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Upper Owyhee Watershed Assessment

VI. Irrigated Agriculture

Contents

VI. Irrigated Agriculture

A. Importance of irrigation

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

B. Sources of information

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

C. History

1. Before 1890

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

2. Irrigated hayfields

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

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

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

3. Expansion of hayfields

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

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

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

D. Climate

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

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

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

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

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

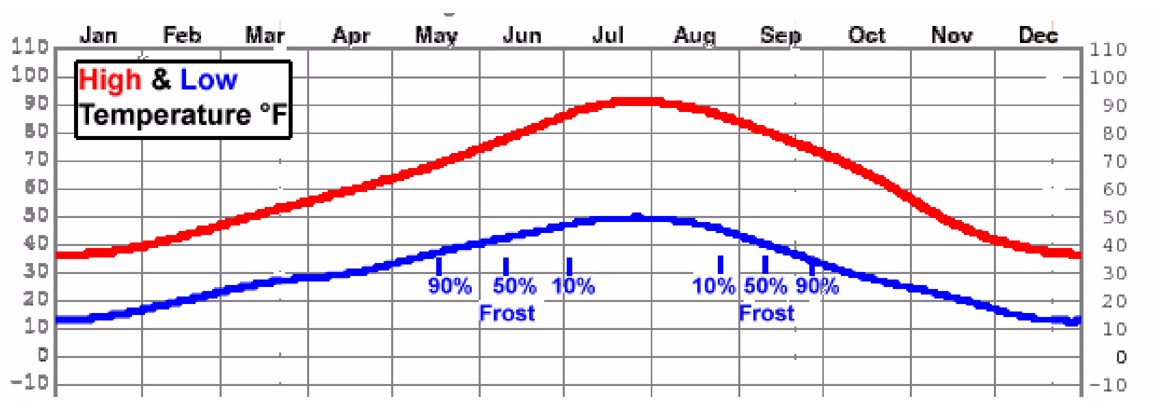


Figure 6.1. Distribution of frost-free days at Elko, Nevada.[3]

E. Areas under irrigation

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

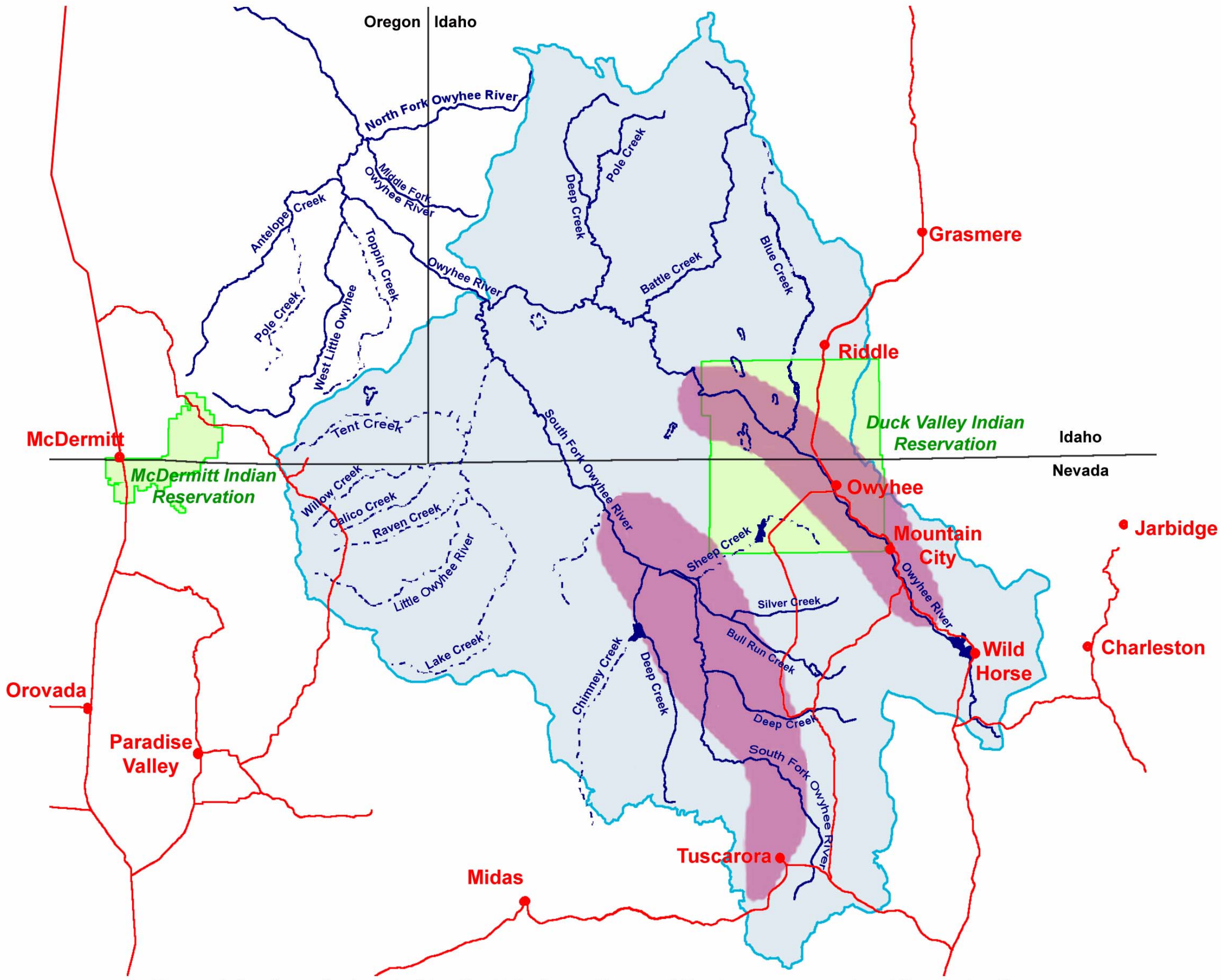


Figure 6.2. Area designated by the U.S. Army Corps of Engineers as a natural flow irrigation service area in the upper Owyhee subbasin.[12]

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

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

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

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

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

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

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

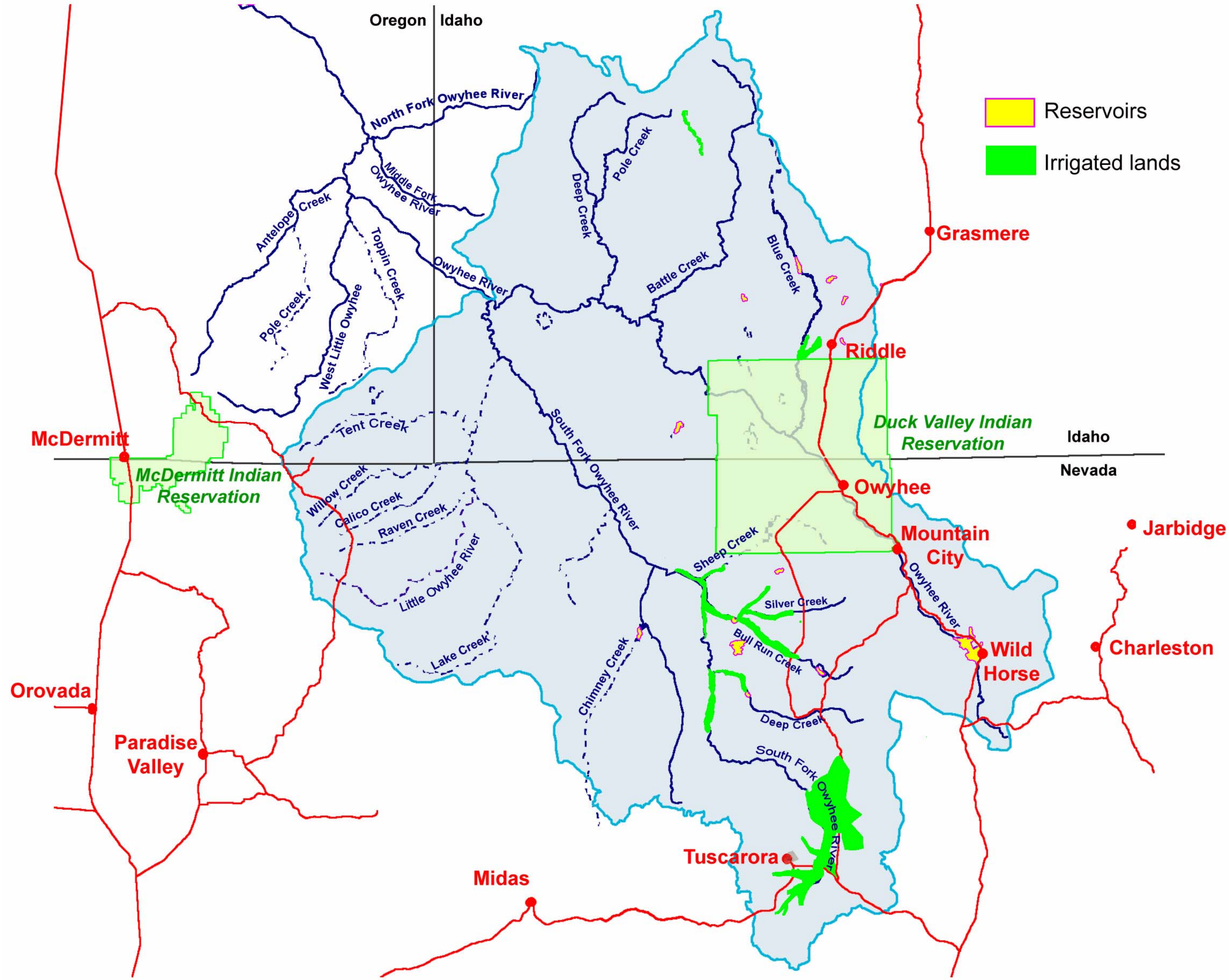


Figure 6.3. Irrigated lands in the upper Owyhee subbasin.

F. Changes in irrigation

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

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

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

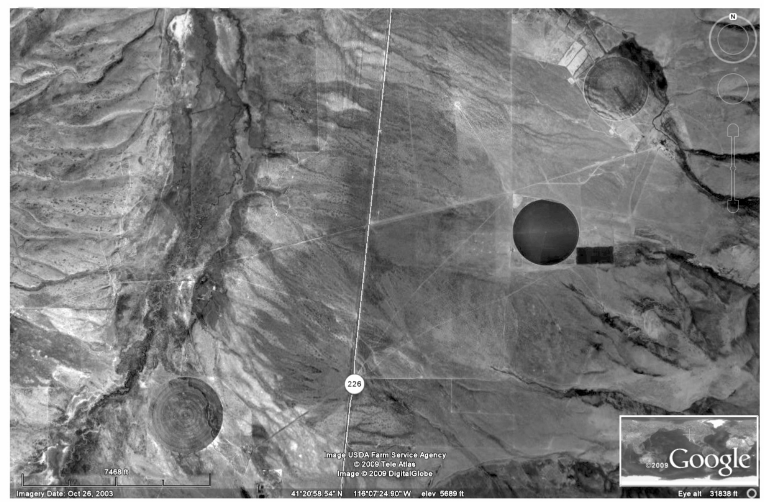
Although the dams and irrigation ditches used to deliver surface irrigation improved with time, flood irrigation of meadows and pastures dominated. The application efficiency of an irrigation system is measured by the quantity of water delivered to the crop root zone to meet crop water needs in relation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

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

1994, no central pivots

1999, one central pivot

2003, two central pivots



2006, three central pivots

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

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Upper Owyhee Watershed Assessment

VII. Rangeland

Contents

VII. Rangeland

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

A. Introduction

1. What is rangeland?

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

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

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

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

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

2. How is rangeland used?

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

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

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

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

B. Rangeland in the upper Owyhee subbasin

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

C. Historical condition of rangeland in the upper Owyhee subbasin

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

Photo 7.1. Rangeland in the upper Owyhee subbasin

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

1. Prior to significant livestock introduction

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

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

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

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

Photo 7.2. White sage (winterfat)

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

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

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

2. Following livestock introduction

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

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

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

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

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

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

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

3. Overgrazing

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

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

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

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

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

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

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

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

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

D. Vegetation

1. Types of rangeland vegetation

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

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

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

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

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

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

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

2. Rangeland types

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

a. University of Idaho[106]

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

i. Sagebrush-grasslands

Sagebrush-grasslands are a mix of sagebrush and bunchgrasses.

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

ii. Salt-desert shrub

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

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

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

iii. Juniper woodland

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

b. Oregon State University Rangeland Department

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

i. Herbaceous range

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

ii. Shrub and brush rangeland

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

iii. Mixed rangeland

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

c. National Vegetation Classification System.

A classification system provides a set of criteria for examining plant communities.[32] Both the Natural Resources Conservation Service (NRCS) and the BLM use the ecological site description, correlated to soil surveys, from the NRCS land classification system to determine vegetation type. Although BLM and NRCS use a different classification system, a National Vegetation Classification System (NVCS) was adopted by the Environmental Protection Agency and the US Geological Survey (USGS) in 1997 [28] and was revised in 2008.[29] It is now used to classify rangeland sites based on plant associations.[57]

> "The national vegetation classification system focuses on existing vegetation rather than potential natural vegetation, climax vegetation, or physical habitats . . . The vegetation types covered in the classification range from the short-lived to relatively stable and persistent plant

> communities. The classification includes natural, seminatural, modified, and cultural vegetation."[128]

In other words, this classification system is based on the plants that are really growing in an area. This differs from the ecoregion approach as it focuses on the current vegetation. The NVCS also includes different levels. One of the higher levels focuses on the way the area looks and for terrestrial vegetation is divided into forest woodland, sparse woodland, shrubland, sparse shrubland, dwarf shrubland, sparse dwarf shrubland, herbaceous, and sparse vascular/non-vascular. The lowest level is delineated by the association of two or more species.[128]

3. Vegetation in the upper Owyhee subbasin

The vegetation of the upper Owyhee subbasin is extremely varied, including plant species growing above the tree line in the Bull Run and Independence Mountains, evergreen and deciduous shrubs of the sagebrush steppe ecosystems, and riparian species along the streams. Not only does it include species native to the area, but it also includes both invasive and introduced species.

a. Surveys of vegetation

There has been one exhaustive survey of vegetation within the upper Owyhee subbasin which focused on a small section of the subbasin. The Idaho Department of Fish and Game, Conservation Data Center (CDC) contracted the Nature Conservancy to conduct an ecological inventory and assessment of the 45 Ranch. The ranch is bordered by the Little Owyhee, South Fork Owyhee and Owyhee rivers on the west, east, and north respectively. Although exhaustive, the survey only recorded species encountered in the 100 square miles of the ranch. The project occurred in two phases. The inventory of riparian and wetland communities was completed in 1998. The phase focused on terrestrial vegetation was completed during the 1999 field season.[73] All of the species of both riparian and terrestrial vegetation which they encountered on the 45 Ranch are identified within the subbasin plant list, Appendix E.

David Charlet used personal observations and visited fifteen herbarium collections to document the distributions of all conifer species occurring in Nevada. Within the subbasin he identified eight species either currently or historically present in the Bull Run and Independence Mountains of the upper Owyhee subbasin.[18,AppendixE]

b. Plant communities

Surveys of vegetation frequently identify broad rangeland types. However, the plants living in association with each other, the plant communities, are classified more narrowly.

The species in a plant community differ in kind or proportion from the species of a different plant community. Traditionally these communities, or associations, are named for two of the species in them. On rangelands this combination of names tends to be the dominant shrub followed by the most obvious grass. However, the community name may be that of two shrubs or include the name of a forb. The NVCS classification system may include the names of two equally present species or differentiate based on a third prominent species. Although there is a recognized superstructure for identifying plant communities, different researchers may identify them more broadly or more narrowly.

i. Plant communities on the 45 Ranch

Using the NVCS classification system, the survey of the 45 Ranch described 37 terrestrial plant associations in the upland environments. Table 7.1 lists 25 of these plant communities. Within some of these plant communities, the Nature Conservancy split the community by the inclusion of a third species so that they have more than 37 associations.[73] Three of the plant communities included in the survey were observed by Moseley in the earlier survey of riparian vegetation.[72] They consist of riparian plant associations that occur in intermittent drainage and pool habitats of plateau environments.

Photo 7.3. The 45 Ranch on the South Fork Owyhee River in the upper Owyhee subbasin

Table 7.1. Terrestrial plant communities identified on the 45 Ranch in the upper Owyhee subbasin.

Artemisia arbuscula/Agropyron spicatum		*Salvia dorri/Oryzopsis hymenoides*
Artemisia arbuscula/Festuca idahoensis		*Juniperus occidentalis/Danthonia californica*
Artemisia arbuscula/Poa secunda		*Juniperus occidentalis/Festuca idahoensis*
Artemisia cana/Muhlenbergia richardsonis		*Juniperus occidentalis/Artemisia arbuscula*
Artemisia tridentata tridentata		*Juniperus occidentalis/Artemisia tridentata vaseyana/*
Artemisia tridentata tridentata/Elymus cinereus		*Juniperus occidentalis/Artemisia tridentata wyomingensis*
Artemisia tridentata wyomingensis-Haplopappapus acaulis		*Acer glabrum-Holodiscus dumosus-Ribes* spp
Artemisia tridentata wyomingensis/Agropyron spicatum		*Haplopappus nanus/Poa secunda*.
Artemisia tridentata wyomingensis/Festuca idahoensis		*Sarcobatus vermiculatus*
Artemisia tridentata wyomingensis/Poa secunda		Riparian Working Group
Artemisia tridentata wyomingensis/Sitanion hystrix		Riparian graminoid
Artemisia tridentata wyomingensis/Stipa thurberiana		Riparian Shrubland
Poa secunda/Eriogonum spp.		

On the 45 Ranch, the dominant shrubs tend to be *Artemisia tridentata tridentata (*basin big sagebrush), *Artemisia tridentata wyomingensis,* (Wyoming big sagebrush), and *Juniperus occidentalis* (western juniper). These are the plants that will be most obvious to an observer looking out over the landscape.

ii. Other plant communities

In addition to the sagebrush/steppe terrestrial vegetation, the upper Owyhee subbasin includes rangeland in pinyon-juniper woodland, mountain shrub, subalpine forest, and alpine tundra.[135] No survey similar to that done on the 45 Ranch has been conducted in the more mountainous regions of the subbasin.

Juniper stands occur throughout the higher elevations of the subbasin, generally as part of the sagebrush steppe vegetation. Starting around the 5,500 foot elevation, juniper can be found with stands of aspen and mountain mahogany. Douglas fir and sub-alpine fir occur on the highest slopes.[10,118] Other high elevation vegetation includes juniper, quaking aspen, snowberry, sagebrush and willow (*Salix* spp.).[9,118] Whitebark pine grows in the highest elevation forest and at timberline. In the Bull Run Mountains whitebark pine is usually associated with limber pine.[3]

iii. Recent mapping of vegetation

Recent improvements in the resolution of remotely sensed data and data analysis have produced new vegetation maps. The Landsat satellites take high resolution images of a small section of the earth. The smallest unit which maps to a single pixel within these images is about 30 meters by 30 meters. These images record wavelengths, levels of brightness, and number of gray scale levels. The Gap Analysis Program is designed to map vegetation using the spectral bands. The upper Owyhee subbasin lies within two of the completed projects: the Northwest Regional Gap project and the Southwest Regional Gap Analysis projects completed in 2004 and 2007.[148,149,150]

Figure 7.1 depicts the distribution of land cover within the upper Owyhee subbasin. The Northwest Regional Gap project and the Southwest Regional Gap project sometimes used slightly different classifications for the land cover, resulting in an artifact at the Nevada - Idaho border. Of the plant associations mapped by the Gap Projects in the upper Owyhee subbasin, 45 account for most the of vegetated land (Figure 7.2).

4. Invasive Species

Invasive species are species which have the potential to expand or invade all or part of their U.S. range and degrade the landscape. Invasive species are commonly called weeds. These weeds are invasive because they grow vigorously and are competitive. Since they out-compete other species for light, water, nutrients, and space, they many rapidly dominate a site. Problems caused by these species include crowding out desirable vegetation, causing crop and forage losses, ruining good wildlife habitat, causing degradation of streams and wetlands, and creating rangeland fire hazards. Although most of these species are nonnative species from outside North America, not all invasive species were introduced to the U.S. Some species are native but have managed to spread and invade habitats such as rangelands or agricultural fields. Other species are native in part of the country but are serious pests in other parts.[64,116,125,126]

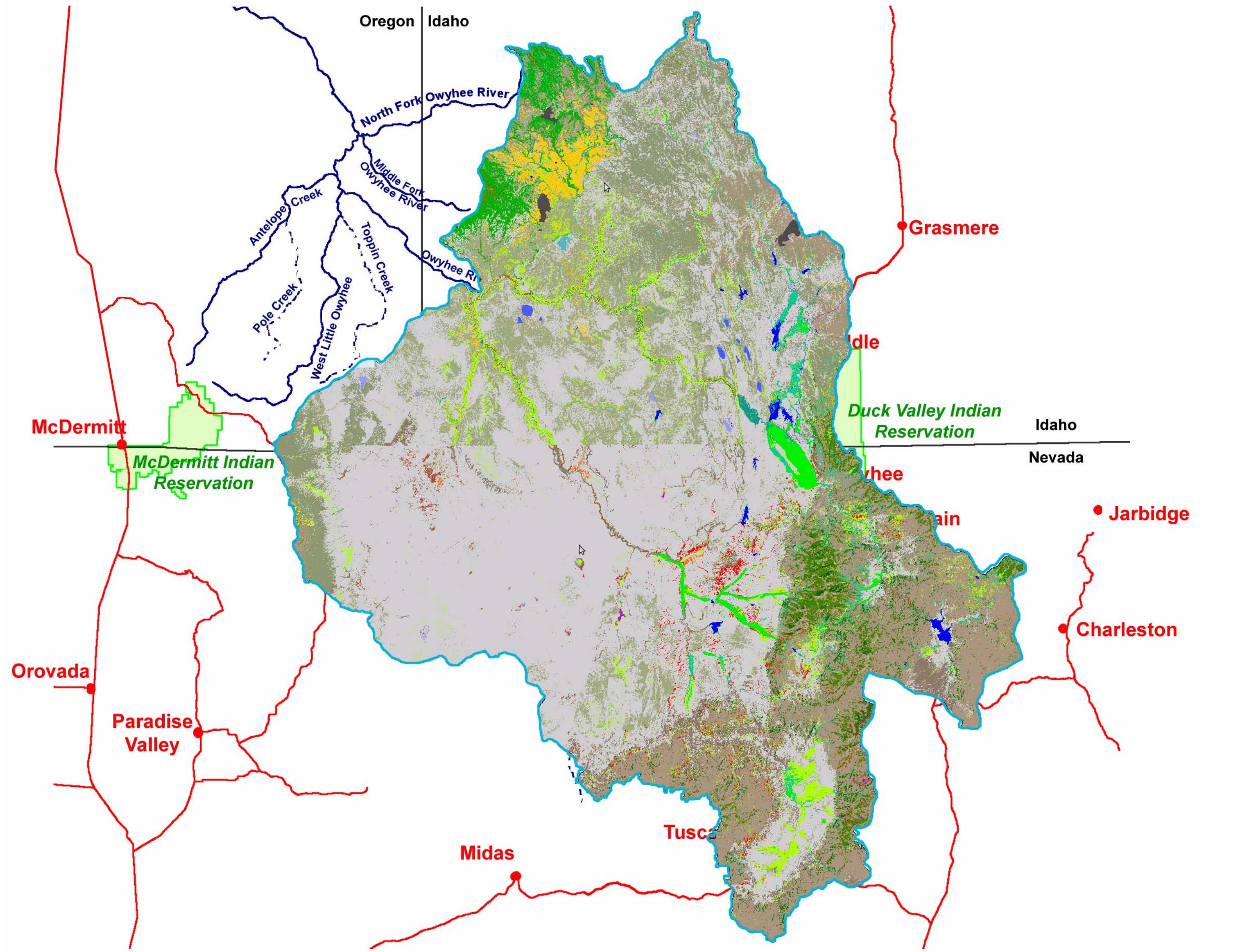

Figure 7.1. Land cover in the upper Owyhee subbasin.

Figure 7.2. Descriptions of the land cover on Figure 7.1.

Species from other countries may have arrived either in the ballast of sailing ships or in shipments of desirable seeds. Some were introduced intentionally as garden plants. The introduction of invasive plants into the US has increased dramatically in the past couple of decades due to the increased ease and speed of national and world travel and the expansion of global commerce. Wind, water, and animals can naturally spread invasive weeds locally, but human activities such as, recreation, vehicle travel, and the movement of contaminated equipment, products, and livestock often greatly increase the distance and rate of dispersal.[83,116]

a. Noxious weeds

A weed is designated noxious when it is considered by a governmental agency to be injurious to public health, agriculture, recreation, wildlife, or property. Noxious weeds are considered to be serious pests because they cause economic loss and harm the environment. Noxious weeds can choke out crops, destroy range and pasture lands, clog waterways, threaten native plant communities or affect human and animal health.[83,116]

Some general characteristics of noxious weeds are their ability to spread rapidly, reproduce in high numbers, and crowd out native plants. Noxious weeds also tend to be very difficult to control. There are many challenges to managing noxious weeds. They are often resistant to mechanical and cultural practices and existing herbicides.

Noxious weeds are generally non-native plants. Noxious weeds appeared and spread with European settlement and new weeds continue to arrive today. A large number of the least desirable weeds are of Mediterranean, European, or Asian origin. Not all weeds are noxious weeds.[116,451]

Invasive plants affect the plant community composition and have profound negative consequences for native biotic diversity. In rangeland, the most significant invasive species affecting the plant community composition are fire-adapted annual grasses, like cheatgrass and medusahead rye. The expansion of these grasses has resulted in annual grass-fire cycles that rapidly replace sagebrush-steppe and salt-desert shrubland systems.[7,17]

b. State designations of noxious weeds

The states of Idaho, Nevada, and Oregon all maintain lists of weeds designated as noxious weeds in that state. Each of the states has a different way of categorizing noxious weeds. Laws governing control of weeds varies from state to state but generally outlines what should be done concerning the identification, reporting, and treatment of noxious weeds. The names of the classifications do not intuitively provide an indication of what the state expects the treatment to be.

Idaho classifies weeds into a statewide EDRR list, a statewide control list, and a statewide containment list.[115] Nevada separates the weeds into categories A, B, and C.[75] Oregon classifies weeds as A or B, either of which can also be classified as T, weeds that represent an economic threat to the state of Oregon.[134]

For Idaho the EDRR list is composed of weeds which must be reported within ten days after identification and "shall be eradicated during the same growing season as identified." Weeds on the control list are considered to already exist in Idaho, but in concentrations where control or eradication may be possible. The control methods should reduce known population within five years. Noxious weeds on the containment list are widespread enough that control efforts are "directed at reducing or eliminating new or expanding weed populations."[117]

Nevada's categories are also based to some extent on the weed distribution. Category A weeds are similar to Idaho's EDRR list in that the weeds are to be "actively eradicated wherever found," and control by the state is required in all infestations. Category B weeds have some established scattered populations and should be "actively excluded where possible." Poorly established populations and populations occurring in locations where they were previously unknown require control by the state. Category C weeds are currently established and generally widespread in many counties of the state and abatement is at the discretion of the state quarantine officer.[75]

In Oregon noxious weeds are "weeds of economic importance" and are classified as either A or B. In addition some weeds in each category are considered to "represent an economic **threat** to the state of Oregon" and should be reported "if you suspect you have found any of these weeds." All A classified weeds should also be reported if found since these weeds "occur in the state in small enough infestations to make eradication/containment possible." Noxious weeds with a B classification are regionally abundant but may have limited distribution in some counties.[98,134]

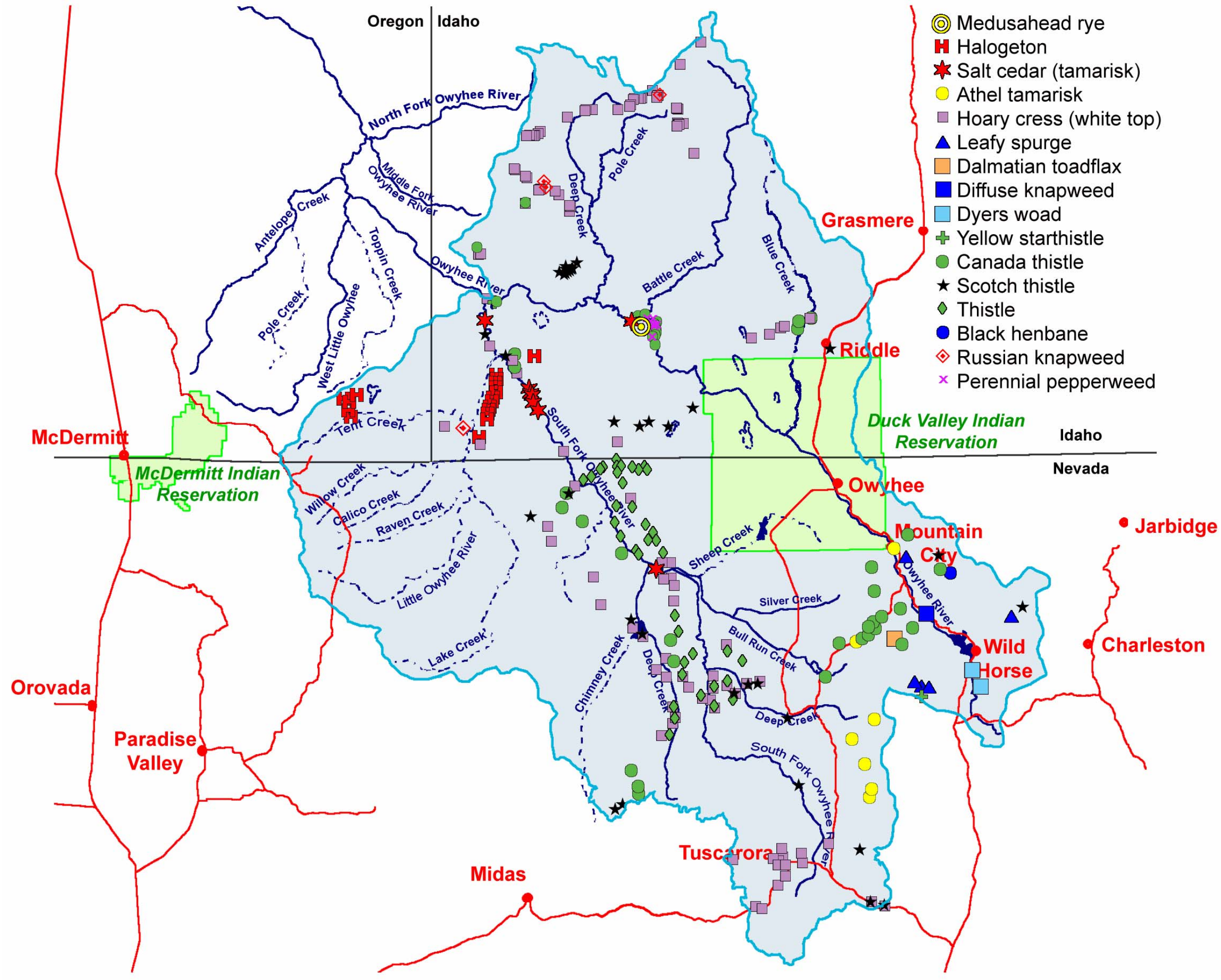

Figure 7.3. Known locations of weeds in the upper Owyhee subbasin.

c. Noxious weed species in the upper Owyhee subbasin

The upper Owyhee subbasin is currently relatively free of noxious weeds compared to some of the surrounding areas. Most of the species identified as within the upper Owyhee subbasin have a very limited range. Individuals, including the authors, familiar with the region and with the species have provided information on the occurrence of a noxious weed species within the upper Owyhee subbasin. Within Elko county, the BLM has identified locations where a specific weed species has been found.[142] The Owyhee field office of the BLM provided a map of the known location of specific weed species. Other mapped occurrences of a species were taken from GPS readings of the locations where they were identified (Figure 7.3).

The potential for a noxious weed to be within the subbasin or to expand into the subbasin has been determined from a number of different sources. The state of Idaho identifies counties in which a noxious weed species occurs. Species identified as noxious weeds by the state of Idaho which are present in Owyhee County have been included in Table 7.2.[115] For species identified as noxious weeds by Nevada, their presence in Elko County as recorded by the USDA plants database has resulted in their inclusion. Within each Oregon county, the state maps where a species has been reported. Species occurring within the boundaries of the upper Owyhee subbasin in Oregon or very close to the boundary have been included in the list.[133] Table 7.2 includes noxious weeds whether they occur primarily on rangeland, in riparian areas, or in cropland or pastures.

Table 7.2. Noxious weeds known to occur in the upper Owyhee subbasin and candidate species for spread into the upper Owyhee subbasin from adjacent areas.

Several sources were used to record the presence of a weed within the upper Owyhee subbasin	
45 - Present on the 45 Ranch[72,73] O - Presence in Owyhee County noted by mapping from the Idaho's noxious weeds list.[115] N - Presence in Elko County from USDA plants database[85]	M - Presence in Malheur County from weedmapper[95] P - Presence noted by individuals

		Present	State classification		
Common name	Scientific name		OR	ID*	NV
Black Henbane	*Hyoscyamus niger*	O, N		c	A
Buffalobur	*Solanum rostratum*		B	c	
Bull thistle	*Cirsium vulgare*	45, P	B		
Canada thistle	*Cirsium arvense*	45, O, N, P	B	d	C
Cheatgrass	*Bromus tectorum*	45, P			
Dalmatian toadflax	*Linaria dalmatica*	O,N, P	B,T	d	A
Diffuse knapweed	*Centaurea diffusa*	O, M, P	B	d	B
Dyers Woad	*Isatis tinctoria*	O	B	c	A
Eurasian Watermilfoil	*Myriophyllum spicatum*	O	B	c	A
Field Bindweed	*Convolvulous arvensis*	O	B	d	
Field sow thistle	*Sonchus arvensis*	N		c	A
Halogeton	*Halogeton glomeratus*	O, P	B		
Houndstongue, gypsyflower	*Cynoglossum officinale*	N	B	d	A
Leafy spurge	*Euphorbia esula*	O, N, P	B,T	d	B
Mediterranean sage	*Salvia aethiopis*		B	c	A
Medusahead rye	*Elymus caput-medusae*	M, P	B		B
Musk thistle	*Carduus nutans*	O	B	c	B
Perennial pepperweed	*Lepidium latifolium*	O, N, P	B	d	C
Poison hemlock	*Conium maculatum*	O, N, P	B	d	C
Puncturevine	*Tribulus terrestris*	O, N	B	d	C
Purple loosestrife	*Lythrum salicaria*	O, M, P	B	d	A
Rush skeletonweed	*Chondrilla juncea*	O	B,T	d	A
Russian knapweed	*Acroptilon repens*	O, M, P	B	c	
Saltcedar, tamarisk	*Tamarix ramosissima*	O, N	B,T	d	C
Scotch thistle	*Onopordum acanthium*	45, O, M, P	B	d	B
Spotted knapweed	*Centaurea stoebe* or *C. masculosa*	O, N, P	B,T	d	A
Spotted water hemlock	*Cicuta maculata*	N			C
White top, Hoary cress	*Cardaria draba*	O, N, M	B	d	C
Yellow starthistle	*Centaurea solstitialis*	N, P	B,T	d	A
Yellow toadflax	*Linaria vulgaris*	N	B	d	A

* b. Idaho EDRR c. Idaho statewide control lists d. Idaho statewide containment list

d. Rangeland noxious weeds

Although there may not be observations of specific occurrences in the upper Owyhee subbasin of the noxious weeds which are described below, all of these weeds have the potential to exist within the subbasin or to expand into the subbasin.

i. Leafy spurge (Euphorbia esula)

Leafy spurge is one of the west's worst weed species because it reduces cattle carrying capacity of infested rangelands by 50 to 75%. Once established, control of even modest-sized infestations is difficult. This weed is most common under dry conditions where competition from native plants is reduced. It is capable of invading disturbed sites, including abandoned cropland, pastures, rangeland, woodland, roadsides and waste areas. A milky latex exists in all broken parts of the plant that can cause skin irritations in humans, cattle, and horses and may cause permanent blindness if rubbed into the eye.[53,86,111]

ii. Medusahead rye (Taeniatherum caput-medusae)

Medusahead rye has the ability to outcompete other annual grasses and generally crowd out perennial grass seedlings by extracting the majority of moisture well before perennial grasses have begun to grow. Medusahead is almost worthless as forage for cattle, sheep or wildlife as it becomes unpalatable in late spring. The stiff awns and hard florets can injure eyes and mouths of grazing animals. Once land is invaded by medusahead, it becomes almost worthless, no longer supporting domestic livestock or native plants, animals, and birds. Medusahead rye changes the temperature and moisture dynamics of the soil, greatly reducing seed germination of other species and creating fuel for wildfires The propensity of medusahead to support frequent fire cycles makes range restoration even more difficult.[76,87,100]

Medusahead rye has invaded and completely dominated large tracts of land in the mid-Snake River region. It can invade stands of bluebunch wheatgrass. Expansion of medusahead rye places economically viable livestock production in peril with far reaching consequences. Medusahead has already had a serious impact on sage grouse habitat. It may also affect the movements of big game.[100,111]

iii. Rush skeletonweed (Chondrilla juncea)

Rush skeletonweed is an aggressive plant in both rangeland and cropland. A deep-rooted, creeping perennial, it also reproduces by seed. Rush skeletonweed has the capability to reduce or choke out native range species, decreasing range productivity and diversity. [51,92,111]

Rush skeletonweed has been found at sites contiguous to and intermingled with Malheur forget-me-not (*Hackelia cronquistii*), Mulford's milkvetch (*Astragalus mulfordae*), Owyhee clover (a*Trifolium owyheense*), and Malheur valley fiddleneck (*Amisinckia crinata*), all of which have been identified by the BLM as threatened or endangered.[100] Despite efforts to eradicate or contain outbreaks, new sites are being found each year.[92]

Rush skeletonweed reaches new sites mainly by wind borne seed. However, increased occurrences at recreation sites indicate that those seeds also arrive with recreationists and their vehicles.[100] It is hard to control because of the deep taproots, and tilling it under can spread the rootstock. Rush skeletonweed does well on road sides, rangelands, grain fields, grasslands, open forest, and pastures.[111]

iv. ***Halogeton (Halogeton glomeratus)***

Halogeton is poisonous to cattle and sheep. The toxic substance is found in both fresh and dry plants. Halogeton is not highly competitive in vigorous range conditions, but thrives in disturbed sites or sites limited by alkaline soils. It produces two types of seeds: one has wings to blow in the wind and can germinate within one year and the other type can lie dormant for several years. Late in its growth stage it can break off and tumble across the landscape, spreading seeds as it rolls.[84,111]

Halogeton has gained a foothold along some of the roads in the upper Owyhee subbasin. From these sites it is expanding into neighboring rangelands since much of the upper Owyhee subbasin has alkaline soils.

v. ***Spotted knapweed (Centaurea maculosa)***

Spotted knapweed is one of the most dominant weed species in the western United States. It has seriously degraded millions of acres of prime range and native habitat throughout the northern Rocky Mountain states. It will form dense stands on any open ground, excluding more desirable forage species and native plants. On heavily infested range, the necessary control measures to recover the land are often more expensive than the income potential derived from grazing. It establishes on disturbed soil and is competitive for soil moisture and nutrients. A spotted knapweed plant can produce up to 1,000 seeds. Control success is hampered by seed longevity.[95,100,111]

vi. ***Yellow starthistle (Centaurea solstitialis)***

Yellow starthistle is an aggressive, adaptable weed that inhibits the growth of desirable plants in pasture, rangeland, and wasteland. It will grow wherever cheatgrass grows as well as growing in canyon grasslands, rangelands, pastures, edges of cropland, roadsides, and disturbed areas. This plant may become a problem in ground where the grass stand is weak. Many large rangeland sites in the western US have become dominated by yellow starthistle. It will grow in any type of soil and intermountain environment. Yellow starthistle is toxic to horses causing “chewing disease”, equine spongiform encephalopathy, if they eat it.[97,111]

vii. ***White top, hoary cress (Cardaria draba)***

Whitetop is a deep-rooted perennial that spreads by seed and vegetative root growth. It forms dense patches that can completely dominate sites, restricting the growth of other species and degrading pastures. The species is not toxic to livestock but is only grazed in the absence of more desirable species. White top had been mainly confined to riparian or seasonally wet areas for much of the time since its arrival in the area around 1930. However, white top has spread and is continuing to advance into many of the rangelands including the upper Owyhee subbasin. Whitetop spreads by seed and vegetatively under the soil and is very competitive with native vegetation on disturbed or alkaline sites. [49,96,100,111]

viii. ***Dalmatian toadflax (Linaria dalmatica) and Yellow toadflax (Linaria vulgaris)***

Both Dalmatian toadflax and yellow toadflax can invade rangeland, overgrazed pastures, and roadsides. Both species are unpalatable, and although yellow toadflax may contain a poisonous glucoside, reports of livestock poisoning are rare. They reproduce by seed and horizontal rootsocks. A mature Dalmatian toadflax plant my produce as many as 500,000 seeds per year. The seeds can remain dormant in the soil for up to 10 years.[16]

ix. ***Scotch thistle (Onopordum acanthium)***

Scotch thistle is a wasteland weed that generally inhabits moist sites or drainages in dry locations. Scotch thistle can be found along roadsides, waste land areas, and lower range slopes, where there is more moisture than in surrounding range. Scotch thistle also invades grasslands and sagebrush communities, especially where there is disturbed soil. If not controlled, it presses into farmland or forms dense canopies in any area overgrazed or not under intense cultivation. It is a major issue in rangeland management.[8 ,54,94,111]

x. ***Diffuse knapweed (Centaurea diffusa)***

Diffuse knapweed will form dense stands on any open ground, excluding more desirable forage species. It is very competitive with native range plants, growing from taproots. It is very aggressive, and invades roadsides, waste lands, grass lands, and dry rangelands. It spreads rapidly and can quickly forms stands. Once established, the necessary extensive control measures are often more expensive than the income potential of the land. Diffuse knapweed grows under a wide range of conditions, such as those of riparian areas, sandy river shores, gravel banks, rock outcrops, rangelands, and roadsides.[82,111]

xi. ***Musk thistle (Carduus nutans)***

Musk thistle is unpalatable to wildlife and livestock. Wildlife and livestock selective graze on native plants and leave musk thistle alone, giving musk thistle a competitive edge. The musk thistle spines can harm animals and hinder their movement through infested areas. Musk thistle may produce chemicals that handicap the growth of other plants. Musk thistle invades fields and pastures, especially under conditions of heavy grazing. It spreads by seeds, taking advantage of human disturbance and is also found on ditch banks, stream banks, roadsides, waste lands, and in grain fields.[88,111]

xii. ***Houndstongue (Cynoglossum officinale)***

Houndstongue can be a serious problem in rangeland and pasture. The weed is highly invasive and can significantly reduce forage. The plant produces barbed seeds, or burrs, which allow the plant to readily adhere to hair, wool, and fur and can in turn reduce the value of sheep wool. In addition houndstongue contains large quantities of alkaloids which can cause liver problems in cattle and horses. Animals may survive six months or longer after they have consumed a lethal amount.[50,85,111] *xiii.* ***Russian knapweed (Acroptilon repens)***

Russian knapweed can grow aggressively, eliminating most native plants. After invading rangelands or fields, it forms dense stands, spreading by rhizomes, horizontal plant stems with shoots above and roots below the ground, or by seed. Once established, it can overrun native grasslands as well as irrigated crops. It is bitter and not palatable to livestock. Its aggressive and deep spreading root system make it very difficult to control and it is drought tolerant. [52,93,111]

xiv. ***Buffalobur (Solanum rostratum)***

Buffalobur is not very competitive and survives in disturbed, dry areas. A native of the Great Plains, buffalobur is drought tolerant and grows most frequently on disturbed, sandy soils. The burs may cause damage and considerable loss in wool and fiber value for sheep and goats.[79,111]

xv. ***Bull thistle (Cirsium vulgare)***

Bull thistle is a biennial found in waste lands, along road sides, in fields and pastures, and many other places where there is disturbed soil. It takes the place of forbs and grasses and if not controlled, presses into farmland. The seeds develop on top of the flowers, with fluffy white tops which can be picked up by the wind and spread all over, infesting more places with this noxious weed. Horses consider the flowers to be a delicacy because the heads are filled with sugary nectar.[80,111]

xvi. ***Canada thistle (Cirsium arvense)***

Canada thistle invades crop fields, pastures, rangeland, riparian areas, roadsides, and waste lands. Individual plants easily grow into dense, persistent thistle patches. A lack of control will result in dramatic reductions in crop production in heavily infested ground. This strong, aggressive perennial is difficult to control. New infestations can be spread from seeds, but are more often caused by redistribution of roots by tillage practices.[81,111]

e. Riparian noxious weeds

Although a number of the noxious weeds grow primarily in riparian areas, they can affect the health of the rangeland. A variety of range animals, both wild and domestic, may rely on the riparian area as part of their habitat.

i. ***Poison hemlock (Cicuta douglasii)***

Poison hemlock is a highly toxic plant and commonly infests riparian areas. It is considered to be one of the most poisonous plants in North America. It has accidentally poisoned many who have mistaken it for water-parsnip or other edible plants of the same family such as celery, parsley, and sweet anise. Several deaths of livestock and humans are attributed each year to poison hemlock. Poison hemlock can be found in marshes, wet meadows and pastures, along stream banks, and on roadsides.[90,100,111]

ii. ***Saltcedar, tamarisk (Tamarix ramosissima)***

Tamarisk or saltcedar is a strong perennial shrub to small tree species that is invading riparian areas in the mid Snake River region, and the upper Owyhee subbasin.

Tamarisk is known to use prolific amounts of water and dry out riparian areas. It has a habit of mining salts from the soil profile and exuding them on the surrounding soil, rendering those areas unable to support plant species that cannot tolerate saline conditions.[100,111]

Salt cedar is at or near the top of the list of noxious invasive weeds for all agencies. There is a high probability that established salt cedar will limit the ground flow of water to an extent that it may affect fish and wildlife. Tamarisk has very prolific seed production and can out compete native riparian trees and shrubs. [65,100,111]

iii. ***Perennial pepperweed (Lepidium latifolium)***

Perennial pepperweed establishes and colonizes rapidly. It degrades riparian areas and nesting habitat for wildlife. It can completely displace desirable species in natural riparian areas and hay meadows. It lowers the digestibility and protein content of hay and inhibits grazing. It can grow in a large variety of habitats but grows best along streams and in other wet areas such as ditches, roadsides, and marshes. Perennial pepperweed had been mainly confined to riparian or seasonally wet areas since its arrival about 1930. However, perennial pepperweed is appearing in some very remote seasonal streams and springs. Perennial pepperweed spreads through root fragmentation and seed.[89,100,111]

iv. ***Purple loosestrife (Lythrum salicaria)***

Purple loosestrife is a vigorous noxious weed that crowds out marsh vegetation required by wildlife for food and shelter. It can eventually destroy marshes and choke waterways. Decreased waterfowl and songbird production has been well documented in heavily infested marshes. Purple loosestrife is an escaped former ornamental species and can be found along wetlands, stream banks, or farm ponds. One plant can produce 300,000 seeds a year, as well as being able to reproduce by offshoots and cuttings.[91,111]

f. Other invasive range weeds

There are other weeds which have not been classified as noxious by the state of Oregon, Nevada, or Idaho, but which may affect the rangeland of the upper Owyhee subbasin.

i. ***Bur buttercup (Ranunculus testiculatus)***

Bur buttercup has rapidly colonized broad expanses of rangeland. Since bur buttercup begins growing early in the spring and has a short growing season, it can use most of the available moisture before many of the annual native species have emerged. It spreads into bare, denuded sites subject to erosion. Because it is comparatively shallow rooted, produces scant biomass, and has a relatively short life span, the potential for soil erosion in areas where it is dominant continues to be very high. It is toxic to sheep and can be competitive with small grain crops. Bur buttercup seed heads are irritating to hands, knees, or bare feet. The seed and seed heads also have the annoying habit of sticking to shoe laces, pants cuffs, etc. with tiny Velcro-like spines. [48,100,111]

ii. Moth mullein (Verbasum blattaria)

Moth mullein is a sun-loving plant usually found on bare hillsides, in worn out fields, in closely grazed pastures, along fence rows that are not overgrown, and in other waste places. Livestock will not eat the hairy, felt-covered leaves. It cannot stand much competition, even by grass, but prospers on dry poor upland soils. Moth mullein can be invasive in pastures and rangelands affecting forage quality and quantity. It has the potential to displace native species.[19,30,111]

5. Cheatgrass, downy brome (*Bromus tectorum*)

Cheatgrass is considered as a desirable forage grass in many places and a valuable forage resource. It provides a substantial amount of forage for many livestock operations and some of the earliest green feed available to deer on some winter ranges.[101,122] Other rangeland scientists and ranchers consider it an undesirable exotic or noxious weed.[17,26,67]

Cheatgrass is vigorous, short lived, and widely distributed. Cheatgrass does provide forage but can form dominate stands following repeated fire events. It grows rapidly and competes with and replaces native grasses. It is a widely adapted plant and has spread throughout the upper Owyhee subbasin.[100,111]

a. Why it spread

As early as 1900 uncontrolled livestock grazing had depleted and permanently altered vegetative composition of rangelands. Although an exotic species, cheatgrass was well adapted to the climate and soils in much of Idaho, Nevada, and Oregon. Cheatgrass filled the void left vacant by the reduction of native herbaceous vegetation by legacy livestock grazing.[67,101,120]

b. Competitive advantage

Cheatgrass competes strongly with native grasses and planted crested wheatgrass. It not only is a prolific seed producer, but the seed is highly viable. The seed is capable of germinating in either the spring or autumn, giving it a competitive advantage over native plants. Viable cheatgrass

Photo 7.4. Rangeland dominated by cheatgrass above Red Basin in the upper Owyhee subbasin

seeds can survive in the soil for up to five years, enabling cheatgrass to survive periodic drought.[67,101]

Cheatgrass germinates early in the season or in the fall and overwinters. It grows rapidly following emergence. It has rapid and extensive root penetration into the soil and extensive root development. Cheatgrass has been shown to reduce the growth of seedlings of bluebunch wheatgrass and crested wheatgrass. By extending its roots during the winter, it gains control of a site before bluebunch wheatgrass seedlings become established. Cheatgrass is capable of producing twice as many roots as bluebunch wheatgrass seedlings during the first 45 days of growth. Its roots also move down into the soil faster than those of bluebunch wheatgrass.[35,36,37,67,101]

Cheatgrass has a short growth period relative to native plants. It can out compete native plants for water and nutrients in the early spring since it is actively growing when many natives are initiating growth. It matures four to six weeks earlier than bluebunch wheatgrass and utilizes the limited moisture supply prior to use by bluebunch. Cheatgrass is tolerant of grazing and increases with frequent fire.[67,101]

c. Fire danger

Cheatgrass ranges burn frequently. Wildfire return intervals are now less than five years on some rangelands heavily infested with cheatgrass. The short growth period of cheatgrass relative to native plants increases the likelihood that wildfires will start and spread. Cheatgrass becomes flammable four to six weeks earlier and remains highly flammable for one to two months later than native perennials. Cheatgrass is usually dry by mid-July when perennial plants may contain 65% moisture. Standing dead cheatgrass and litter are extremely flammable resulting in shorter wildfire return intervals. As cheatgrass ranges burn frequently, the population of native plants is limited so that natural reseeding of the site doesn't occur.[17,67,101]

As fire cycles increase, cheatgrass abundance increases until the rangeland is essentially a cheatgrass range. Some federal land managers call this a "locked in" range. The name "locked in" refers to the never ending cycle of fire with more cheatgrass filling in the interspaces until perennial plants such as Wyoming sagebrush and bluebunch wheatgrass become replaced.[67] In these rangelands, each fire further reduces the native plant population with the accompanying loss of native plant seed production.

d. Removal of livestock

Some cheatgrass communities have maintained a steady state that would not return to native vegetation after livestock removal. Some researchers have speculated that the removal of livestock from rangeland could increase the rate of conversion of the range to cheatgrass because of the increased fuel accumulations which would result in more frequent wildfires.[101] Livestock will eat cheatgrass, limiting fuel accumulation.

e. Other considerations

Cheatgrass normally provides adequate soil cover for watershed protection. Cheatgrass litter effectively reduces raindrop energy and promotes infiltration. However in drought years and after a wildfire, this protection is reduced and the potential for erosion is increased.[101]

Forage quality and digestibility also affect cheatgrass use by livestock. The period that cheatgrass is palatable and nutritious for herbivore consumption is considerably shorter than for most native herbaceous plants. Forage quality declines as cheatgrass matures, therefore early spring to early summer grazing provides the greatest nutritional benefits to livestock.[101]

f. Research, solutions, and unknowns

i. Greenstrips to reduce fire danger

Strips of fire resistant vegetation, greenstrips, can be used to manage the fuels on rangeland. These strips are designed to slow or stop wildfires. As early as 1946, Platt and Jackman proposed planting fire resistant species in strips in cheatgrass areas.[102,104]

Wildland fires burn differently depending on the type of vegetation, the amount of fuel, the proximity of fuel sources to each other, the water content, and the fuel volatility. Greenstrips slow fires by separating volatile fuels and disrupting fuel continuity, reducing the amount of accumulated burnable material, and increasing the proportion of plants with a higher moisture content. Fine fuels that readily ignite and carry fire are replaced with perennial, less flammable vegetation.[39,102]

Reports suggest that forage kochia (*Bassia prostrata*) is a very effective greenstrip species to decrease fire frequency by successfully competing with and decreasing cheatgrass density. Forage kochia has four times the moisture content of crested wheatgrass and ten times the moisture content of cheatgrass. Fires have burned up to a forage kochia greenstrip and stopped because of the green biomass and sparsity of contiguous fine fuels. When fires burn in forage kochia the flame length and intensity are both reduced, aiding fire fighting.[39,102]

There have only been a few burning trials of forage kochia and there is a lack of published data on its fire suppressant qualities. The most efficient greenstrip width, best establishment practices, and potential combinations with other greenstrip species are unknown.[39]

ii. Competitive native vegetation

There have been promising initial studies that show that squirreltail can invade both cheatgrass and medusahead stands. Is it a more promising native plant to seed in cheatgrass infested areas?[67]

iii. Management to increase native vegetation

A five-year research project is being conducted that will explore ways to improve the health of sagebrush rangelands across the Great Basin in the western United States. The purpose of the SageSTEP project is to conduct research to be able to provide land managers with improved information about sustaining and restoring sagebrush rangelands. The project is a collaboration among the USGS, Oregon State University, University of Idaho, University of Reno-Nevada, Brigham Young University,

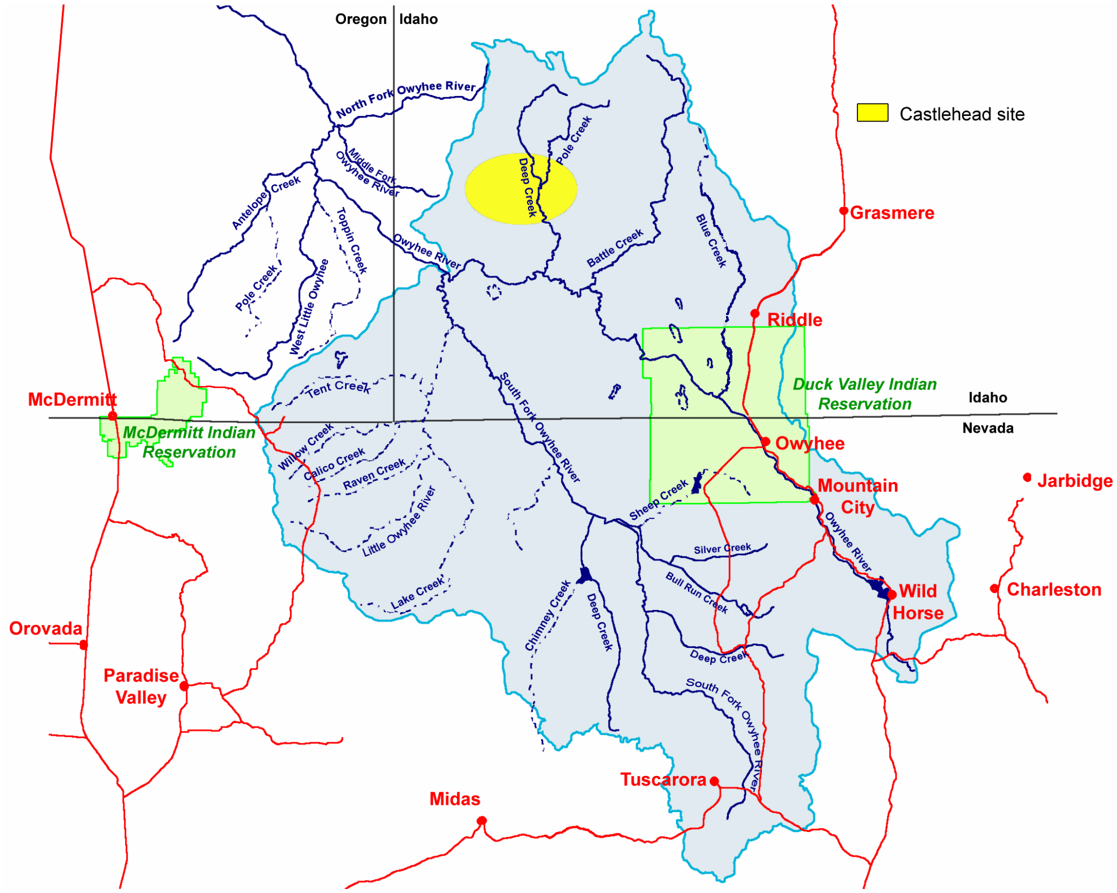

Figure 7.4. Location of the Castlehead site of the SageSTEP project in the upper Owyhee subbasin.[107]

US Department of Agriculture (USDA) Forest Service, USDA Agriculture Research Service, and BLM.[1,114,127]

One of the two experiments of this project is focused on sagebrush communities threatened by cheatgrass invasion. Four primary land-management treatment options will be studied including prescribed fire, mechanical thinning of shrubs and trees by mowing, herbicide applications, and a control with no management action. Some sections within the treated areas will have an additional herbicide application applied to control cheatgrass. One objective is to discover how much native perennial bunchgrass needs to be present to create a community that will be more resistant and resilient to fire and weed invasion without having to conduct expensive restoration.[1,127] One of the cooperating sites, the Castlehead Site, is within the upper Owyhee subbasin. Three 35 to 60-acre core plots will include a control and be treated mechanically and by burning. Burning will also be done on a 3200 acre plot with a 2545 acre control plot (Figure 7.4).[107]

In cheatgrass infested rangelands, could livestock grazing management practices be used strategically to improve the vigor and quantity of native perennial vegetation by reducing the competition from cheatgrass?[101]

iv. Understanding conditions favoring and retarding cheatgrass dominance

Dominance by cheatgrass varies depending on the elevation. At higher elevations cheatgrass performance is closely related to temperature. At lower elevations it is related to soil water.[123] Can we use these relationships to anticipate which areas are most subject to cheatgrass dominance?

The USGS has begun an investigation of factors related to cheatgrass performance including climate, sources and forms of soil nutrients, soil characteristics, underlying geology, and topologic location.[7]

6. Western juniper (*Juniperus occidentalis*)

a. Juniper expansion

Since the settlement of Euro-Americans, juniper has been spreading throughout the Great Basin including the Owyhee uplands and the upper Owyhee subbasin (Figure 7.5). Although the data on expansion are not specific to the upper Owyhee subbasin, anecdotal information indicates that the trends documented in adjacent areas apply to the subbasin. In southwestern Owyhee County of Idaho, the area occupied by western juniper has more than doubled from what was occupied in 1860.[69] "Analysts estimate the annual encroachment rate in Owyhee County to be as high as 2500 acres/year."[145]

The invasion of juniper into sagebrush steppe communities over the last 120 years has been documented by various methods including determining the age of trees, studies of juniper pollen increases, and comparisons of aerial photographs. The expansion of juniper in southeastern Oregon began in the late 1860s and accelerated in the 1880s. In the state of Oregon the estimated area of juniper forest and savanna is over four times the acreage of 1930.[5,38,68,69,123,136]

b. Problems of juniper expansion

Juniper expansion into sagebrush communities results in many negative consequences. These changes result primarily from the fact that juniper hogs water.

i. Changes in plant community

Juniper invasion results in major changes in the plant community composition. Increasingly abundant juniper outcompetes other native vegetation for water. Biomass production is significantly affected and there can be a serious loss of forage. The diversity of plants in the community is reduced and desirable understory vegetation can disappear. The amount of ground covered by herbaceous (non-woody) plants is diminished. The grass clumps are smaller and more widely spaced so there is an increase in bare ground. As juniper utilizes more of the water and nutrients at a site, other plants lose vigor and die.[5,69,70,136]

ii. Wildlife

A change in the plants growing in an area alters the wildlife habitat and impacts the wildlife species. Increasing dominance by juniper results in a decline in wildlife abundance and diversity. Much of the food for large herbivores like mule deer, pronghorn antelope, and elk disappears. Fawning habitat for deer is reduced by

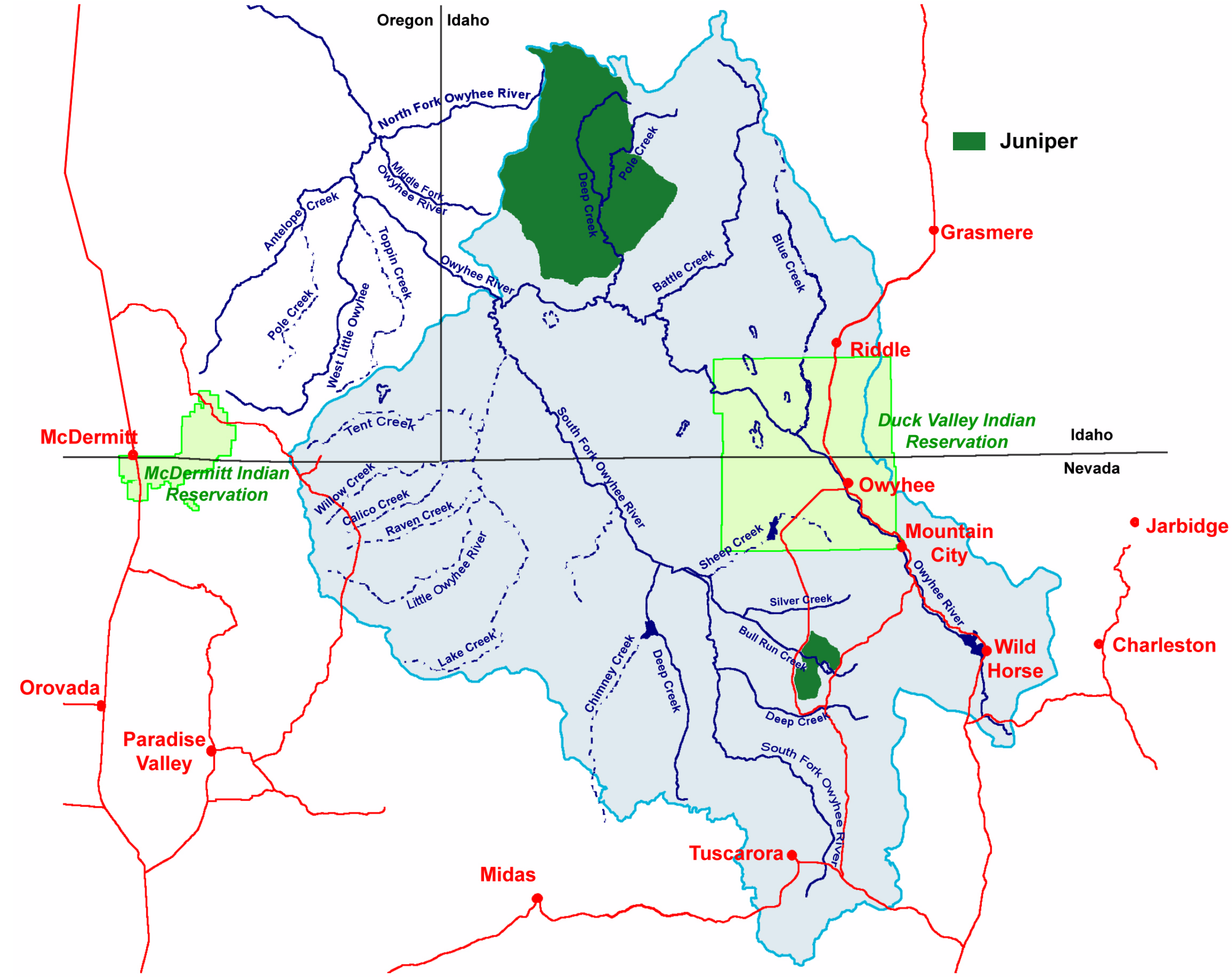

Figure 7.5. Locations of juniper in the upper Owyhee subbasin.[70]

replacement of big sagebrush with juniper. Some of the shrub-steppe communities which pronghorn antelope prefer in winter and spring disappear. The small mammal population is affected by both decreases in food and cover.[5,68,70,136]

With juniper encroachment, there are fewer shrub-steppe birds. How much the population of a species decreases with increasing western juniper varies. Species which require sagebrush, including the sage grouse, are very sensitive to juniper invasion into sagebrush communities. Nesting habitats for birds such as the sage grouse disappear.[5,68,70,136]

c. Changed hydrology

"Juniper encroachment into shrub-grassland communities modified historical patterns on the land, and the new resident truncates the hydrologic cycle in the watershed. Juniper is a voracious water consumer, leaving less for sagebrush, grasses and forbs."[145]

Juniper roots extend over a wide area and deep into the soil, depleting water from the soil. In addition, the juniper canopy intercepts a large amount of precipitation, reducing the amount of moisture actually reaching the soil. Measurements below

Photo 7.5. Juniper expansion into the rangeland of the upper Owyhee subbasin near Juniper Mountain

juniper show a reduction in precipitation of 20% near the canopy edge to 75% under the canopy by the trunk.[5,68,70,136]

The structure of the changed plant community can affect infiltration rates and overland flow of water. Where plant cover has changed from more evenly dispersed to clumped plants, there is increased soil erosion. Hillsides with juniper had runoff in a thunderstorm with an intensity that occurs about every two years. Similar hillsides with no juniper only had runoff from the type of thunderstorm that occurs every 50 years. With a 50-year thunderstorm, the hillside without juniper lost no sediment, but the hillside with juniper lost 275 lb/acre of sediment. The loss of nutrients off site in sediment will ultimately change soil fertility and cause a reduction in plant community productivity.[68,69,70,103]

Juniper expansion may lead to the loss of sustained stream flow. There is ample anecdotal evidence that streams, springs, and meadows have dried due to increased juniper. Where juniper has been removed the flows have returned. Juniper expansion may be a substantial factor in the loss of stream function.[6,24,41,70,119]

An indication of the amount that juniper expansion may result in diminished stream flows is the result of changes in hydrology following juniper removal. In Eastern Oregon, two watersheds were paired and monitored for twelve years. Following this monitoring, in 2005 all juniper trees less than 140 years of age on one of the watersheds were cut. After two years, in the watershed where juniper were cut, the spring flow, groundwater, and soil moisture had all increased when compared to pre-treatment levels. There was no clear trend in the flows in ephemeral channels. The results suggested that juniper removal in the uplands can create a herbaceous groundcover across hillslopes. The resulting reduction in bare ground should decrease soil erosion.[23]

d. Previous range

A characteristic of the location of older western juniper stands is that the sites where they are growing are mostly naturally shielded from fire. Old-growth juniper typically occupy rock outcrops, rocky ridges, or rimrock. Junipers grow in fractured bedrock in these spots .[15,14,69,70,121,136]

A small minority of juniper stands are ancient with trees that are 1,000 years old or older. One juniper tree growing east of Bend has been determined to be 1600 years old. Old juniper growth is a relative term. Younger juniper trees are between 80 and 130 years old and typically are an inverted cone shape. Older trees have a round-topped crown and become unsymmetrical in appearance with spreading canopies that may be sparse.[69,70,136]

About 10 percent of the existing western junipers were established before the 1870s. Stands of these older trees have long achieved a steady state. The other 90 percent of areas occupied by juniper are still in transition.[70,136]

e. Reasons for juniper expansion

i. Previous fire intervals

Fire has been an important natural factor in the environment of southwestern Idaho and southeastern Oregon for "at least several centuries preceding white settlement."[15] Native Americans deliberately set fires to improve forage for game, maintain or increase the yield of certain wild edible plants, or increase seed production. In the 1820s Peter Skene Ogden noted abundant evidence of fires caused by Native Americans. These fires had probably been set throughout the 1700s, if not earlier, to add to the number of fires started naturally. Following a fire ignited naturally or by man, there would be a new flush of grasses and wildflowers. Young juniper would be killed.[68,136]

Young juniper is much more severely affected by fire than older trees. Just scorching of the crown and stem can kill young juniper, especially seedlings and saplings. In some recent burns nearly all the juniper less than 50 years old was killed. Prehistoric fire frequency was probably less than every 50 years. The plant species comprising sagebrush communities are a product of an environment which included relatively frequent fires and are adapted to survive periodic burning. Although big sagebrush is readily killed by fire, the stands generally regenerate quickly from

Photo 7.6. Juniper trees on Juniper Mountain burnt by fire in 2007

surviving plants and seed. Juniper, especially young juniper, is not adapted to survive burning. Juniper became established in areas which fires would not completely burn.[15,14,131]

In big sagebrush plant communities with Idaho fescue the fire return intervals typically ranged between 10 and 25 years. Large fires occurred about every 40 years. However, in the more arid areas with big sagebrush, fire return intervals could range up to 50 to 100 years. In Eastern Oregon large fires in sagebrush-steppe communities were preceded by at least one year with above-average precipitation. A series of wet years would allow greater quantities of fuels to accumulate that could carry fire. When fire return intervals become greater than 70 years, the probability that juniper will establish and successfully mature greatly increases.[15,69,70]

ii. Juniper encroachment

Invasion of juniper and its phenomenal expansion is attributed to the reduced occurrence of fire. Fire return intervals now exceed 100 years and there has been a reduced role of fire since the 1870s with a large decline in the occurrence of fires since 1910.[15,69]

Livestock have grazed on the Owyhee Plateau since the late 1860s. When Griffiths crossed from Nevada to Ontario, Oregon in 1902, he commented that "no open-range lowland was seen on the whole trip which had much feed upon it excepting that consisting of the tough and persistent salt grass."[31] Overgrazing by domestic livestock reduced not only the supply of feed but also the supply of fine fuel available to carry fire. Fire was less effective and did not spread far. Fire suppression did not become a major factor in range management until after World War II.[5,15,68,69,70]

Overgrazing at the close of the 19th and beginning of the 20th centuries and fire suppression by state and federal agencies during the last 60 years have reduced the occurrence of fires that would have killed smaller juniper. Juniper expansion in eastern Oregon occurred at the same time fire return intervals increased.[5,15,17,24,68,69] Most of the upper Owyhee subbasin is part of the Owyhee Plateau where "A cause and effect relationship between the decline in periodic fires and the initiation and rate of juniper invasion on the Owyhee Plateau is suggested by the data."[15]

f. Progression of invasion

Overgrazing is not the direct cause of juniper invasion, but indirectly affects juniper expansion through decreasing fire frequency and intensity. Most older trees grew on ridges or rimrocks and juniper seedlings establish downslope from the old juniper. Most juniper seed is spread close to the parent plant, about 4½ feet downhill and two feet uphill. Seeds are apparently spread by small mammals as the seeds are found in the droppings of cottontail rabbits and ground squirrels. Although mule deer will eat juniper when other food is not available, this is generally after most juniper seeds have dropped to the ground. Birds also spread juniper seed. Seed buried in the soil can germinate a number of years later.[15,69,136]

Juniper seedlings establish in the protected areas under the crown of shrubs, usually big sagebrush, possibly because this is a bird perch. The density of seedlings is negatively related to bare ground and positively related to the presence of shrubs and trees. In an unusually dry year in the Owyhee uplands, 1967, 71% of seedlings survived the first year and 60% survived for two years.[5,15,56]

When juniper is first established the trees are widely scattered and the community is dominated by sagebrush and grasses. The understory of grasses and shrubs begins to decline when the trees reach 45 to 50 years old. Juniper begins to exclude other species through moisture competition and halting juniper expansion becomes more difficult. Eventually juniper outcompetes other native vegetation including smaller junipers, sagebrush, and grasses. By the time the trees are around 100 years old the juniper has become so dominant that it is unlikely that there is enough native understory community left to reestablish itself even if the trees are removed.[5,70,136]

Much of the sagebrush-steppe in the Owyhee uplands with juniper trees already growing on it is still developing into juniper stands. Juniper seedlings on these lands indicate that juniper is still in an establishment stage, and that the probability juniper on these lands will continue to increase in density is greater than for areas with a single old juniper.[5]

g. What to do

Without treatment, areas of range that have been invaded will continue to decline in forage productivity due to the effect of young trees already present. The problems created by juniper invasion can not be solved by grazing manipulation alone. There is no reason to believe that competition from other vegetation will either crowd out existing juniper or prevent the establishment of new juniper plants. In the early and middle stages of development, juniper invasion can be successfully treated by various methods, particularly fire. Where native grasses, forbs, and shrubs were present in southeastern Oregon, they increased following juniper removal and there was a good chance they would regain dominance.[15,69,70,136]

The ability to predict the outcome of western juniper removal decreases when juniper becomes more dominant. Several reburns might be required to destroy all the residual seed in the soil in established juniper stands. The composition of the understory prior to juniper removal affects the chance of reestablishment of desirable species. Instead of reverting to native grasses and shrubs, the range can achieve a new steady state with invasive species such as cheatgrass or medusahead and leave the site in poorer shape than before.[17,68,69,70,136]

Chemical treatments to control western juniper have had limited success. Sites where chemical control is appropriate are limited. Prescribed fire and mechanical treatment have both been effective reducing juniper dominance of an area. The Sagebrush Steppe Treatment Evaluation Project has produced a field guide to selecting the appropriate management actions for different juniper woodlands.[71] (Available on-line at http://pubs.usgs.gov/circ/1321/). Appropriate management actions are determined by the composition of the vegetation layers, economic feasibility, and social acceptability. Where the understory vegetation is more sparse, fire will not necessarily carry well. Where fire will carry, preparation of the land for burning and predicting the r

Photo 7.7. Adjacent plots in the upper Owyhee subbasin in the spring. The photo on the left shows the untreated area. The picture on the right shows the regrowth following juniper mastication the previous fall.

esponse to fire are difficult. Mechanical treatments have been used successfully in many areas, frequently leaving cut trees or slash on the site.[71]

To remove encroaching junipers, the Owyhee County Sagegrouse Local Working Group partnered with the Jordan Valley Cooperative Weed Management Area and the Nature Conservancy on a mastication project on private land near Juniper Mountain within the upper Owyhee subbasin. Hayden-based Environmental Forestry used masticators to destroy juniper trees in the mud flat section of the subbasin in the fall of 2009. There was “minimal impact to the soil, sagebrush and bunchgrasses.”[144] The principal goal for the local sagegrouse working group was to improve sagegrouse habitat by controlling juniper encroachment on ranch land. The site will also be monitored for forb and grass populations so that this conservation practice can be weighed against other juniper control methods.[47,143,144] The authors visited the site of the mastication project in early July, 2010. The treated area appeared to have more bunchgrasses and native forbs than the nearby untreated areas.

The current increase in juniper is aided considerably by human activity. Continued increase can affect the ecological functioning of the natural communities of juniper, sage, and bunchgrass. It's important to maintain functioning hydrological and nutrient cycles and healthy understory communities to provide habitat for sage grouse and food and shelter to a rich diversity of wildlife.

7. Invasive weed control

a. Fire

Periodic fire has been mentioned above as a means to keep juniper from invading rangelands. However in some areas fires have become more frequent and severe. Historic overgrazing followed by vigorous fire suppression reduced the number of fires. Reduction in fires meant that sagebrush and juniper cover increased. With removal of overgrazing, fine fuels, especially cheatgrass, filled the interspaces between the shrubs allowing fires to spread. Increases in the continuous proximity of fuels allows rapid spread of fires. These fires can be very destructive to existing perennial vegetation and extremely difficult to control. Cheatgrass may become the dominate species following fire in some areas. Dominance by cheatgrass then promotes frequent burns to the detriment of existing or reestablishing shrubs and perennial grasses.[22,43,131]

Fire is an important tool in range management. Another grass which is invading areas of the upper Owyhee subbasin is medusahead rye. Although medusahead rye supports frequent fire cycles, prescribed burning has shown great success in the management of medusahead. Timing is critical. Medusahead seed maturity needs to be in the milk or soft dough stage. The fire is best set when the relative humidity is about 30% to 50% and it will burn slowly into a light breeze. A complete burn is necessary. There is no germination of medusahead seeds which are completely burnt. Uncharred seeds may still have 87% germination. Under wildfire conditions only 50% of the seed is usually destroyed.[25,100]

Controlled burns are also effective on yellow starthistle. Unfortunately the proper timing, early to mid-summer, is when the risk of escaped fires is very high. Also the seeds can survive three or more years in the soil and three consecutive years of burning are needed.[25]

Studies show that few non-target plants respond negatively to prescribed summer burning. Those that do respond negatively are generally non-native species. The most important positive impact of prescribed burning for invasive weed control is the potential increase in native perennial grasses. In general controlled burns increase the plant diversity, particularly of native plants. Most studies show that this is due to an increase in forbs. The amount of land covered by summer native legumes can increase. Although most species benefiting from burns are desirable, in some cases invasive perennials can increase following a prescribed fire.[25]

Controlled fires or wildfires have some effect on diffuse knapweed if the seeds are exposed to the direct heat from the flames of the burn. Prescribed burns don't control spotted knapweed, leafy spurge, or dalmatian toadflax regardless of the timing. Saltcedar is favored by fire. It readily resprouts from the base following fire or mechanical damage. In most cases, successful control of invasive perennial forbs involves integration of other control options.[25]

b. Integrated management

Noxious rangeland weeds are highly competitive and persistent and control requires an integrated approach. Since invasive weeds know no boundaries, they can infect both public and private lands. Weed control efforts will be more successful if local public and private property managers develop coordinated management strategies. Fire, herbicides, and grazing management plans can all be part of weed control. An integral part of any control program is mapping where weeds exist.[22,25,64]

The most effective method for managing noxious weeds is to prevent their invasion into new areas. Possible methods to limit noxious weed encroachment include early detection and eradication of new weed introductions, limiting weed seed dispersal, containing neighboring weed infestations, minimizing soil disturbances, and establishing competitive species.[108,109]

Successful weed species have seed adapted to spread. Wildlife and livestock can ingest seeds which pass through unaffected and are introduced to new areas. Timing of livestock grazing on weed infested areas can minimize both the amount of seed which matures and the amount of mature seed which is carried to other areas. A vehicle driven through spotted knapweed can pick up 2000 seeds and still be carrying 10% of them 10 miles from the infestation. Flowers picked by hikers, campers, and recreationists can produce viable seed after they are discarded. Seed can stick to the coats of wildlife or livestock and to the clothing of people. [108,109]

Weed infestation can be contained to existing areas to protect neighboring uninfested rangeland. Spraying borders of infested areas may contain the weeds although it doesn't eliminate the infestation and is a long-term commitment to weed control. It also enhances the future success of eradication efforts. [108,109]

Eradication of existing weed species depends on using control techniques appropriate for the site and weed species. This includes the effectiveness of the technique, the availability of control agents including labeled uses of herbicides, the presence of grazing animals, and environmental considerations. Some control measures may need to be repeatedly applied until the weed seed bank and root reserves are exhausted. [25,109]

Herbicides with short half-lives need to be available for use whenever herbicides are part of the management program.

Reestablishment of native species can prevent reinfestation with noxious weeds. Replanting in the upper Owyhee subbasin needs to be with species that are competitive with cheatgrass and medusahead.

c. Weed control efforts

Part of the upper Owyhee subbasin is within the Jordan Valley Cooperative Weed Management Area (CWMA). The Jordan Valley CWMA has brought together everyone with responsibility for weed management within the CWMA including, but not limited to, landowners, cattlemen, Owyhee and Malheur Counties and their weed departments, the Oregon and Idaho departments of agriculture, the Nature Conservancy, the local sage grouse working group, Oregon and Idaho BLMs, and the Oregon Watershed Enhancement Board. The Jordan Valley CWMA "developed common management objectives, set realistic management priorities, facilitated effective treatment methods, and coordinated efforts along logical geographic boundaries with similar land types, use patterns, and problem species. The CWMA has also provided educational opportunities to the general public as well as to local landowners raising their awareness of the problems associated with noxious and invasive weeds."[12,99]

In addition to involvement in cooperative spray projects for selected weeds, the Jordan Valley CWMA has been involved with the release of biocontrol agents. Educational efforts have not only included monthly meetings but also the publication of information sheets on specific weeds and their control. Annual weed seminars have provided education about the problems associated with noxious and invasive weeds and treatment options for different weed species. Funding continues to be a hurdle to accomplishing the goals of the CWMA.[12,47]

Although the Elko County CWMA in Nevada focuses primarily on the Ruby Mountains to the south of the upper Owyhee subbasin, they have held an annual Elko Weed Summit to supply information to all residents of Elko County about noxious and invasive weeds, particularly on public lands. Ranchers have also been introduced to the idea of using ruminants to control weeds.[74]

The Elko County CWMA also was a sponsor of an extension manual for weed control in NE Nevada that contains guidelines for 24 invasive weeds and seven “nuisance” weeds. For each species, the weed is pictured and identified with distinguishing characteristics. Methods to control the weed are listed, along with the rates of chemicals to use when chemical control is indicated. In May of 2011, the guide was available on the Internet at http://www.unce.unr.edu/publications/files/ho/2005/eb0502.pdf.[64]

d. Special considerations

Rush skeletonweed is hard to control with herbicides because of the deep taproots and spreading roots, and tilling it under can spread the rootstock.

Whitetop spreads by seed and vegetatively under the soil and is very competitive with native vegetation on disturbed or alkaline sites. It has also been found that one time tilling of the soil will spread this noxious weed, and that it takes 3 consecutive years of tilling to destroy the root system.

Russian knapweed can be successfully controlled with combinations of grazing and herbicides but control programs must persist for several years.[93]

Special species of fruit fly (*Urophora affinis* and *U. quadrimaculatus*) have been introduced as a partial biological control of spotted and diffuse knapweed. Larvae within galls on knapweed seedheads eat the developing seeds, leaving only 5-20 seeds instead of 30.[27]

The leafy spurge flea beetles (*Aphona czwalinae*, *A. lacertosa*, and *A. nigriscutis*) are a promising biocontrol for leafy spurge. Trials have shown that the flea beetles dramatically reduced the cover and expansion of leafy spurge. However, there is some indication that species richness of treated areas declined.[20,55]

Expanded biological weed control efforts are warranted.

E. Fire suppression

Prescribed burns in the spring when the vegetation is still moist may be part of the management system of an area. However, wildfires when the vegetation in tinder dry are a different matter.

Fire is a natural component of many ecosystems. However, the invasion of cheatgrass has been fueling larger, more frequent fires. The more dense and continuous source of fuel extends the fire season and increases the frequency of fires. These fires may diminish or eliminate many of the native plant species. Cheatgrass also out-competes many of the native forb and grass species that are part of the ecosystems. The BLM actively fights most wildfires on BLM land.[105]

In 2005 and 2006, wildfires burnt significant areas of rangeland in the Nevada section of the upper Owyhee subbasin (Figures 7.6 and 7.7). In 2007, a wildfire on Juniper Mountain burnt an area in the Idaho section of the subbasin (Figure 7.8) . Figure 7.9 shows the areas of the upper Owyhee subbasin burnt by wildfires between 2001 and 2007. There were no significant fires in the subbasin in 2008 or 2009.

Following a fire on BLM land, cattle are removed from that section of range for at least two grazing seasons to allow the area to recuperate.[11] The primary goal of rehabilitation for a burned area is to protect the burned area from erosion and halt the spread of invasive species by developing a stable plant community. If a burned area will recover naturally, no reseeding is done. If it will not naturally recover, the burned area may be reseeded. Reseeding may be done with either native or non-native plants. An executive order of President Clinton directed that native forbs and grasses be used wherever possible.[45,105]

Restoration differs from rehabilitation. Restoration is the use of a mixture of only native species to obtain a plant community that is similar in appearance and function to the vegetation prior to European settlement. Restoration is designed to develop ecosystems such that they are self-sustaining. One challenge is to figure out whether these area were naturally dominated by sagebrush, grasslands, or both. Total

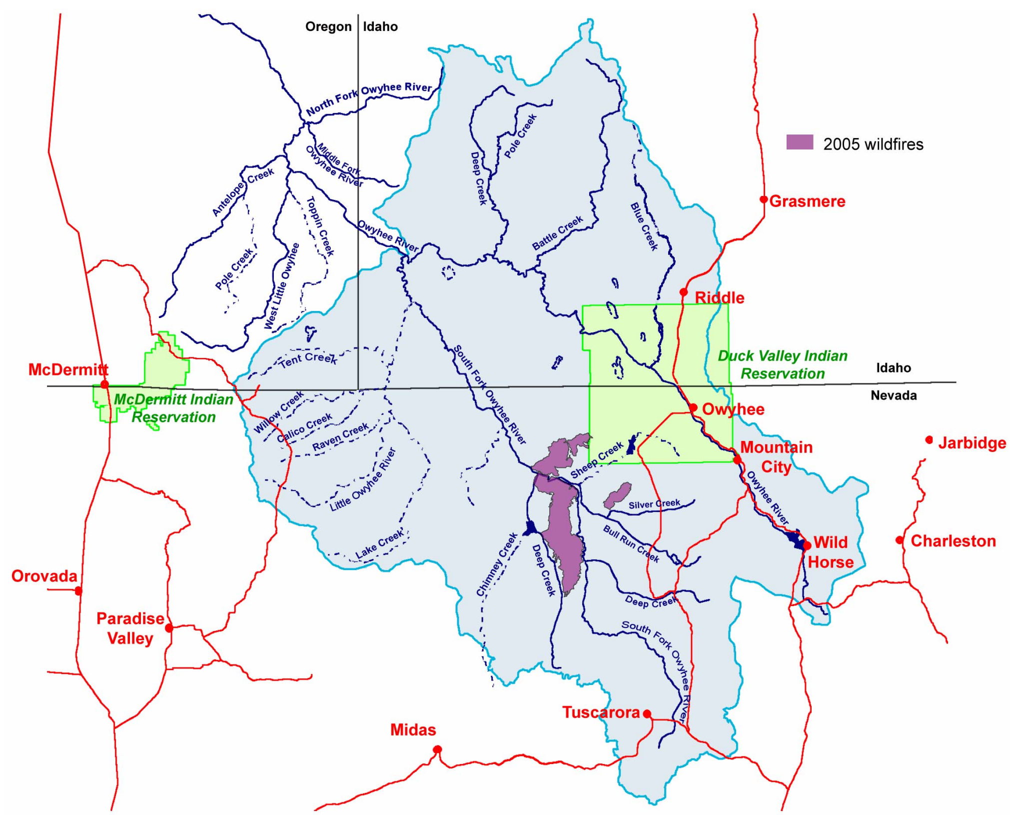

Figure 7.6. 2005 wildfires in the upper Owyhee subbasin.

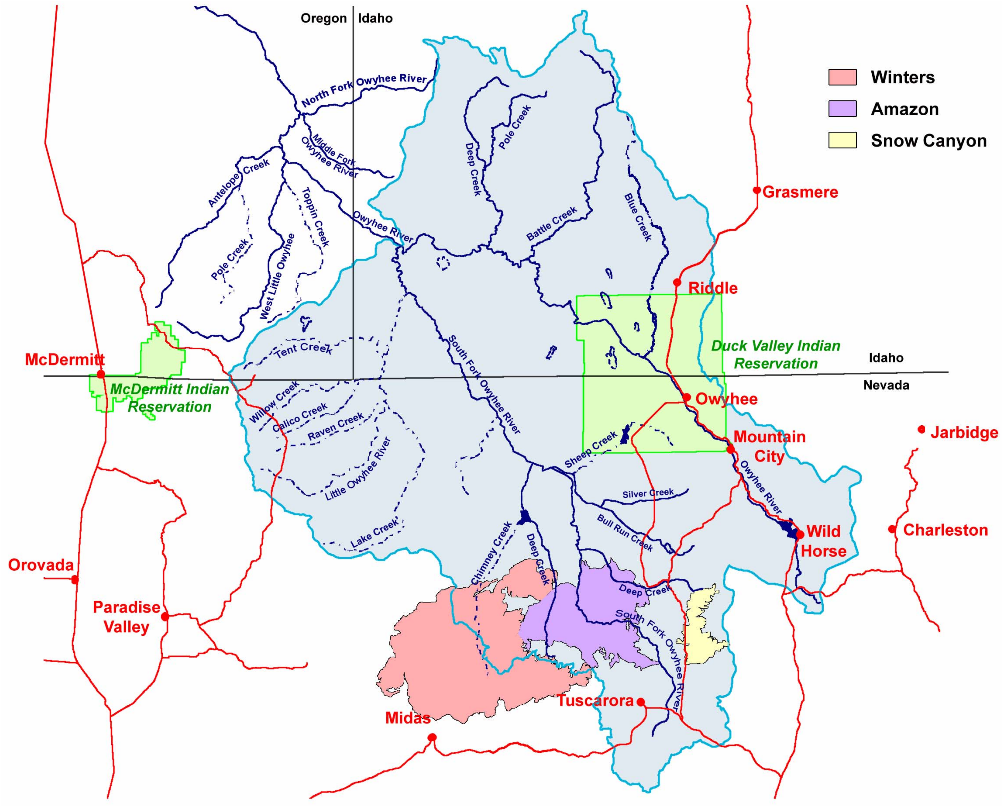

Figure 7.7. 2006 wildfires in the upper Owyhee subbasin.[Appendix A]

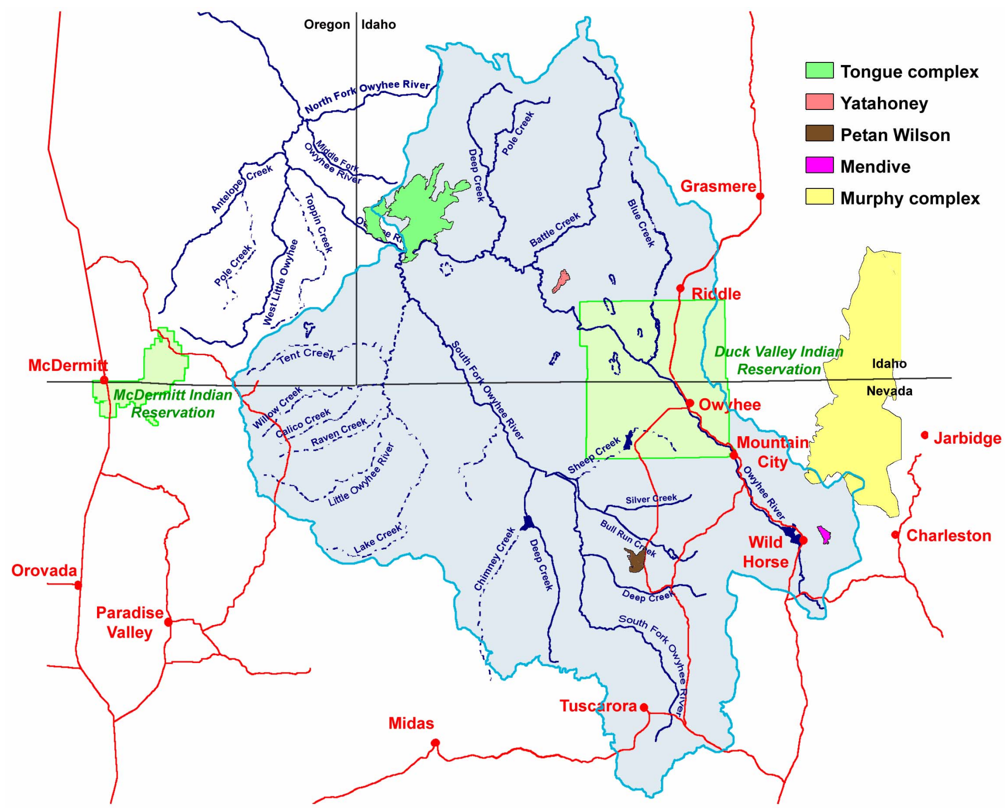

Figure 7.8. 2007 wild fires in the upper Owyhee subbasin.[Appendix A]

of a burned area is outside the scope of most fire rehabilitation programs.[45,105]

Following fire, non-native species tend to invade many burned areas. In the past many burned areas have been reseeded largely with grass species. Although native forbs are components of most native communities, their use in revegetation has been limited, largely due to inadequate seed supplies. The availability of native forb and grass species is developing. The Great Basin Native Plant Selection and Increase Project is a multi-state, multi-agency collaborative research project. The goal is not only to increase the availability of native plant materials for restoring Great Basin rangelands, but to both develop the seed technology and cultural practices to produce native seed and the practices necessary to improve the establishment of native seedings.[112,124]

F. Wilderness study areas

Within BLM managed land, there are a number of wilderness study areas (WSAs). No new WSAs are being designated, but existing WSAs remain WSAs until Congress makes a decision to designate the area as wilderness or to release the area for non-wilderness uses. Wilderness study areas in the upper Owyhee subbasin are shown on Figure 2.9 in the background section of this assessment.

According to the BLM web site, management of wilderness study areas is less restrictive than management of wilderness areas. "For example off-highway vehicles may drive on designated routes in WSAs and WSAs are open to location of new mining claims. Both activities are prohibited in wilderness."[13] Similar to wilderness areas, in WSAs outdoor recreation is allowed, including hunting, fishing, hiking, horseback riding,

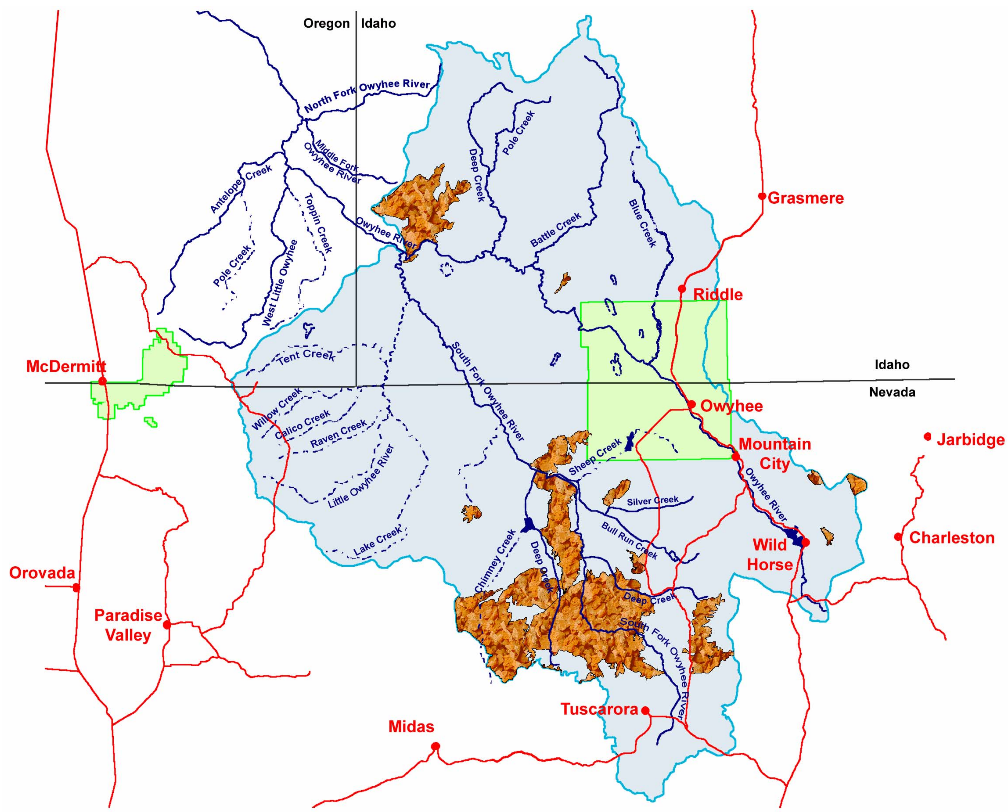

Figure 7.9. Areas of the upper Owyhee subbasin burnt by wildfires between 2001 and 2007.[Appendix A]

and camping. Although livestock grazing is permitted by law, some BLM districts interpret their mandate to manage WSAs to retain their wilderness character by restricting livestock grazing. If an area has previously been grazed and becomes wilderness, then the grazing may continue. There is no similar mandate that grazing continue to be permitted in a WSA.[13,4] However, the "majority of WSAs are grazed by domestic livestock. Livestock grazing may continue in the same manner and degree as it took place in 1976. Developments such as fences, wells, and pipelines may be maintained. New livestock facilities may be constructed if they are temporary, or they benefit overall management of wilderness values. Vehicles may be used on designated routes to support grazing management."[13]

G. Use of the upper Owyhee subbasin rangeland

The majority of the rangeland in the upper Owyhee subbasin is used for grazing.

> "Ranchers in the Owyhee Uplands effectively manage their land, adeptly handling the arid landscape that hosts their family business. Operating a ranch requires financial capital, and the economic values depend on the composition of the range vegetation rooted in soil - the underlying natural capital. Driving from Jordan Valley, Oregon towards Juniper Mountain in Idaho, the visitor can view a mix of vegetation that survives on a meager 13 inches of annual precipitation. Every good manager recognizes constraints on production. The soil moisture limits productivity, and is a production cap faced by the range manager. . . The changing vegetation and soil moisture [from juniper expansion] further constrain range production for the rancher."[145]

BLM lands (Figure 2.8) are managed by the Elko field office of the BLM in Nevada, the Owyhee and Bruneau field offices of the BLM in Idaho, and the Vale field office of the BLM in Oregon. The agency has regulations, revised in 1995, for administering livestock grazing. Ranchers may "lease" portions of the public rangeland for grazing. These leased areas, called allotments, are grazed under a management plan which may include the season, the amount of time the grazing may occur, the number and kind of livestock permitted, and the distribution of the livestock over the landscape achieved by herding, water development, salting, fencing, or other methods. A management plan is developed for each allotment in coordination with the permittee.[146,147]

Permittees pay a fee based on the number and type of livestock they graze. "Grazing permittees purchase Animal Unit Months (AUMs) of livestock forage. An AUM is the amount of forage needed to sustain one cow and calf, five sheep, two burros, or one horse for one month."[147]

H. Discussion

The native vegetation of the upper Owyhee subbasin was greatly changed at the end of the 19th and beginning of the 20th centuries. We have descriptions of what the area was like at the time of Euro-American settlement, but we don't really know the composition of the native species. Following the abusive livestock grazing which ended between the passage of the Taylor Grazing Act of 1934 and World War II, the rangeland has improved. Vegetation cover of the landscape has increased. The ecoregion is recovering. However the plant communities undoubtedly remain altered. There has been a public shift in the perception of the role of range. The idea of maintaining a sustainable long-term output of livestock products has been replaced by one of continuing to produce livestock products while maintaining ecological functions and multiple uses.

Wildlife, as well as livestock, is endangered by a perception that water which is currently stored in stock ponds could instead increase the flows into the river.

Current knowledge should provide for continued improvement in ecological conditions. Throughout the Great Basin ecoregion, the reintroduction of fire as a management tool is having a very positive effect in reducing the amount of late successional sagebrush and invasive juniper dominance that has occurred with past fire suppression practices. Livestock management for riparian zone enhancement is in its infancy, but where practiced significant positive results are occurring. However, any management activities on public land require an extensive paper trail and public scrutiny before implementation.[121]

I. Conclusions

The use of the important resources of the rangelands of the upper Owyhee subbasin affects all of us. Therefore, proper use and management is vitally important.

> "Thou shalt inherit the holy earth as a faithful steward, conserving its resources and productivity from generation to generation. Thou shalt safeguard thy fields from soil erosion, thy living waters from drying up, thy forests from desolation, and protect thy hills from overgrazing by thy herds, that thy descendants may have abundance forever. If any shall fail in this stewardship of the land thy fruitful fields shall become sterile stony ground and wasting gullies, and thy descendants shall decrease and live in poverty or perish from off the face of the earth". - W.C. Lowdermilk [62]

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Upper Owyhee Watershed Assessment

VIII. Water quality

Contents

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

VIII. Water quality

A. Introduction

The water in the upper Owyhee subbasin is a valuable resource. Not only does it provide natural beauty, both within and downstream from the upper Owyhee subbasin, but the water supports farming, ranching, recreation, drinking water, wildlife, and aquatic life. We all want to maintain the quality of our water so that it can continue to meet human and habitat needs.

In examining the water quality of the rivers in the upper Owyhee subbasin, it is necessary to distinguish between naturally existing conditions and conditions caused by human activities (anthropogenic causes). A distinction also needs to be made between legacy use of the landscape and current use. Naturally existing conditions are not open to remediation.

B. Regulatory background

The Federal Water Pollution Control Act (PL92-500, commonly known as the Clean Water Act) requires each state to develop a program to monitor and report of the status of its water quality. The 305(b) process evaluates the quality of all of the waters of the state. The 303(d) process identifies impaired waters. These are waters that the state classifies as too polluted or otherwise degraded to meet the water quality standards set by the states. A state develops Total Maximum Daily Loads (TMDLs) for these waters. A TMDL is a state's calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards.[8,9,10,33]

The national Clean Water Act (CWA) defined two principal goals: 1) to restore and maintain the chemical, physical, and biological integrity of the nation's waters and 2) where ***attainable***, to achieve water quality that promotes protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water. This goal is commonly known as "fishable/swimmable." "Federal regulations are not intended to result in standards that are so stringent that compliance would cause severe economic impacts."[11]

Under the legislation, the states are responsible for developing water quality standards to implement the goals of the CWA. The policies are supposed to protect, maintain, and conserve existing uses of the water. The water quality necessary to protect these existing uses needs to be maintained. This policy is known as the "antidegradation" policy.[19] It was developed "so that it minimizes adverse effects on economic growth and development and at the same time protects CWA goals."[11]

States are also responsible for establishing designated beneficial uses of a waterbody. In a way these uses are provisional, they are an initial guess as to how the waterbody can be used in addition to existing uses. This is obvious from the fact that the CWA clearly states that "Designated uses, on the other hand, may be changed upon finding that the use cannot be attained."[11]

The designated use can be modified if attainment is not possible because of one or more of the following factors: 1) naturally occurring pollutant concentrations; 2) natural, intermittent or low-flow water levels; 3) anthropogenic conditions or sources of pollution that cannot be corrected; 4) dams, diversions, or other hydrologic modifications; 5) physical conditions associated with the natural features of the waterbody, unrelated to quality; 6) more stringent controls would result in substantial and widespread economic and social impact.[11]

In the past each state submitted two documents to the EPA: a list of impaired waters in the state (303(d)) and a report summarizing the status of all the waters of a state (305(b)). Now the two documents are combined into one document called an Integrated Report.

C. Naturally occurring conditions

The upper Owyhee subbasin is an extensive tract of land with extremely low population density. Developing information about the naturally occurring conditions relies on more limited information than is available in more densely populated areas.

1. Vegetation along water courses

a. Historical

Revisiting the descriptions in the historical section, the earliest Euro-Americans in the area noted a lack of any trees away from the Bull Run and Independence Mountains (see the "at contact" section of the history component of this assessment), even along the waterways.

If the banks of the rivers and streams did not have trees growing on them, what did they have? Ogden's statement "excepting a few willow on the banks of the river"[35] gives us some idea. Willows are mentioned when vegetation along the banks is discussed. Most of Ogden's references to willows indicated that in general they were sparse. "When we reach[ed] . . . a fork of [upper] Owyhee River but from all appearances destitute of beaver. . . also wood there being but a few willows and thinly scattered."[35] Traveling one day east of the Owyhee on the Snake River, Ogden records that "wormwood [sagebrush] is more abundant but wood of any other kind equally scarce with the exception of a few scattered willow on the banks of the river, and even these not in abundance."[35]

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

The willow which the trappers mention is not a tree but coyote willow. It is an upright, deciduous shrub which may grow to 23 feet but is generally about 12 feet tall and about 15 feet wide. It grows in sagebrush country along creek bottoms, both on the shoreline and sometimes in the water. Willows form dense thickets of pure, even-aged shrubs. Short-lived, they are one of the most shade intolerant native species and are threatened by both fire and drought. They can not survive long if the water table becomes too low.[5,6]

Coyote willows along a waterway would provide limited shade, however the historical observations indicate that they were only found in some areas. They also would disappear in times of drought and would probably not be found along most sections of intermittent streams and never in draws identified as ephemeral streams.

b. Flooding

High flows in the spring would send a river out of its banks. It could be a mile wide in some places when the water was high and cover vegetation not normally under water.[2] The high flows could carry ice and rocks and scour vegetation along the banks.[27]

2. Stream temperature

a. Stream flow

There are tremendous natural variations in water flow in the Owyhee River and tributaries. These variations cause scouring of the banks and have been characterized by both flooding and diminution of the water flow to almost a trickle.

b. Climate

The discussion in the background section characterizes the air temperatures in the upper Owyhee subbasin (see the climate section of the background component of this assessment).

The expectation from both the temperatures of the air above and the soil below the stream courses increasing during the summer months is that the stream temperature would be somewhere between the maximum and minimum temperatures.

c. Topography

The lower reaches of the upper Owyhee River, of the South Fork Owyhee River, and of their tributaries frequently have cut and run through deep canyons. These canyons are generally 50 feet to 1300 feet below the level of the plateau.[44] Where there are sheer rock walls, they are frequently 600 to 1200 feet tall. Thus, in many places, the canyon itself provides shading for the river during part of the day.

3. Geological

Minerals which occur naturally in rocks can slowly leach and end up in river waters to be moved in solution. The minerals can also be carried in the rocks and sediment moved by the water.

a. Mercury

"While mercury most frequently occurs as deposits in rock fractures and veins, it may also be found in low concentrations in other geological formations. Considering the entire Owyhee River watershed, mercury is commonly found as an anomaly, present in 12 of 23 random outcrop rock-chip samples."[2]

b. Arsenic

Arsenic is naturally associated with volcanic activity and the hydrothermal activity following volcanism. In the upper Owyhee subbasin, the principle source of arsenic in surface water and groundwater is volcanism and the subsequent hydrothermal activity that has deposited arsenic in the rocks and soil.

D. Legacy anthropogenic conditions

1. Mercury

Except for iron and platinum, all metals dissolve in mercury and chemists refer to the resulting mercury mixtures as amalgams. In the late 1800s into the early 1900s, gold miners in the upper Owyhee subbasin used mercury for processing much of the gold ore. The gold-bearing rock was crushed and treated with mercury to dissolve the gold out of the ore and form a gold amalgam. The amalgam of gold and mercury was then heated to separate the gold from the mercury by a process of distillation.[60] Silver ore can be recovered in a similar fashion. Precious metal separation by boiling off mercury works because the boiling point of mercury is 357°C but the boiling point of gold is 2808°C and silver is 2210°C. The volatilized (gaseous) mercury would be condensed and reused. "Due to inefficiencies and poor handling practices, large amounts of mercury vapor and liquid often escaped into the environment."[60]

The result of using a mercury amalgam process to recover gold and silver was elevated mercury levels "in steams located near the processing sites."[60]

2. Copper

The Rio Tinto Copper Mine near Mountain City processed copper-sulfide ore. The processing and reprocessing of the ore had the potential of introducing pollutants into environment.

E. The upper Owyhee subbasin constituents

The area considered as the upper Owyhee subbasin for this assessment consists of the drainages of three rivers, the South Fork Owyhee River, the East Fork Owyhee River (or just Owyhee River), and the Little Owyhee River. The drainage of each of these rivers, respectively, defines the boundaries of a fourth-order HUC: the South Fork Owyhee HUC (17050105), the East Little Owyhee HUC (17050106), and the Upper Owyhee HUC (17050104) (Figure 2.2). For a discussion of 303(d) lists and Total Maximum Daily Loads (TMDLs) it is frequently convenient to refer either to a HUC or to a state or to the portion of a HUC within a state.

F. 303(d) listings

CWA Section 303(d) requires the identification of waters that do not meet water quality standards where a Total Maximum Daily Load needs to be developed. Each state develops a 303(d) impaired waters list of all waters that the state has identified where "required pollution controls are not sufficient to attain or maintain applicable water quality standards. . . Once states submit their 303(d) list to EPA, EPA then has 30 days to approve or disapprove the 303(d) lists. If EPA disapproves a state list, EPA has 30 days to develop a new list for the state; although historically, EPA has rarely established an entire list for a state. Sometimes EPA partially disapproves a list because of omission and adds waters to the state's list."[7] Table 8.1 includes only 303(d) streams in the upper Owyhee subbasin, not other 303(d) water bodies. The EPA 303(d) identified streams are those listed on the EPA website for each of the fourth order HUCs as of September 2010 (Table 8.1).[13,14,15,40]

In Nevada, the EPA has approved the listing of all or part of the South Fork Owyhee River, Jack Creek, Jerritt Canyon Creek, and Snow Canyon Creek in the South Fork Owyhee HUC. In the Upper Owyhee HUC, Owyhee River, Mill Creek, Badger Creek and Tomasina Gulch are listed. In Idaho, the South Fork Owyhee River is listed for the South Fork Owyhee HUC. Battle Creek, Beaver Creek, Camel Creek and Nickel Creek are listed in the Upper Owyhee HUC. Idaho DEQ also has recommended water bodies to include on the next 303(d) list and these are included in Table 8.1. There are no water bodies listed in the East Little Owyhee HUC. Although no Oregon section of the upper Owyhee subbasin is 303(d) listed, Oregon has included the Owyhee River starting at the Idaho - Oregon border on its 303(d) list (Figure 8.1).[13,14,15,20,27] The initial inclusion of a waterbody on a 303(d) list includes the pollutant of concern.

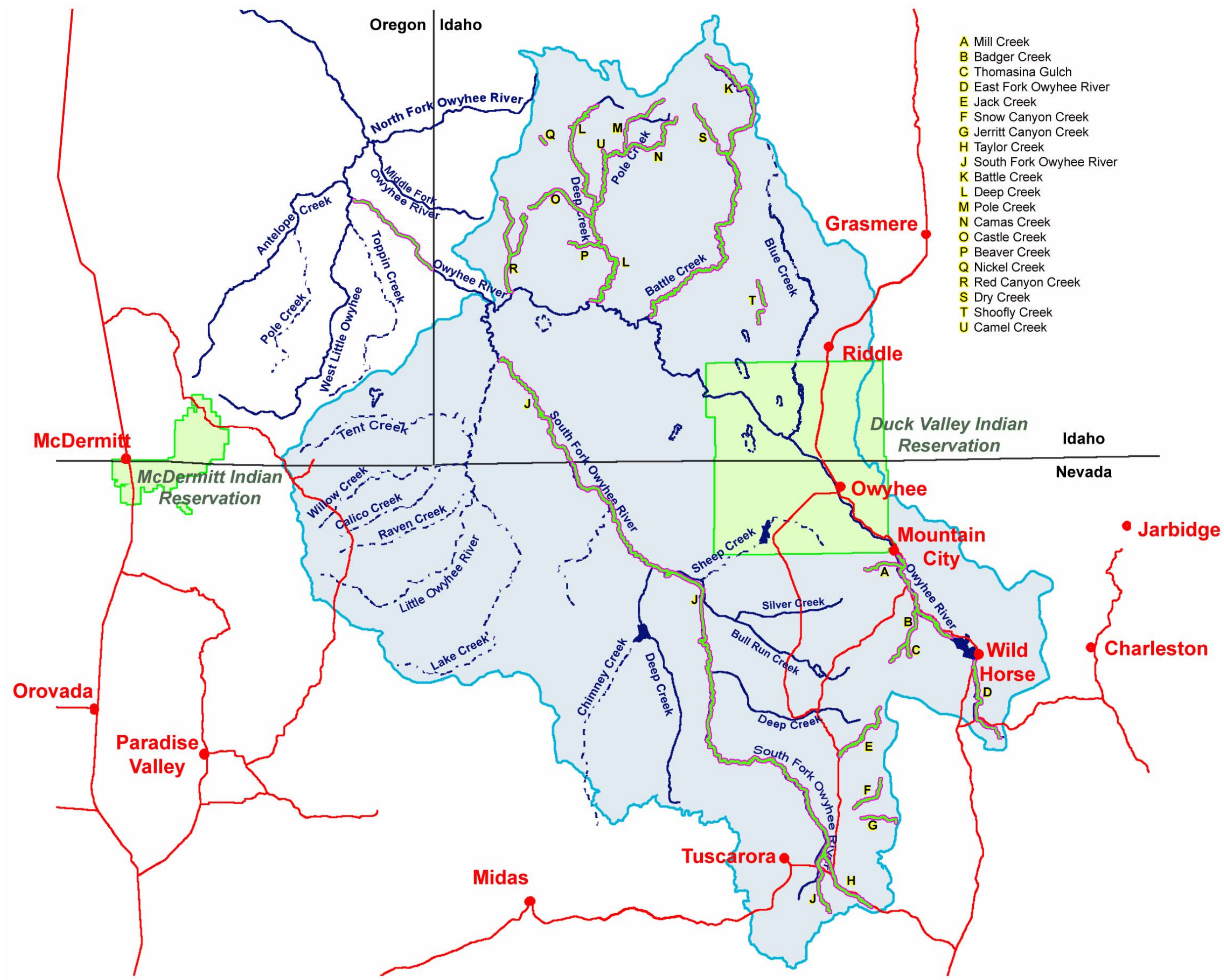

Figure 8.1. Streams in the upper Owyhee subbasin listed as 303(d) as of December 2010.

Table 8.1. Streams in the upper Owyhee subbasin listed on EPA and State 303(d) lists and existing TMDLs or regulations.[13,14,15,20,27]

Subbasin (4th order HUC) Stream name	State	EPA 303(d) listed	State 303(d) listed	State TMDL
South Fork Owyhee				
South Fork Owyhee River from its origin to the Nevada-Idaho state line	Nev	X		X
Jack Creek from its origin to its confluence with Harrington Creek	Nev	X		
Jerritt Canyon Creek from its origin to the national forest boundary	Nev	X		
Snow Canyon Creek from its origin to the national forest boundary	Nev	X		
South Fork Owyhee River Nevada-Idaho border to confluence with the East Owyhee	Id		X	X
Taylor Canyon Creek from its origin to its confluence with the South Fork of the Owyhee River	Nev			X
Upper Owyhee				
Owyhee River from Wildhorse Reservoir to its confluence with Mill Creek	Nev	X		X
Owyhee River from its confluence with Mill Creek to the border of the Duck Valley Indian Reservation	Nev	X		X
Mill Creek from the Rio Tinto Mine to the Owyhee River	Nev	X		X
Badger Creek from its origin to the Owyhee River	Nev	X		
Tomasina Gulch from its origin to Badger Creek	Nev	X		
Battle Creek from its headwaters to its confluence with Owyhee River	Id	X		
Beaver Creek	Id	X		
Camel Creek	Id	X		
Nickel Creek from its headwaters to Mud Flat Road	Id	X		X
Deep Creek From Mud Flat Road to its confluence with the Owyhee River	Id		X	X
Castle Creek from its headwaters to its confluence with Deep Creek	Id		X	X
Pole Creek from its headwaters to its confluence with Deep Creek	Id		X	X
Red Canyon Creek from its headwaters to its confluence with Owyhee River	Id		X	
Dry Creek	Id		X	
Camas Creek	Id		X	
Shoofly Creek from its headwaters to its confluence with Blue Creek	Id		X	
Subbasin (4th order HUC) Stream name	State	EPA 303(d) listed	State 303(d) listed	State TMDL

The EPA is in the process of collecting TMDL information from the states. Since these efforts are ongoing, the table above only shows that a state has developed a TMDL, not whether or not it has been approved. If a TMDL has been developed, that waterbody may no longer be included in the 303(d) list. A state may also have a 303(d) list which has not been approved by the EPA. In Nevada administrative regulations rather than a TMDL set standards for the South Fork Owyhee River.[27,34,40]

Although Oregon does not have any 303(d) listed waterbodies in the upper Owyhee subbasin, the Owyhee River at the border with Idaho is on the 2006 EPA 303(d) list.

The Idaho Soil Conservation Commission (ISCC) and Idaho Association of Soil Conservation Districts (IASCD) point out in the Upper Owyhee Watershed TMDL implementation plan for agriculture that the East Fork of the Owyhee River itself is not 303(d) listed. "This indicates that the tributaries to the river are not negatively impacting the water quality in the East Fork of the Owyhee River." The ISCC and IASCD assessment also points out that "other 303(d) stream segments are dry throughout most of the year with the exception of spring runoff during parts of May and June."[57]

G. Total maximum daily loads

The Clean Water Act mandates a water-quality based control program. Water quality standards define the goals for a waterbody by designating its uses and setting criteria to protect those uses. After a waterbody has been identified on the 303(d) listing as not meeting water quality standards, a Total Maximum Daily Load (TMDL) is developed. In the development of a TMDL the current condition of a waterbody is evaluated and, if needed, the amount of pollutant a water body can receive and still meet water quality standards is calculated. The TMDL attempts to assign part of the responsibility for improving the condition of the waters to each of the different contributing factors.   Pollutants can either be attributed to a specific discharge into the water or they can be from nonpoint sources, sources with no one origin that can be pinpointed.[12,16,33,40]

Within a TMDL, the state either determines the most beneficial designated use of a particular water body or uses already established beneficial uses. After designating a waterbody's uses, water quality standards define goals for the waterbody, set criteria to protect those uses, and establish provisions to protect water quality from pollutants. To develop criteria protective of water quality, states are required to examine the effects of specific pollutants on plankton, fish, shellfish, wildlife, plants and recreational activities and determine the levels of pollutants that can exist without harming human and aquatic life.[12,16,24] When developing a TMDL for a waterbody, a state may not only establish limits for the pollutant initially identified when the waterbody was designated as 303(d) but may also set limits for other potential pollutants.

1. Existing TMDLs

The state of Nevada has written one TMDL for waterbodies in the upper Owyhee subbasin. The document presents the problems resulting in degraded water quality in the East Fork Owyhee River and Mill Creek and establishes amounts of pollutants those waterbodies can receive and still meet water quality standards. The TMDLs for those streams are detailed in Appendix F. In addition, standards set by proposed regulations of the State Environment Commission for the South Fork Owyhee River are included in the appendix. The remaining 303(d) listed streams in the upper Owyhee subbasin in

Nevada have the lowest priority on Nevada's prioritized list for developing TMDLs.[,22,31,32,34]

The Idaho Department of Environmental Quality (DEQ) has conducted assessments and developed TMDLs for the Upper Owyhee Watershed subbasin and the South Fork Owyhee River subbasin. In addition to determining pollutant loads to meet water quality standards, the assessments looked at some of the characteristics of each watershed including the climate, geology, hydrology, land ownership and use, and fisheries.

Total maximum daily loads for previously listed 303(d) waterbodies in the Upper Owyhee hydrologic unit in Idaho are established in the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load*. The assessment also includes action items for the next 303(d) list and for future TMDLs (Appendix G). In 2009, the Department of Environmental Quality (DEQ) produced a five-year review of that TMDL. The *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load* assessed the condition of the South Fork Owyhee in Idaho. These assessments provided the information used to develop Appendix G summarizing the Idaho TMDLs for the upper Owyhee subbasin.[20,27]

The State of Oregon has not developed any TMDLs for the Owyhee River and its tributaries.

2. Designated beneficial uses

Designated beneficial uses are assigned to a specific water body by a state. In designating beneficial uses, the Clean Water Act requires each state to include any existing uses, to consider the ability of the waterbody to support a future use, and to meet the basic goal of the Clean Water Act that all waters support aquatic life and recreation where attainable.[25]

Nevada considers the potential beneficial uses of a waterbody to be the watering of livestock, water supply for irrigation, habitat for fish and other aquatic life, recreation involving contact with the water, recreation not involving contact with the water, municipal or domestic water supply, industrial water supply, propagation of wildlife and waterfowl, extraordinary ecological or aesthetic value, and enhancement or improvement of water quality in any water which is downstream.[34]

Idaho's water quality standards establish the potential beneficial uses to be habitat for aquatic life, recreation, water supply, wildlife habitat, and aesthetics. The first three uses are further divided. Aquatic life includes cold water, salmonid spawning, seasonal cold water where coldwater aquatic life may be absent or tolerate seasonally warm temperatures, warm water, and modified "with aquatic life limited by one or more conditions that preclude attainment of reference streams or conditions."[22]

Recreational uses are divided into primary contact recreation in the water with a chance of swallowing water and secondary contact recreation with possible occasional ingestion of water. Water supply is further broken down to providing domestic drinking water, agricultural water for irrigation, drinking water for livestock, or industrial water.

Industrial water use as well as wildlife habitat and aesthetics are considered to apply to all of the surface waters of the state.[22]

The TMDLs for a waterbody identify the beneficial uses of that waterbody. For the Nevada streams these are included in Appendix F. For Idaho waterbodies, the beneficial uses are noted in Appendix G. Those identified by Oregon for the Owyhee River at the Oregon - Idaho border are included in Appendix H.

"Idaho presumes most undesignated waters will support cold water aquatic life."[22] In the Idaho administrative code, beneficial uses for the entire length of the Owyhee River, of the South Fork Owyhee River and of the Little Owyhee River are cold water aquatic species, salmonid spawning, and primary contact recreation.[19] In Oregon all of the waters of the Owyhee Basin are designated for redband or Lahontan cutthroat trout.[37]

3. Water quality assessment

The primary reason for including a waterbody on the initial 303(d) listings in Idaho was the probability that cold water biota and salmonid spawning might not be fully supported by existing conditions. Both assessments found that criteria established by the state as essential for the support of cold water fish and salmonid spawning did not exist in some of the streams considered.

The principal pollutants addressed in Idaho's *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load* are temperature and sedimentation. Sedimentation is covered in the sediment sources section of this assessment. Only temperature is considered to be a pollutant in the *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load.* All pollutants in both the Upper Owyhee HUC and the South Fork Owyhee HUC are identified by the Idaho DEQ as coming from nonpoint sources.[20]

A TMDL management plan allocates load reductions to different sources. In the Upper Owyhee HUC, the contributing factors, or "loads", are considered to be the different streams and the amounts of change which are required in each one, therefore some streams which are not listed as 303(d) have recommended shading requirements (Appendix G).

Idaho's 2010 integrated 303(d)/305(b) report attributed other pollutants to some of the waterbodies in the Upper Owyhee HUC. These included flow regime alterations, Escherichia coli, mercury, metals, organic enrichment, and inadequate dissolved oxygen. Additionally, bioassessments of aquatic plants and combined biota/habitat were included not as pollutants but as indicators of problems.[4,21,23]

In the *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load* temperature was also determined not to support either cold water biota or salmonid spawning. Although it was concluded that "a total maximum daily load management plan for temperature is an appropriate vehicle for addressing temperature concerns in the South Fork Owyhee River," it also concluded that the "load" should include an "allocation as water enters the State of Idaho."[27] The assessment recognizes that the naturally occurring "flashy nature of flows in the South Fork Owyhee River appears to be the limiting factor for the presence of large woody vegetation."[27]

In Nevada, the *Total Maximum Daily Loads for East Fork Owyhee River and Mill Creek* addresses not only temperature, but also dissolved and total copper, total iron, total phosphorus, total suspended solids, turbidity, dissolved and total cadmium, dissolved oxygen, total iron, and pH (Appendix F). Although the Rio Tinto Mine area is identified as a contributor for several of the pollutants, other natural and anthropomorphic (human-caused) sources are considered including elements in the soils. These may enter the waterbodies by erosion that would occur naturally or that is increased by human activities. Since the TMDL identifies many of the pollutants as coming from nonpoint sources, "a gross load allocation that accounts for all these sources has been set" for those pollutants.[32]

Although no TMDL has been written for the South Fork Owyhee River nor its tributaries identified as 303(d) in Nevada, pollutant levels have been established in Nevada administrative regulations (Appendix F). Before establishing a TMDL for the South Fork Owyhee River, the Bureau of Water Quality Planning of the Nevada Division of Environmental Protection had concerns about standard appropriateness and conducted a preliminary temperature source assessment. In the observations at the conclusion of the assessment, R. Pahl states "The data show that the temperature standard (21 degrees C) is exceeded for extended periods of times during various flow conditions. . . Unfortunately, it is not possible to accurately determine what temperature levels could be achieved . . . *without spending significant funds for monitoring*."[43] "It becomes difficult for us to develop appropriate temperature standards and/or a TMDL."[43]

Although Oregon has not developed a TMDL for the Owyhee River, on the 2006 EPA 303(d) list the Owyhee River at the border with Idaho is listed for temperature and arsenic. Oregon's draft 2010 integrated report retains these two pollutants and adds phosphate, phosphorus, alkalinity, pH, ammonia, chloride, and dissolved oxygen as pollutants that may impair water quality and have an Oregon water quality standard which is not fully attained (Appendix H).[41]

H. Stream temperature

The principal pollutant of concern which has been identified in waterbodies in the upper Owyhee subbasin is water temperature based upon the beneficial use being cold water aquatic life or salmonid spawning. Water temperature is also identified as a pollutant where the Owyhee River leaves the upper Owyhee subbasin and enters the Middle Owyhee HUC in Oregon.

The East Fork Owyhee River and Mill Creek TMDL also includes temperature as a potential pollutant. However, there is also concern about the copper levels in these two streams below the old Rio Tinto copper mine.

1. Data collection locations

There are only a few locations in the upper Owyhee subbasin where water temperature measurements have been made and are readily accessed for analysis.

a. Upper Owyhee HUC in Nevada

Nevada has several Nevada Division of Environmental Protection (NDEP) sites on the East Fork Owyhee River in the Upper Owyhee HUC. Miscellaneous water temperature readings have been taken on the river below Wild Horse Reservoir, above Mill Creek, below Mill Creek, and below Slaughterhouse Creek. There is also a site at the southern boundary of the Duck Valley Reservation run by the Shoshone-Paiutes. On Mill Creek the NDEP has taken miscellaneous water temperature readings above the Owyhee River confluence, at Patsville, and above the Rio Tinto mine site.

b. Upper Owyhee HUC in Idaho

In Idaho the USGS does not have any sites with surface-water data in the upper Owyhee subbasin.[51] For the Idaho DEQ Upper Owyhee Watershed TMDL, water temperature data was based on available temperatures taken with recording thermographs from June 2000 through September 2001. Data was collected for Deep Creek at Mud Flat Road, at Castle Creek, and at Road Crossing. For Pole Creek it was collected near Mud Flat road, near Camel Creek, and upstream of Camel Creek. Water temperatures were also recorded for Castle Creek and Red Canyon Creek (Figure 8.2).

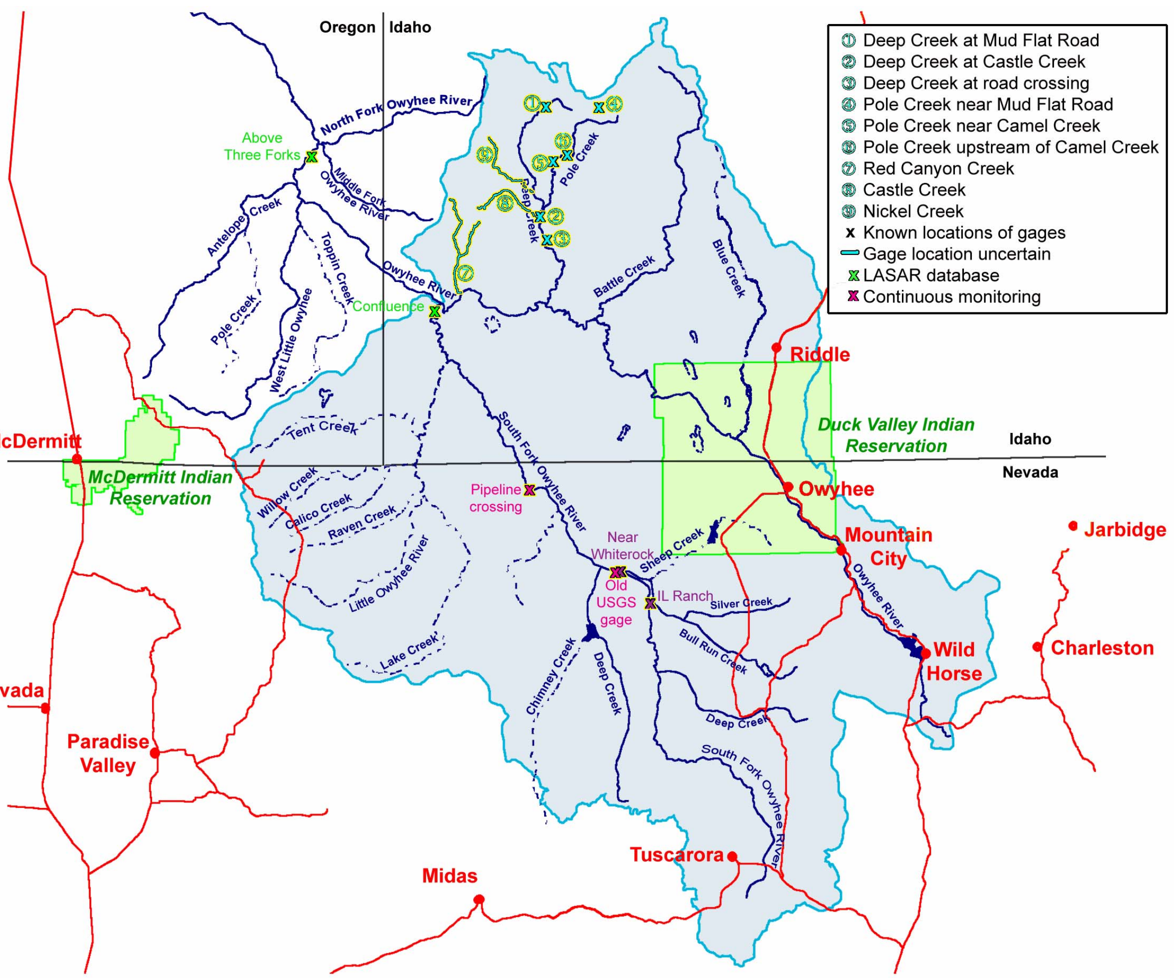

Figure 8.2. Location of prior water temperature monitoring sites in the upper Owyhee subbasin.

In the summer of 2004 the Bureau of Land Management (BLM) installed temperature loggers at six locations in the Upper Owyhee HUC. There was one logger on Nickel Creek, one on Pole Creek, two on the East Fork Red Canyon Creek, and one each on the West Fork Red Canyon Creek and on Red Canyon Creek.

c. South Fork Owyhee HUC in Nevada

In 1999, a water temperature monitoring site was set up at the El Paso Pipeline Crossing in Nevada at river mile 36.8 from the Idaho-Nevada border. The water temperature of both the South Fork Owyhee at this site and at the old USGS gage upstream was recorded in 1999, 2000, and 2001, with only the old USGS gage recording in 2002 and only the pipeline gage with 2003 records. These data and miscellaneous temperature readings near Whiterock and at the IL Ranch were included in the preliminary temperature assessment of the South Fork Owyhee River in Nevada (Figure 8.2).

d. South Fork Owyhee HUC in Idaho

For the South Fork Owyhee TMDL in Idaho the data from the monitoring site at the El Paso Pipeline Crossing in Nevada was used. In addition, water temperature was monitored at the 45 Ranch in Idaho. Samples were collected at these two sites in June, July, August and September of 1999 (Figure 8.2).

e. Oregon

The Oregon DEQ operates a database of information on air and water quality monitoring data, the Laboratory Analytical Storage and Retrieval (LASAR) database. The information entered in the database comes from over 100 different entities as diverse as state agencies, watershed councils, BLM offices, the Idaho DEQ and the Denver USGS.[39] The database contains the record of continuous 2001 temperature readings on the South Fork Owyhee River above the confluence with the East Fork in Idaho and on the Owyhee River above Three Fingers in Oregon (Figure 8.2).[38]

2. Recorded temperature data

In the upper Owyhee subbasin, the measurements of water temperature are usually made in degrees Celsius (°C). Most Americans outside of scientific fields are accustomed to thinking in degrees Fahrenheit (°F). A five degree change in degrees Celsius is equal to a nine degree change in Fahrenheit. Complexity in converting a temperature from one scale to the other is introduced by 0°C equaling 32°F. Where comparisons are made between stream water temperature and criteria, the criterion for Oregon is 20°C (68°F), the criterion for Idaho is 22°C (71.2°F), and the criterion for Nevada is 21°C (69.8°F).

a. Upper Owyhee HUC in Nevada

The water temperatures in the East Fork Owyhee River and in Mill Creek were measured at the same time that water samples were taken from these waterbodies. The data represent discrete moments in time. The data were collected over a number of years. Some of the data have the time of day that the sample was made recorded, but the majority do not (Table 8.2).

Table 8.2. Sample water temperature data in the Upper Owyhee HUC in Nevada from the *Total Maximum Daily Loads for East Fork Owyhee River and Mill Creek*

Sample location	Years	Number of discrete samples	Number of samples over 21°C (69.8°F)	Maximum recorded temperature	
				°C	°F
East Fork Owyhee below Wild Horse reservoir	1996 - 2003	15	1	25.3	77.5
East Fork Owyhee above Mill Creek	1967 - 2003	81	11	25.0	77.0
East Fork Owyhee below Mill Creek	1995 - 2003	51	7	24.9	76.8
East Fork Owyhee at the south boundary of Duck Valley Indian Reservation[a]	1999 - 2003	10	0	18.3	64.9
Mill Creek above Rio Tinto	1995 - 2003	20	2	26.1	79.0
Mill Creek at Patsville	1997 - 2003	9	5	31.0[b]	87.8
Mill Creek above the East Fork Owyhee River confluence	1995 - 2003	23	4	25.7	78.3

[a] All the temperature measurements were taken before 1:30 in the afternoon.

[b] Taken during a period of low flow. 26°C was the second highest temperature recorded.

b. *Upper Owyhee HUC in Idaho*

The Idaho DEQ's TMDL for the Upper Owyhee Watershed did not present continuous data for water temperature at the monitored sites but only a tabular analysis of the 2000 and 2001 data without the inclusion of data other than the extreme high temperatures observed for the time period recorded (Table 8.3).

Table 8.3. Water temperature data analyses for the Upper Owyhee HUC in Idaho from the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load*.

Location of the thermograph Dates considered, year		Maximum water temperature °C	Maximum water temperature °F	Days with maximums over 22°C (71.2°F)
Deep Creek at Mud Flat Road				
	June 23 thru Aug 31, 2000	27.5	81.5	90%
	June 1 thru Aug 12, 2001	26.3	79.3	
Deep Creek at Castle Creek				
	June 23 thru Aug 31, 2000	29.1	84.4	98%
	June 1 thru Aug 31, 2001	28.3	82.9	
Deep Creek at Road Crossing				
	June 22 thru Aug 31, 2000	31.1	88.0	85%
	June 1 thru Aug 31, 2001	29.6	85.3	
Pole Creek near Mud Flat Road				
	June 23 thru Aug 31, 2000	25.5	77.9	Went dry
	June 1 thru Aug 12, 2001	24.9	76.8	Went dry
Pole Creek near Camel Creek				
	July 12 thru Aug 31, 2000	25.6	78.1	90%
Pole Creek upstream of Camel Creek				

	July 12 thru Aug 31, 2000	22.7	72.9	16%
Castle Creek				
	June 23 thru Aug 24, 2000	31.1	88.0	100%, went dry
	Not included 2001			Went dry
Red Canyon Creek				
	June 23 thru Aug 31, 2000	25.2	77.4	47%, went dry
	Not included 2001			Went dry

Each maximum shown in table 8.3 represents only one day's reading and provides little information. However, more information can be gleaned from the inclusion of the percentage of days with the maximum water temperature over 71.2°F. For all the reaches of Deep Creek, the maximum water temperature exceeded 71.2°F on at least 85% of the days between June 23 and August 31, 2000. Castle Creek and Red Canyon Creek went dry. Pole Creek went dry above the confluence with Camel Creek. The water temperature in a drying stream would tend to rise as the flow diminished.

The results of water temperature measurements made by BLM in the summer of 2004 are graphed in the five year review of the Upper Owyhee TMDL. These graphs show the maximum daily water temperature and the average daily water temperature. The minimum daily water temperature is absent.[46] Four of the monitored locations were in the Red Canyon Creek drainage.

From upper East Fork Red Canyon Creek (Figure 8.3) to downstream in lower East Fork Red Canyon Creek (Figure 8.4), the temperature loggers

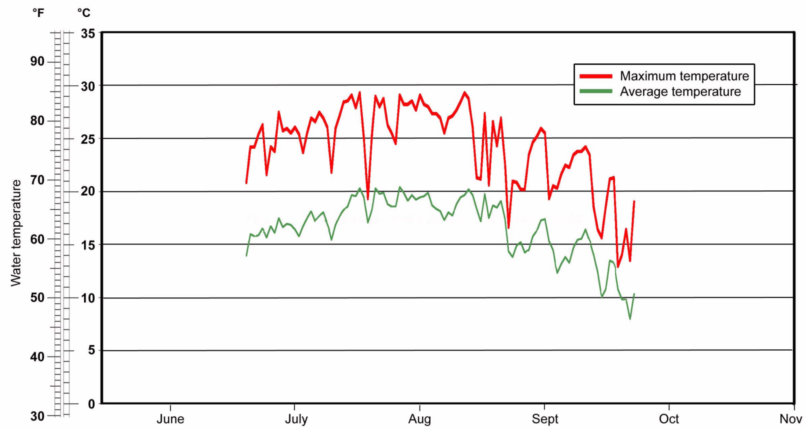

Figure 8.3. Daily maximum and average water temperatures in upper East Fork Red Canyon Creek, Idaho in 2004.

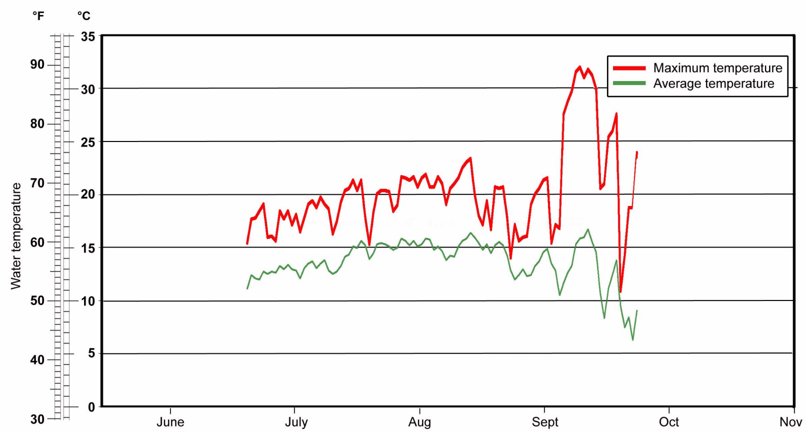

Figure 8.4. Daily maximum and average water temperatures in lower East Fork Red Canyon Creek, Idaho in 2004.

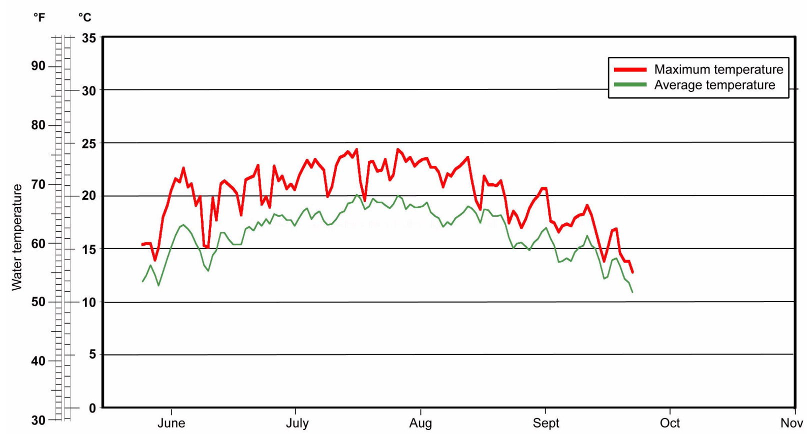

Figure 8.5. Daily maximum and average water temperatures in lower Red Canyon Creek, Idaho in 2004.

show a general decrease in water temperature. In the upper creek they tended to peak above 70°F and many of the maximum temperatures were over 77°F, up to 85°F. In lower East Fork Red Canyon Creek, most of the maximum water temperatures were between 60 and 70°F. Further downstream in lower Red Canyon Creek (Figure 8.5) the water temperatures tended to be slightly higher than in lower East Fork, but not as high as in the upper East Fork. The data for West Fork Red Canyon (Figure 8.6) span a much shorter time period, but during this time period the maximum water temperatures are also lower than downstream in lower Red Canyon Creek. The spikes in temperature at the end of July on the West Fork (Figure 8.6) and in September of the lower East Fork (Figure 8.4) were consistent with the creeks going dry.[46]

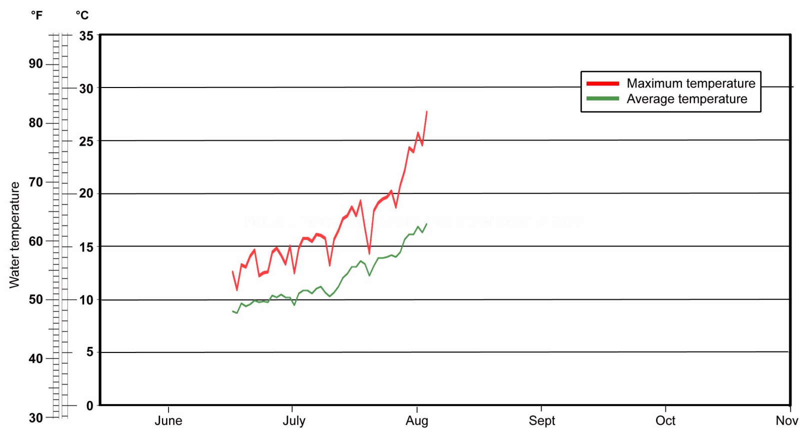

Figure 8.6. Daily maximum and average water temperatures in West Fork Red Canyon Creek, Idaho in 2004.

Data that is included in the five year review of the Upper Owyhee TMDL from the temperature loggers in Nickel Creek (Figure 8.7) and in Pole Creek (Figure 8.8) represent only about two months of monitoring at each location. The maximum water temperatures spike in each of these creeks in July. The large difference between the maximum water temperature and the average water temperature at Pole Creek indicates significant drops in temperatures at night, as much as 32°F.

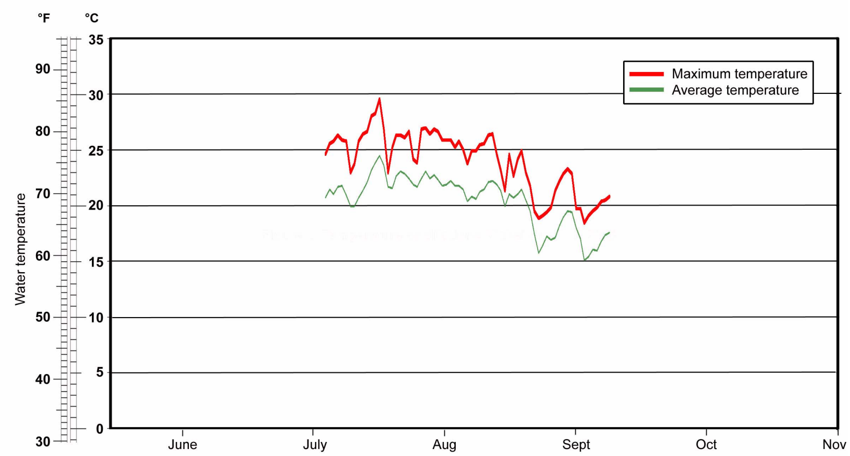

Figure 8.7. Daily maximum and average water temperatures in Nickel Creek, Idaho in 2004.

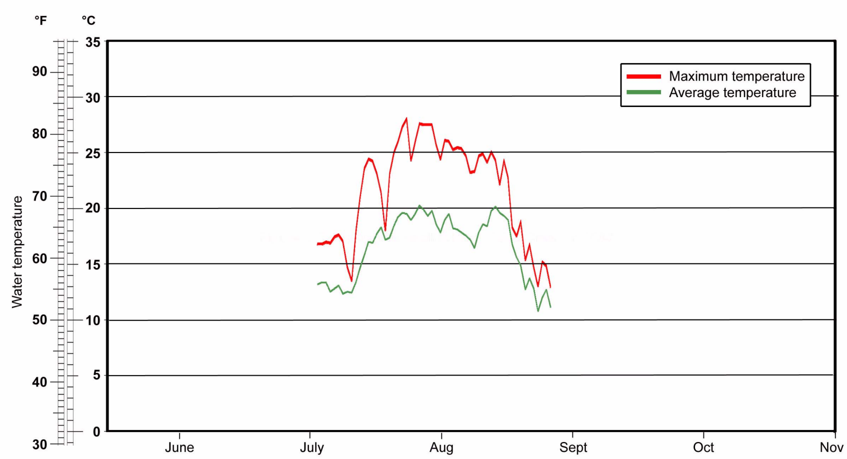

Figure 8.8. Daily maximum and average water temperatures in Pole Creek, Idaho in 2004.

c. *South Fork Owyhee HUC in Nevada*

Sporadic readings of the water temperature were made on the South

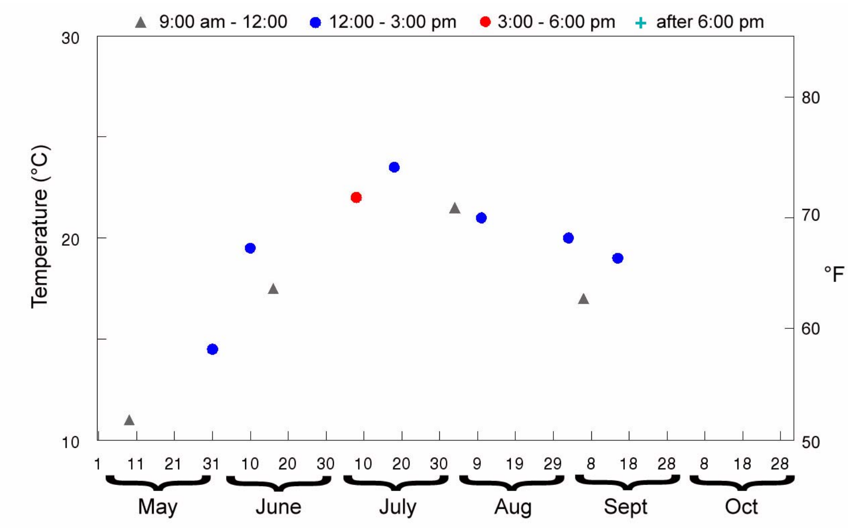

Figure 8.9. Miscellaneous water temperature readings on the South Fork Owyhee River near Whiterock, Nevada between 1977 and 1981.

Fork Owyhee River between 1977 and 1981 near Whiterock (Figure 8.9) and between 1966 and 1995 on the IL Ranch (Figure 8.10). Near Whiterock, these spot checks of water temperature in July or August were all above 19.5°C (67.1°F). One of these temperatures, 70.7°F, was recorded in the morning at 9:35 am on August 3, 1978.

The spot checks for the water temperature of the South Fork at the IL Ranch were made over a larger number of years than those near Whiterock. Of the sixteen readings made sometime in either July or August, only three were below 20°C (68°F). Of these three, two were made in the morning.

In Nevada, the old USGS gage on the South Fork Owyhee River is upstream from the El Paso pipeline gage. The data from these two gages was recorded on the same graph in 1999, 2000, and 2001 (Figures 8.11, 8.12, and 8.13). The lines represent continuous data. Due to the compressed nature of the graph and the overlaying of two sets of data, the small differences within a day are not visible. The peaks show the maximum water temperature for a day and are followed by a dip to the minimum water temperature the next night. To visualize these graphs as graphs of maximum daily temperatures like those in Figures 8.3 to 8.8, imagine a line connecting the peaks.

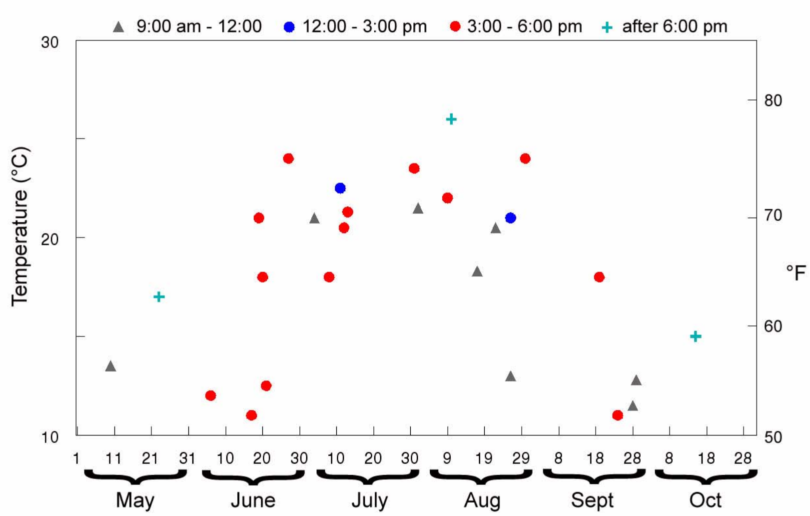

Figure 8.10. Miscellaneous water temperature readings on the South Fork Owyhee River at the IL Ranch, Nevada between 1966 and 1995.

At both the old USGS gage and the pipeline gage, there is a considerable difference between the daytime maximum water temperature and the nighttime minimum water temperature. The fluctuations in water temperatures at the two gages

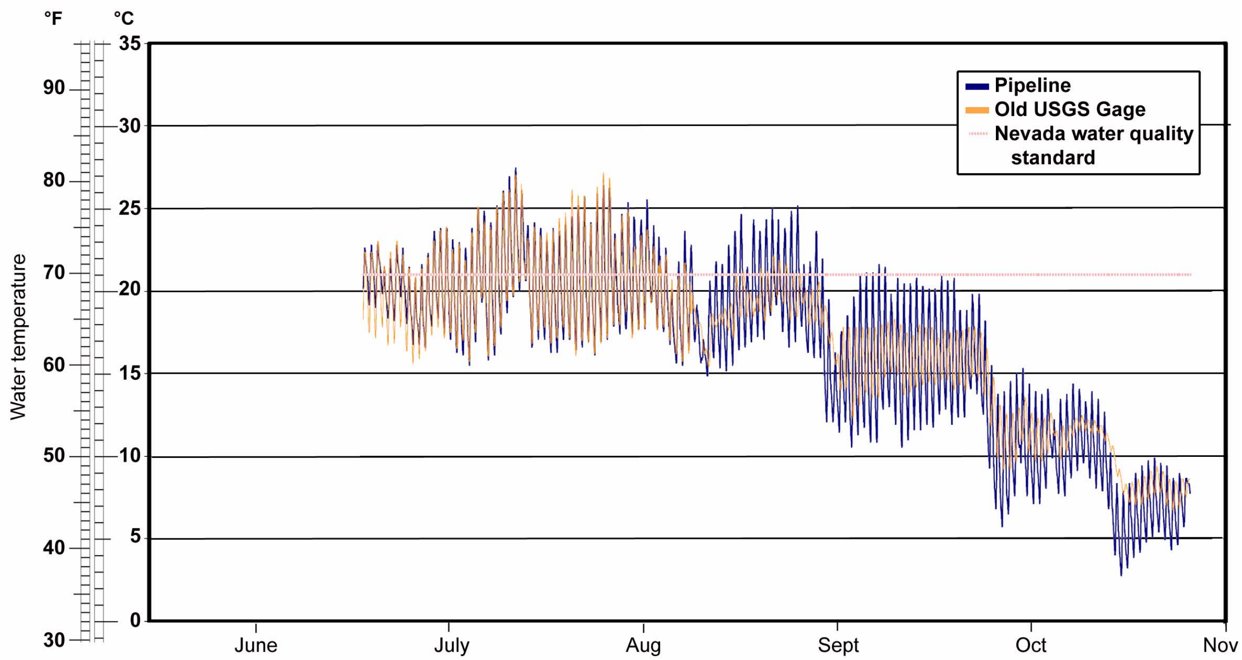

Figure 8.11. Water temperature fluctuations at two gages in the South Fork Owyhee River, Nevada in 1999 .

tend to have a similar pattern. At the end of summer and in the fall In 1999 the temperature of the water passing the pipeline gage was hotter during the day and was colder at night than the water upstream at the old USGS gage which maintained a more constant temperature. In 2000 and 2001 the water temperatures at the two gages accompanied each other more closely.

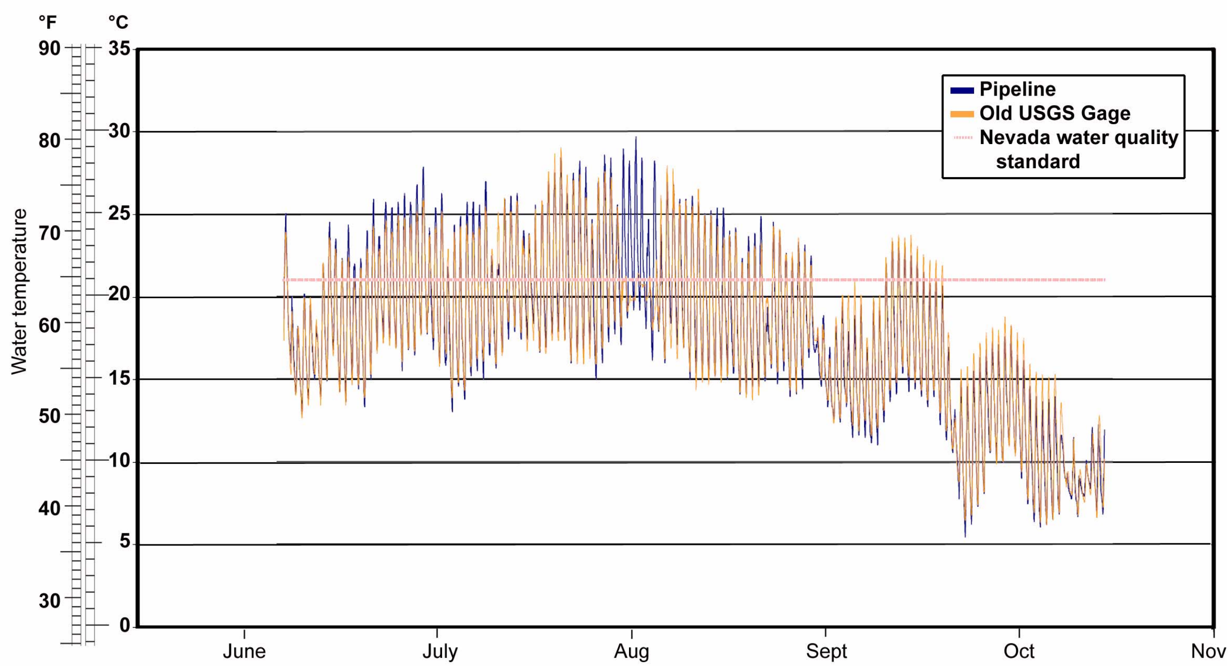

Figure 8.12. Water temperature fluctuations at two gages in the South Fork Owyhee River, Nevada in 2000.

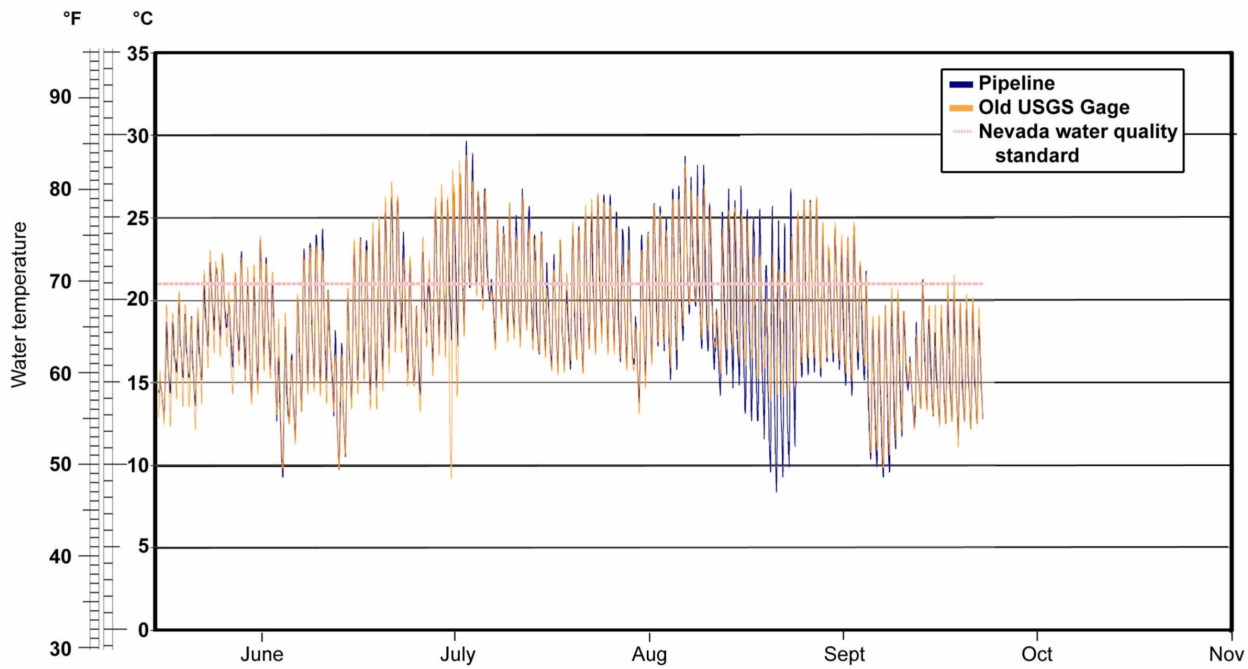

Figure 8.13. Water temperature fluctuations at two gages in the South Fork Owyhee River, Nevada in 2001 .

Only the data for the old USGS gage was available for 2002 (Figure 8.14). For 2003, only the water temperature data for the El Paso pipeline gage was available (Figure 8.15). Maximum daily temperatures in July and August of all reported years were constantly above the Nevada water quality standard of 21C (69.8°F).

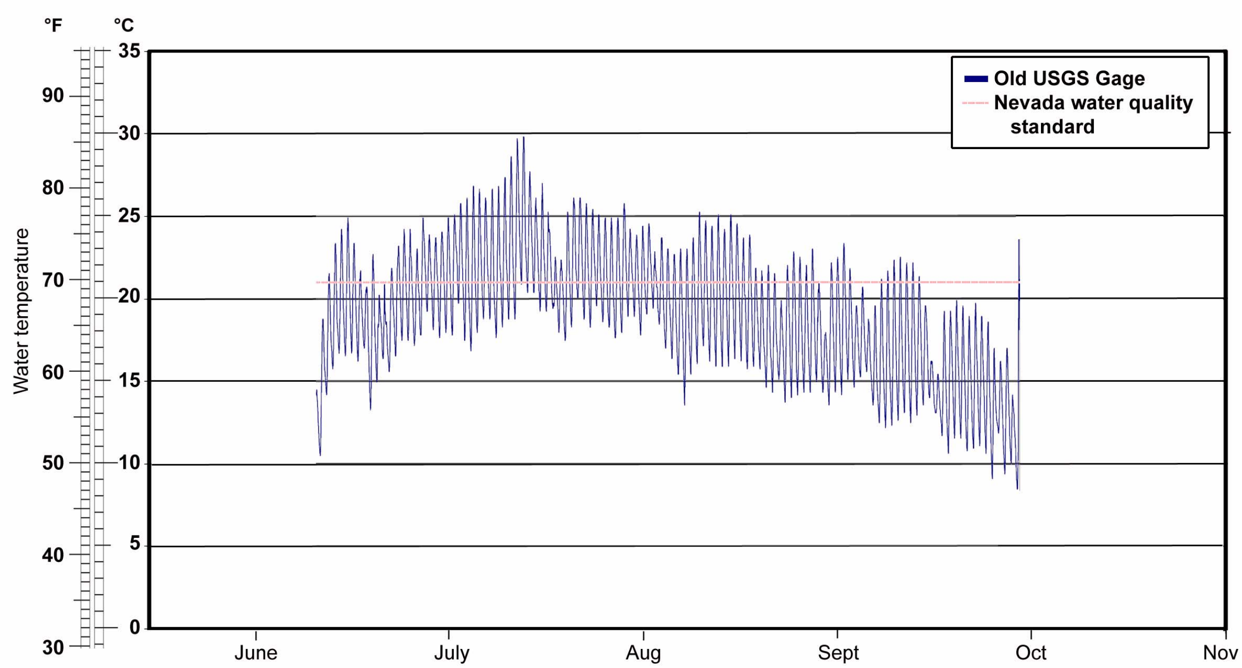

Figure 8.14. Water temperature fluctuations at the old USGS gage in the South Fork Owyhee River, Nevada in 2002 .

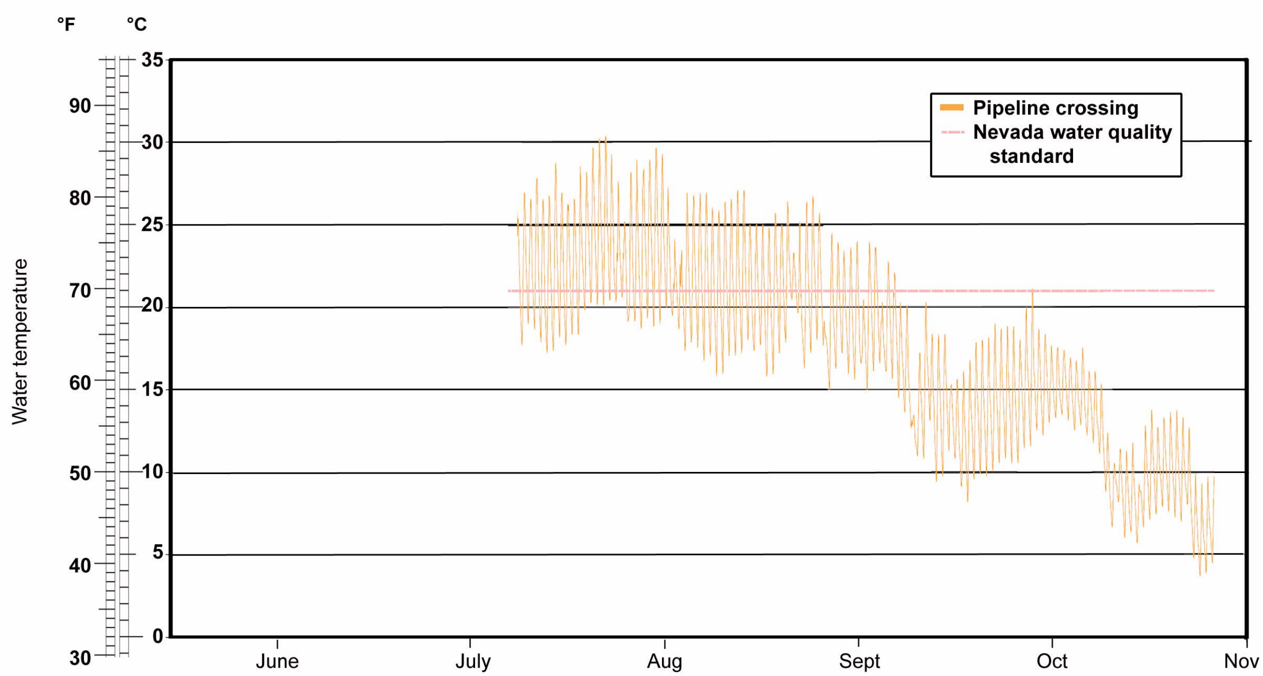

Figure 8.15. Water temperature fluctuations at the pipeline crossing gage in the South Fork Owyhee River, Nevada in 2003.

d. South Fork Owyhee HUC in Idaho

In 1999, the water temperatures at the 45 Ranch on the South Fork Owyhee at the confluence with the Little Owyhee River in Idaho were compared to the recorded data from the El Paso pipeline site in Nevada. "Average maximum daily temperatures were similar at the 45 Ranch and the El Paso Pipeline sites." Regression analysis also showed that there was "a strong correlation between water temperatures entering Idaho and those recorded in Idaho at the 45 Ranch."[27] At the 45 Ranch, the diurnal (change between daily maximum and minimum) water temperature changes were less than upstream at the pipeline site.

In Idaho, just before the South Fork Owyhee River joins the Owyhee River, water temperature data was continually monitored during 2001 (Figure 8.16). During 2001 the water temperature was also monitored on the Owyhee River in Oregon above Three Forks (Figure 8.17). Above the confluence with the Owyhee River, the daily fluctuations in water temperature in 2001 were smaller than upstream at the pipeline site (Figure 8.13) . Farther downstream at the Three Forks site, the daily fluctuations were even less. Observing the graphs of the water temperatures at the pipeline site and at the Owyhee confluence, there doesn't seem to be much difference in temperatures.

Figure 8.18 shows the maximum daily water temperatures at the three successive downstream locations, the South Fork Owyhee River at the El Paso pipeline in Nevada, the South Fork Owyhee River above the confluence with the Owyhee River in Idaho, and farther downstream on the Owyhee River upstream from Three Forks in Oregon. The maximum water temperatures at the pipeline gage and above the confluence mirror each other fairly closely with the maximum temperatures at the pipeline gage being slightly higher than those downstream above the confluence. Over

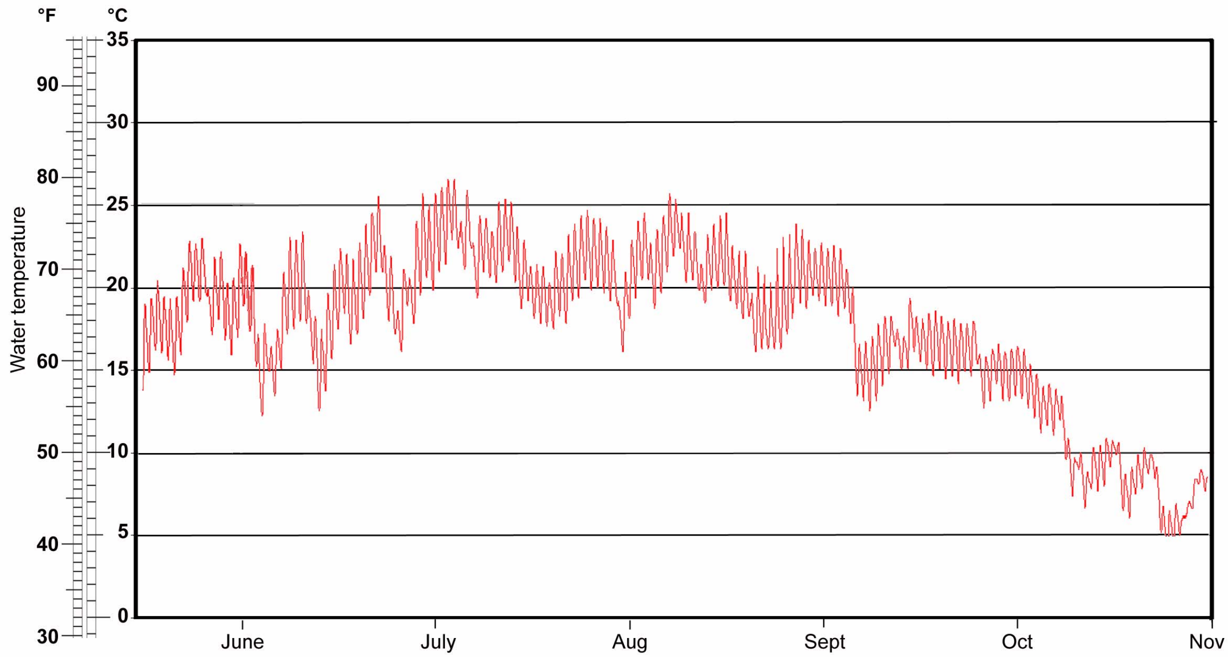

Figure 8.16. Water temperature fluctuations in the South Fork Owyhee River above the confluence with the East Fork Owyhee River, Idaho in 2001.

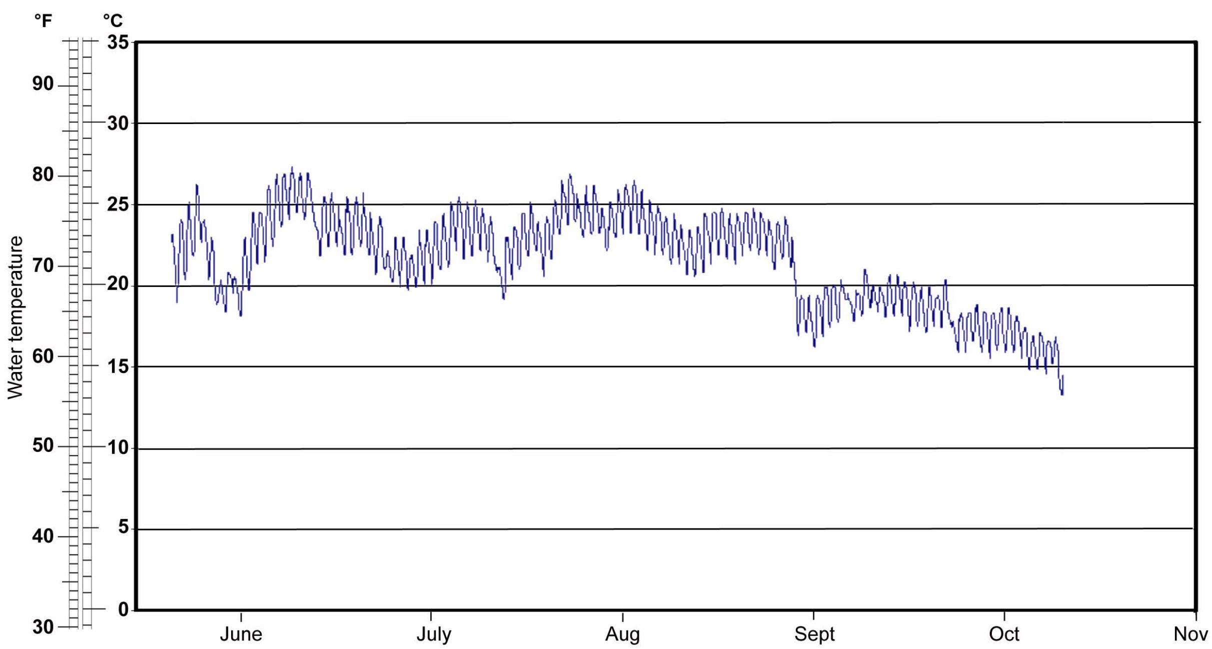

Figure 8.17. Water temperature fluctuations in the Owyhee River above Three Forks, Oregon in 2001.

the recorded season, the maximum water temperatures above Three Forks tended to be higher than the those at the other two sites. However, during some time periods the pipeline gage maximums were higher than at either of the other two sites. It would be difficult to determine to what extent the increase in water temperature and the decrease

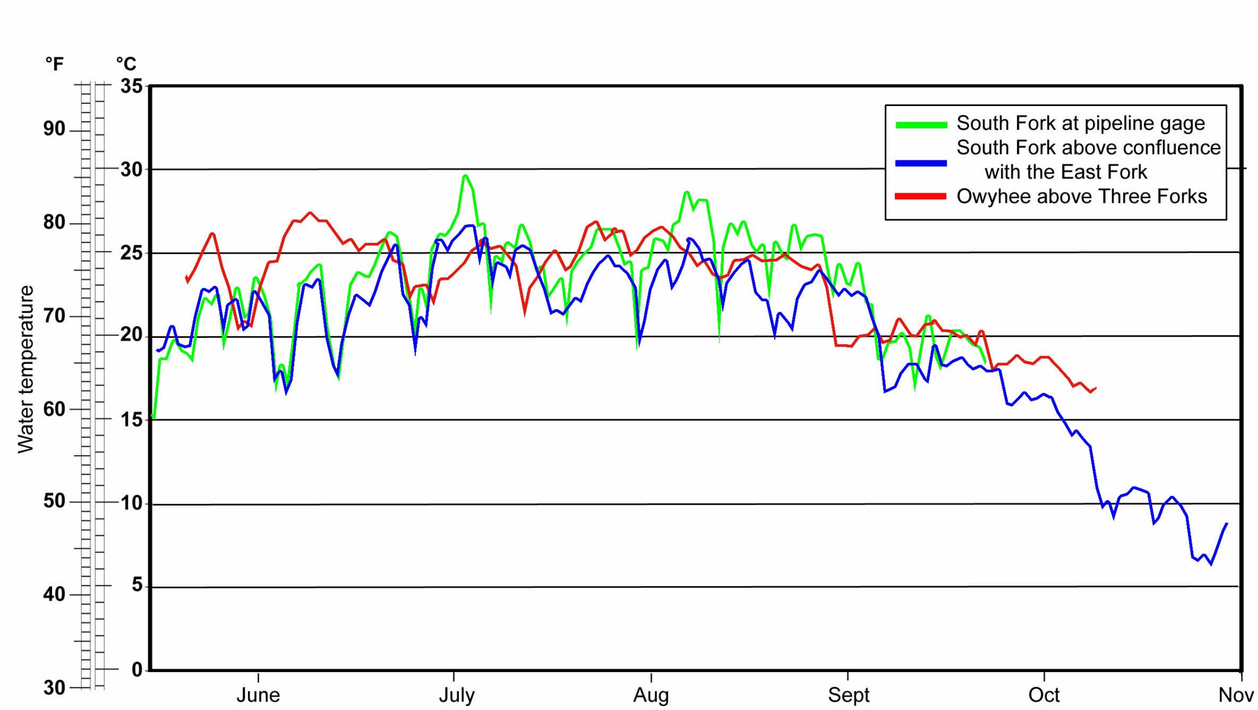

Figure 8.18. Maximum daily water temperature at three successive downstream locations (Nevada, Idaho, Oregon) in 2001.

in daily temperature fluctuations at the Three Forks site was due to the addition of the waters of the Owyhee River to the waters of the South Fork Owyhee River.

3. Discussion of stream temperature

Based upon the beneficial uses established for waterbodies in the upper Owyhee subbasin, temperature is identified as the major pollutant of concern. The most restrictive beneficial use assigned to the upper reaches of the Owyhee river in Oregon is redband and Lahontan cutthroat trout. In Idaho, Deep Creek, Pole Creek, Castle Creek, Red Canyon Creek, and South Fork Owyhee River are designated for cold water aquatic life and salmonid spawning. In Nevada the South Fork Owyhee River is considered habitat for redband trout, brook trout, and whitefish. East Fork Owyhee River and Mill Creek are designated for aquatic life. The standards established for the maximum water temperature for the designated use is 20°C (68°F) in Oregon, 22°C (71.6°F) in Idaho, and 21°C (69.8°F) In Nevada.

a. Summary of existing data

The available data on current water temperatures in the streams of the upper Owyhee subbasin substantiate the fact that the water temperatures in those reaches frequently exceed the established standard. Twenty one percent of the temperature samples taken on Mill Creek were over 21°C. On the East Fork Owyhee River in Nevada, 13% of the samples showed temperatures over 21°C. In Idaho, during July and August of 2000, Deep Creek's maximum daily temperature exceeded 22°C over 85% of the time. In 2001, at the pipeline gage in Nevada and at the gage at the confluence of the South Fork Owyhee River with the Owyhee in Idaho, only four days recorded maximum water temperatures less the 20°C and most of the readings were above 22°C during July and August 2001. By the time the waters of the Owyhee reached the gage above Three Forks in Oregon, during July and August 2001, not only did the maximum water temperature remain above 20°C, but the minimum temperature only dipped below 20°C a couple of times.

The months of July and August have the highest water temperatures in the upper Owyhee subbasin. During these months the diurnal changes in water temperature at the 45 Ranch, at the South Fork - Owyhee confluence, and upstream from Three Fingers were relatively small compared to other sampled sites, frequently less than 15°F.

b. Attainability

In defining the purpose of the clean water act, the EPA in their "Introduction to Water Quality Standards" stated that the goals of the act were applicable "where ***attainable,*** to achieve water quality . . ." The italics and bold attributes are from the EPA document. In examining the water quality in the rivers within the upper Owyhee subbasin it is essential to first consider what is attainable. If the realities of the situation are not taken into consideration, meeting the goals is doomed to failure.

Some of the assessments already conducted in the upper Owyhee subbasin express doubts about the attainability of the established water quality criteria. In his five year review of the Upper Owyhee TMDL, Stone says, "Originally, the targets for full support of beneficial uses were the temperature criteria in the water quality standards. These criteria are not appropriate for the sparsely flowing desert streams of the Upper Owyhee River watershed. A pristine stream in this area would probably still violate water quality criteria at certain times of the year."[46]

In the TMDL for the South Fork Owyhee River in Idaho, Ingham concludes "One of the influences on water temperature in the South Fork Owyhee River is ambient air temperature. With warm water temperatures originating from Nevada and the ambient air temperature, the South Fork Owyhee River may not ever have an opportunity to cool itself enough to meet State of Idaho water quality criteria for cold water biota and salmonid spawning."[27]

Not only does the East Fork Owyhee River and Mill Creek TMDL suggest that more monitoring might be appropriate, but it includes the statement that "Mill Creek temperature standards should recognize the ephemeral nature of the stream. Current temperature standards are “single value” standards, without any consideration of duration."[32]

c. Stream flow

There are tremendous natural variations in water flow in the Owyhee River. These variations include both flooding and diminution of the water flow to almost a trickle and cause scouring of the banks. Downstream in Oregon, since 1950, the minimum flow at Rome was 42 cubic feet per second (cfs) on four different dates.[49] Gene Stuntz states that before the construction of the Owyhee Dam the amount of water in the Owyhee varied, dwindling to a small trickle in the hot summer time.[47] Before reservoir development in the watershed, Chesley Blake who also lived in an area now inundated by the Owyhee Reservoir remembers that when the river level went down the water would get warm, and the children would swim in the river.[3]

The hydrology section of this assessment discusses the stream flows in the upper Owyhee subbasin in greater detail. With naturally decreased flows, streams in the subbasin would be expected to experience heating similar to or greater than that recorded downstream on the Owyhee River.

d. Effect of climate

How does climate affect the water temperatures in the upper Owyhee subbasin? The discussion in the background section characterizes the air temperatures in the upper Owyhee subbasin (see the climate section of the background component of this assessment). The greater part of the subbasin lies between 5000 feet and 5500 feet in elevation. Meteorological stations within and adjacent to the subbasin that are located between these elevations and might most closely represent a larger area are Il Ranch at 5203 ft, Owyhee at 5397 ft, and Grasmere at 5144 ft. In July, the respective average maximum air temperatures at these three stations are 88.1°F, 85°F and 87.7°F.

In studies in northeast Oregon, Meays et al. discovered that the atmosphere provided a strong buffer on stream temperatures. The effect of the atmosphere on stream temperature was to effectively set limits within which stream temperatures would occur.[29] Carr et al. also found that climatic factors, including air temperatures, were the dominant factors in stream temperature patterns.[4]

In the Truckee River at Reno, the stream temperature could be predicted using maximum air temperature and average daily flow as variables.[61] The Truckee River at Reno is also in a semiarid desert. Since maximum air temperature of the Truckee River at Reno was a large factor in predicting the stream temperature, it is quite probable that the maximum air temperatures in the upper Owyhee subbasin are major indicators of the expected water temperatures in the streams. Taylor et al. state that it is generally accepted that there is an inverse relationship between stream flow and the size of daily variation in stream temperature, the more water there is in a stream the less it will cool during the night or heat during the day.[48] Conversely, as the streams of the upper Owyhee subbasin carry less water in the summer, they would heat more during the day and cool more during the night than if they had greater flow. Meays et al. related the stream temperature to both the velocity and the distance. The more slowly the water traveled and the greater the distance that it traveled, the closer the stream came to achieving an equilibrium with mean air temperatures.[29]

The Malheur Experiment Station near Ontario, Oregon has recorded soil temperatures as well as air temperatures. Compared to air temperatures, the maximum soil temperature rises and falls in a similar pattern, but doesn't quite reach temperatures as high as the air temperatures. However, although the minimum soil temperatures follow a similar curve, they remain considerably higher than the minimum air temperatures (Figure 8.19).[52,56] Except for the maximum temperatures each day, the soil temperature is above the air temperature for much of the time.

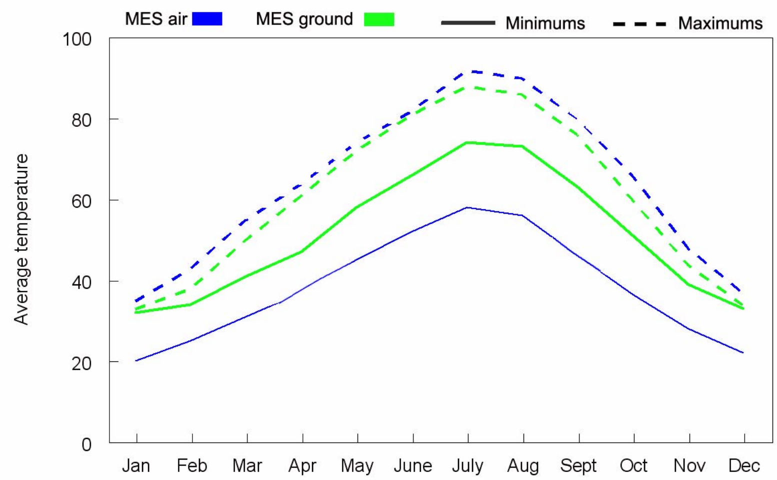

Figure 8.19. Average maximum and minimum air temperatures from 1942 to 2005 at Malheur Experiment Station Ontario, Oregon, compared to average maximum and minimum soil temperatures from 1967 to 2005 at 4-inch depth at the same location.

The histogram in Figure 8.20 indicates how often a combination of a specific air temperature and soil temperature occurred between 1992 and 2007. Shading of the dots on the graph varies from dark red for the fewest readings through yellow to green for the most readings. The points to the left of the blue line are the readings when the soil temperature was higher than the air temperature. There are many more particles in the soil than in the air, so the soil absorbs more of the sun's energy than the air does. At the Malheur Experiment Station Agrimet weather station the soil temperature is higher than the air temperature more of the time.[56]

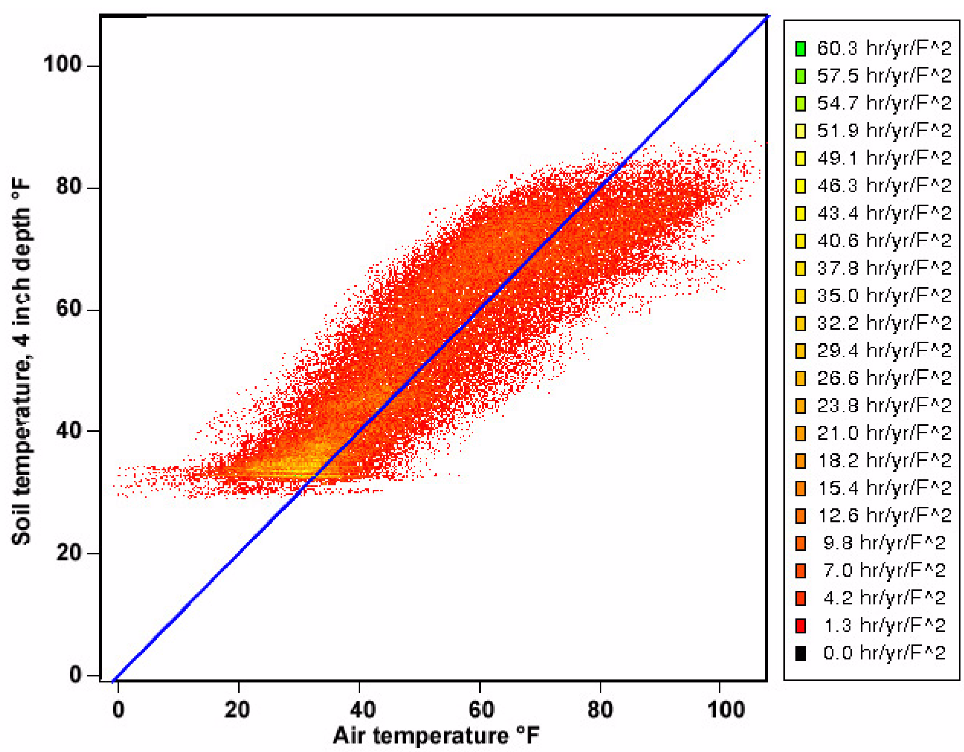

Figure 8.20. Histogram of the soil temperature at 4 inch depth vs. the air temperature at the agrimet weather station, Ontario, Oregon from 1992 to 2007.

If the air temperature is predictive of the water temperature, it doesn't matter whether the water is being heated by the air, by the soil, or by direct solar radiation. Probably the soil is absorbing solar radiation and reradiating it to both the air and elsewhere. In the upper Owyhee subbasin, no well developed understanding of the physics involved in stream heating has been used to determine stream temperature standards. It is possible that stream temperature standards have been established that violate physical principles of heating and cooling.

e. Effect of shading

In Idaho DEQ's 2003 TMDL, Deep Creek, Pole Creek, Castle Creek, and Red Canyon Creek were judged to be water quality limited due to temperature. Therefore shade requirements were established for the different stream segments to achieve the predetermined temperature standards. Depending on the stream segment, the shading requirement ranged from 52% to 95% shade for July and 57% to 67% shade in August (Appendix G). No data have been developed that indicate the amount of shade that is feasible given the natural precipitation regime, natural vegetation types, natural scouring frequency, and natural fire frequencies.

When the relationship of shade to maximum stream temperatures was studied by Kruegar et al., they concluded that the "study does not provide evidence that shade is a driving force in temperature change on these streams."[28] Similarly Meays et al. found that canopy cover alone was not sufficient to prevent water temperature from trending toward equilibrium with air temperature.[29] Carr et al. concluded that shade functioned in a subordinate role to climate in affecting stream temperature.[4]

i. Vegetation

The primary way that more shade could be provided along a waterway would be to increase the amount of vegetation growing on the banks.

The present vegetation currently along the river banks seems to be similar to what it was at the time of the first entry of Euro-American trappers into the upper Owyhee subbasin in the early 19th century. There is no evidence that at the time of Euro-American contact there was substantial riparian vegetation anywhere along the streams outside of the Bull Run and Independence Mountains (see the at contact section of the history component of this assessment).

The woody species which exist at higher elevations in the Bull Run and Independence Mountains do not naturally extend to lower elevations. There is not enough precipitation on the Owyhee plateau to support these species. Even along the streams, these species would have difficulty obtaining adequate water during many years of lower flow. In addition, a large portion of the stream banks have little capability to support vegetation due to their deeply incised position in bedrock and lack of sediment. There is little possibility of vegetation shading the river at these incised locations.

There is evidence that any woody vegetation which starts to develop along the banks has been periodically scoured away by flooding. In the Idaho South Fork Owyhee River TMDL, Ingham states that on the South Fork, "This flashy flow is the predominant cause for lack of established large woody vegetation."[27] Moseley explains that the snow accumulation zone for the South Fork "constitutes a small percentage of the South Fork basin, however, with most of it being arid lowlands of the plains. There is virtually no snow pack on the plains and streams tend to be intermittent and ephemeral, largely flowing during winter and spring and in summer only during storms. This makes for a very flashy hydrologic regime where the river rises rapidly and dramatically in response to spring snow melt patterns and episodic storm events, quickly returning to near base flow."[30] Although the USGS gage near Whiterock recorded a high discharge of 3200 cfs in 1957 (Figure 5.18), in 1993, the "USGS gauging station at Rome, Oregon, recorded a flow of nearly 48,000 cfs. On quick observation, the hydrographs for the Rome and South Fork stations appear similar. If this is (statistically) true, the 1993 discharge on the South Fork was around 9300 cfs, three times greater than the recorded high in 1957."[30]

ii. Models

In the Upper Owyhee TMDL, both the temperature standard established and the amount of shade required to achieve the standard were calculated using the Stream Segment TEMPerature model (SSTEMP). A wide variety of data is needed for the SSTEMP.* Due to the relatively few meteorological stations in the upper Owyhee subbasin, particularly in Idaho (Figures 5.1 and 5.2) and to the lack of stream gages for flow (Figure 5.15), many of the underlying parameters used can not be specific to a stream. To utilize the model for the TMDL, assumptions must have been made about the parameters for which no data is available.

If there are assumptions about vegetation distributions in the subbasin which are significantly different than those species found at present, they would be not be based of actual specie distributions but on the theoretically generalized site potentials and hypothetical ranges of native species. The primary limiting factor to the actual existence of a specie is rainfall.

f. Geology

A factor affecting the temperature of the South Fork Owyhee River and possibly stretches of other streams in the upper Owyhee subbasin is the underlying geologic material. "The South Fork Owyhee River meanders through volcanic material of either basalt or rhyolite. Both materials are dark in nature and have high heat absorbing capability. These factors may impact the ability for cooling to occur both within the water column and the ambient air temperature."[27]

g. Conclusion

Major causes of the high water temperatures in the upper Owyhee subbasin are water scarcity and heat load from solar and other ambient sources. Riparian shading is naturally limited by precipitation, scouring, and fire frequency. Objective thermal potential studies have not been made for the upper Owyhee subbasin.

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* Data and parameters needed for SSTEMP:[50]

Average stream width, elevation, and slope; streambed thermal gradient; shade factor or site latitude and azimuth, vegetation height, offset, density, and crown measurement if the shade model is used.

Average daily discharge at upstream boundary; average daily tributary inflows and outflows; average daily lateral inflows and outflows.

Latitude, elevation, mean annual air temperature at a representative meteorological station; average daily relative humidity, average daily relative sunshine; average daily wind speed; average daily extraterrestrial solar radiation; average daily solar altitude; (optional) observed solar radiation at ground level.

Average daily temperature at upstream boundary.

Average daily dust and ground reflectivity coefficients.

I. Other pollutants

In addition to temperature, each of the states has a different list of pollutants or candidate pollutants (Appendices F, G, and H). Where the waters enter Oregon, currently only arsenic is considered an additional pollutant. Since aquatic life is the primary beneficial use of the Owyhee River in Oregon at the Idaho border, in the 2010 integrated report, Oregon also included other factors thought necessary for aquatic life. Phosphate phosphorus, alkalinity, ammonia, chloride, dissolved oxygen, and pH were all listed as being of potential concern or only attaining some criteria.

The East Fork of the Owyhee River in Idaho at the border with Oregon is not 303(d) listed for any pollutant. There is a political dilemma introduced by a river with water quality criteria that change as the river crosses the border between states.

1. Historic anthropogenic activities

Underground mining of copper-sulfide ore was conducted at the Rio Tinto Mine from 1932 to 1947. The mine sits above Mill Creek about 2.5 miles south of Mountain City. Since the underground operation closed, old tailings have been reworked and there has been leaching of both stockpile ore and of the underground workings. Acid mine drainage has degraded the water quality of Mill Creek and the East Fork Owyhee River.[32]

This legacy mining is believed to be a "major contributor of cadmium loads to Mill Creek" and is "a known contributor of copper loads to Mill Creek and the East Fork Owyhee River."[32]

2. Geologic sources

a. Iron

In Nevada, iron is a fairly common constituent of rock and soil. Throughout Nevada, waterbodies show fairly high concentrations of iron introduced by natural run-off and seepage. Anthropogenic activity at the Rio Tinto Mine site may be a significant contributor to iron in the Mill Creek drainage.[32]

b. Arsenic

Traces of arsenic in the watershed are from natural volcanic and subsequent hydrothermal activity with no other significant source.

c. Mercury

There are many natural mercury deposits in the upper Owyhee subbasin (see the background section). Mercury occurs naturally in the environment and the occurrence of mercury is not an issue of concern. Only concentrated levels of mercury are of concern because there is an increased likelihood of mercury release by natural or human processes.[216]

Mercury has not been a major problem in the upper Owyhee subbasin. However, it is listed as a possible impairment in Shoofly Reservoir in Idaho's 2010 Integrated §303(d)/§305(b) Report.[23]

Mercury is a problem when it ends up in fish tissue. Although larger amounts may affect adults, small amounts of mercury can damage a child's brain resulting in behavioral and learning problems.[42]

3. Dissolved oxygen

Oxygen solubility in water is inversely related to temperature. In other words, as water temperature rises, the solubility of oxygen is reduced.[18] The reaches of the streams of the upper Owyhee subbasin where the temperature is high can be expected to also have lower levels of dissolved oxygen than are recommended for fish.

Although concentrations of oxygen rise during the day when algae are creating oxygen as a byproduct of photosynthesis, algae uses oxygen at night so the concentrations go down.[18] Since the temperature of the river is a product of the natural conditions in the upper Owyhee subbasin, the amount of dissolved oxygen is controlled, at least in part, by water temperature fluctuations.

4. Phosphorus

Both phosphorus and nitrogen are essential to aquatic plant growth. However, high levels of phosphorus may lead to too vigorous growth and algal blooms. The overabundance of phosphorus in warm surface water promotes the growth of algae. When unusually large amounts of phosphorus overpower a body of water, they cause a sharp increase in algae production known as an algal bloom. As the large mass of algae begin to die, vast amounts of oxygen are used in the decomposition. Little oxygen remains for the fish.[26]

Volcanic ash, lava flows, or basalt often contain relatively high concentrations of phosphorus as compared to many other rocks.[18] Some western SRP lavas contain anomalously high concentrations of phosphate.[54] Many soils in the upper Owyhee subbasin are believed to be naturally high in phosphorus.[32]

Where Idaho has monitored phosphorus in water samples, it has not found high phosphorus concentrations in the upper Owyhee subbasin that would indicate impairment of beneficial uses.[20,27] An anomaly exists on Nickel Creek. The system seems to be phosphorus deficient, limited by low phosphorus concentrations. The creek is spring fed, and "it would appear that phosphorus would be limited since natural bioavailable forms of phosphorus in ground waters are usually found in very low concentrations."[20]

The United States Geological Survey (USGS) sampled the Owyhee River at several points between the Oregon state line and the Owyhee Reservoir in 2001 and 2002 in cooperation with the Vale office of the BLM. The water at each site was sampled once each in April 2001 and April 2002.[18]

Figures 8.21 and 8.22 show graphical comparisons of the sediment and phosphorus in the water of the Owyhee River at seven sampling sites progressively downstream. OR7 is at the Idaho border, OR6 above the confluence with the West Little Owyhee River, OR5 at Three Forks, OR4 at Rome, OR3 below the Crooked Creek confluence, OR2 at Bull Creek, and OR1 at Birch Creek.[18]

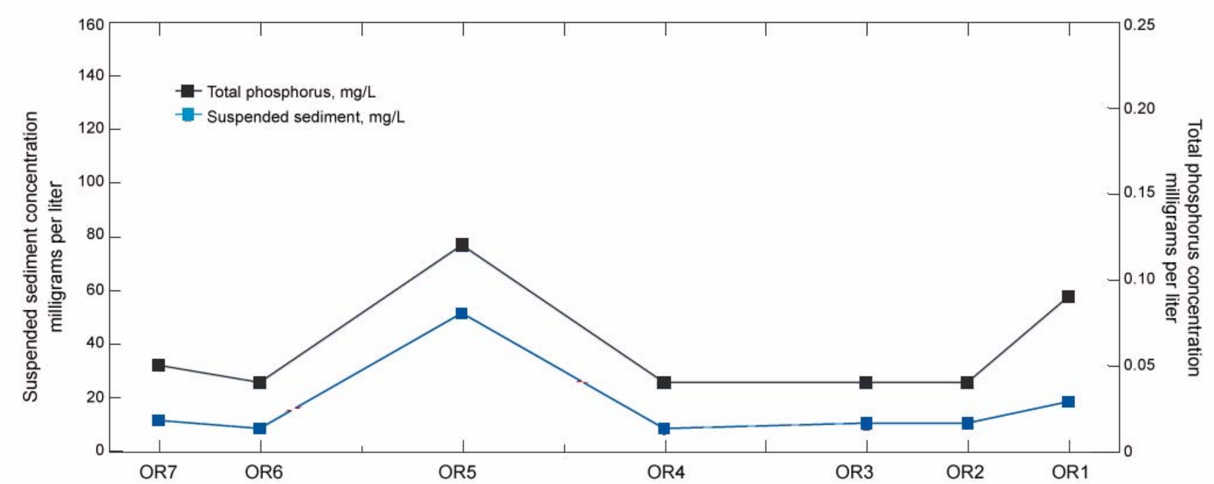

Figure 8.21. Comparison of phosphorus concentrations and suspended sediment concentrations in the Owyhee River, April 2001

An analysis of the data shows a linear relationship between the amount of sediment and the amount of phosphorus. As the amount of sediment increases, the amount of phosphorus increases. This indicates that much of the phosphorus load is being transported with the sediment. The highest concentrations of sediment increase exponentially with increased runoff.[45] We infer that the largest phosphorous loads being carried by the Owyhee River occur at times of peak flow.

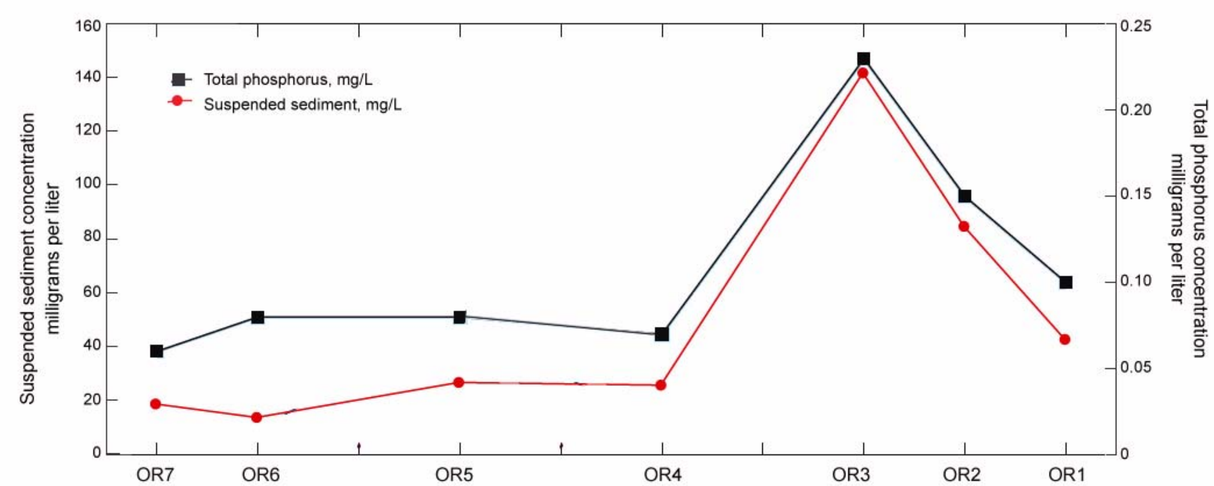

Figure 8.22. Comparison of phosphorus concentrations and suspended sediment concentrations in the Owyhee River, April 2002

Phosphorus loads may be originating from naturally occurring watershed and stream bank erosion. Other disturbed land may also be more subject to erosion. However, identifying the exact sources and pathways of phosphorus enrichment is difficult due to lack of detailed data.

5. pH

The pH of stream water tends to be increased by the photosynthesis of aquatic plants during the day and decreased by the respiration of plants and animals at night.[18]

Sulfides such as those found in the area of Mountain City-Patsville-Owyhee may also affect the pH. Calcium carbonate is widespread in the upper Owyhee subbasin and causes the waters to generally have a pH above 7.

J. Beneficial uses

Since cold water aquatic life and salmonid spawning were beneficial uses assigned to Deep Creek, Pole Creek, Castle Creek, and Red Canyon Creek, in the Idaho 2003 TMDL, the DEQ judged these streams as being water quality limited due to temperature. The temperature criteria used in the TMDL for cold water aquatic life was less than a maximum of 22°C (72°F).

In their 1996 survey of streams of the upper Owyhee subbasin in Idaho, Allen et al. did not find any redband trout in the Little Owyhee River, the South Fork Owyhee River, Blue Creek, Little Blue Creek, or Shoofly Creek. Four redband trout were found on the Owyhee River above Crutcher's Crossing.[1] In 1993 and 1997 no redband trout were found in Deep Creek, although a 1977 survey had found redband trout. The 1997 survey found a low density of redband trout in Red Canyon Creek and in the Owyhee River near the mouth of the creek. Floating the Owyhee River in July 1997, five fish biologists "extensively fished the river while paddling downstream, and only one redband trout was captured by angling in the Idaho reaches of the Owyhee River."[2]

Desert redband trout inhabit streams which appear to have unusually high temperatures.[59] Several studies have investigated the possible mechanisms which the subspecies employs to deal with these high temperatures. In northeast Oregon stream reaches, when the afternoon stream temperatures were highest, 10-40% of the redband trout occupied thermal refugia.[58] "However, whether individual redband trout respond to summer temperature extremes by moving sizable distances has not been investigated."[59]

Although there are redband trout in some of the streams of the upper Owyhee subbasin, designating cold water aquatic and salmonid spawning as beneficial uses needs to be site specific and will not apply to many of the streams of the subbasin. Even in those streams with redband trout, they may be retained in stream reaches by isolated cold water refugia and cold water aquatic life may be an inappropriate designation for the whole stream.

The CWA provides a method of changing a designated use. This assessment presents data which should be taken into account in evaluating the attainability of water quality criteria mandated by a specific designated use.

K. Need for water standard based on natural conditions

The basis of the temperature standards is rooted in opinions of what the temperature should be, not based on the environmental potential to provide cool and cold water.

The Idaho Division of Environmental Quality studied the inconsistencies between water temperatures and fish data that indicated viable, self-sustaining assemblages of fish existed. They concluded that "current water temperature criteria for Idaho appear to be not working well since they do not comport with biological reality"[17] and suggested that a scientific basis be developed for water quality to assure the relevance of temperature data. Climatic and geographic differences were postulated as primary factors affecting natural stream temperatures. A factor presented to account for the discrepancy between stream water temperatures and the presence of salmonids was the presence of thermal refugia.[17]

Redband trout "appear to have the capability to adapt to adverse conditions, such as low or intermittent flows, and water temperatures greater than 28°C."[27] In his preliminary assessment of the South Fork in Nevada, Pahl states that "According to NDEP files, the current temperature standard was set to protect rainbow trout. Under the current standards review process, the [actual] needs of the redband trout should be considered."[43]

The redband trout of the desert basins of the western states are thought "to have evolved adaptation to live in harsh environments characterized by extremes in water temperature and flow." They have been observed feeding at water temperatures of 28.3°C in Chino Creek, a Nevada tributary of the Owyhee River.[43]

There are inland redband trout in the upper Owyhee subbasin. The stream temperatures in the subbasin frequently exceed the criteria established for redband trout. The temperature criteria guidelines were developed by the EPA. They recognize that there may be inconsistencies and provide some alternatives to using the recommended "biological numeric" criteria. States may adopt a "narrative natural background provision that takes precedence over numeric criteria when natural background temperatures are higher than the numeric criteria. This narrative can be utilized in TMDLs to set water quality targets and allocate loads."[36] However, if the narrative standards are composed of unrealistic expectations of stream shading, an unattainable criteria of shade could be substituted for unattainable temperature standards. Realistic narrative standards could be based existing knowledge of geology, historic information including early accounts of vegetation and streamflow, and the last century's records for air temperatures and streamflows.

New temperature standards for the streams of the upper Owyhee subbasin need to be developed that take into account the natural condition of the water and the climate of the upper Owyhee subbasin. They also need to take into consideration the biological adaptations of species present in the environment.

L. Conclusion

Immense data gaps exist in determining whether the streams of the upper Owyhee subbasin meet the goals of the Clean Water Act. What are the naturally occurring conditions of the subbasin? How do these conditions determine whether designated uses are actually attainable or are only an idealized vision of what would be desirable? Will establishing standards result in economic hardships directly contravening the CWA statement that "regulations are not intended to result in standards that are so stringent that compliance would cause severe economic impacts."[11]

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Upper Owyhee Watershed Assessment

IX. Sediment Sources

Contents

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