] Walter Perry says they hunted ducks and geese.[72]

Another animal which was abundant in the late 1800s and early 1900s was the jackrabbit. The jackrabbit population cycles peaked every few years. With extra pressure on their natural food supplies, the rabbits migrated to irrigated fields.[43] In January 1888, W.L. Geary of Ontario, shipped a train carload of rabbits to the Portland meat market. During the next two years the jackrabbits "bred like rabbits" and again destroyed gardens and decimated young alfalfa crops. The county put a bounty of three cents on each pair of rabbit ears. Later they had to reduce, then eliminate the bounty because there weren't enough funds to pay for as many jackrabbits as were being brought in.[27]

Rabbit drives were organized to reduce the jackrabbit population. Large numbers of settlers would gather. They would encircle an area and gradually drive the rabbits towards the center. As rabbits tried to break out of the circle, they would be clubbed to death. To prevent accidents to the participants, firearms were banned.[27]

Sam Boardman, the father of Oregon's park system, explained eastern Oregonians' frustration with the jackrabbits' habit of eating bark on young trees. He said, "after I'd plant a tree, I'd come out in a few days to water it and I'd notice a young jack would come loping over the prairie. He'd see my tree and think to himself he'd never seen that before. So he'd hop up to it, smell it, then sit down and start to eat the bark."[39]

Coyotes, wildcats, and an occasional cougar were problems since they killed calves, sheep and chickens.[7,43,68] Skunks, raccoons, chicken hawks, and porcupines also killed chickens.[43]

The scalp bounty of $1.00 put on coyotes and wildcats was supposed to be for the protection of the sheepmen.[27] It wasn't worth it for many ranchers or sheepherders to collect it. They just killed the animals. Likewise, government hunters were prohibited from collecting the bounty. Even assuming that the bounty wasn't paid on many bobcat kills, between October 1, 1913 and December 31, 1914 there were 595 bobcat bounty payments in Malheur County.[39]

There was another problem in the wild coyote and bobcat populations in the 1920s. There were a lot of rabid coyotes. They transmitted hydrophobia to domestic stock when they bit the animals.[68] They also posed a health problem to residents of the lower Owyhee subbasin. Opel McConnell's father was bit by a rabid bobcat near Dry Creek (Figure 4.6) and they had to get the medicine sent to Vale from San Francisco to treat him.[43]

Trapping provided extra income for some people. The furs of bobcats, coyotes, muskrats, beaver, and a very occasional lynx would be shipped out. Bobcat were trapped around the rimrock, muskrats up and down along the river banks, and coyotes in pastures or along trails.[61,72]

4. Fish

In 1871, James Henoty began operating a salmon fishery at the Washoe Ferry on the Snake River upstream from the Malheur River. The fishery continued operating until at least 1888. Although salmon from the Snake River were not recorded as entering the Owyhee River, in 1873 they filled the Payette river and adjacent sloughs so thick that they could have been caught with forked sticks.[27] In 1902 a salmon hatchery was established on the Snake River where fish racks across the river at the lower end of Morton Island were used to harvest salmon eggs. However, it was abandoned about three seasons later because of "a decline in the salmon specie of the finny tribe."[27]

Walter Perry recalls the water wheel at Island Ranch in the Watson area (Figure 4.6) on the Owyhee picking up a salmon about 30 inches long and putting it into the ditch. The other migrating fish that his water wheel used to catch were lampreys. He says he's seen "them so thick in the field after they come up the flume that you couldn't hardly get out into the field because of them old dead eels."[72] Wally Jones of Ontario remembers the lampreys piling up at the base of the Owyhee dam right after it was built.[44]

There were also bullhead catfish in the Owyhee. As soon as the line hit the water they would bite. James Page says they "used to catch a hundred or two of them and clean and fry them."[68]

5. Vegetation

Since there was no timber to make into lumber left nearby in 1903, Bud Baltazar's parents brought lumber from Winnemucca, Nevada and from Drybuck near Ola, Idaho.[6] Bill Murphy's parents hauled lumber from the mills in Burns to build their "tar paper shack."[61]

The lack of other fuel meant that sagebrush was used for both heating and cooking in a wood range.[7,17,43,69] Sagebrush burnt hot but didn't last very long.[61,7] His wife says that one of Bill Murphy's memories is "of dragging in sagebrush for fuel for both cooking and heating. As he tells it they had to have several 'mountains' near the house all year round, and he and his brothers, Rae and Dick, had this never-ending chore, drag it in and chop it."[60]

Besides burning sage, sometimes the residents along the Owyhee River near Watson (Figure 4.6) burned mountain mahogany or juniper.[43,69] There were juniper trees on Cedar Mountain to the west of the Owyhee River.[69] That is probably where Sophia Bethel's father got their big juniper Christmas tree every year.[9]

Mountain mahogany wooden blocks were used on the moving parts of the water wheels along the Owyhee. The mountain mahogany came from Mahogany Mountain (Figure 4.6).[9,17]

Settlers wanted trees like they had "back home." In 1885 "Aunt Phyann" Van Ness planted the first tree in Ontario. Although she irrigated the silver maples by hand with well water, only one survived. It was still growing in 1950.[27] After getting irrigation onto the rich bottom lands of the Watson area, at least three of the residents planted large apple orchards which grew well.[43,68]

The lack of timber meant that there was still a lot of construction from willows (Figure 4.3). James Page says that if there was a barn in the Watson area, it was made out of willow and sagebrush. Their barn had walls of willows woven together, a sagebrush roof and some straw over the sagebrush. There were also lots of willow corrals.[68] When the first alfalfa field in the county was planted, the alfalfa seed was harrowed into the ground with a drag made of willow boughs."[27]

Not all range plants were edible. George Palmer remembers that seven head of cattle out of around 30 died after eating larkspur.[68]

In 1930, Mahogany Mountain still had good bunch grass. Walter Perry says "if it weren't for the sagebrush and rock in it, it would have mowed a half ton to the acre." He says the "only time we had to feed was when the snow got so deep the cattle couldn't get to grass.[72]

6. Geology

George Palmer moved to the mouth of the Blue Canyon (Figure 4.6) between Birch Creek Ranch and Leslie Gulch along the Owyhee River in 1902. He said that although the "geologists claim that the Jordan Valley [Figure 4.6] volcano hasn't been active for thousands of years. But since we moved out there in 1902, up until 1909 or '12, I saw ashes blow out of that old volcano and heard it roar."[69] He says that it would shake the country and even shook dishes out of the cupboard at a home on Cow Creek.[69]

Since he occasionally did welding, he knew where there were some small veins of high grade coal along the Owyhee River. When he wanted a little good coal for welding, he would dig it out of the cracks.[69] He also noticed that there were some pieces of ground covered with alkali. The horses would dig at it until they had made a puddle that would fill up with water.[69]

7. Settlements

Within the lower Owyhee subbasin, one of the earliest homesteads was at the area currently known as Hole in the Ground (Figure 4.6). Mr. Horn not only filed on the homestead, but he also filed on the water rights in the 1860s.[17]

In 1871 there were four towns in Malheur County: Glennville, Eldorado, Malheur City, and Jordan Valley.[27] The settlements in the lower Owyhee watershed were slow to grow at first, since a community needs an economic base. The primary settlements were small towns around the perimeter of the lower Owyhee subbasin. Besides Jordan Valley to the southeast, in 1883 Vale acquired a post office[52]. That same year Ontario was platted, named, and held the first school term.[43] The rail line reached Nyssa in December 1883 and by 1886 they held school. Vale didn't have a school until 1887.[43] Arcadia, north of Nyssa, was established by the company of Kiesel, Shilling & Danilson in 1892[15] and had a post office from 1896 to 1908.[73]

Although none of these towns were located in the lower Owyhee subbasin, they continued to be important to the people who did settle in the subbasin. As Ray Gregg explains, "When I came in 1886, the population of the town [Ontario] was about fifty. The business transacted by the two general stores was more than double the trade of any ordinary town of that size. Supplies for the interior for more than 150 miles inland were hauled by freight teams from Ontario, which was the railroad center for Malheur and Harney counties.[27]

There was a period of growth on the Snake River Plains in the early 1880s. By 1883 the lands bordering the lower Owyhee River had some settlers on them.[43] When Charles Bradly came in 1887 there were only eight families located between Mitchell Butte and the Snake River.[43] By 1892, the Owyhee School was established, and in 1893, 18 children attended.[43] The Owyhee post office began operation in 1886 (Figure 4.6).[73]

The first settlers to establish homesteads along the Owyhee River (thirty-five to forty miles above where Owyhee Dam is today) arrived in 1893-94. They settled in a large warm valley known at the time as "The Hole in the Ground" (Figure 4.6) and now covered by Owyhee Reservoir.[27,43] A school district was organized in 1896[29] and the Watson post office began operating in 1898 (Figure 4.6).[73]

Another area that had some homesteading in the late 1890s was the Barren Valley area (Figure 4.6). There were homesteads around Cord in 1892 and a school house was built at Cord in 1896 (Figure 4.6).[43] The Cord post office began operations in 1897.[73] In the early 1900s there were small settlements spread out along the road north of Cord from Crowley to Harper. Crowley had a post office in 1911[52] and the Crowley school district was organized in 1912 (Figure 4.6).[43] There was a post office established at Skullspring in 1902, but in 1914 there were only two students in the one-room school (Figure 4.6).[43] Mud flat south east of Skullspring had more students, although there wasn't a post office (Figure 4.6).[43]

By 1913, there was enough population in the Sand Hollow area southeast of Nyssa that the Sand Hollow school was organized.[43]

Possibly many of these towns were like Watson. A private dwelling served as the post office and that was all there was to town.[7,9] The post office and the school served scattered ranches; in Watson the ranches were up and down along the river.

8. Farming and the first irrigation along the lower Owyhee River

During the 1870s, the first settlers along the rivers in the Treasure Valley were living on wild hay ranches. The wild hay was naturally sub-irrigated from sloughs adjacent to the rivers. Meadow lands were considered the most desirable.[43] After alfalfa was introduced in about 1880, it became the main forage crop, largely replacing wild grass hay.[27]

In order to farm in this arid region, water is necessary. There were about eight families farming lands bordering the lower Owyhee River who joined together in 1883 to construct a ditch along the north bank of the Owyhee River to supply water for a gravity system of irrigation. The "Old Owyhee Ditch" took water out of the river downstream from Mitchell Butte (Figure 4.6). The farmers annually built a diversion dam across the river of rocks and sagebrush to funnel water into the ditch. The original ditch was not very long and only watered their own lands.[27,43,87]

The diversion structure was built where the river bed was soft. Sections of the dam gave way from time to time and it washed out in flood seasons and had to be reworked every year. In the summer when the water level in the Owyhee River was lower, the dam had to be reworked and tightened up so that it could raise the water level high enough to go into the ditch.[43,87] Over time other settlers along the banks of the Owyhee "extended the ditch to their own lands, so that eventually the ditch reached six miles in length."[43]

There were settlers above the ditch who wanted water for their land. In 1888, they formed the Owyhee Ditch Company. All the water users under the Old Owyhee Ditch joined the venture since the new ditch would be five feet higher and would irrigate more of their land. The diversion dam was southeast of Mitchell Butte at the site of the present diversion works and two and a half miles above the original dam.[43,87] The Owyhee Ditch Company was granted a permit allowing them to take 41,000 acre feet of water from the Owyhee River.[87] By 1894 the ditch had been extended clear to Ontario.[27,43,87]

"The Owyhee Ditch Company's diversion dam was constructed with a row of rocks across the river, then a row of sagebrush, another of rocks, then a row of big long willows, then more rocks and sagebrush. It was some four feet high, and also had to be tightened in the summer months with loads of sagebrush, manure, straw, and mud. Every spring flood would take the top of the dam off and much of the sagebrush, and the stockholders would have to repair it before irrigation season began."[43]

The ditch brought not only water but maintenance and political problems. Because of the great fluctuation in the amount of water in the Owyhee River, there was lots of water in the early spring and very little by the hot dry summer. Since the Owyhee River could dwindle to little more than a trickle during the summer, some farmers took more than their share of the water. Ditch breaks could result in flooding and destroyed crops. There were lawsuits from farmers who suffered damages and enough fights over water that attorney Robert Lytle handled mostly water litigation cases.[48,87]

There was also a problem of how to raise the water up out of the ditch and on to the adjacent lands. Water wheels were not permitted in the ditch; they were an obstruction and prevented cleaning and maintenance. Water wheels were being used upstream to lift water out of the Owyhee River by settlers on lands adjacent to the river. "The problem with a water-wheel was that unless it was very securely protected from the spring-runoff and the movement of ice and boulders, it would be destroyed annually."[87]

9. River functioning

The problem of spring-runoff and resultant damages is a common source of stories for people who lived along the river and used water wheels. High flows in the spring would send the river over the tops of dams and out of its banks. It could be a mile wide in some places when it was high.[10] The high flows could carry ice and rocks. Walter Perry explains that they would have to fix the rock dams in the spring since the "dam would back up the ice, and the ice would get the rocks rolling, and the first thing you know, you had a hole through there."[72]

The flooding could also wash away improvements. Joe Beach recalls his father standing on the side of the river channel in 1904. The river was high and flooding so it had torn out fences and buildings. His father lassoed "posts and poles and pieces of lumber . . . He got enough for posts for fencing and corrals, and sheds to give us a start."[7] Josephine Lytle says that when "Old man Page's wheel went out, and the whole neighborhood was along the river with ropes, trying to catch that waterwheel. They finally did catch it."[69] It then had to be dismantled, moved back, and rebuilt.

The flooding of properties could also result in losses. When a sudden flood caused ice to jam the river in January 1920, water flowing over adjacent feeding grounds drowned 3,500 sheep and 800 cattle. It also damaged the railroad bridge over the Owyhee on the Homedale spur. A.H. Keck's ferry near the mouth of the Owyhee river was swept away.[87]

Gene Stunz explains in his history of hydroelectric power in the Owyhee Project how "The Owyhee River drains about 11,000 square miles of desert and mountainous country. When there is significant precipitation or runoff in that vast area and all of the water is channeled to the narrow Owyhee Canyon, a tremendous natural force is generated."[87]

When government agencies set up a station "on the Owyhee near its mouth to measure stream flows, their charts revealed what every farmer and stockman in the county already knew, the waterways have a high run-off in the early spring when the snows melt, and then usually drop to a comparative trickle in the summer and fall."[43]

The water could be so high in the spring that it had to be crossed in a boat. Walter Perry remembers that it could be unsafe to cross the Owyhee River with a team and wagon until the middle or end of June.[72] There would then be little flow in the summer.[87] Some of the tributaries of the Owyhee River have even more irregular patterns of flow. Clinton Anawalt lived on Bogus Creek. Although Bogus Creek comes from a spring, it would go dry sometimes and stay dry for four or five years. It could also flood to the extent that "you could swim a horse in it" when there was a cloudburst on the upper end of the creek.[2]

Several people who lived in the Watson area commented on some of the benefits of the river freezing over in the winter. The youngsters used to ice skate up and down the river for miles.[7,72] Ice blocks could be cut from the river during the winter for use in the summer. In an ice house they layered ice with layers of sawdust and it could last almost to the end of the summer.[54,75,87]

A frozen river was also easy to cross. Walter Perry says they used to take not only sheep or a team and wagon across, but even cars.[72] Chesley Blake's parents' house burnt down. They bought the house across the river from them. Using seven or eight teams of horses, they pulled the house across the frozen river.[10]

Conversely, when the river level went down and the water would get warm, the children would swim in the river.[10]

10. Watson Area

a. People

In 1980, Julie Ann Martin conducted interviews for the Vale District Bureau of Land Management with people who had lived along the Owyhee River in places that were later inundated by filling the Owyhee Reservoir. At one time there had been about 32 families who lived up and down the river. About eight families lived near the mouth of Birch Creek and another concentration near the mouth of Dry Creek (Figure 4.6). In 1906 about 44 children attended the one school at Watson. Later there were three schools; one at Watson, another about two miles below Leslie Gulch and the third one 12 miles downstream from Watson. About 65 children attended one of these schools in 1930.[10,68,69,72]

The ranches were largely self sufficient although the largest irrigated ranch was about 60 acres. The families used to go to town about twice a year to get supplies like flour, sugar, salt, and dried fruits.[10,54,68,69] Although Opell McConnell remembers going into town in the spring and fall with four or six horses and two wagons,[54] James Page says they only went into town once a year with one team and one wagon.

b. Roads

The road conditions and isolation meant that three or four families might go into town about the same time so that they could have help in case one of them broke down.[10] Most of the travel was still by team and wagon in the early 1900s but later a few cars would use the roads. There were three principal routes that were used: up Leslie Gulch, from Dry Creek past Twin Springs to Vale over 51 miles of rough road, and from Dry Creek past Twin Springs coming out at Nyssa (Figure 4.6).[54,62,68,72] Joe Beach says there really wasn't much of a road. Since many people went by horseback, there were lots of cut-off trails that a wagon couldn't follow.[7]

The mail came in by "stage" from Rockville (Figure 4.6) on the road through Leslie Gulch. When Old Man Symes drove, he would leave on Thursday and come back Friday. In the spring it might be so muddy that it would take him longer.[54,68] On the other roads mud was also a problem in the winter and spring. Wheels could get so much mud on them that they wouldn't even turn and freight wagons could sink in the mud clear up to the axle.[10,68] When George Palmer was freighting, he explains "I drove with a jerk line . . . I usually drove eight horses, two wagons".[69]

The river was a barrier to dealings between the two sides of the river. Sophia Bethel's family lived on the opposite side of the river from the road leading out to Vale. She says there were two or three months of the year when the water was so high that there was no way of getting out.[9] When the water went down, a temporary bridge to get sheep across could be made by running a couple of wagons into the river and putting planks across them.[68] A bridge was constructed across the Owyhee River in 1912. After the bridge was built, it might be necessary to go up one side of the river to the bridge and back down on the other, but it was possible to get across all year.[7]

When the CCC was operating in the area, there was one of the corpsmen who "was a whiz with a bulldozer." With the help of ranchers dynamiting, he dozed off the rim above the current Hole in the Ground (Figure 4.6) so that they could build a road from there to Jordan Valley.[17]

c. Vegetation

Around the Watson area the land was dry and full of sagebrush except where people lived. In addition to crops and gardens, they had planted trees, lawns, shrubbery and flowers.[54] George Palmer worked with his mother for two or three summers to completely clean up their ranch. He says it was all "sagebrush, big high sagebrush"[69] and they chopped out the sagebrush and greasewood. Playing games at school, it would take a while to find the ball if it were hit into the greasewood.[7] The younger children would "ride stick horses out in the brush at noon."[54] When they had to return to school, they would race back "jumping all the gullies."[54] However, Palmer says the range was so good that they never even fed their milk cow hay.[69]

d. Climate

The weather along the Owyhee River varied depending on whether it was in the river canyon or up on the rim. There wasn't as much snow along the river, but it would come in the fall and stay till spring on the rim. Even though the river would freeze over, snow wouldn't stay long.[7,72] At the present day Hole in the Ground there could be snow at the Rinehart Ranch on the mesa, and it would be warm enough for shirt sleeves down by the river.[17]

Some of the things that the residents of the Watson area remember about the climate reflect the observations of the earlier settlers. Temperatures from one year to the next could be unpredictable so that even in the Owyhee Breaks (Figure 4.6) in bad weather they could lose all the lambs to a freeze. On Big Mud Flat (Figure 4.6) 18 inches of snow fell on the 18th of April and killed a number of bucks.[69]

Some changes in the climate were noted by different people. Stacia Davis said that before the dam filled, present day Hole in the Ground never had fog. After the dam was constructed, there would be foggy mornings, but the fog would burn off by noon.[17] Bill Ross, Walter Perry, and George Palmer all comment that the weather used to be colder in the winter.[69,72,75] George Palmer also thinks that it has become hotter and drier with fewer water holes on the desert.[69]

e. Crops

The crops were irrigated. Alfalfa hay was raised as winter feed for stock.[7,69,68,72] Corn was also raised to feed animals. George Palmer says they got 110 bushes per acre of corn. Everyone raised a big garden including all kinds of vegetables.[68,72] There were also berry patches and irrigated apple orchards.[7,54,68] Joe Beach says that just as their trees began to produce, the beavers would come every night or two and cut one down. His father waited up at night until he had killed the beavers that were attacking the orchard.[7] The soil up and down the river was termed as the "best in the world"[69] and "as good a soil as there was in Malheur County".[72]

f. Livestock

Some of the animals on the ranches were what could be expected for personal use. There were chickens, cows and horses. Hogs were butchered for bacon and ham. A few sheep could provide fresh meat since with no refrigeration, a small animal could be used up. James Page's family had seven or eight milk goats. Some animals were also raised as commercial stock.[7,9,17,68,69]

A number of the ranchers ran cattle on the range. They might have 25 head or 300 head. Some of the people who ran cattle also ran sheep and some of the ranchers were just sheepmen. The large sheep outfit ran as many as 30,000 sheep[41] on the open range from the Owyhee Breaks to the Blue Mountains, but generally 1200 to 4000 head.[7,10,17,68,69,72]

There were wild horses on the range and Joe Beach and his father would catch them. Sophia Bethel says they traded for a bunch of range horses; they were really wild and they spent two or three years chasing them. Most of the wild horses went for chicken feed.[9] Ranchers also raised horses. It was Stacia and Conley Davis's primary source of income. They raised horses to sell to the government remount service. The government furnished the stallions and the ranchers furnished the mares. She says they registered more mares "than anyone in the United States."[17] The horses along with the cattle were turned out and ran on the open range.[7,17,68,72]

g. Turkeys

During the years just before the dam was built, many of the ranchers in the Watson area raised turkeys as a cash crop. They raised corn for feed and the "kids used to herd them out in the fields for them to get the bugs -- that was part of their feed".[9] They had to be herded to keep the coyotes out. After cooling the turkeys over night, they were wrapped and hauled out with freight teams.[9,10,68,69]

h. Moonshine

Another source of cash income was moon shine. There were stills up nearly every canyon and gulch.[9,10,62,68,72] Bill Ross says that there "was always someone holding up a moonshiner and stealing his whiskey. They couldn't complain to the law".[75]

i. Watson water use

Stacia Davis says that although all the other ranches along the Owyhee used water wheels, their place had a canal. They had a dam across the Owyhee River and it moved water into a large ditch. The canal moved more water than a wheel. They had the oldest water rights in the valley, filed at the same time the land was homesteaded in the 1860s.[17]

Figure 4.7. The water wheel at Birch Creek Ranch, May 2007

The rest of the ranches irrigated with water wheels.[7,10,17,68,69,72] In order to install a water wheel, a rancher had to file for a water right for a water wheel. The right was recorded at the courthouse just like a homestead right.[69]

Dams were used to divert water from the Owyhee River and through the water wheel. A head gate before the wheel could be used to control the amount of water provided to the wheel and it was closed to stop ice from going through the wheel. The amount of water entering the wheel determined the speed of the wheel and the speed of the wheel governed the amount of water delivered.[7,68,69,72]

The height of the wheel depended on the location of the ditch above the land to be watered. Joe Beach's father used a homemade level to survey a ditch around the edge of the hill. The smallest water wheel mentioned was 12 feet high. Around 32 feet tall was probably average. One steel wheel was 50 feet high and some may have been 60 foot wheels.[7,68,69] The original wheels had metal parts from a foundry in Baker, timber from Drewsey, fir spokes, and mahogany blocks. When people started using metal wheels, they were shipped from Seattle.[7,17,69]

Water wheels would last a long time even though they ran day and night during the irrigation season, but they required maintenance. They had to be perfectly aligned. Normal maintenance included greasing them. Damage to the wheels had to be fixed. A tree felled by a beaver that went through the water wheel would tear off a bunch of paddles. Ice through it in the spring also could tear out pieces. Dams that washed out had to be built back up to get water through the wheel.[7,68,69,72]

Some people along the Owyhee River started using gasoline pumps. They weren't as satisfactory because they were heavy, clumsy, and hard to start. The fuel had to be freighted in.[7,68]

Joe Beach explains how his father prepared to irrigate. The first year they leveled the land and corrugated it for irrigation. He ran water and made adjustments so that the water wouldn't pool in low places. Even after planting, if he found a place that was a little high or low, he would work to level it out.[7]

j. Attitude to the dam

After it was obvious that the dam would be built, the farmer's didn't improve anything. One of the farmers who had purchased a developed farm in 1920 sold all the orchard trees for wood. Most of the residents felt gypped by the amount of money they received. The land was priced as if it were unimproved range land. They also lost a way of life.[7,68,69,72] To establish new water rights for the people who were going to irrigate from the dam, the existing water wheels were locked up for 30 days, although the ranchers unlocked them as soon as the government personnel left.[17]

11. Water use - below dam

The arrival of the Oregon Short Line Railroad in 1883 provided a means for valley settlers to move their livestock and farm crops to eastern markets. There was also an increase in the late 1880s and early 1890s of settlers who had been farmers in the Midwest. Farming using irrigation had gradually increased until the government finally became interested.[27,87] The development of irrigation in the lower Owyhee and adjoining lands was the result of decades of cooperative community involvement and promotion.[27,43]

Although the Owyhee Ditch company was examining the feasibility of a dam and looking at potential reservoir sites to secure a more reliable water supply, the money to support such a venture was not available. From 1903 to 1905, the USBR made a topographical survey of the land which could be irrigated from the Owyhee River and of potential reservoir sites. In 1905 they even drilled at the Red Butte site in the Watson area and decided that the rock formations wouldn't be suitable for a dam and the canyon was too wide.[87]

In 1910 the Owyhee Ditch company voted to construct the High Line Canal. It would provide irrigation water to land up to 275 feet higher than their present Owyhee Ditch. The government had a policy of not interfering with private enterprise developing irrigation projects, so they stopped work on the proposed Owyhee government project. When the company financing the High Line Project went broke, the private attempt to irrigate more land was abandoned.[27,43,87]

Early irrigators decided in 1912 that a key to a better future was a dam that would hold enough water to reliably provide irrigation water throughout the growing season. In 1913, the Argus reported that the Shoestring ditch between Ontario and Nyssa was completed and 6,200 acres were being irrigated by that project.[87]

There were different irrigators or groups of irrigators using electrical pumps in 1923. Pumping by irrigators became much more dicey when Idaho Power Company instituted a policy that irrigators would only be able to use surplus power. Also, the low water levels in the Owyhee River during the summer meant that there was adjudication of water rights between at least two factions.[87] As in all of the arid west, the availability of water and its use was of great concern. Upstream from the lower Owyhee subbasin, the water in Jordan Creek had been used by ranches along the creek. By 1924, the construction of Antelope reservoir had already modified the way water was fed into the lower Owyhee from the Jordan Creek basin. Some of the runoff water from South Mountain in Idaho was now diverted into Antelope reservoir. Water stored in Antelope Reservoir would be gradually released and fed into ditches by a diversion dam in the creek.[32,43,61]

In 1924, the Secretary of the Interior, Hubert Work, articulated that the "primary purpose of all reclamation construction is to extend irrigation. In all storages there will be incidental benefits to come from the development of power . . . there should be such control by the government as to prevent interference with the use of the stored water in irrigation.'[87]

A study presented to President Calvin Coolidge in 1926 recommended that the Owyhee Project be authorized. The Owyhee River was described as having an adequate average annual flow, but its flow was completely utilized by the Owyhee Ditch Company during the summer and the Owyhee ditch company required supplemental water.[87]

In 1928, the board of the Owyhee Ditch Company began work to replace the loose rock dam with a new concrete diversion dam in the river. By October, the first train used the completed railroad to the construction site of the Owyhee dam. In the following months, power and telephone lines were extended to the dam and the fifty buildings of the permanent camp for construction workers grew to include a school with 40 students, a hospital, and a movie theater which showed movies twice a week.[43,87]

Most of the landowners in the Watson area whose land would be inundated by the water behind the dam had settled their claims. Lawsuits to condemn their land were brought against the four who had not settled, and the new Owyhee Irrigation District board purchased the Watson School district property. The Attorney General sought and established a water right for the Duck Valley Reservation of 90,000 acre-feet.[87]

When the diversion tunnel was completed in August 1929 and the Owyhee River water was diverted through it, the natural river bed was left dry to permit construction of the dam. Construction work on the dam took three years and $6,000,000. At the time it was dedicated in 1932, it was the tallest irrigation dam in the world. It was also the first dam built with an elevator in it. However, a new system of canals, ditches and laterals was needed to deliver the water to farmers. It was 1935 before the first water from the Owyhee project was supplied to farmers.[27,43,87]

12. Water on the range.

Adjacent to the Owyhee River, the water table was shallow, replenished by the river. Wells were 12 to 24 feet deep. However, it wasn't very practical to drill wells on the range, although some people tried. Instead, dirt dams were placed in dry draws and intermittent streams to make reservoirs to supply water for the stock. Sometimes portable gasoline operated pumps supplied a novel way to water the cattle. "There were pockets of water in these lavas that did not dry out. Pipe was put into these pockets and water was pumped into watering troughs. This had to be done about every other day."[61,69]

Walter Perry discovered that he could build a reservoir on his homestead on Mahogany Mountain, but the reservoir could only be used for stock water. He couldn't get a water right for irrigating and making a stock ranch out of the homestead.[72]

13. Taylor Grazing Act

Years of unbridled use of the range 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 property, a system of seniority that gave old time operators preference over late comers, and prior use of the federal land.[32]

The Taylor Grazing Act also reversed the policy of the previous 150 years of getting 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 can prove that is to get water enough to irrigate it."[39]

F. Into the future

By 1935, the public rangelands of the lower Owyhee subbasin were being managed to turn back damages of overgrazing in the previous decades. The mechanisms were in place to determine who could use them and how they could be used. Irrigation water from the Owyhee project was being delivered to the farmlands of the lower Owyhee subbasin below the dam. The area was moving into a new chapter of productive development and environmental awareness and stewardship.

Endnote

1. The Sherman Silver Purchase Act was enacted in 1890 as a United States federal law. While not authorizing the free and unlimited coinage of silver, it increased the amount of silver the US government was required to purchase every month by an additional 4.5 million ounces of silver bullion every month. The law required the Treasury to buy the silver with notes that could be redeemed for either silver or gold. People (mostly investors) turned in their silver Treasury notes for gold dollars, thus depleting the government's gold reserves and threatening to undermine the

gold standard. After the panic of 1893 broke, President Cleveland called a special session of Congress and secured the repeal of the act.[97,98]

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In some cases the date for the original observations follows the bibliographical entry in italics.

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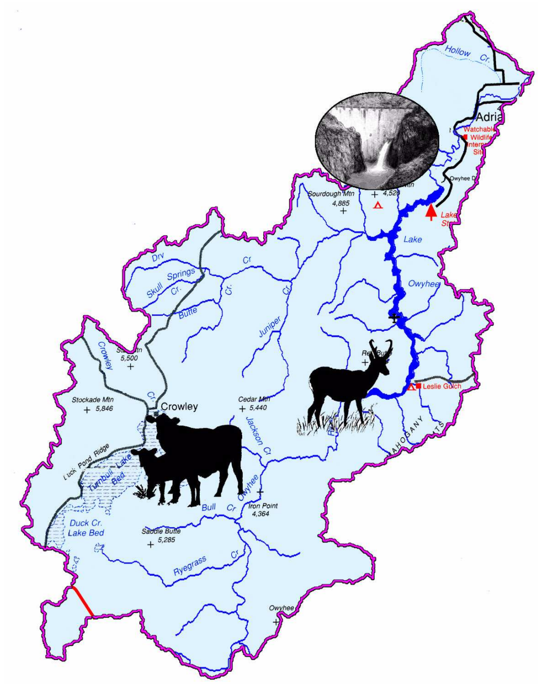


Lower Owyhee Watershed Assessment

V. Hydrology

Contents

V. Hydrology

Hydrology is the study of how water moves within a system. This is more complex than just rain falling and running down into streams and eventually to the ocean. In addition to describing how water travels across the landscape, it takes into account the source of the water and the fate of the water. The processes involved are described as the water cycle.

This discussion will demonstrate that most precipitation in the subbasin is lost to evapotranspiration and that the subbasin has very little capacity to generate water for storage or groundwater recharge.

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.[11,33]

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.[11,34]

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.[11,33] 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. The water table is the location where the groundwater stops moving downward. If there are large natural underground reservoirs which can store the water, they are called aquifers.[11]

Runoff is the water that travels downslope on the soil surface towards streams. Runoff is made up of water that has fallen on the surface and has flowed across the ground 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.[11,33,42]

Transpiration is a plant's "sweating". Plants remove the 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.[11,33,17]

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).[11,34]

Condensation is the change in the physical state of water from a gaseous state to a liquid state. Condensation forms liquid water droplets in the air when the air cools or the amount of vapor in the air increases to saturation point.[11,34]

Water is stored in three basic locations: in the atmosphere, on the surface of the earth, and in the ground. Storage on the surface can be in lakes, reservoirs, glaciers, and the oceans. Underground storage is in the soil, in aquifers, and in small cracks in rock formations.[11,33]

2 Discussion

In general, the water cycle is described as evaporation off ocean and other water bodies 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, and buildings. Some of the precipitation 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.[11,33]

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.[11,34]

The different aspects of the water "cycle" affect the fate of water differently in different environments. Desert environments have low amounts of overall precipitation. Noam Weisbrod defines a desert as an arid region which generally receives less than 10 inches of precipitation in a year.[37] He distinguishes cold "winter deserts" from other deserts because they have a large temperature difference from season to season.[37]

B. The water cycle in the lower Owyhee subbasin

The lower Owyhee subbasin is part of a desert created by the rainshadow of the Cascade Mountains and other mountain ranges. The area east of the Cascade Mountains receives much less rain and snow than the western side. The prevailing wind direction moves air from the west to the east. It 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 Cascades. The water has been "wrung out" so little rain falls to the east.[11,33,12,37] The Steens Mountains, the Owyhee Mountains, and the Blue Mountains can all capture moisture if the air flow across them still contains sufficient moisture. The capture of precipitation by the surrounding mountains is important to the amount of water received by the lower Owyhee subbasin.

1 Sources of primary precipitation data

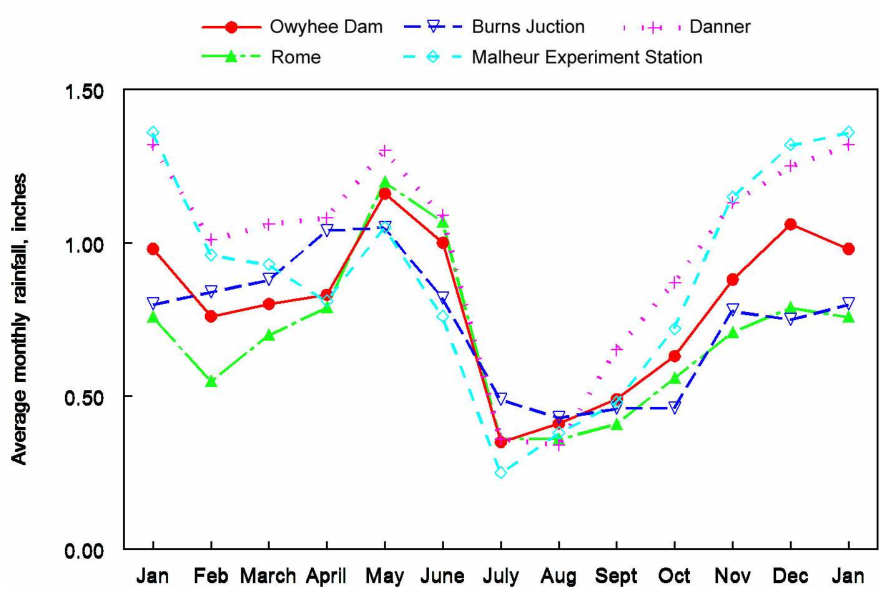
Within the subbasin, there is only one meteorological station, at Owyhee Dam, which measures and records precipitation and temperature. There are other stations around the perimeter of the subbasin. The station at Rome, Oregon is slightly south of the southern boundary of the subbasin and upstream along the Owyhee River. The station at Burns Junction is on the plateau to the west of Rome. The station at Danner is on the plateau to the east of Rome. The Malheur Experiment Station (MES) station is to the north of the lower Owyhee subbasin but still within the Owyhee Irrigation District.

The pattern of rainfall over the year is similar between these five locations although both Danner and MES receive slightly greater total amounts of precipitation

(Figure 5.1). Over the year, there is significantly less rain on average in July and August, also the hottest months of the year.

In addition to precipitation data from the Owyhee Dam, the analyses in this section will use data from the Rome station. It is essential that the reader understand that only these two points are available to extrapolate to the entire subbasin. However, the similarity of the data from these two stations to data for stations around the subbasin make it reasonable to assume that they are fairly representative of the region. The 55 years of data from the Rome station used here were recorded between December 9, 1950 and December 31, 2005. Collection of data at Owyhee Dam began on July 1, 1948. The records used here go through December 31, 2005.

Figure 5.1. A comparison of rainfall patterns at five meterological stations in and around the lower Owyhee subbasin.[2,38,39,40,41]

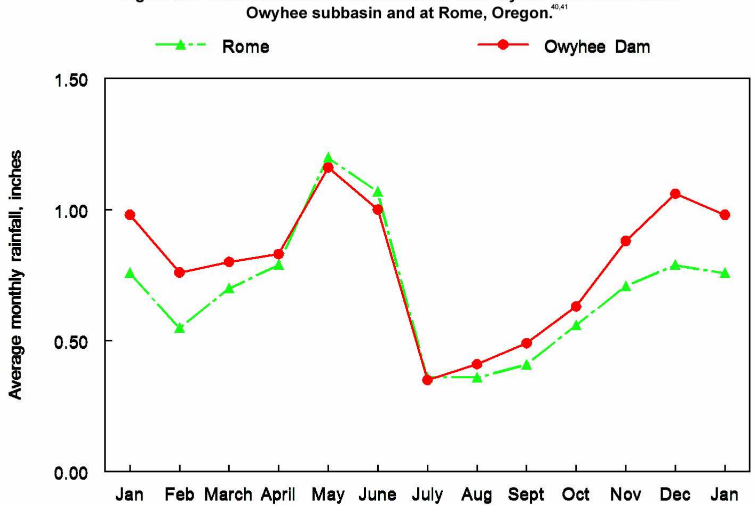


2 Water cycle interactions

How does the water cycle operate within the lower Owyhee subbasin? The subbasin is at the lower end of the Owyhee River and includes the mouth of the river. Much of the flow in the Owyhee River comes from upstream outside the subbasin. Meteorological events beyond the subbasin affect the functioning of the river within the subbasin. Owyhee Dam and Lake Owyhee are within the subbasin. The distribution system for the water stored in the reservoir exports water to the east and north outside of the subbasin. The Owyhee River is also the source of potential flooding downstream.

Other than the water entering the lower Owyhee subbasin in the Owyhee River, the primary source of water in the subbasin is precipitation. The amount and the timing of precipitation affects what happens to the precipitation.

Figure 5.2. Distribution of annual rainfall at the Owyhee Dam in the lower Owyhee subbasin and at Rome, Oregon.[40,41]



Yearly rainfall at Owyhee Dam averages 9.34 inches and at Rome averages 8.24 inches. The rainfall is not evenly distributed over the year. Rainfall in May is over two and a half times the rainfall in July . Precipitation is also higher during the cold months of November, December, and January (Figure 5.2). Year to year precipitation varies significantly from the average.

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, ΔS = change in soil water.[42] In some cases rainfall is directly intercepted by plants.

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

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

a. Runoff

Runoff is the water which 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.[42] Although world wide about a third of precipitation which falls on land runs off into streams and rivers,[22] 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."[42] Although small, runoff is important as it redistributes and concentrates the limited water resource.

There are a number of factors which help determine the proportion of a rainfall event that is lost to runoff. Some of the physical characteristics which affect runoff include soil permeability, prior precipitation resulting in soil moisture, 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.[22] 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 is no data for the lower Owyhee subbasin on how much runoff will occur with rain events of different intensities and on the different soil types. Specific streamflows within the lower Owyhee subbasin will be discussed later.

b. 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.[17,42] 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.[21,34] Almost all the water from small, infrequent precipitation may be evaporated back into the atmosphere. With wind or heat, greater amounts of precipitation evaporate.[11,22]

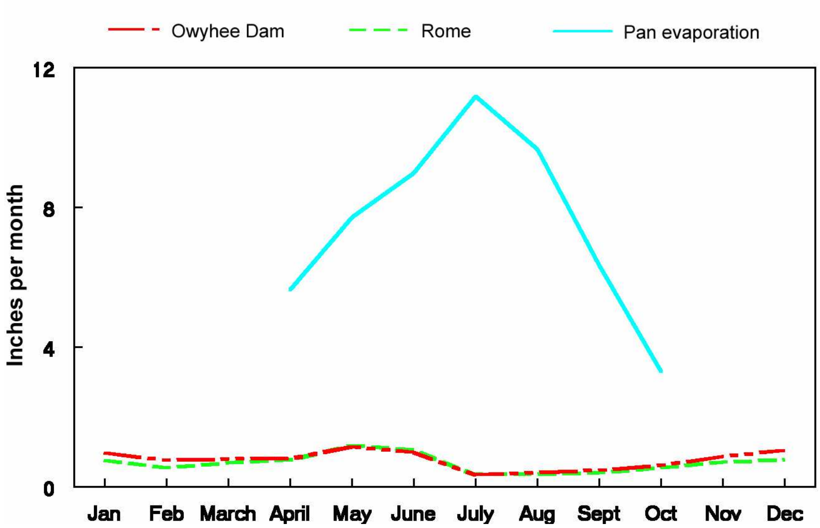
c. Evaporation

Evaporation is the 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 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.[11,4,1,6,36] A shaded stock trough may have 36% less evaporation than an unshaded trough.[36]

The amount of water evaporated depends on the water still present, on how much surface area the water covers, and on the rate of evaporation.

Looking at the climatic data from the lower Owyhee subbasin, it is obvious that the temperatures for part of the year are relatively high. At Owyhee Dam, the monthly average maximum temperatures for the five months from May through September are 74, 83, 93, 92, and 81 degrees Fahrenheit average maximum and the temperatures at Rome are about one degree lower. These are comparable to the temperatures at MES. When the average rainfall at Rome for the last 55 years and at the Owyhee Dam is compared to the MES 58-year average of measurements of the amount of water which evaporates from a flat class A pan (Figure 5.3), the rainfall is only a small portion of the amount which could evaporate. Just considering evaporative potential, the rainfall from April to October could all return to the atmosphere. A larger rainfall event during these months might find some of the water infiltrating into the soil or running off, but a large portion of precipitation during these months evaporates.

Figure 5.3. Average monthly rainfall at Rome and Owyhee Dam compared to the class A pan evaporation at the Malheur Experiment Station.[2,40,41]



In rangelands, soil water evaporation generally accounts for 30 to 80 percent of the water budget. Soil water evaporation is limited to the very uppermost layers of the soil.[42]

d. 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.[11,42]

The vegetative cover affects interception. Generally 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.[42]

Although figures for the percentage of precipitation intercepted by different types of canopy covers are available for other areas, interception data has not been developed for the local region.

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.[14] 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.

e. Transpiration

In a desert environment transpiration contributes a smaller percentage to the total evapotranspiration. Many arid region plants have developed adaptations that conserve water, allowing them to transpire at a very slow rate when there is less available soil moisture.[11,17] 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 lower Owyhee subbasin summer. However, as plants start to senesce (die), they transpire less.[17]

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. Plants can also draw water from substantially greater depths if water is available, so moisture from uptake by plant roots can reach the leaves and be transpired.[11,17,42]

f. Sublimation

Since much of the precipitation in the lower 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 probability 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. [5,21,34]

Many winter days in the lower 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.[21] 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."[15]

Since the lower 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.

g. Infiltration

There are a number of factors which 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. Vegetation slows the movements of runoff and allows more time for water to seep into the soil.[19,7,14]

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 and saturated soils can hold no more water.[19,7,14]

The soils for most of Malheur county have not been mapped. Without knowing the types of soils in the lower Owyhee subbasin, it is difficult to estimate the maximum infiltration rate and the percentage of rain that could be infiltrated.

h. Groundwater recharge

The high evaporative demand in an arid climate means that eventually water that has infiltrated and is stored in the soil will mostly 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 percolation and higher groundwater recharge.[11,42]

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.[11,33,18,34,13] There has been no mapping of groundwater reserves or calculation of groundwater recharge for the lower Owyhee subbasin.

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 watertable for its recharge will have a more variable flow based upon precipitation, infiltration and use within the last few years. The predominance or water use by deep rooted vegetation, such as big sage or juniper, will reduce flows from shallow aquifers.[44,45,46]

The wells in the lower Owyhee subbasin above the dam may remove some of the groundwater which could be providing the base flow for streams.

i. Storages in small dams

Throughout the lower Owyhee subbasin there are many small dams that have been built to impound intermittent stream flows. Dams create a different distribution of surface storage.[11] These dams 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 very much water. The guide for estimating the acres of drainage area required for an acre-foot of pond storage shows that more than 80 acres are required in the lower Owyhee subbasin.[23] Using this figure, all of the lower Owyhee subbasin could only supply enough water for roughly 15,000 acre-feet of storage.

j. Subbasin water balance

Within the relatively arid lower Owyhee subbasin, the water balance is determined by the fact that potential evapotranspiration is much greater than precipitation, which in turn contributes to a large soil water deficit. As a rule, evapotranspiration is the largest component of the water balance equation, in comparison other components are generally quite small.[42]

3 Below the dam

The hydrology below the dam is affected by the storage of water in the dam and the controlled release of water below the dam. The Owyhee Irrigation District supplies full irrigation water to 105,000 acres and supplements water to 13,000 acres. About 85,000 of these acres are in Oregon, the remainder are in Idaho.[26] About 22,000 of these irrigated acres are in the lower Owyhee subbasin.[9] The water balance on the irrigated acres is very different since much more water is being applied to the soil than from precipitation alone. For each crop there are ways of measuring the crop's evapotranspiration needs and, if at all possible, at least enough water is supplied to meet the crop's needs. Some of this water percolates down to recharge the ground water, some of the water runs off the end of the field and drains to the Owyhee River and Snake River, and most of the water is utilized by the plants: some to grow plant matter and most for transpiration.

C. Actual data

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 try to anticipate what might happen in the future.

Although the lower Owyhee subbasin only occupies 1,983 square miles[33], the Owyhee dam (Figure 5.4) and reservoir capture runoff from about 11,160 square miles.[45] Runoff from this larger area provides the greatest potential for flooding.

Much of the Owyhee River corridor above the dam is designated as wild and scenic river. There are no remaining inhabited areas on the banks of the river so flooding is not a major concern for human safety. However, along the part of the Owyhee River below the dam there are farms and houses. Here flooding is of great concern.

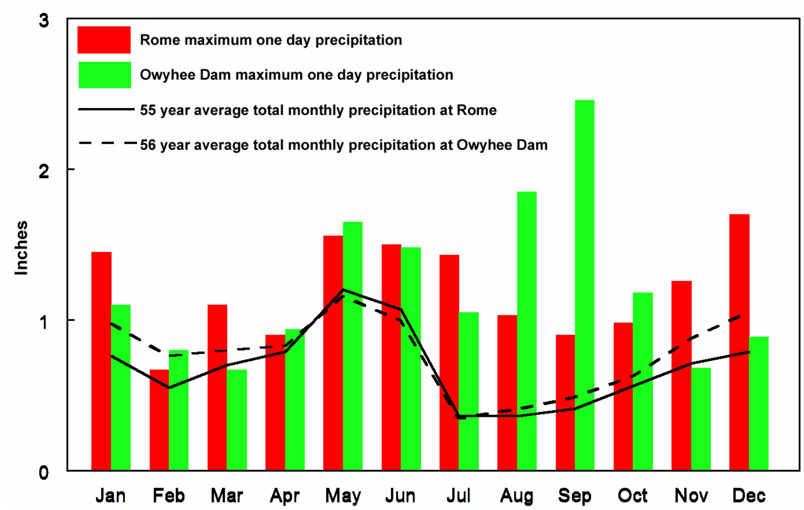
The Owyhee Dam was built for the purpose of irrigation (Figure 5.4). The storage capacity of usable water in the reservoir (Lake Owyhee) is 715,200 acre-feet. Although flood control criteria have been developed, they are advisory only. The Owyhee Irrigation District and the South Board of Control operate Owyhee Dam to store and supply irrigation water.[26]

Figure 5.4. Owyhee Dam.

1 Precipitation

The precipitation that fills Lake Owyhee comes from two principal sources. Snow fall in the higher elevations of the Owyhee drainage melts in the spring. This is supplemented by run off from the rainfall events in the spring. Figure 5.2 shows the average monthly rainfall at Rome and at the Owyhee Dam. As discussed earlier, between April and October, the evaporative potential of the area far exceeds the average rainfall (Figure 5.3).

Figure 5.5. Maximum measured one day precipitation compared to average total monthly precipitation.[40,41]



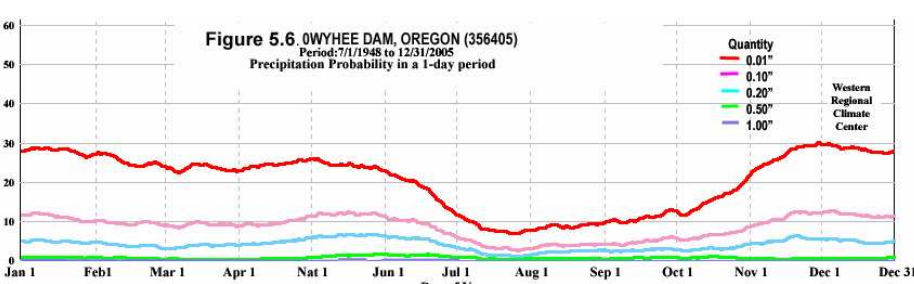
There is a very great variation in both the amount of precipitation and when it occurs. In one day more rain can fall than would be expected for total rainfall for the whole month. Figure 5.5 compares the average total monthly rainfall to the recorded maximum one day rainfall each month at Rome and the Owyhee Dam. In almost every month there has been 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.

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."[43] Figure 5.6 shows that there is a small probability of half an inch of rain falling at Owyhee Dam around 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.

There are many drainages in the lower Owyhee subbasin which can carry water. However, there are very few that carry water all year, every year. USGS topographic maps distinguish between perennial streams, those that essentially flow year-round, and intermittent streams which flow for only part of the year.[10] These



Probability of precipitation on a specific day of the year designations are not changed in map revisions unless the information has been verified on the ground.[27]

a. Perennial streams

A careful examination of the USGS topographic maps that cover the region of the lower Owyhee subbasin shows that only the Owyhee River is perennial throughout all its reach. A few other streams are shown as perennial for part of their reach. Figure 5.7 shows the stretches which are identified as perennial on the USGS maps.[AppendixA] There are four streams entering the Owyhee River from the east that are shown as having water year round in their lower reaches: Spring Creek, Willow Creek, Birch Creek and Bogus Creek. The longest of these, Bogus Creek, is about nine miles long. From the west, the last one to one and a half miles of the creek down Rinehart Canyon to the Owyhee River is shown as perennial. There are two segments of upper Dry Creek, a small stretch of creek in Road Canyon, the creek from Long Spring to Crowley Creek and a small stretch of Crowley Creek, the creek past Porter Springs which disappears into Porter Field, and the Little Crowley Creek from Little Crowley Springs south for about three miles which are also indicated as having water year round.

The short distances of perennial tributaries which do not continue as perennial after joining a larger stream are typical of desert landscapes where runoff decreases over distance because of transmission losses in the alluvial stream channels.[42]

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."[28] 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."[28]

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."[3] Ephemeral streams have channels which are always above the water table. They only carry water during and immediately after rain, particularly storm events.[16,3] "Most of the streams in desert regions are intermittent or ephemeral."[3]

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 lower 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.

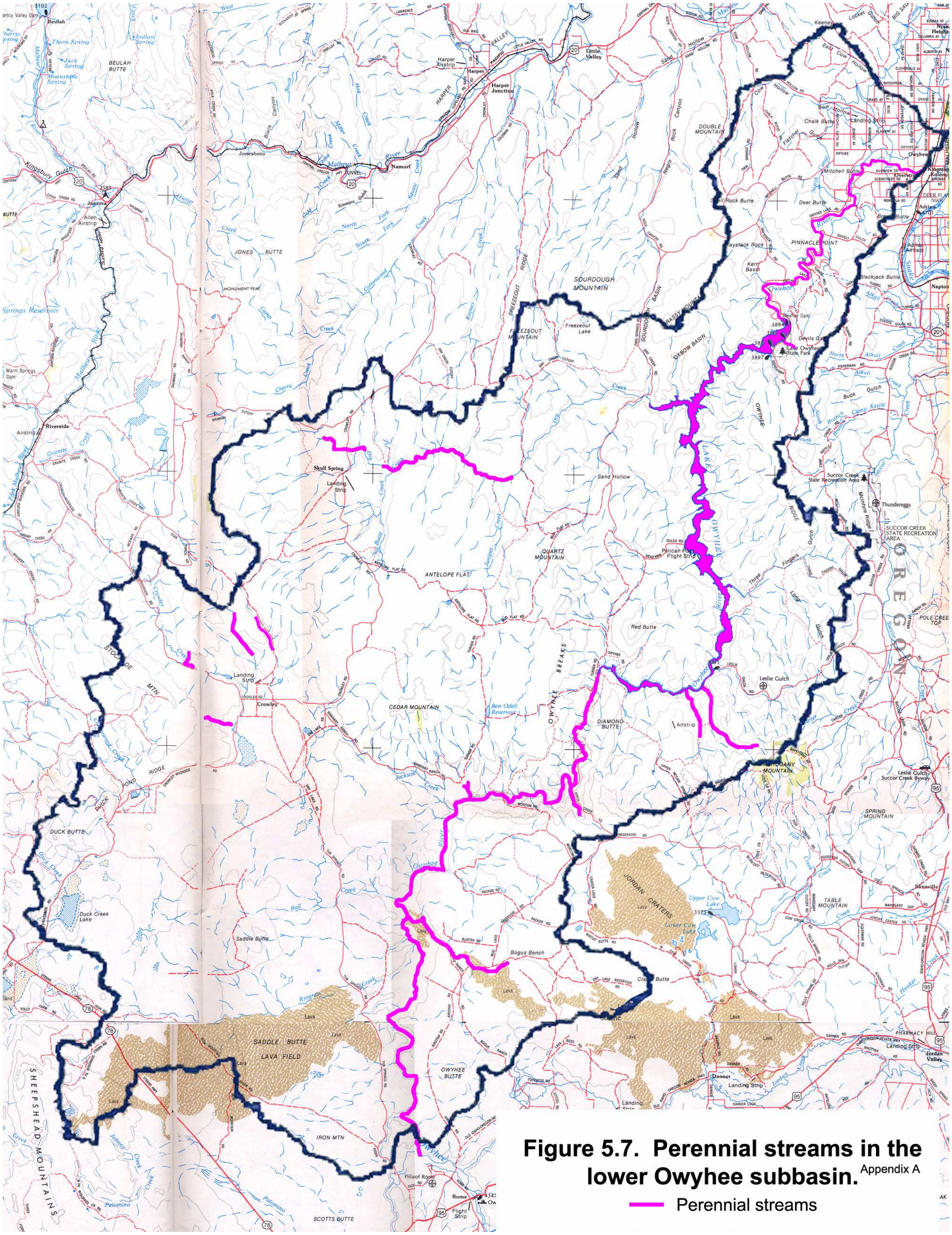


Figure 5.7. Perennial streams in the lower Owyhee subbasin. Appendix A

Perennial streams

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.

Figure 5.8. An ephemeral stream in Leslie Gulch with sagebrush growing in the bottom of the wash or "streamed".

Sagebrush dies when flooded. Streams channels that have sagebrush growing directly in the bottom of the wash are most likely ephemeral (Figure 5.8). Sagebrush does not tolerate saturated soil, and if the soil stays saturated for two weeks, sagebrush dies. Water spreading 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 due to scarcity of water.[10]

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.

3 Runoff

Because the other parts of the water balance equation account for the destination of most 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.[35] 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.[22]

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 lower 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.[33] The steepest gradient funnels water into the established water courses of intermittent and ephemeral streams. In the beds of intermittent streams and in dry washes where the streambed flows only after significant rainfall, the sudden torrent of water from rains upstream may cause a flash flood.[16] Entering Leslie Gulch there is a flash flood warning posted. A similar danger exists for many of the other streambeds in the lower Owyhee subbasin.

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.

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 and below the dam.

a. Sources of Owyhee River flow data

No measurements were taken and recorded of the flow in the Owyhee River prior to the 1890s. A gauge was installed near Owyhee Corners and records of the flow in the river were kept daily from March 26, 1890 to May 15, 1897. Recording was resumed August 28, 1903 stopped September 30,1916, resumed May 17,1920 and continued until July 2, 1929.[32] On February 25, 1929 a gauge was installed at the current location below the dam and the data used in this discussion include flows through June 28, 2006.[31]

A gauge near Birch Creek Ranch above Lake Owyhee began measuring flow in 1930 at the beginning of the water year, October 1. It was in operation until the end of the water year, September 30, 1951.[30] Data from that gauge overlap data collected at a gauge on the Owyhee River at Rome. Collection there began on October 1, 1949. The analyses made here include data through June 29, 2006.[29]

b. Before dam construction

Before the dam was constructed, farmers and ranchers were utilizing water from the Owyhee River, both upstream around Watson and on the land near the lower Owyhee, but irrigation water would not have been needed during winter and early spring. Therefore, the flows at the Owyhee Corners gauge can be assumed to be a fairly accurate representation of the amount of water in the Owyhee River prior to the irrigation season.

Figure 5.9. Receding floodwaters of the lower Owyhee River, April 2006

Analyzing data through July 7, 1933 from the gauge near Owyhee Corners and then the gauge below Owyhee Dam, high flows occurred in the spring months when snow was melting. Of 9,119 days with records, the average daily flow exceeded 20,000 cubic feet per second (cfs) only three times: once in February and twice in March. During this time the average flow exceeded

10,000 cfs nine times in February, 43 times in March, 46 times in April, and 37 times in May. Only 1.5% of the days had flows over 10,000 cfs.

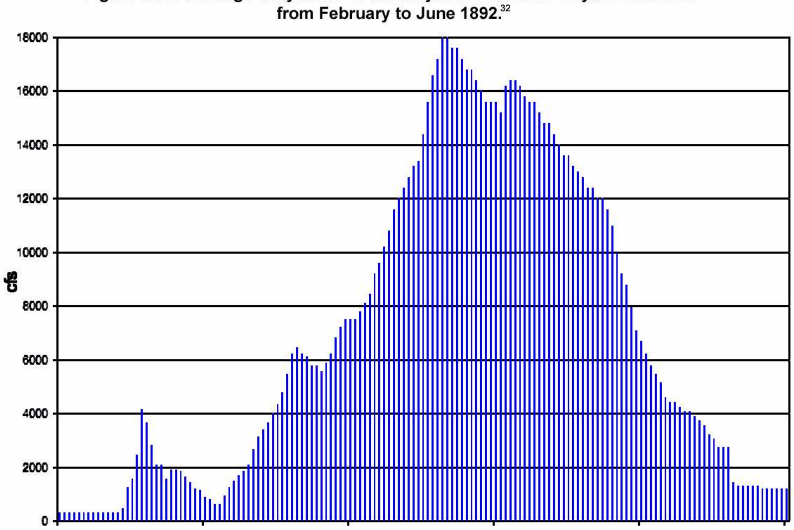
However, this does not tell the complete story of the amount of water coming down the river. Today 12,000 cfs below the dam is considered a moderate flood flow (Figure 5.9). "Flood water will approach houses near Owyhee Junction. Farm land between the dam and Owyhee Junction will be flooded. Flooding will be about 1 foot deep near the Overstreet Bridge."[8] In 1892 there were 40 days with flow over 12,000 cfs and 24 days with flow over 15,000 cfs (Figure 5.10). Today with 15,000 cfs below the dam, "flood waters will cover roads near Owyhee Junction. Some houses near Owyhee Junction will be flooded."[8]

c. After construction of the dam

Today the peak flows below the Owyhee Dam are mitigated by reservoir management even though the dam is operated primarily for irrigation purposes. The "glory hole", the spillway for the dam, only operates after the reservoir is 80% full and water reaches the base of the glory hole. Before the level of the water is high enough to spill through the glory hole, the Owyhee Irrigation District can only release about 2300 cfs, mostly through the jet valves. The glory hole has a maximum spillway capacity of 41,790 cfs.[24] Most of the flow into the reservoir comes from snow melt at higher elevations in the Owyhee watershed. This flow is measured on the Owyhee River at Rome.

Although Owyhee Dam has a total storage capacity of 1,183,300 acre feet[38], over 400,000 of these are below the level of the outlets. The number of usable acre feet is considered to be 715,000 acre-feet of water and this is the base from which calculations are made. In the 69 years of records[39], the reservoir has filled to more than 700,000 acre-feet in 37 of those years. When the reservoir no longer has the capacity to capture the water which enters it from upstream, the excess must be spilled through the glory hole. This is when the danger of flooding downstream is the greatest. A rough calculation of the number of acre feet per day entering Owyhee Lake can be made by multiplying the flow in cubic feet per second by 1.98.

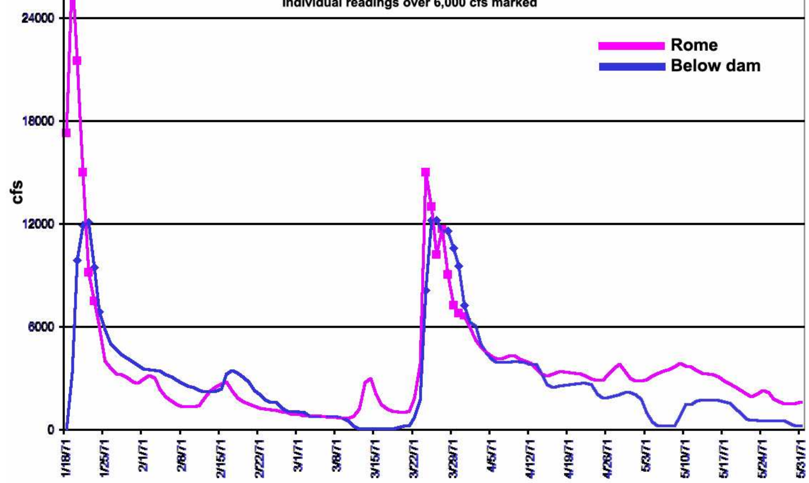
Figure 5.10. Average daily flows of the Owyhee River near Owyhee Junction from February to June 1892.[32]



The earliest in the year that the reservoir held 700,000 acre-feet was on January 20, 1971. The water in the reservoir remained above 700,000 acre-feet for 152 days. The latest date in the year when it reached 700,000 acre-feet was May 30, 1956.[25]

Although there were 152 consecutive days with the reservoir behind Owyhee

Figure 5.11. 1971 Owyhee River average daily flow at Rome and below the Owyhee Dam.[29,31]
Individual readings over 6,000 cfs marked

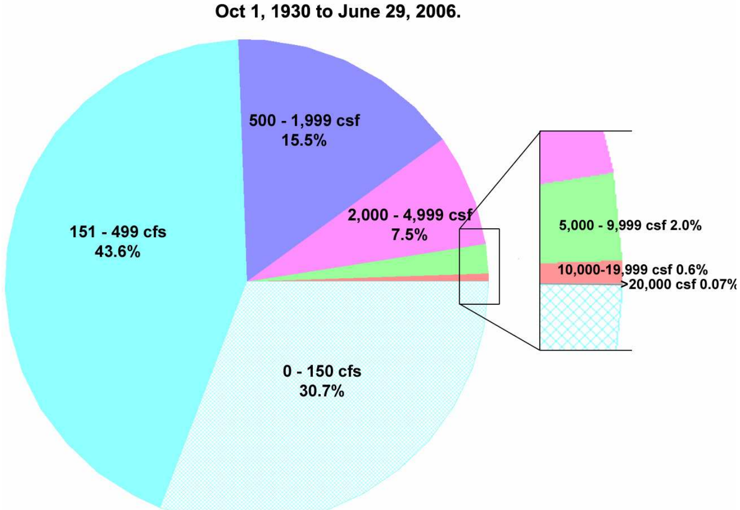


Dam filled to over 700,000 acre-feet in 1971, 1971 is not a year renowned for flooding. Water measured at Rome usually takes about two days to reach the reservoir. Figure 5.11 compares the flows of the Owyhee River at Rome with the flows below the dam for the period from January 18, 1971 to May 31, 1971. On January 18 there were 643,120 acre-feet in the dam. Despite spilling 3,300 and 9,860 cfs in the next two days, in the succeeding days the capacity of the dam was exceeded and all the excess overflowed into the Owyhee River. From the graph, it is obvious that the flow in the river below the dam mirrors the flow coming in from upstream since there was no remaining storage capacity available in the reservoir. As irrigation began, outflow fell below inflow in April 1971.

To provide capacity in the reservoir to accommodate water which is expected to come down from upstream, the Owyhee Irrigation District surveys the snow pack and watches the flow at Rome. Since the ability to release large amounts of water is only reached when the reservoir is 80% full, there isn't very much wiggle room.

The greatest chance of flooding will occur when the dam is already fairly full and there are large flows entering from upstream. Flows in excess of 20,000 cfs for one day will add 40,000 acre feet or more of water to the dam. Although this type of flow has occurred only 0.07% of the time, we can anticipate that the chance of future occurrences will continue to be about 7 out of 10,000 (Figure 5.12). In the over 37,000 readings made since 1930 there have only been three times the flow entering the reservoir as measured upstream exceeded 30,000 cfs. On March 18, 1993, 46,900 cfs were measured at Rome and there was substantial flooding above the dam. However, the reservoir only had 263,513 acre-feet in it and was able to accommodate the extra 93,000 acre-feet plus runoff from elsewhere.

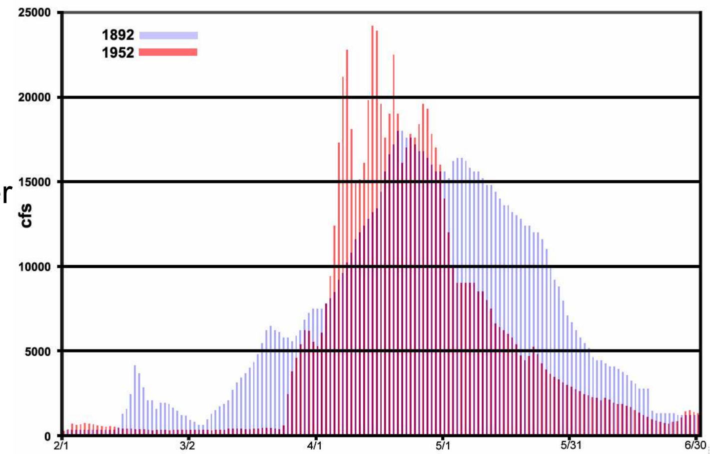
Figure 5.12. Distribution of average daily flows in the Owyhee River from Oct 1, 1930 to June 29, 2006.



Data from 10/1/30 to 9/30/49 from near Birch Creek above the Owyhee Dam and data from 10/1/1949 to 6/29/06 from Rome.[29,30]

Continued high flows for several days is reason for concern since such flows can easily fill the reservoir and necessitate dumping the excess water into the Owyhee River below the dam. In 1952 flooding below the dam washed out the old bridge. Compared to 1892 there were fewer days in 1952 with high flows, but the peaks were higher (Figure 5.13). Although statistically unlikely to occur, the chances of successive days with high flows are probably greater than the chance of winning the lottery, and large numbers of people are willing to bet on the lottery.

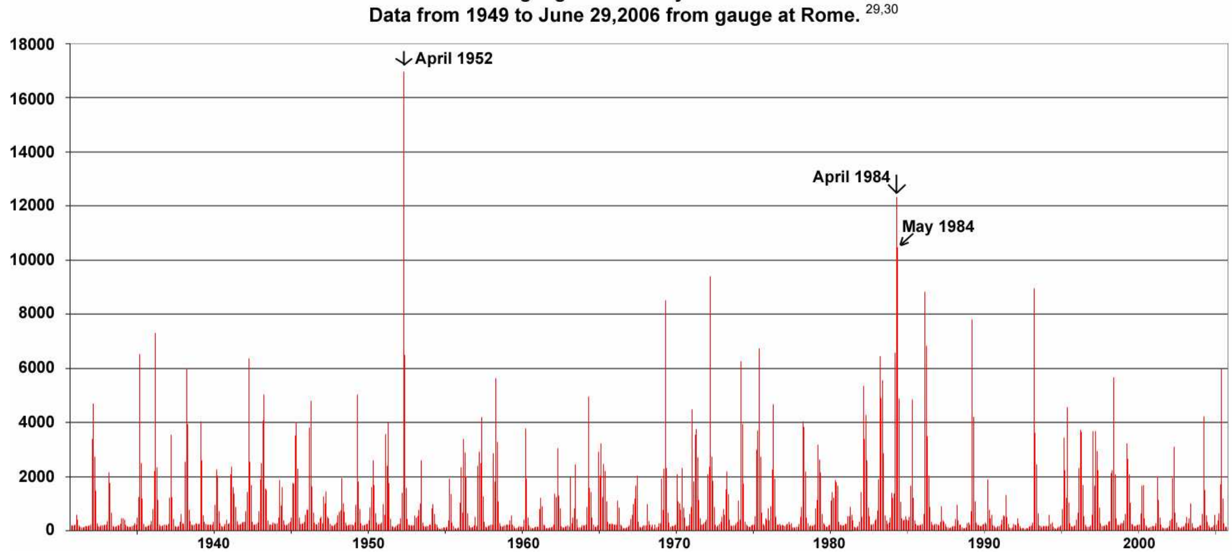
Figure 5.13. Comparison of 1892 Owyhee River flows to those of 1952. [29,32]



Besides day to day fluctuations in the flow of the river, the distribution of flows month to month varies from year to year. A chart of the average daily flow for a month shows these year to year variations (Figure 5.14). Since most months are of approximately the same length, the relative amounts indicate the total flow for the month. In 13 of the 76 years there was at least one month where the average daily flow exceeded 6,000 cfs (approximately 357,000 acre feet). However, by contrast, there were 21 years where the average flow per month never exceeded 2,000 cfs.

Assuming a definition of 15,000 cfs or higher as a "high inflow", historically the month with the greatest chance of high inflows into Lake Owyhee from upstream is April with 46.8% of the high flows. This is followed by March with 19.8%, February with 12.6%, January with 8.1%, and December with 1.8%. Since a large portion of the flow in the Owyhee River is from snowmelt, these are logical months to have higher flows. The potential for snowmelt to cause flooding is increased by rain-on-snow events. Besides flooding downstream, rain on snow events can trigger landslides, produce debris flow, and damage riparian areas.[20]

Figure 5.14. Average daily flow for the month
Data from 1931 to 1948 from gauge above Owyhee Reservoir near Birch Creek
Data from 1949 to June 29,2006 from gauge at Rome. [29,30]



The conditions to produce flooding below the dam will inevitably occur. Before the dam was constructed, the stream channel below the dam was periodically scoured by the higher flows. Fast flowing runoff also picked up more sediment and eroded the channel. If ice blocks were carried by the floodwaters they increased the amount of scouring.[22,20] Watson residents remember ice damaging their water wheels. Since the construction of the dam, the stream channel below the dam has had sediment settle in it and vegetation grow up along it and in it. These impede the amount of water which the channel can accommodate and increase the danger of flooding with lower flows. Levels of flooding which have occurred historically are extremely likely to recur.

The Bureau of Reclamation (BOR) estimates that for the Owyhee Dam the "probable maximum flood", the most severe "reasonably possible", would be 1,917,000 acre-ft over 15 days.[24] If the dam were empty when the flows started and the jet valves were releasing 2300 cfs, water could start spilling over the glory hole near the end of the 4th day. If 41,000 cfs went over the glory hole continuously, towards the end of the sixth day the dam would be full. The glory hole and jet valves could no longer get rid of the water entering, and 18,900 cfs would be going over the top of the dam while 64,500 cfs would be roaring down the Owyhee River below the dam. All this is assuming a constant inflow with no peaks above the 64,500 cfs.

This scenario seems far fetched when compared to the historical one day peak flow of 46,900 cfs entering the reservoir. However, a couple of flows like the March 18, 1993 flow of 46,900 cfs (93,000 acre-feet) could quickly cause problems with dam capacity if the reservoir were already spilling over the glory hole. Forty thousand cubic feet per second flowing in the Owyhee River below the dam would cause catastrophic flooding, especially if the Snake River were also high at the same time.

d. Prehistoric, precontact flooding

Historically flows of the magnitude conceived as possible by the BOR have not occurred. However, at "Hole in the Ground" upstream (southwest) from Birch Creek Ranch there is evidence that much more catastrophic events have happened at some time in the past. Well above the presumed level of the 1993 floodwaters, there are single boulders taller than a man that were deposited there some time in the past. The event that left them high and dry may have been a combination water-ice flow to have been able to lift them that far. These boulders have been polished by water passing over them, most probably after they were deposited in their current positions. This would indicate subsequent prehistoric flood events that rose to that level. These tremendous natural flood events occurred prior to any Euro-American use of the area for grazing or other activities.

D. Land use effect on flows

Since most of the lower 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 which is further discussed in the rangeland assessment section.

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 denude and compact the soil, leaving many paths for accelerated water runoff.

Human activities have the potential to affect the path water takes and might possibly contribute to the base flow in a stream. In the lower Owyhee subbasin, human activities are not responsible for the peak flows and their potential destructive force. The construction and management of the Owyhee Dam, stock ponds, and small reservoirs up stream tend to mitigate peak flows.

E. Data gaps

There is data missing for the lower Owyhee subbasin which is available for most of the United States. There are no soil studies except for the irrigated lowlands, no mapping of groundwater aquifers, and no data for water infiltration rates, key variables for hydrology. The mapping of vegetative coverage is basic: it is mixed sagebrush shrubland and grass.

There has been no ground verification of which streams are ephemeral, intermittent or perennial. The three types can not be looked at in the same fashion when considering if any remediation is feasible. Rainfall estimates only model rainfall between one point in the subbasin and stations surrounding it. These models are probably only somewhat accurate and give no idea of any local conditions that differ.

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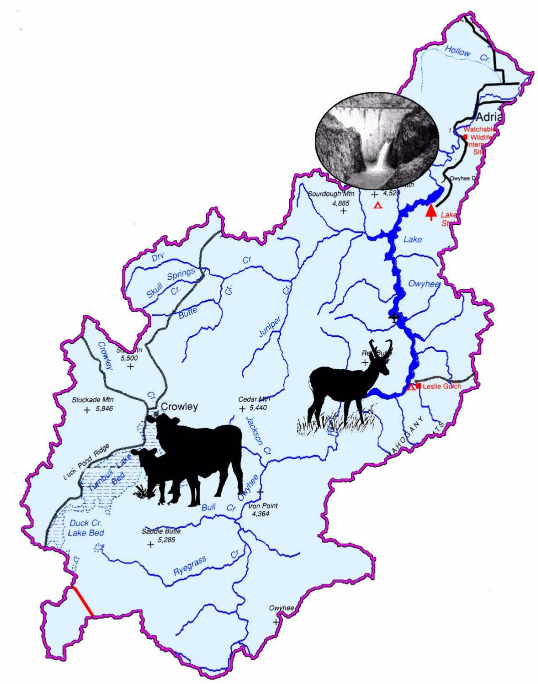

Lower Owyhee Watershed Assessment

VI. Water Use

Contents

VI. Water Use

A. Water sources

There are various sources of water used within the lower Owyhee subbasin. Water in wells comes from ground water in aquifers below the surface. Ground water from springs or seeps contributes to the surface water in streams. Water from snow melt is carried in streams.

The water from wells or springs can be used at the source. Water in the streams can either be diverted from the stream for direct use or can be captured within a pond or reservoir behind a dam. The water from any one of these sources can be used by cattle or wildlife, for irrigation, or for human consumption.

B. Water rights

Under Oregon law, all water is publicly owned.[18] Rights to use water are determined and administered by the State of Oregon as laid out in ORS 537.211 and ORS 537.250.[12] In general water right permits are issued for the development of water and water right certificates are issued to use the water after the source has been developed. Water right certificates specify the source and location of the water, how the water may be used, where the water will be used, and how much water may be used. There are both senior water rights, those granted at the earliest time, and junior water rights, those granted at a later date. In the case that there is not enough water to satisfy the needs of all entities with a right, the state can require those with a junior right to stop using water so as to provide water to the senior right.[8,18] A water right is subject to cancellation if it hasn't been used for five consecutive years.[18]

Most use of surface water in the lower Owyhee subbasin, either from a stream or a reservoir, requires a water rights certificate issued by the Oregon Water Resources Department. Most of the wells do not need a water rights certificate since all stockwater use of groundwater is exempt.[12,8]

C. Water use

1 Dams

a. Regulations

All dams within the subbasin are required to have a State of Oregon water use certificate. Many dams built before January 1, 1993 did not have a certificate. These unpermitted reservoirs had to have an application filed for a water right certificate before January 1, 1995.[12] At that time the Bureau of Land Management (BLM) filed multiple applications where the only identification of the dam was "a reservoir", "reservoir 48-0 1", or "reservoir 48-0 2". In this assessment there has been a concerted effort made in distinguishing between dams within the same township, range and section to ensure that they are distinctly different dams. This endeavor has been complicated by new permits and certificates being issued for the enlargement or increased use of an existing dam without the previous certificate being canceled and by apparent duplicate filings by the BLM on the same dam.

One of the criteria for applying for a right to use an unpermitted reservoir constructed before January 1, 1993 is that the dam is "located off-channel" and does not "divert water directly from a natural stream, lake or other on-channel source."[12] In other words, for these dams to receive a water right they can not be in a perennial or intermittent stream. An example of the location of an "off-channel" dam is taken from a private party's application in which he explains, "There is no defined stream or water course, but it is the flood water from melting snow and surface drainage from Juniper Mt. to west of reservoir. It may be called 'Juniper Creek'."[10] In many of its applications for reservoirs the BLM states that the impounded water will be from an "intermittent" stream. The BLM has not distinguished between intermittent and ephemeral streams in its applications. However, in order to have obtained the permits, the streams on which dams have been constructed must be ephemeral streams. (See the hydrology section for a discussion of the difference between intermittent and ephemeral streams.)

b. Dams in the lower Owyhee subbasin

Water rights for a specific township, range and section can by accessed on the internet on the Water Resources Department web page.[11] In this assessment of the

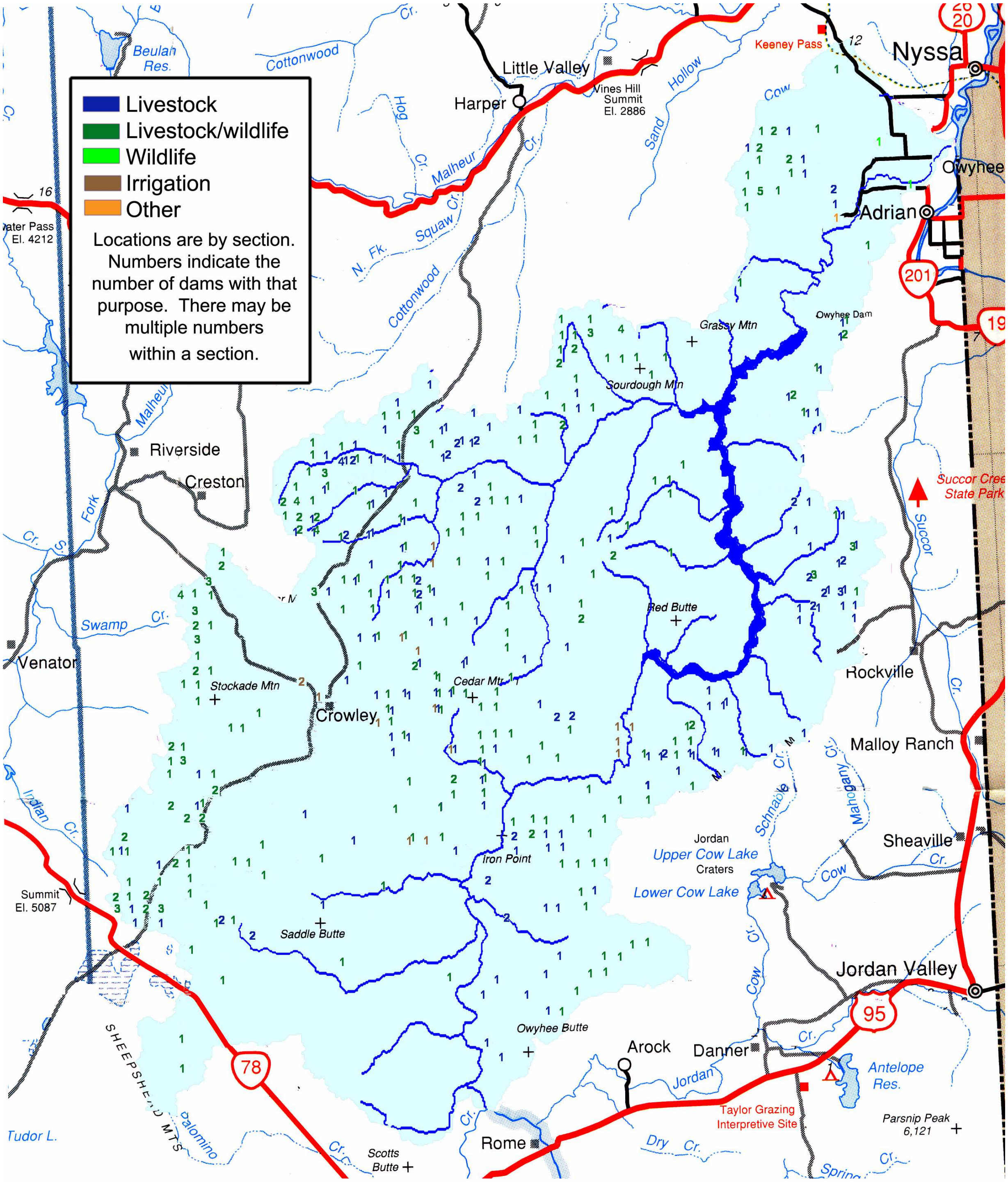

Figure 6.1. Reservoirs and ponds in the lower Owyhee subbasin .

lower Owyhee subbasin we have tried to compile a list of locations for every dam, well, or surface water right by examining the record for every section in the lower Owyhee watershed. The compiled record includes the location by section, the permitted use of the water, the name or source of the water, and whether the permittee is the BLM, a

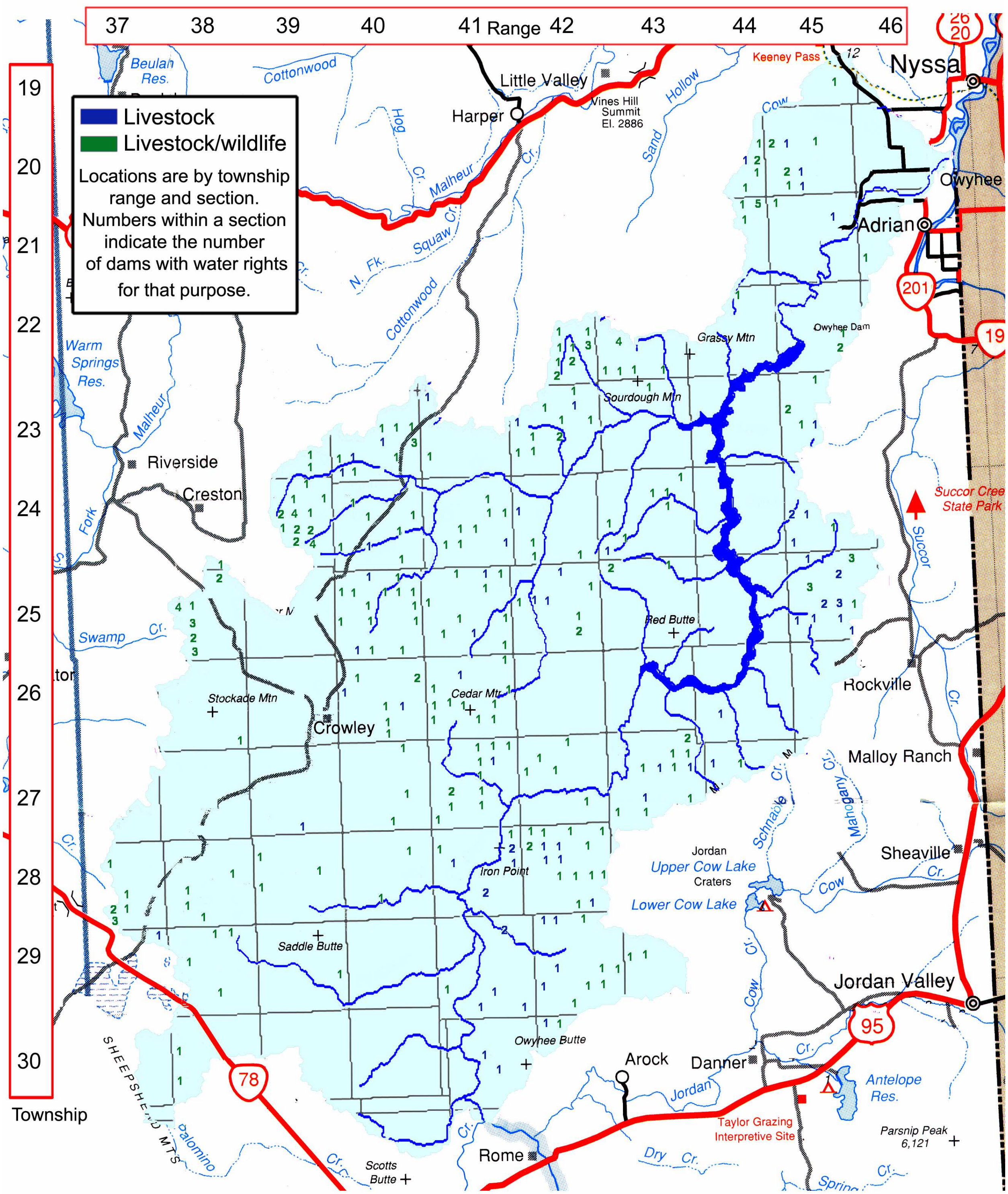

Figure 6.2. Reservoirs with BLM water rights in the lower Owyhee subbasin .

private individual or company, or another public agency. Appendix C contains the compiled list.

There are 540 dams other than the Owyhee Dam in the lower Owyhee subbasin (Figure 6.1). BLM has certificates for 336 dams (Figure 6.2), private entities have

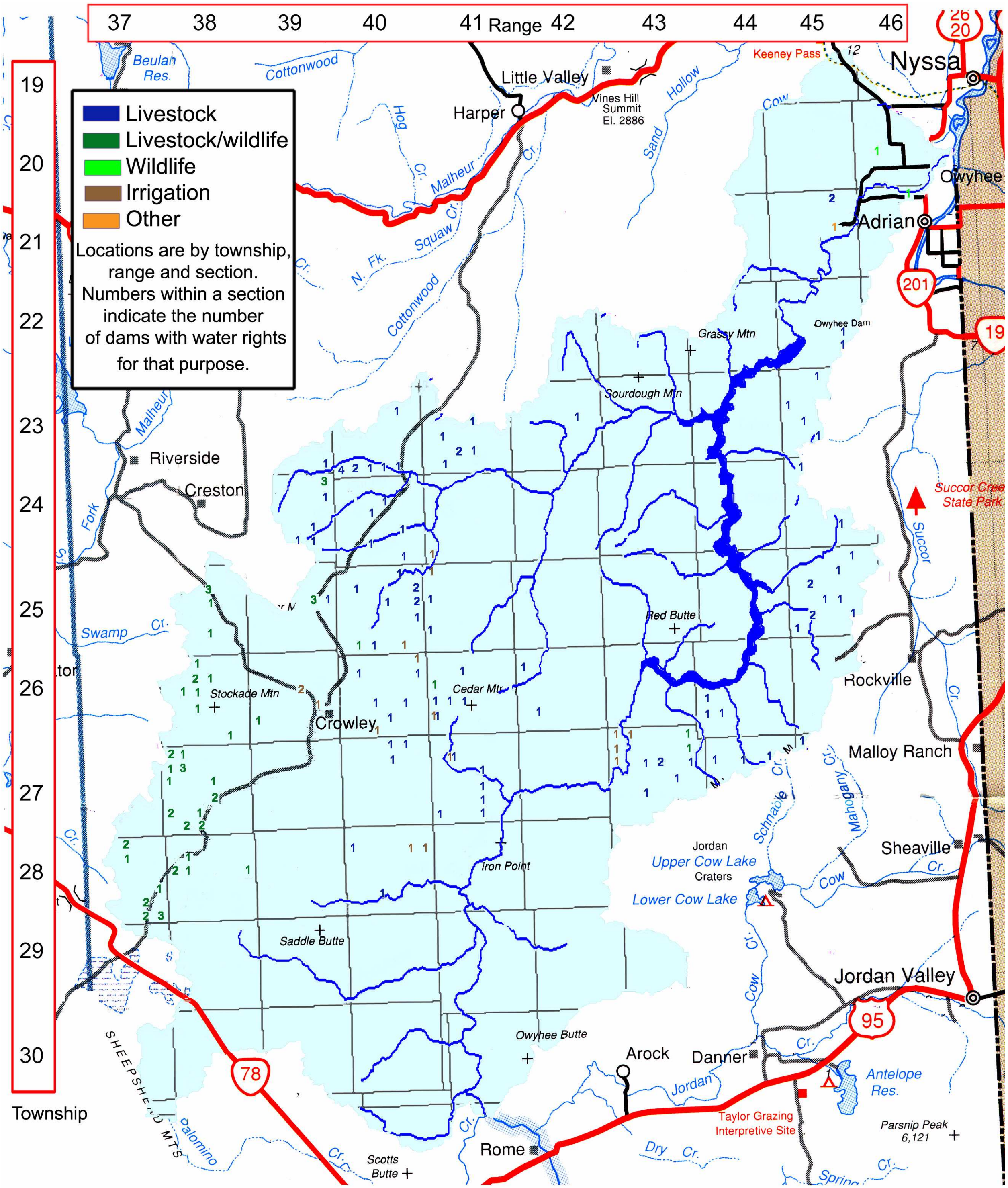

Figure 6.3. Reservoirs with privately held water rights in the lower Owyhee subbasin .

certificates for 172 dams (Figure 6.3), Oregon Department of State Lands has certificates for 31 dams (Figure 6.4) and the Bureau of Reclamation for one small dam.

Two hundred and eight of the certificates were issued specifying use by livestock, 311 specifying both livestock and wildlife, 2 for wildlife, 16 for agriculture or irrigation and the remaining three for multiple purposes (Table 1).

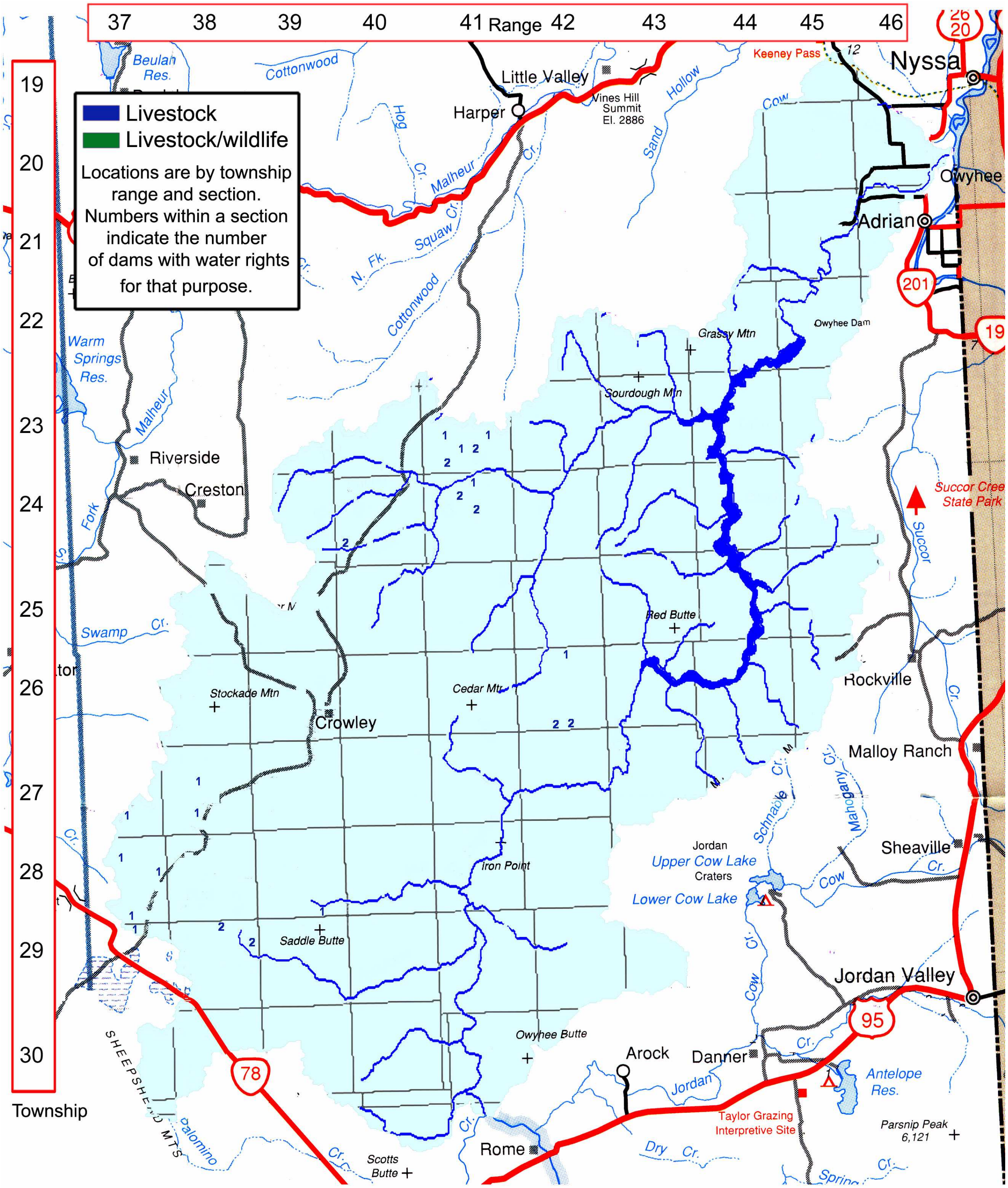

Figure 6.4. Reservoirs with water rights held by Oregon Division of State Lands in the lower Owyhee subbasin .

If the certificate for a reservoir allows a specific use, water from that reservoir which is diverted to water tanks or troughs may be used for that use and do not require a second water permit or certificate.[12]

Table 1. Ownership of water rights and use of water for dams other than the Owyhee Dam in the lower Owyhee subbasin. October 2006.[11,10]

	BLM	Private	State lands	BOR	
Livestock	83	94	31		208
Livestock/wildlife	253	58			311
Wildlife		2			2
Agriculture		5			5
Irrigation		11			11
Multiple		2		1	3
	336	172	31	1	540

There are approximately 15 dams in the subbasin that the state watermaster checks every year or every 5th year depending on their height. These are reservoirs where a failure of the dam could possibly create damage downstream to either human life or property. The watermaster is currently surveying other dams to see whether they should be included on this list. The survey of encompasses looking for buildings downstream from the dam that are potentially at risk.[8]

There are a number of factors which the watermaster looks at when the dams are checked. Vegetation on the banks, particularly deep rooted vegetation could create voids through which water could flow. Any rodent activity would also potentially create a problem as would any other erosion. The spillways are checked to be certain that there is no debris which could plug them. The discharge facilities, either head gates or spillways with flashboards, are checked.[8]

2 The Owyhee Project

The Owyhee River itself is captured and dammed by the Owyhee Dam. The Bureau of Reclamation holds the certificates for the water rights from the dam.

a. History

Lands in the Owyhee project area were first irrigated in the latter half of the nineteenth century.[1] There were about eight families farming lands bordering the lower Owyhee River who joined together in 1883 to construct a ditch along the north bank of the Owyhee River to supply water for a gravity system of irrigation.[14,7,9] In 1888 the Owyhee Ditch Company was formed and built a diversion dam southeast of Mitchell Butte with a permit allowing them to take 41,000 acre-feet of water from the Owyhee River.[14] By 1900 farming areas in the lower Owyhee subbasin were being irrigated with water diverted from both the Snake and Owyhee Rivers. Several Snake River pumping plants were later installed.[1] In 1926, as part of a series of legal decisions on water rights known as the Owyhee Decree, it was determined that the original families had consigned their rights to the Owyhee Ditch Company and the priority date for all Owyhee Ditch Company rights was October 1888.[5]

Early irrigators had decided that a dam which could hold enough water to reliably provide irrigation water throughout the growing season was essential to future prosperity.[14] By 1924, the federal government was interested in construction of dams with the primary purpose of extending irrigation and with "such control by the government as to prevent interference with the use of the stored water in irrigation.'[14]

Water shortages occur repeatedly throughout the entire Owyhee basin. When Owyhee Dam was constructed, there was a realization that water shortages would be of critical importance below the dam when irrigation became essential to the anticipated intensive agriculture. Due to the highly variable runoff in the Owyhee basin, Owyhee Dam was sized to provide a two year water supply.[1,16]

In 1926 the Owyhee Project was authorized and by October the first train used the completed railroad to the construction site of the Owyhee Dam.[3,14] Although the dam was dedicated in 1932, it was 1935 before the first water from the Owyhee project was supplied to farms.[14,7,9,1]

b. Owyhee Project facilities

The total capacity in the Owyhee Reservoir behind the dam is 1,120,000 acre-feet with an active capacity of 715,000 acre-feet. Originally plans were to use gravity to supply the entire project with water from Owyhee Reservoir.[1,3] However, because "of the irregularity of flow of the Owyhee River" it was "necessary to use Lake Owyhee on a holdover basis. To make this accumulation of storage possible, the construction of facilities to pump from the Snake River to lower-lying project lands was begun in 1936."[1]

In addition to the Owyhee Dam and the Snake River pumping plants, the facilities of the Owyhee Project include the North and South Canals. Water is released from Owyhee Reservoir through a three and a half mile long tunnel to the headworks of the North and South Canals. The water enters the tunnel in the reservoir 80 feet below the normal maximum water surface. The North Canal delivers water to the north and the South Canal delivers water to the southeast.[1,3]

The BOR operated and maintained all of the Owyhee Project until 1952. In 1952, all project works other than Owyhee Dam and related works were turned over to the North and South Boards of Control. In 1954 the operation and maintenance of Owyhee Dam and related works were also turned over. The North Board of Control is now the Owyhee Irrigation district. The Owyhee Irrigation District operates Owyhee Dam in cooperation with the South Board of Control.[1,17]

The Owyhee Irrigation District controls the release of stored water from Owyhee Reservoir.

c. Water use

i. History

In 1924, the Secretary of the Interior, Hubert Work, articulated that the "primary purpose of all reclamation construction is to extend irrigation. In all storages there will be incidental benefits to come from the development of power . . . there should be such control by the government as to prevent interference with the use of the stored water in irrigation.'[14] The water in Owyhee Reservoir was designated for irrigation.

Irrigated acreage in the Owyhee Project has increased since the beginning in the 1930s. In 1936 the Owyhee Project irrigated 8,609 acres. By 1939 there were 73,040 acres irrigated. In 1951 the number of irrigated acres had increased to over 97,000. By 1965 more than 111,000 acres of crops were receiving irrigation water through the project.[13] Today the project provides water to fully irrigate over 105,224 acres of land and supplemental irrigation water for 13,000 acres of land.[3,2] About 72 percent of the lands irrigated by the project are in Oregon and about 28 percent are in Idaho.[3]

ii. Irrigation in the lower Owyhee subbasin

The Bureau of Reclamation has a certificate to use the water from the Owyhee Reservoir to irrigate about 15,970 acres in the lower Owyhee subbasin (Figure 6.5). The bureau has a certificate for supplemental irrigation on about 2,555 acres in the subbasin with rights for about 800 of these acres being pumped from the Snake River. Of these 2,555 acres, the bureau rights for supplemental irrigation are the principal source of water on about 2,170 acres.[11,10] The water right is restricted to a maximum of 3 acre-feet per acre from the dam and a maximum of 6.7 acre-feet per acre secured under any combination of existing rights for the same lands.[10]

The principal crops grown in the lower Owyhee subbasin with this irrigation differ in the amount or water they consume in a year in acre-feet per acre averaging: 3.5 for alfalfa, 2 for winter grain, 2.2 for spring grain, 2.8 for sugar beets, 2.4 for onions, 2.3 for potatoes, 1.7 for dry beans, and 2.3 for field corn.[6] Irrigation amounts are usually required in excess of crop consumptive use due to inefficiencies in any irrigation system and the need for a leaching fraction to avoid the accumulation of salt in the soil.

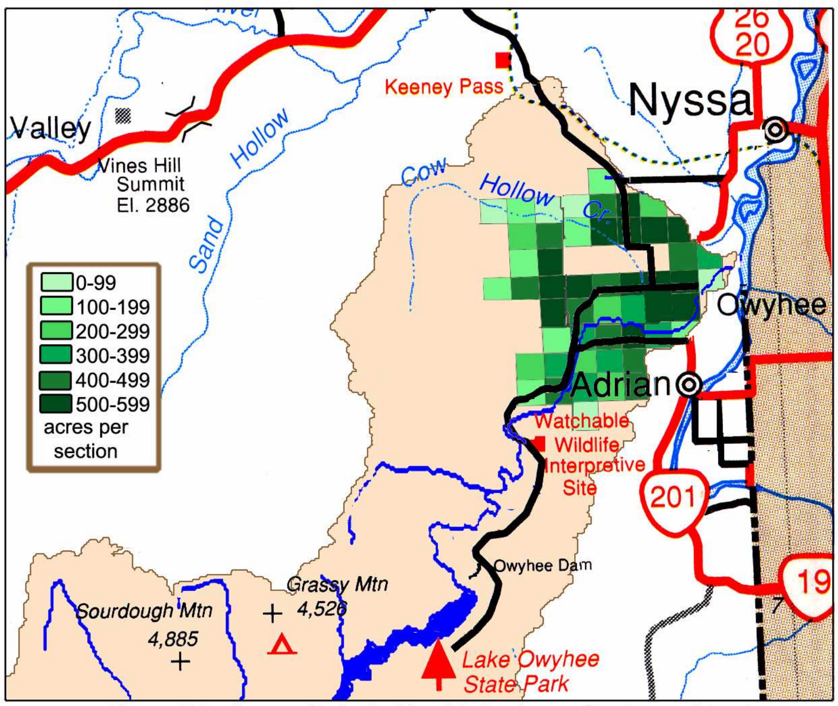

Figure 6.5. Acres of irrigated land in the lower Owyhee subbasin irrigated with water from the Owyhee Project.

Growers have increased their efficiency in using irrigation water through the incorporation of many innovations. These innovations are discussed in the Irrigated Agriculture section of this assessment.

In addition to the acreage irrigated with water from the reservoir and pumped on the Snake River, there are substantial return flows in drainage canals which are reused for irrigation. District-wide approximately 30 percent of the water entering main drainage canals is reused.[17]

iii. Recreation

By 1937, a park had been created at Owyhee Reservoir with trees and grass planted and two double-unit stone fireplaces. Although the rocky shoreline of the reservoir was not very appropriate for much swimming, both boating and fishing became popular in the area. The Bureau of Reclamation stocked the Owyhee Reservoir with both cutthroat and rainbow trout. It was also stocked with crappies, bass, perch, and Eastern brook trout.[10]

Both fishermen and recreational boaters take advantage of Owyhee reservoir. The water which provides opportunities for recreation in the reservoir is later used for irrigation by the Owyhee Project.

There is also water being released from the dam to maintain an artificial cold water fishery below the dam. A minimum flow of 30 cfs is being maintained.[4]

iv. Hydroelectric generation

In addition to being used primarily for irrigation, there are three hydroelectric generating facilities on the Owyhee Project. In the 1980s irrigators obtained Federal Energy Regulatory Commission licenses to construct and operate hydroelectric power-plants. During dam construction of Owyhee Dam, an outlet facility was installed and now contains a 5,000 kilowatt power-plant. There is also an 8,000 kilowatt power-plant at Tunnel No. 1, the major diversion works for the project, and a 2,000 kilowatt power-plant on the Mitchell Butte lateral. These power-plants went online between 1985 and 1993. These power-plants generate a combined total of 15,000 kilowatts of electricity used by power customers in Idaho and Oregon.[3,17, 16]

The certificate for use of the water for power generation explicitly states that the "right granted herein is expressly made inferior in right and subsequent in time to any appropriation of water from this source which may hereafter be made for domestic, municipal, irrigation or any other beneficial consumptive use, or for storage for such purposes."[10]

v. Flood control

Flood damage has occurred below the Owyhee Reservoir along the Owyhee River. A flood similar to that of 1894 or 1910 before construction of the dam would inundate about 2,000 acres that is cultivated today.[1] The 1952 flood caused damages to 1,800 acres of agricultural land[15] and the 1984 flood caused damages to a similar number of acres.

Although all of Owyhee Reservoir's active storage capacity of 715,000 acre-feet is contracted for irrigation, the Bureau of Reclamation has developed informal flood control guidelines for the reservoir.[16] Water released for flood control passes through the lower Owyhee subbasin without being intercepted for any other purpose.

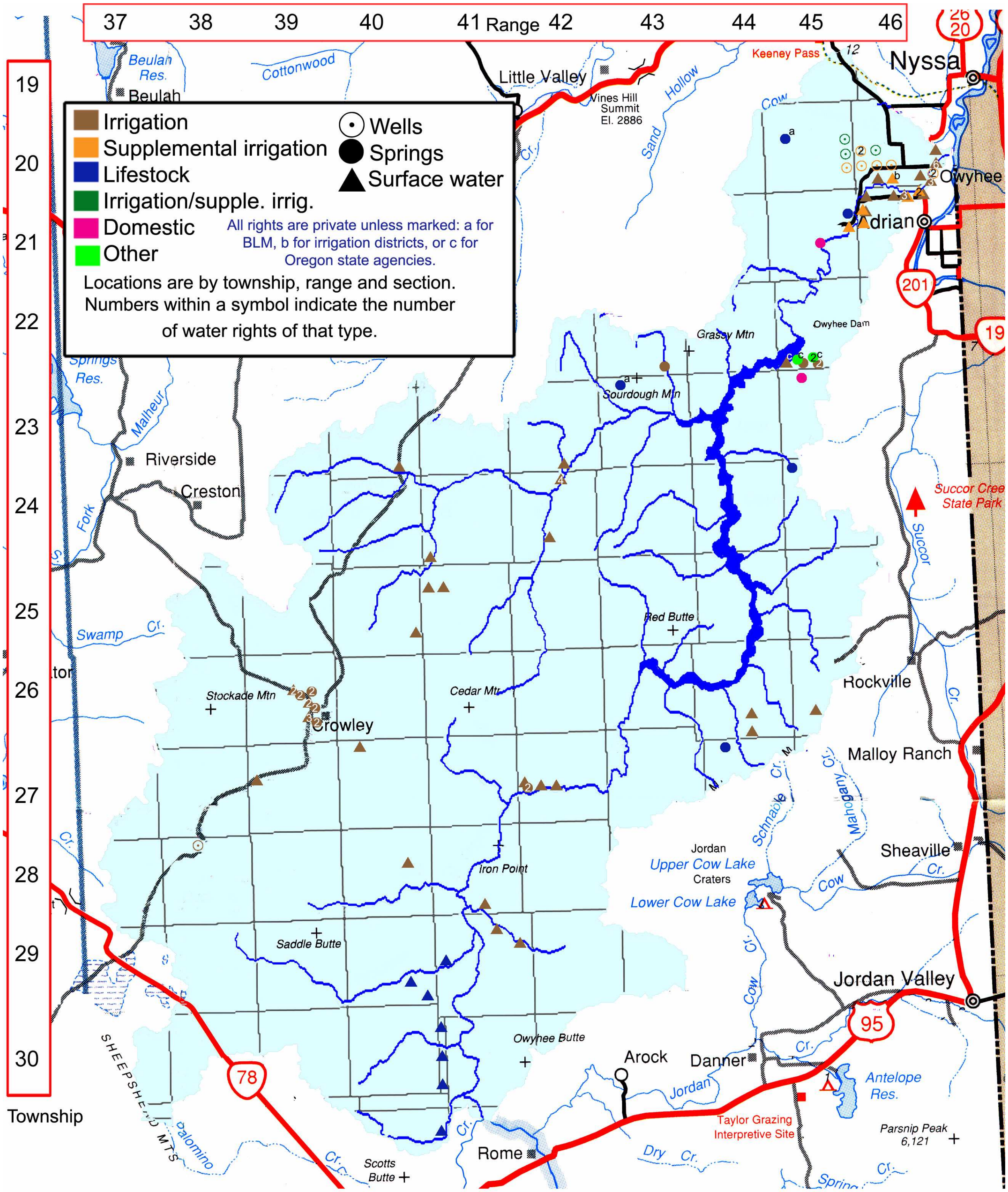

Figure 6.6. Surface water, spring, and well water rights in the lower Owyhee subbasin .

vi. Water export

A large portion of the water in the Owyhee River is intercepted by Owyhee Dam and diverted to irrigation. About 85% of this water is not utilized within the lower

Owyhee subbasin but is exported for the irrigation of crops outside the subbasin in Malheur County or in Idaho.[3,17]

3 Surface water

The majority of the surface water rights in the lower Owyhee subbasin, both from streams and springs, are for irrigation or supplemental irrigation. In addition to the rights below the dam, mostly from the Owyhee River, there is a concentration of water rights for irrigation around the Crowley area, some opposite the modern "Hole in the Ground" on the Owyhee River, three along Bogus Creek, several in the Dry Creek drainage, and the others scattered around the subbasin (Figure 6.6).

Although generally the 15,970 acres irrigated from the Owyhee Project use the irrigation water to grow crops or alfalfa hay, most of the water rights for irrigation in the upland areas of the lower Owyhee subbasin are used to grow hay for winter feed for livestock. This irrigation is usually in conjunction with a livestock operation.

There are seven surface water rights at the south end of the subbasin for livestock.

The Oregon Department of Fish and Game has applied for in-stream rights in parts of the Owyhee River above the dam for fish.

4 Wells

Most of the wells in the lower Owyhee subbasin do not require a certificate as they are used for livestock and all stockwater use of groundwater is exempt.[12]

Wells also do not require a permit from the Oregon Water Resources Department if they will be used to water a "lawn or noncommercial garden not exceeding 1/2 acre in area."[12] And, there is also a statutory exemption from permit requirements for domestic use of groundwater of not more than 15,000 gallons per day.[12]

The wells with a water use certificate within the lower Owyhee subbasin are primarily used for supplemental irrigation (Figure 6.6).

There is one permit for developing two wells in conjunction with an open pit mine. To obtain a certificate to use this water for mining purposes, the wells must be completed by October 1, 2008.[10] The water from these two wells would be used in many sections of the subbasin around Grassy Mountain.

5 Fire fighting

"Water used for emergency fire fighting is exempt from permit and certificate requirements regardless of the source of water."[12]

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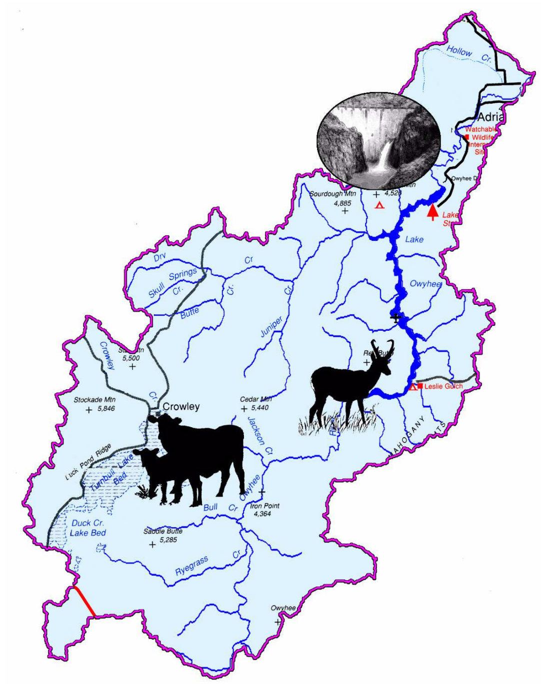


Lower Owyhee Watershed Assessment

VII. Irrigated Agriculture

Contents

VII. Irrigated Agriculture

Prior to the development of irrigation projects, agriculture in Malheur County was impossible due to arid conditions during the growing season. Agriculture was restricted to narrow strips of irrigated land along rivers. Some water could be diverted with water wheels or in-stream diversion structures. With the construction of Owyhee Dam in the 1930s, irrigated agriculture expanded in Malheur County below the dam. The number of acres irrigated in Malheur County with water from the reservoir behind the dam has grown from about 8,600 acres in 1936 to about 85,000 acres which are wholly or partially irrigated with water from the dam. Of these 85,000 acres, approximately 18,000 are in the lower Owyhee subbasin.[4,5,60] About 30,000 additional acres in Idaho are irrigated from the Owyhee Dam.

The Owyhee River water for irrigated agriculture comes not only from the lower Owyhee subbasin but from the entire Owyhee basin. The principal use of water originating in the Owyhee basin and stored in Owyhee Reservoir is irrigation.

Irrigated agriculture throughout the Treasure Valley basin of Malheur County is managed similarly, so the discussion of irrigated agriculture in the lower Owyhee subbasin does not differ from the discussion of irrigated agriculture in Malheur County.

Today agriculture in Malheur County uses up to date practices producing diversified products. Family owned farms use crop rotation practices that keep soil healthy and reduce disease and weed pressures. Growers associations cooperate to improve the yield and quality of the products and foster sustainable agricultural practices. Many by-products of agricultural processing are recycled into the local agricultural sector.

A. Importance of irrigation water

Malheur County agriculture not only has a farm gate value of about 185 million dollars per year (Table 1, Endnote), but is fundamental to the county economy, directly generating 800 million dollars due to sales, processing, packing, and services.

Table 1. Malheur County yields and farm gate crop values 2005. Malheur County Extension.

Sugarbeets	7,700 acres	$10,500,000
Onions	11,200 acres	$48,899,000
Potatoes	4,800 acres	$9,778,000
Alfalfa hay	52,300 acres	$8,891,000
Wheat	35,550 acres	$9,279,000
Alfalfa Seed	4,350 acres	$3,344,000
Barley	2,400 acres	$400,000
Dry field beans	2,470 acres	$1,288,000
Corn as grain	14,550 acres	$5,323,000
Corn as silage	6,140 acres	$1,575,000
Other crops	42,060 Acres	$13,463,000
Cattle	250,400 cows	$81,452,000
Milk cows	4,000 cows	$10,360,000
Sheep	10,400 ewes	$1,141,000
Other livestock, livestock products		$733,000

County agriculture is dependent on irrigation. Since most precipitation falls during the time of the year when freezing temperatures prohibit crop growth and the soil dries before dryland crops can set seed, having irrigation water available during the growing season is indispensable to the economic health of the county. This water comes from snow melt and spring rains captured and stored behind Owyhee Dam and other dams. Having water available during the growing season is essential to maintaining agriculture's economic contribution to the county.

Good agricultural farm management can not only conserve scarce water resources, but can minimize agricultural contributions to sediment loss and water pollution.

B. Crops

The crops that have been grown in Malheur county have changed with changing economic opportunities over the years. In 1935 when the county agricultural agent made a survey of crop yields, the record shows the number of farms growing a crop, not the number of acres planted. The largest number of farms grew some alfalfa, wheat, or red clover seed, followed by corn, potatoes, and barley. There was also some production of oats, alfalfa seed, apples, and prunes. By 1944 the greatest number of acres produced wild hay, sugar beets, and potatoes. Acreages for wheat, corn, and lettuce were less, followed by onions and celery.[13] In 1961 the way of surveying crops changed; Malheur County Extension now estimates acreage and values of the major crops (Table 2, Endnote).

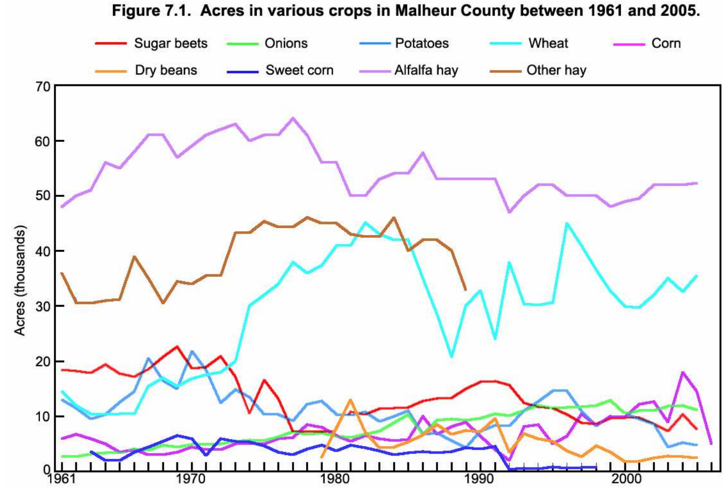
Table 2. Malheur County agricultural production acreage in different crops by year from 1961 to 2005. Estimated by Malheur County Extension staff, Oregon State University.

Year	Wheat	Sugar beet	Onion	Potato	Corn (grain)	Corn silage	Alfalfa hay	Alfalfa seed	Mints	Barley	Dry beans	Sweet corn	Oats	Other grain	Red clover seed	Other hay	Misc. crops	Total listed acreages
1944	8,000	15,000	2,800	12,000	5,000												24,260	
1961	14,500	18,500	2,750	13,000	6,000	11,000	48,000	7,500	1,000	11,500			2,500	3,100	2,000	36,000	4,500	181,850
1962	12,000	18,200	2,750	11,500	6,800	10,500	50,000	9,500	1,150	11,500			2,200	3,000	2,000	30,600	4,500	156,800
1963	10,500	17,928	3,200	9,500	6,000	10,000	51,000	14,500	1,050	11,000		3,650	2,700	3,000	1,000	30,500	1,500	177,028
1964	10,400	19,411	3,400	10,400	5,000	7,000	56,000	13,000	800	10,000		2,000	2,500	2,500	1,100	31,000	1,800	176,311
1965	10,500	17,811	3,400	12,600	3,500	8,000	55,000	11,000	700	11,000		2,000	2,500	2,500	1,000	31,200	2,150	174,861
1966	10,500	17,200	4,132	14,500	4,000	9,000	58,000	9,000	700	12,000		3,500	3,000	2,500	600	39,000	2,150	189,782
1967	15,500	18,551	3,900	20,500	3,100	9,500	61,000	8,250	750	10,500		4,500	2,500			35,000	1,750	195,301
1968	17,000	20,773	4,800	16,500	3,000	7,500	61,000	8,400	1,200	10,500		5,500	2,000			30,500		188,673
1969	15,500	22,600	4,400	15,000	3,500	7,500	57,000	7,200	1,400	17,000		6,500	2,000			34,500		194,100
1970	16,800	18,748	4,900	21,800	4,500	7,500	59,000	7,500	1,500	19,000		6,000	2,800			34,000		204,048
1971	17,500	18,894	4,900	18,500	4,000	7,500	61,000	8,300	1,450	22,000		2,900	2,500			35,500		204,944
1972	18,000	20,950	5,000	12,500	4,000	3,600	62,000	8,700	1,890	19,000		5,900	2,500			35,500		199,540
1973	20,000	17,250	5,500	14,900	5,000	7,700	63,000	9,000	2,435	15,000		5,500		2,900		43,300		211,485
1974	30,000	10,600	5,735	13,500	5,000	7,700	60,000	8,600	2,950	11,000		5,375		2,400		43,300		206,160
1975	32,000	16,600	5,650	10,300	5,000	7,000	61,000	7,100	3,100	10,000		4,625		2,400		45,300		210,075
1976	34,000	13,300	6,300	10,300	6,000	8,000	61,000	6,800	3,250	11,000		3,525		2,700		44,300		210,475
1977	38,000	7,200	7,200	9,200	6,200	5,500	64,000	8,100	4,700	14,000		3,000		3,400		44,300		214,800
1978	36,000	7,200	6,800	12,200	8,500	5,000	61,000	9,640	4,820	12,500		4,065		2,500		46,000		216,225
1979	37,400	7,200	7,010	12,760	8,000	4,800	56,000	10,000	3,620	12,300	2,600	4,742		2,500		45,000		213,932
1980	41,000	7,180	6,401	10,300	6,500	5,000	56,000	7,600	3,435	12,500	8,015	3,800		2,000		45,000		214,731
1981	41,000	10,840	6,200	10,200	5,500	4,500	50,000	5,000	3,320	11,000	13,000	4,800		2,000		43,000		210,360
1982	45,100	10,310	6,800	10,768	6,500	4,500	50,000	4,500	2,930	12,100	7,150	4,300		2,300		42,600		209,858

Year	Wheat	Sugar beet	Onion	Potato	Corn (grain)	Corn silage	Alfalfa hay	Alfalfa seed	Mints	Barley	Dry beans	Sweet corn	Oats	Other grain	Red clover seed	Other hay	Misc. crops	
1983	43,000	11,340	7,300	9,100	6,000	5,000	53,000	5,750	2,560	9,000	4,300	3,772		2,500		42,600		205,222
1984	42,000	11,500	8,800	10,000	5,600	7,000	54,000	6,000	2,930	9,000	4,500	3,000		2,200		46,000		212,530
1985	42,000	11,600	10,300	11,000	5,800	5,700	54,000	6,000	3,400	11,000	5,400	3,450		2,100		40,000		211,750
1986	35,000	12,800	6,800	6,800	10,000	5,400	57,800	6,000	1,995	14,500	6,700	3,600		2,100		42,000		211,495
1987	28,600	13,230	9,300	7,000	6,800	6,800	53,000	6,500	2,360	13,400	8,500	3,400		1,500		42,000		202,390
1988	20,800	13,400	9,540	5,600	8,200	6,500	53,000	7,000	2,720	6,900	6,800	3,650		1,000		40,000		185,110
1989	30,000	15,000	9,300	4,330	9,000	7,000	53,000	7,000	2,800	8,000	7,500	4,300		1,400		33,000		191,630
1990	32,800	16,300	9,620	7,300	6,400	6,400	53,000	7,300	2,350	4,000	7,200	4,125						156,795
1991	24,000	16,400	10,500	8,360	4,000	6,500	53,000	7,600	3,000	7,500	9,685	4,550						155,095
1992	38,000	15,700	10,100	8,300	2,000	5,000	47,000	5,500	2,660	8,500	3,510	430						146,700
1993	30,400	12,400	11,000	11,000	8,200	6,300	50,000	6,000	2,150	7,100	6,921	620						152,091
1994	30,150	11,800	12,000	12,700	8,500	6,400	52,000	6,200	1,950	9,760	6,000	520					26,470	184,450
1995	30,650	11,557	11,500	14,600	5,000	7,200	52,000	7,250	2,400	3,550	5,500	900					32,910	185,017
1996	45,000	10,370	11,600	14,600	6,400	9,600	50,000	7,300	2,265	6,000	3,800	580					32,910	200,425
1997	41,000	8,877	11,800	10,900	10,500	5,100	50,000	5,900	2,590	4,200	2,700	715					32,860	187,142
1998	36,500	8,640	12,000	8,300	8,400	9,100	50,000	7,650	1,980	7,900	4,730	715					38,060	193,975
1999	32,750	9,700	12,900	10,500	9,960	9,430	48,000	9,342	1,240	7,775	3,500						38,060	193,157
2000	29,950	9,750	10,500	10,500	9,850	9,850	49,000	6,960		7,250	1,750						38,500	183,860
2001	29,700	9,790	11,000	9,500	12,200	5,700	49,500	6,060		8,500	1,940						42,400	186,290
2002	32,000	8,570	11,000	8,600	12,700	6,350	52,000	4,310		7,000	2,450						42,000	186,980
2003	35,000	7,350	11,900	4,500	9,000	4,500	52,000	4,110		6,000	2,790						42,000	219,650
2004	32,650	10,300	12,000	5,200	18,000	6,250	52,000	5,150		5,700	2,690						38,500	188,440
2005	35,550	7,700	11,200	4,800	14,550	6,140	52,300	4,350		2,400	2,470						42,060	183,520

1. Forage crops

Figure 7.1. Acres in various crops in Malheur County between 1961 and 2005.



Over the last 45 years, alfalfa, other hay, and wheat have been grown on the most acreage in Malheur County (Figure 7.1). Hay is grown not only with irrigation below the dam, but is the principal crop on irrigated acreage in areas of the lower Owyhee subbasin above the dam. Eighty-five percent of the alfalfa hay produced in the county is either fed to animals by the producer or sold for local animal consumption. The best quality alfalfa hay is normally utilized by dairies and the remainder is utilized as feeder hay. Grass and rye hay are consumed locally (Figure 7.2).[19]

About 40,000 irrigated acres are devoted to pasture production. The majority of pasture is produced on ground that is not well suited for intensive farming. The ground may either be too steep, the growing season too short due to elevation, or the soil is too shallow for annual cropping but it still is quite productive for producing feed. The majority of irrigated pasture is utilized by beef cattle with some also being produced for dairies as well as sheep operations. Corn grown for silage is all fed locally, either by the grower or nearby neighbors. It contributes heavily to the nutrient requirements for local dairy cattle and feedlots.[19]

Figure 7.2. Newly baled alfalfa

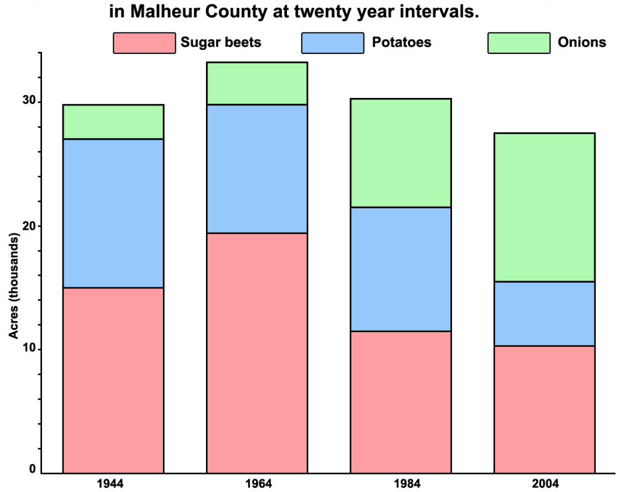
2. Cereal crops

Wheat is the major cereal crop produced. Soft white wheat is famous in world markets for quality pasta and pastries. In addition to serving as a cash crop, wheat is also produced as a rotation crop with row crops in order to maintain soil with lower amounts of weeds and diseases of the cash crops. Over 90% of the wheat is raised on irrigated soil. Barley and field corn are raised primarily as feed grains and are utilized locally by feed lots and dairies.[19]

3. Row crops

Onions, sugar beets, and potatoes have produced the greatest income per acre and have had a very large impact on the county economy in terms of jobs created by processing and handling in addition to the field production. Recently, Amalgamated Sugar, the principal processor of sugar beets, closed the Nyssa factory. After being purchased by Heinz Foods, the Ore-Ida factory in Ontario quit producing some lines of products which had utilized local crops (sweet corn and onions).

Figure 7.3. Comparative acreage in sugar beets, onions, and potatoes in Malheur County at twenty year intervals.



Onions are generally considered the most important cash crop in Malheur County. All the onions are produced for the open market which can be quite volatile; the value of onions is based on the national and worldwide supply of onions and consumer demand. The county's overall economy is impacted quite heavily by the fluctuating onion market. A large majority of the onions produced are yellow Sweet Spanish. Some acreage is also planted to red and white onions. Most of the onions are stored either in growers' storages or packing shed storages to be sold at a later date. Some are shipped fresh. Onions are packed locally and shipped by truck or rail.[19] The number of acres of onions has tended to increase over the years compared to

Figure 7.4. Acres in sugar beets, onions, and potatoes in Malheur County between 1961 and 2005.

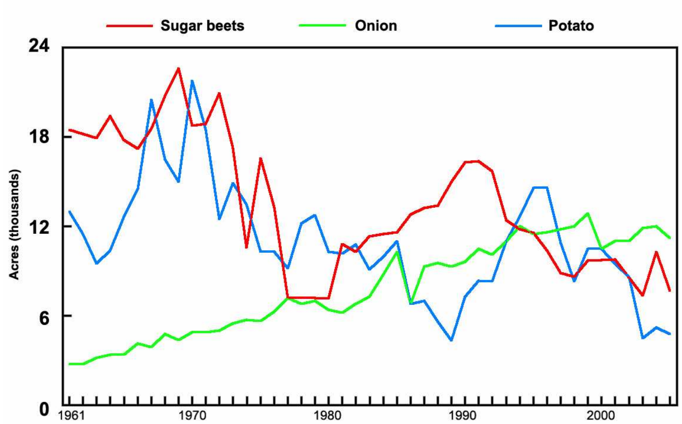
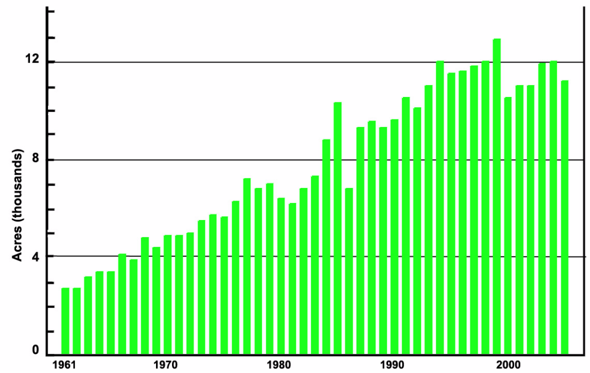


Figure 7.5. Acres in onions in Malheur County between 1961 and 2005.



the other row crops (Figures 7.3 and 7.4). The volatility of the onion market causes fluctuations in the amount of acreage planted (Figure 7.5). Onions are also processed into frozen chopped onions or onion rings at factories in Ontario, Oregon, Fruitland, Idaho, and Weiser, Idaho.

Most of the potatoes in the county have been produced for processing under contract with Heinz and Simplot. Contracts have continually become more stringent on quality. Potatoes are the most difficult crop to produce because of their sensitivity to heat stress which makes it imperative that excellent irrigation techniques be practiced.[19] Potato acreage in the county has been declining due primarily to subsidies to and lower costs of processors in Canada (Figure 7.6).

Sugar beets are a traditional row crop that has been produced in Malheur County since the 1940s. All sugar beets are grown under contract with the Amalgamated Sugar Company. The beet company regulates the number of acres and subsequent production that can be produced based on the company's processing capacity and sugar market quotas. Sugar beets have been a relatively stable crop in terms of price and yield but the effect of recent trade agreements is as yet unknown.[19] Acreage planted to sugar beets in Malheur County has been declining (Figure 7.7).

Figure 7.6. Acres in potatoes in Malheur County between 1961 and 2005

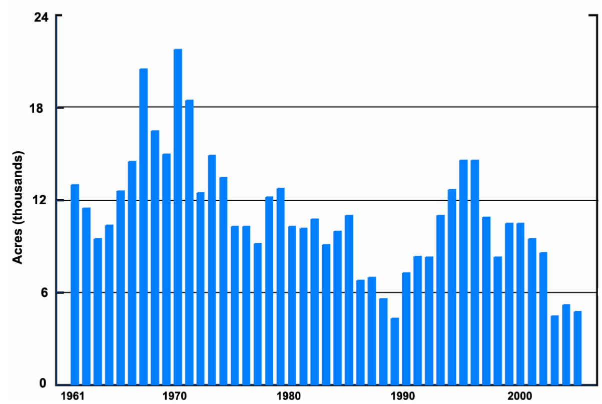
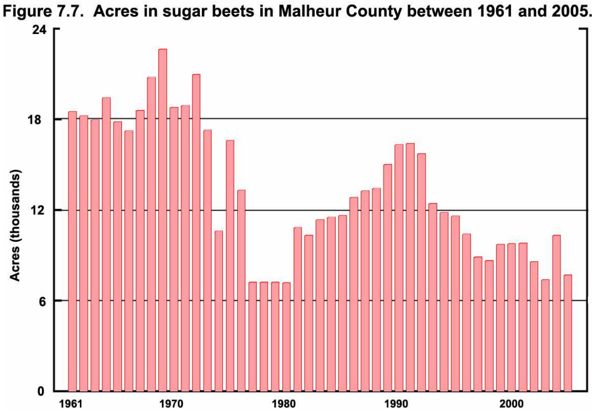


Figure 7.7. Acres in sugar beets in Malheur County between 1961 and 2005.



C. Management

1. After the dam, before 1980

Most of the land that farmers settled in the lower Owyhee watershed had to be modified before it could be brought into production. The surface soil in the alluvial basins was very salty and sat atop a hard layer of caliche. The caliche developed by calcium carbonate leaching from the surface soil into subsoil over thousands of years. After irrigation water from the dam became available it was first used to eliminate salt from the surface soil. A berm was built around a field and the field was flooded to leach the salt from the soil. In the 1940s the Malheur Experiment Station discovered that deep plowing would break up the nearly impermeable caliche and mix it with the topsoil and salt, promoting salt leaching.[66,67]

Prior to the advent of modern herbicides, growers used the same land year after year for crops which required excellent weed control. Onions cannot compete well with weeds. Fields were kept fairly weed seed free by frequent hand weeding. The onion yields and size would decline considerably with repeated years of planting onions in the same field since root disease organisms proliferated. Onions are a high user of nitrogen fertilizer and are sensitive to water deficits. Supplying the needed water and nitrogen probably caused nitrogen to leach into the vadose zone (the zone between the roots and above the ground water level) and into the shallow aquifers.

In early agriculture of the area, the only rotation crops used with onions were sugar beets and potatoes. Potatoes and sugar beets could also benefit from the dominance over weeds which had been established in the onion fields. High rates of nitrogen were also applied to sugar beets. Growers were paid by the ton, so growers disregarded the low percentage of sugar in highly fertilized beets and tried to achieve maximum tonnage per acre. Alfalfa, wheat or corn could have helped use up the excess or carry over nitrogen in the fields following row crops, but they were not used until the advent of effective herbicides which allowed growers to use most of the fields at their disposal in rotation with row crops.

After World War II, chemical fertilizer was readily available and inexpensive. More row crops were planted due to the increase in consumer demand and higher commodity prices created by the war effort and the strong economy following the war. Due to high demand and commodity prices, more farmers switched from cereal crops to row crops. Row crops were fertilized at higher nitrogen rates and these crops were more sensitive to water management. Fewer cereal crops were grown because they were less profitable.

2. Situation about 1980

a. Irrigation

In 1980, irrigation in meadows and pastures was still dominated by surface flood irrigation from dirt ditches. Irrigation of crops was primarily surface furrow irrigation from dirt and concrete ditches. Siphon tubes were used to deliver the water from the ditch to the irrigation furrows (Figure 7.8). Fields had been leveled, but not with laser leveling. Irrigation scheduling was based on the calendar and grower intuition and experience.

Figure 7.8. Siphon tubes irrigating onions with water from a concrete ditch.

Gated pipe, turbulent fountain weed screens, PAM, and straw mulch were not used. No soil moisture measurement tools were used.

b. Soil preparation

Soil was prepared in the fall after harvest and in the spring. Spring soil preparation tended to compact and dry the soil. Since efficient weed control was becoming established through the adoption of herbicides in the 1970s, this innovation was already leading to fall bedding of the soil (conserving winter soil moisture and protecting the soil from physical damage when the soil was worked wet in the spring) and leading to the adoption of environmentally sound crop rotations. Crop rotations included onions, sugar beets, wheat, corn, dry beans, potatoes, alfalfa, alfalfa grown for seed, spearmint, peppermint, and other crops. Growers used many different crop rotations.

The herbicide Dacthal (DCPA) was widely used in Malheur County by onion and alfalfa seed growers to control a wide spectrum of weeds. Several chemicals such as Dacthal were applied at the full broadcast rate, 12 pounds per acre broadcast to prepare the ground for planting. Ample labor was usually available to help conduct supplemental hand weeding.

Groundwater became contaminated with the breakdown products of DCPA and with nitrate from the heavy use of nitrogen fertilizers.[3]

c. Fertilization

Prior to the 1980s, fertilization management decisions were based on perceived need of crops, not chemical assessments of what nutrients were lacking. Farmers formulated their own special mixes of fertilizer. Few soil analyses or follow-up plant tissue testing of root or petiole (the stem that supports the blade of a leaf) samples were taken. Each grower had his own special blends of fertilizer for onion, potatoes, and sugar beets. Up through the early 1980s it was common practice for farms to have their secret crop mix made up of 1000 to 1500 pounds of 16-16-16 per acre for fall fertilizer. Fall fertilizer mixes containing 150 to 200 lb/acre of nitrogen were followed up in the spring with another 150 to 300 lb/acre of nitrogen sidedressed. Due to relatively high commodity prices and relatively low fertilizer prices, excess nitrogen was applied, trying to achieve maximum yields.

Two of the main reasons for fall applications were that the fertilizer acted as a soil conditioner to help mellow the crust that builds up during the winter months and fall application helped avoid soil compaction from spring broadcast fertilizer application and other spring tractor work.

Fertilizer rates were determined by the growers financial condition and yield aspirations, not based on carefully identified crop needs. Published fertilizer guides appeared to be based on assured yield maximization, with little thought as to the fate of excess nutrients, not yet a part of the public environmental mindset.

d. Pesticides

Prior to their being banned, growers used DDT, Aldrin, Endrin, and other similar products. These products have very long half lives. Hence they decay slowly. Traces of the legacy pesticides can be found in runoff water and sediment.

e. Crop residues

Crop residues from growing wheat and sweet corn and growing and processing sugar beets were largely recycled. Beet pulp was recycled into cattle feed. Manure from dairies was recycled onto farm lands as a fertilizer.

Alfalfa seed screenings, the by-product of processing alfalfa seed, were hauled to the landfills for burial due to environmental regulations against their traditional use as an animal feed supplement. Alfalfa seed screenings constituted 16 percent of local land fill volume in the 1980s. Potato processing waste was fed to cattle, but the residual sludge from processing was trucked to holding ponds where it was stored and accumulated. Cull onions were buried in shallow pits.

3. Challenges in 1980

By the end of the 1970s, environmental concerns for irrigated agriculture in the Treasure Valley included: 1) the reduction of soil loss and nutrient loss from crop land, 2) improvement in irrigation efficiency, 3) the reduction of nutrients added to groundwater, 4) preservation of soil structure, and 5) the transformation of agricultural chemical use so that very low rates of agricultural chemicals would be required. Where chemical products were required, they needed to degrade quickly without effects off the farm plot. Irrigation-induced losses of phosphorus (P) and sediment were documented problems.[16]

Looking back we can see the types of changes which would solve the environmental challenges of the 1980s. The reduction of soil and nutrient losses from crop land would be managed with field leveling and irrigation management. Increases in irrigation efficiency would facilitate reductions in irrigation-induced erosion and nitrate leaching. Irrigation management also would better time watering to plant needs. Reexamination of fertilization practices was needed to redirect fertilization toward only satisfying plant nutrient needs and economical crop responses. Keeping sediment on the crop fields and water in the root zone of the crops would reduce the contaminate load leaving the field in both runoff and in losses to the ground water. Reduced and timely tillage could reduce the physical damage to the soil that was resulting from cultivation. Innovations in the development of integrated pest management and the use of short half-life agricultural chemicals would reduce the pesticide load carried off of farms.

Nitrogen management and irrigation management are closely linked, and trying to manage one without the other becomes self-defeating. Nitrogen only leaches when excess water is applied and conversely excess water can only leach nitrogen if substantial amounts of nitrate are available to be leached from the soil profile. The goal is to have just enough nitrogen available to maximize crop growth and just enough water in the soil profile to keep crop growth adequate without excess water carrying nutrients to greater depth. Both goals required irrigation innovation since reducing the application of excess nitrogen is hard with furrow irrigation systems. It is difficult to use furrow irrigation systems without substantial downward water movement and nitrate leaching. Nutrients are also washed off the field when large amounts of water move across the field with substantial force and remove soil from the field.

D. Changes since 1980

Major changes in agricultural practices have occurred over the last two and a half decades in Malheur County. Progress has been made in reducing groundwater contamination, reducing soil loss and nutrient loss in runoff, and improving water use efficiency.

These changes have been made through a cooperative process led by the Malheur County Soil and Water Conservation District (SWCD), the Natural Resource Conservation Service (NRCS), the Farm Services Agency (FSA), the Malheur Watershed Council, the Owyhee Watershed Council, and both the Malheur Agricultural Experiment Station (MES) and the Malheur Cooperative Extension Service (CES) of Oregon State University (OSU) with participation of growers' associations, growers, ranchers, other members of the community, and agency representatives. Research, education, and implementation funding was obtained to pursue long term environmental goals while respecting economic constraints faced by producers.

Agencies contributing to this cooperative endeavor included the Oregon Watershed Enhancement Board (OWEB), Oregon Department of Agriculture (ODA), Oregon Department of Environmental Quality (ODEQ), and the Agricultural Department of Treasure Valley Community College (TVCC).

A wide range of research, demonstration, and implementation efforts were planned and conducted to improve production efficiency and ameliorate environmental problems associated with conventional farming practices. With each initiative the potential benefits and extent to which a new practice would be adopted were unknown, as was how it would eventually modify crop production, product quality, or the ease of farming.

Incentives toward implementing change include attitudes of stewardship and farming practices which result in decreased costs, improved productivity, improved crop quality, and the eligibility for cost share programs. Disincentives for change are practices which increase costs, reduce productivity, increase risk or uncertainty, require large capital outlays, or involve substantial red tape.

1. Furrow irrigation

A wide array of practices were investigated to improve the efficiency of furrow irrigation and reduce irrigation-induced erosion.

a. Laser leveling

i. The challenge

Prior to the 1980s, fields had been leveled by conventional means. Fields were surveyed, staked, and soil was moved about within a field by farm tractor powered equipment. Fields with slopes of 0.6 to 0.7 or more feet per hundred feet required too much water to irrigate due to excessive runoff and resulted in too much soil erosion. Fields with slightly irregular slopes or flat spots would have parts which required long duration furrow irrigation resulting in excessive water infiltration and associated with excessive deep leaching in other parts of the same field. Crop plants growing on steeper, drier spots were subject to yield and quality losses from water stress. Plants growing on flatter spots were subject to losses from ponded water and decomposition.

ii. The changes

Dressing fields with laser leveling to a slope of 0.3 to 0.4 feet per hundred feet provided immediate benefits for surface irrigation. Herb Futter was able to show less soil was lost from the field and the field irrigated much more uniformly. The uniformity of irrigation allowed for the conservation of water, less leaching in the wetter parts of the field, and improved crop performance. During the early 1980s the Agricultural Stabilization Conservation Service (ASCS) would not fund laser leveling, but starting in the latter half of the 1980s they did participate in cost share based on Herb Futter's results.

From 1985 through 1999 approximately 4500 acres of cropland in Malheur County were laser leveled through cost share programs, improving irrigation efficiencies. Efficiency increases of 15 to 20 percent have been obtained from leveling alone. The practice is widely accepted by growers at their own initiative to the point that the practice now seldom receives cost share incentives.

b. Straw mulch

i. The challenge

In the early 1980s Malheur County growers Vernon Nakada and Joe Hobson were applying wheat straw mulch by hand to reduce irrigation-induced erosion. The process of using straw mulch on fields is not a new concept. In fact, the hand mulching of onions and other various crops has been used for many years. Spreading the mulch by hand can be extremely expensive, so there was a need for another cost effective way to spread mulch.

ii. The changes

One method of reducing soil movement within the field and loss of sediment and nutrients off the field is to use mechanical straw mulching techniques.[47] Joe Hobson's mechanical mulcher made the spreading of mulch economically feasible for farmers. Several variations of his original idea are used in the Treasure Valley. Early mechanical mulching trials starting in 1985 demonstrated its effectiveness in reducing erosion [45] and improving sugar beet yields.[56] Mechanical straw mulching furrows that were compacted by tractor wheel traffic improved onion yield and size. The measurements made in onion fields showed that mechanical straw mulching had conservation benefits by reducing soil erosion and irrigation water runoff.[47,51] In addition, onion yield and market grade were improved,[48] a financial incentive to growers to adopt this practice.[46]

From 1985 to 1999 growers applied straw mulch to approximately 4000 acres through cost share funds.

c. Gated pipe

Gated pipe was introduced to allow more uniform irrigation of many surface irrigated fields. The water set in each furrow can be less than with siphon tubes. Gated pipe allows for surface irrigation with conservation of water, reduced irrigation induced erosion, and lower leaching potential.

Gated pipe was first used in a substantial way in Malheur County in 1977, a year of severe drought. The project was promoted by the Soil Conservation Service (SCS) (later the NRCS) and was cost shared by the ASCS. The fiber glass pipe proved to have poor durability outdoors in the sunlight. More durable plastic gated pipe was introduced and supported by cost share programs. From 1985 to 1999 growers converted the water delivery systems from siphons off open ditches to gated pipe on approximately 60,000 acres of cropland. Gated pipe decreased water use by 35-40%.

d. Weed screens

With trash flowing in the water, gates in gated pipe have to be set to wider openings or larger siphon tubes have to be used to ensure that trash does not clog the gate or tube. With trashy water, more water has to be set on a field than is really necessary, hence more water is present than is required to irrigate the row. The extra water promotes irrigation induced erosion and excessive leaching of nitrates to groundwater. With cleaner water, gates and siphon tubes can be set with greater accuracy insuring that the furrow irrigation will continue to run as set without clogging.

Figure 7.9. A small bubbler weed screen.

Herb Futter of the SCS introduced weed screens to Malheur County to clean irrigation water. Several small weed screens were installed at the Malheur Experiment Station and were highly visible near other trials and helped show growers their advantages. Adoption of weed screens followed the 1985 Malheur Experiment Station field day when Herb Futter promoted the use of bubbler weed screens to remove weed seed and trash from irrigation water (Figures 7.9 and 7.10). Growers started building and installing weed screens on their own, with fabrication by local irrigation dealers. Especially noteworthy were the efforts of Dale Cruson in Ontario, who gave a big boost to screen adoption by manufacturing many of the screens.

Figure 7.10. Debris in the water is removed by the weed screen and won't clog subsequent parts of the irrigation system.

In 1990 cost sharing was implemented to promote weed screens. By 1999 the practice had become wide spread enough that cost share incentives were only being used in large scale projects where the size of the weed screen might be cost prohibitive.

e. PAM to reduce irrigation-induced erosion

Polyacrylamide (PAM) is a synthetic water-soluble polymer made from monomers of acrylamide. It binds soil particles to each other in the irrigated furrow. PAM is highly effective in reducing soil erosion off of fields and can increase water infiltration into irrigated furrows.[15,62] PAM was shown in experiments done at the Malheur Experiment Station to significantly reduce sediment loss, generally a 90-95 percent reduction. Increases in infiltration rates varied from 20-60 percent. PAM added to irrigation water in either liquid or granular form reduced sediment losses and increased water infiltration into the soil.[6,55] From 1990 to 1999 irrigation systems serving approximately 3500 acres of cropland in Malheur County were treated with PAM via cost sharing. Use of PAM diminished both soil losses and concomitant nutrient losses to streams.[17,74]

f. Sedimentation basins and pump back systems

A sedimentation basin is a pond at the bottom of an irrigated field to catch water runoff. Water can be pumped back uphill to reuse in irrigation. Sediment in the pond can be dredged and added back to the fields it came from.

Some of the first sedimentation basins promoted by the SCS in Malheur County were designed as demonstration-education systems. They demonstrated to grower the dimensions of their irrigation-induced erosion problem. Many functional sedimentation basins with pump back features were built in the late 1980s and 1991 and 1992 with active participation of the SCS (later the NRCS), ASCS, and SWCD. From 1990-1999 cost share assistance was provided for approximately 15 tail-water recovery sediment basin systems with water savings of 0.5 acre-feet of water per acre irrigated under each system.

2. Changes in irrigation systems

a. Sprinkler irrigation

Prior to 1985, very little sprinkler irrigation was used on row crops in Malheur County. Research and demonstrations were conducted in 1987 and 1988 to compare the efficiency of sprinkler irrigation to surface irrigation and to determine the effectiveness of sprinkler irrigation in producing better quality potatoes. Water was used more efficiently and potato quality was improved through the use of sprinkler irrigation.[49,78] Solid set sprinkler systems are a means to cool the potato plant during hot weather and decrease water and nutrients loss from the plant's root zone. From 1990-1999 approximately 16,000 acres of cropland in Malheur County were converted from furrow irrigation to sprinkler irrigation through cost share programs.

Figure 7.11. Sprinkler irrigation of an alfalfa field.

Dick Tipton spearheaded a large scale demonstration project using gravity fed water to power sprinkler irrigation sponsored by the SCS, the SWCD and the Agricultural Research Service (ARS) on Morgan Avenue. Alfalfa, small grains, pasture, and sugar beets were successfully grown by the project (Figure 7.11). Other gravity pressured systems were built following Tipton's example. In 2002-2003 a gravity pressured system to power sprinkler irrigation was installed by the South Board of Control and cooperating growers south of Adrian. Large cooperative piping projects have recently been installed northeast of Mitchell Butte in the lower Owyhee subbasin and in lower Willow Creek. The successes of these projects are due to the cooperation of many growers and partners.

There has been an expansion of gravity fed sprinkler irrigation. Micro sprinklers have been used effectively in experiments [38] and in growers fields for poplar production.

b. *Drip irrigation*

Starting in 1992, drip irrigation, sprinkler irrigation, and furrow irrigation were compared for onion bulb production on fields in Malheur County that were difficult to irrigate.[10,11,12] Drip irrigation was very promising in terms of bulb yield, bulb quality, water use efficiency, and apparent nitrogen (N) fertilizer use efficiency. In 1993 the first Treasure Valley grower adopted drip irrigation for onion production. The success of these efforts prompted further research to optimize the irrigation criteria for drip-irrigated onions,[32] determine the duration of irrigation sets [37] and use ideal plant populations and N fertilizer rates with drip irrigation.[36]

Figure 7.12. Drip irrigation of onion. Water is not applied between the rows.

Drip irrigation uses approximately 32 acre-inches of water or about 60 to 65% as much as furrow irrigation with gated pipe.[27,34,37]

Drip irrigation has been shown in Malheur County to combine the environmental advantages of less leaching of nutrients into the aquifer, less use of scarce water (Figure 7.12), and less nitrogen application with the financial advantages of higher onion yields and quality.[43] The benefits to the growers mean that even though the concept of drip irrigation is relatively new in the region, by 2004 there were 1,800 acres of drip-irrigated onions in Malheur County and approximately 1,200 acres in adjoining areas of Idaho. These acres have vastly reduced N inputs and no irrigation-induced erosion and associated pollutant runoff. The drip irrigation of onion pioneered in Malheur County was rapidly adopted by onion growers in other parts of the country.

Preliminary work on other crops in Malheur County supported by ODEQ and OWEB has examined potato variety performance with drip irrigation,[7] irrigation criteria for drip-irrigated potato, and potato plant populations and planting configurations under

Figure 7.13. Drip irrigation of potato.

drip.[33,40,41] Drip irrigation can be used effectively for poplar production[35,42] and alfalfa seed production.[52,73]

3. Irrigation scheduling

Irrigation scheduling consists of applying the right amount of water at the right time. Irrigating only when crops need water avoids both under-irrigation and over-irrigation. Crops highly sensitive to water stress, like potatoes, onions, and many vegetable crops, require precision irrigation scheduling, that is determining both irrigation frequency and duration.[40]

Over-irrigation leads to a loss in water to runoff and subsurface aquifers and increases crop needs for nitrogen due to leaching. Nitrogen is lost to groundwater. Soil losses in terms of sediment in runoff are aggravated by over-irrigation. Irrigating only when a crop needs water means that less water is used, less energy is used for pumping, less nitrogen is leached preventing additional groundwater pollution, and both crop yield and quality can be higher.

Under-irrigation of potato and onions may lead to losses in yield and quality.[9,26,31,32,33,57,76]

In 1984 irrigation scheduling in Malheur County was based exclusively on intuition and a calendar, specifically the number of days since the last irrigation. Although growers had tried to use tensiometers these meters were cumbersome. No instruments were used to measure soil moisture to assure that irrigations were applied at the right time for the plants.

a. Criteria for irrigation

Soil water criteria for irrigating vary depending on the crop, the type of soil, and the type of irrigation.[77] For Malheur County, the criteria for different crops have been developed at the Malheur Experiment Station of Oregon State University.[9,26,31,32.33.38.57,76,77]

b. Soil moisture monitoring devices

When irrigation criteria based on soil moisture have been established, an easy reliable method of measuring soil water is essential for grower adoption of this irrigation scheduling technique.

Watermark soil moisture sensors (GMS) Model 200 were introduced at the Malheur Experiment Station in 1986. Studies were initiated comparing various soil moisture monitoring techniques. Tensiometers were compared with Watermark soil moisture sensors, neutron probes, gypsum blocks and gravimetric soil water content.[8,20,25] New innovative GMS designs were evaluated at the Malheur Experiment

Station.[21] In 2001 and 2002 GMS were compared to AquaFlex, Gopher, Gro-Point sensors, Measure-Point, Tensiometers, Neutron Probe and gravimetric soil moisture calculations.[24] GMS are effective at measuring soil water. Meters to read the GMS data or log soil moisture change over time make these sensors a valuable tool for scheduling irrigation.[44]

Growers in Malheur County have adopted GMS and automated data loggers to record soil water conditions and frequently use them in drip irrigated onions.[44] Lower cost logging of GMS sensor readings has been accomplished by numerous companies. These systems have proven to be effective and reasonably easy for growers to use.[29]

c. Irrigation scheduling

Starting in 1988, after the initiation of a successful research program at the Malheur Experiment Station, GMS soil water potential readings made in growers' fields were used to schedule irrigations. In the beginning the potato extension specialist, Lynn Jensen, lead the program. As the experimental trials went forward, Lynn Jensen started demonstrating the effectiveness of these scheduling practices on grower fields through funding from the US Department of Agriculture (USDA). This effort was later expanded by Ron Jones of the SWCD through funding from the Oregon DEQ. The program evolved to the point where 87 Malheur County potato fields were monitored in 1995 by the Soil Water Conservation District under the management of Ron Jones. The cost was paid for by the growers. Actual readings were made and graphed by student summer labor.

Figure 7.14. Watermark monitor.

Eventually the Malheur County Potato Growers Association directed the program in conjunction with their potato integrated pest management program until the growers were familiar enough with the program to conduct irrigation scheduling on their own.

The advent of the Hansen Meter to read GMS installations eliminated the need for students to manually read and graph soil moisture since a series of GMS could be attached to the meter and could then be read and graphed three times per day. The process was simplified to the point that a grower could readily install the sensors and meter and track soil moisture with a minimum of training. Currently most soil moisture monitoring is being conducted by growers, especially those using drip irrigation, with the aid of Hansen Meters or Watermark Monitors (Figure 7.14).

d. Crop evapotranspiration

Crop evapotranspiration is a fancy word for the consumptive use of water. Consumptive water use is composed of evaporation of water off of the soil surface, transpiration of water through plant tissue to the air, and the small amount of water incorporated into a crop's tissues. Crop evapotranspiration is estimated using weather station data or an atmometer. Excellent estimates of crop water use can be provided by automated weather stations and local knowledge about when crops emerged, how quickly they developed, and when they matured.

In 1992 an AgriMet weather station was installed at the Malheur Experiment Station to provide evapotranspiration measurements. The annual maintenance costs are paid by the agricultural experiment station. The data are especially useful for the management of sprinkler and drip irrigation. Growers in Malheur County who use crop evapotranspiration to schedule irrigation have local data on which the calculations are based. Written explanations are available on how to use evapotranspiration data to schedule irrigations.[23,40]

4. Nutrition management

a. Changes to nitrogen fertilization management

Nitrogen fertilizing practices have changed in Malheur County. Current practices are much more environmentally sound than traditional fertilization practices. These changes have come about due to the research and outreach/demonstration projects completed by the OSU Malheur Experiment Station, the OSU Cooperative Extension Service, SWCD, NRCS, the Malheur Watershed Council, the Owyhee Watershed Council, United States Department of Agriculture programs such as Environmental Quality Improvement Program administered by the Farm Service Agency and NRCS, and others. The economics of fertilization and the cooperation of the local fertilizer dealers have played important roles in these changes. These changes occurred through cooperative financial and educational help from many partners. Some of those partners include United States Environmental Protection Agency (EPA), ODEQ, CES, MES, ODA, SWCD, FSA, NRCS, TVCC Agriculture Department, the watershed councils, and the local fertilizer dealers.

The improvements in nutrient management can be summarized as reducing the amount of nitrogen fertilizer used, budgeting the nitrogen to meet crop needs and account for all sources of nitrogen, and utilizing deep-rooted crops planted in rotation with shallow-rooted crops.[30,39,50,61] All of these improvements decrease the amount of nitrogen available for leaching into the groundwater and decrease the amount of nitrogen that a grower must purchase. These improvements have been made without damage to crop quality and productivity.

The amount of nitrogen fertilizer applied to a crop can be reduced through determination and utilization of optimal timing, placement, and rate of fertilizer. Budgeting nitrogen allows a better match to be made between the amount applied during a year to the amount used by the crop while it is growing. To do this, the growers can incorporate soil testing results (how much nitrogen is already in the field from previous crops), plant tissue testing results (how much nitrogen the plant has taken up), and nitrogen mineralization (knowledge of how nitrogen will be freed by the soil during the summer and become available) into the budget. Growing deep-rooted crops (e.g., sugar beets and wheat) after onions and potatoes allows the deeper rooted crops to recover residual soil nitrate and mineralized nitrogen that the previous shallowly rooted crops did not use.[39,50,54,61]

Very little nitrogen is now applied in the fall because fall nitrogen is more apt to be leached and interfere with crop seeding establishment . Soil samples are now commonly analyzed prior to any fertilizer application, and the amount of residual nitrogen in the soil nitrate and ammonium is factored into the total amount of fertilizer to be applied to the next crop. Nitrogen applications are typically applied in the spring, with split applications starting in March and ending in July. After the plants reach a prescribed maturity, tissue samples are taken to see if more nutrients are needed for the plant to continue to be productive through full maturity. Petiole samples are taken from potato[63] and sugar beet plants, root samples are taken from onion, and flag leaf samples are taken from wheat.

The Ontario Hydrologic Unit Area (HUA) Final Report indicates that traditional nitrogen application rates had been reduced by 1997.[1] The report also indicates nitrogen was being applied more efficiently and at rates closer to plant needs. Since 1990, information and education activities targeting awareness of how much nitrogen is needed for crops as well as more efficient application methods have resulted in dramatic increases in practices such as soil testing, petiole testing, side dressing, banding, split applications, and converting from fall to spring nitrogen applications. Field acres where nutrient management practices are being applied in cooperation with the SWCD and NRCS steadily increased throughout the seven-year period of the HUA project from less than 5,000 in 1991 to over 44,000 acres by 1997, representing approximately 28% of the 157,000 acres in the HUA.[1,2] Many other areas had careful nutrient management based entirely on private initiative.

Crops grown in Malheur County without N fertilizer consistently obtained more natural N from the soil environment than predicted by soil tests.[30,36,39,50,54,61] Large amounts of naturally occurring available-N complicate fertilizer recommendations because it is difficult to predict the naturally occurring N. Since large natural N supplies can occur, crop responses to applications of N fertilizer may be small in many fields. Growers are adjusting N application rates downward. Reducing N application rates can reduce crop production costs, increase profits, and reduce nitrate leaching.

b. Summary of N management practices

Fertilizer and chemical application practices in Malheur County have changed significantly over the past 25 years. Large amounts of fertilizer are no longer being applied to assure high yields without regard for plants' usage or the fate of excess fertilizer.

In the mid 1980s more growers started soil sampling and tailored their fertilizer rates according to the soil sample recommendations. Following recommendations by the Malheur Experiment Station in 1990 to reduce nitrate leaching, growers cut down on the amount of fertilizer applied in the fall. In the spring, they put the rest of their fertilizer needs on by sidedressing one to three times.

In the early 1990s farmers cut out all fall nitrogen except for the nitrogen required to break down crop stubble. The remainder of the fertilizer was spoon fed over three sidedress applications determined by petiole sampling before each application.

Today, the soil in one to two acre grids may be sampled in the fall to determine what each acre's fertility needs are. GPS technology is then used to help variable fertilizer applicators apply only what each acre needs. Simplot Growers Services is the leader in precision fertilization in Malheur County.

Efficient use of soil nitrate and the other available N sources listed above depends on irrigation being roughly in balance with crop water needs so that nitrate leaching is minimal. The first furrow irrigation has the most potential to leach because the dry subsoil has a high infiltration rate beyond the reach of most of the roots of plants. Applying nitrogen after the first irrigation dramatically reduces the potential of leaching. This technique has allowed onion growers to reduce nitrogen applications by 25% without reducing yield or quality. The goal of reducing ground water nitrate addition is being met by fertilizer management and the right amount of irrigation water applied at the right time.

5. Use of crop residues

Organic agricultural wastes are recycled as fertilizers and soil conditioning agents. Potato and onion wastes from processing facilities were not utilized as fertilizer until recently. These materials are now being used in partial substitution for commercial fertilizers. Nitrogen release curves were developed for potato and onion sludge by local OSU extension and research.[68.69.70,71,72] Following testing by the Malheur Experiment Station and Oregon Trail Mushrooms (Vale, Oregon), alfalfa seed screenings are no longer hauled to the land fills but are being used as an ingredient in the compost used to grow mushrooms. Spent mushroom compost is no longer accumulating as waste but is utilized as a soil conditioner, largely for landscape purposes. Animal manures from confined animal feeding operations are used extensively for their nutrients on crop and pasture lands, through well defined nutrient management plans.

6. Transformations in agricultural chemical use

Agricultural chemicals and their uses have changed in the entire Snake River plain with our greater understanding of chemistry and the environment. From the inception of modern agriculture through the 1950s, little attention was paid to the persistence and unintended effects of pest control products. In recent decades the pesticide industry has been transformed by the adoption of products, including herbicides, with much narrower target species and short half lives so the products break down more quickly. With three quarters of a million cultivated and irrigated acres in the Treasure Valley in Idaho and Oregon, we know of no currently used agriculture pesticide that is reaching the streams, rivers, or groundwater.

All pesticides sold or distributed in the US must be registered by the EPA, based on scientific studies showing that they can be used without posing unreasonable risks to people or the environment. Because of advances in scientific and environmental knowledge, the law requires that pesticides that were registered before November 1, 1984 be reregistered to ensure that they meet the current, more stringent, standards.

Onions are one of the most important irrigated crops in this valley. Onions compete poorly with weeds and efficient weed control is essential to maintain an economically viable onion industry. DCPA (sold as Dacthal) is an effective herbicide to control weeds in onion fields and was commonly used in the past. DCPA metabolites, however, have been found in shallow aquifers underlying parts of the intensively farmed areas of Malheur County, Oregon.[3,18] This product is not known to be in current usage.

DCPA was first registered as a pesticide in the US in 1958 as a selective preemergence herbicide for weed control on turf grasses. This herbicide is effective in other situations such as onion fields. When it was reregistered in 1988, the EPA concluded that “DCPA and its metabolites do not currently pose a significant cancer or chronic non-cancer risk from non-turf uses to the overall US population from exposure through contaminated drinking water”. However, they also stated that DCPA "impurities have chronic toxicological properties (including oncogenic, teratogenic, fetotoxic, mutagenic or adverse effects on immune response in mammals) that are of particular concern in the reregistration of DCPA pesticide products."[65]

Due to concerns about residues of DCPA and its metabolites in surface water and sediment runoff from furrow-irrigated crop land, as well as through deep percolation through the soil profile, MES conducted intensive studies to trace the fate of DCPA and DCPA metabolites' with both banding and broadcast DCPA application techniques.[53]

The method of herbicide application has a role in how much herbicide leaves the field. Under traditional furrow irrigation, banded applications were better. The quantities of DCPA and its metabolites in transported sediment was 33% less when banded than when broadcast. In surface water runoff, the difference was greater with 41% less of the herbicide lost from banded applications. For both application methods, straw mulch reduced DCPA and DCPA metabolite losses in transported sediment by about 90% from losses in traditional furrow irrigation. Straw mulch also reduced DCPA and its metabolite losses in surface water runoff by 30% for banded application and by 50% for broadcast application. The benefits of straw mulch were primarily achieved by reductions in soil erosion and volume of runoff water.

In the mid 1980s, farmers started banding all the post emergence chemicals on onions.

Even without a product to substitute for DCPA, it was possible to lower the amount of chemical loading by banding DCPA in a narrow band directly where the onions would grow, rather than broadcasting DCPA over the entire soil surface. Less DCPA was applied. The area of soil between the banded DCPA did not need the product because weeds were controlled there by cultivation. Growers were quick to adopt the banding of DCPA, because costs were reduced with no loss in weed control. By 1990, many growers using DCPA banding were saving two thirds of the DCPA expense.[14]

Malheur Experiment Station studies concluded that omitting DCPA or banding DCPA during onion production immediately reduced the losses of DCPA residues through downward leaching or runoff. One objective of the Ontario HUA had been to reduce DCPA application by 30%. Surveys conducted by the Malheur Extension Service showed that this goal was easily met by the end of 1997.

Additional research at MES and "on farm" demonstrations by Lynn Jensen of OSU Cooperative Extension have shown that other herbicides with shorter half-lives could control weeds in onions on a wide range of fields at lower cost.[58,59] The use of DCPA was no longer necessary. With the registration of pendimethalin (sold under the trade name of Prowl) in about 1993 or 1994, growers rapidly switched to pendimethalin because it was lower in cost, more effective, and did not have the undesirable environmental effects of DCPA. DCPA inventories in Malheur County were depleted by the 1998 growing season and is no longer applied.

E. Notes on the implementation of new practices

The primary method of water application for Treasure Valley crops is furrow irrigation. Large investments have been made in the effort to improve furrow irrigation.

Many best management practices (BMPs) have been implemented in the Northern Malheur County Groundwater Management Area (GWMA) that are protective of groundwater quality. Some of this progress is documented in the Ontario Hydrologic Unit Area Final Report 1990 - 1997.[1]

Major changes in agricultural practices have occurred since groundwater contamination was identified in the Malheur River area in the late 1980s.[28] The method of nitrogen application in this area has been changed. Reduced nitrogen loading has been accomplished by changes in the timing and the application of nitrogen as well as the rate of application. Plant tissue and soil sampling have also played a major role in modifying practices for the application of nitrogen and other nutrients, enabling producers to apply only the amount of nutrient needed and only when that nutrient is needed. Changes in irrigation management practices have also occurred that increase the protection of groundwater quality.

Table 3 identifies the extent of some practices implemented through SWCD and NRCS programs between 1990 and 1997. Other improvements have occurred before and after this time. Activities conducted exclusively through private efforts are not included.

Table 3. Specific best management practices implemented between 1990 and 1997 for groundwater protection, surface water protection, erosion protection, irrigation water management, and animal waste management through direct grower cooperation with SWCD and NRCS programs.

Best Management Practice	**Extent of Implementation**
Conservation Cropping Sequence	27,576 acres
Grasses & Legumes in Rotation	1,231 acres
Irrigation Water Management	46,891 acres
Pasture / Hay Land Management	676 acres
Pasture / Hay Land Planting	285 acres
Nutrient Management	44,010 acres
Waste Utilization	1,670 acres
Soil Testing	35,595 acres
Fertilizer Application Timing	21,324 acres
Tissue Analysis	19,098 acres
Split Application of Nitrogen	15,125 acres

Banding of Nutrients	7,625 acres
Surge Irrigation	160 acres
Irrigation Scheduling	18,053 acres

Extension brochures have been prepared to help growers effectively implement many of the newer BMPs. Oregon State University publishes extension brochures on the use of PAM, on irrigation scheduling, and on drip irrigation.[22,40.41,42,43,44,74,75]

Some challenges continue. Growers use many different crop rotations. Crop rotations with onions every third year tend to degrade the field with infestations of yellow nutsedge.

F. *Water quality farm plans*

Water quality farm plans are viewed as a set of progressive steps utilizing BMPs that lead to implementation of a Resource Management System. Plans are periodically reviewed and updated to include the newest BMPs available. Nearly all water quality plans written in the HUA include irrigation water management, nutrient management, and pesticide management as basic plan recommendations. Additional practices are included on a case-by-case basis and plans are tailored to individual farm requirements.

1. Adoption of plans

The number of water quality farm plans completed through the seven-year period of the HUA project and beyond indicates continued interest and involvement by the local growers. The total number of plans completed was 9 plans by 1991, 39 plans by 1992, 69 plans by 1993, 98 plans by 1994, 121 plans by 1995, 146 plans by 1996, and 156 plans by 1997. The 156 plans completed by 1997 represent approximately 44,000 acres, or about 28% of the total irrigated acres in the GWMA.

From 1997 through 2000, 65 new water quality farm plans were completed (averaging 12 to 15 per year).

2. *Shortage of federal support for farm plans*

Numerous growers seek cost share support for adoption of farming practices with positive environmental effects. Although approximately 70 and 170 applications were filed in Malheur County during 2003 and 2004 respectively, less than 10 percent of growers seeking cost share support have received that support. It is probable that even more producers would apply if the success rate were greater. Both the low profitability of agricultural production and the scarcity of public resources currently limit the adoption of new farming practices.

G. Future uncertainties

1. Water availability and competition for water

Water is the grower's second most important resource after the land itself. Some years there is a serious irrigation water shortage due to nature's unpredictable ways. However, the growers in the lower Owyhee subbasin also face increasing pressure to restrict their water use so that the water can be redirected to other purposes.

With the current power crises, there may be more and more pressure applied to use the water for power generation. Increased demands for water in the cities of the deserts of Nevada may place pressure upstream to divert water from the upper reaches of the Owyhee to uses in Nevada. There may be pressure to release water for endangered species such as salmon.

A Bureau of Reclamation study concluded that "based on the historical period of record (1939-1992), the Owyhee River basin above Owyhee Reservoir would yield no additional water for storage in over 50 percent of the years."[4] Although the study was conducted to see if increased storage in Owyhee Reservoir would be a potential source of water for flow augmentation in the lower Snake River for salmon, the conclusion that extra "water would be available . . . only in good water years,"[4] means that any allocation for other purposes would remove water from that available to irrigated agriculture in the lower Owyhee subbasin and other areas benefiting from this irrigation water.

Growers have made and are making many changes to conserve water. These changes will help cushion the effect on irrigated agriculture from drought years. These changes can not generate a reliable source of water for allocation to other uses. Any allocation for other purposes would be detrimental to the health of irrigated agriculture in Malheur County.

2. Population growth

Reallocation of land in Malheur County to residential and industrial purposes will have a concomitant reallocation of water away from agriculture.

3. Regulations

Since the water which growers use contains more nutrients and has a higher temperature than is allowed by the Total Maximum Daily Load (TMDL) to return to the Snake River, once this water is used on farms it will continue to exceed TMDL parameters for the Snake River. To reduce or eliminate water run off from farm ground, vast capital investments in irrigation will be required by the rules being adopted by the Oregon Department of Environmental Quality and the Environmental Protection Agency.

4. World economy

US policy is global free trade without consideration of whether trade terms are fair. Other trading partners often establish non-tariff barriers that greatly restrict the movement of US products to other countries. It is not known if the US will continue these practices that are unfair to US producers.

The US allows the importation of goods produced with low standards of environmental protection, of labor protection and benefits, of permitted pesticide use, etc. to compete freely with US goods conforming to all US regulations. It is not known if the US will continue these practices which place US producers at an unfair disadvantage.

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Endnote

Year	Estimated sales $
2005	206,426,000
2004	166,603,000
2003	174,432,000
2002	161,153,000
2001	171,109,000
2000	213,676,000
1999	183,829,000
1998	207,152,000
1997	208,119,000
1996	200,122,000
1995	182,402,000
Average	188,638,000