Upper Owyhee Watershed Assessment

IX. Sediment Sources

Contents

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

IX. Sediment sources

Sediment enters rivers from water runoff from the basin that is being drained. The greatest movement of sediment to the rivers is dependent upon extreme weather events that create substantial surface runoff. This section considers runoff as well as the resulting sediment loss, or erosion, principally from rangelands. As a precursor, soils are discussed. The composition and amount of the sediment that enters streams and rivers is influenced by the types of soils found within the drainage basin and the vegetation that covers the soil.

A. Soils

1. Basics of soil

Soil can be defined as the product of weathering processes. Physical weathering breaks rock down into minerals, but does not change the composition of the original rock. The amount of physical weathering generally affects the grain size. Since chemical weathering alters the mineral composition of rocks, it slowly removes the least stable minerals.

The make-up of soil is controlled by six factors: the original bedrock, time, vegetation, slope, precipitation, and human action. The minerals that make up the soil begin with those which were in the **bedrock**. The bedrock breaks into smaller particles with weathering. **Time** is also a factor in soil development; the longer a soil has been exposed to the surface the more weathering can occur. **Precipitation** serves as a basic control on the amount of chemical weathering that goes on in the soil by providing water to carry away dissolved minerals and help facilitate soil development. The **vegetation** growing on any spot of soil can change the soil chemistry by taking up nutrients, by providing organic matter from fallen leaves and dead plant parts, by rain leaching nutrients from the plants into the soil, and by the root structure helping secure the soil in place. The **slope** of the land surface determines in part the stability of the soil surface. Steep slopes that are prone to landslides will have little chance for soil development as the slides remove developing soils. On a smaller scale, any hill slope will experience erosion while flat areas have greater opportunity to hold onto soil. **Human action** can change soils by adding organic matter, removing vegetation and adding mulch. Human action is most pronounced in areas with long term agriculture, road development, or urbanization, for example some soils in Europe have experienced so many years of mulching that their present composition is greatly influenced by human action. The development of a soil, also known as **pedogenesis,** is controlled by these six factors.

Soils are described on the basis of a **soil profile**, a description of the physical and chemical characteristics of the soil from the surface to the bedrock.[18] Researchers dig multiple holes across the landscape to map out a soil type and its variations. To describe soil, scientists designate **horizons**, or layers that have consistent physical and chemical characteristics. The combination of horizons found in a single hole allows a researcher to classify the type of soil they have found. In addition the soil scientist uses principles of geology to understand the distribution of soils because different parent materials and different land forms, like hills, slopes, and flood plains will have different types of soil.

2. Desert soils

"The climatic regime of arid lands can be expressed as one in which potential evaporation greatly exceeds precipitation during most of the year, and no or little water percolates through the soil. This implies of course a slow rate of chemical weathering and other water based chemical transformations, a low rate of biological activity because of water stress on plants of all kinds, and a consequent reduction of plant cover."[9:16] While semiarid climates, like the upper Owyhee subbasin, have a slightly higher quantity of precipitation than arid climates, chemical weathering is less rapid than physical weathering. One of the results of less chemical weathering is that, "soils inherit many of their characteristics from the parent material"[9:17] With physical weathering, the bedrock is broken down into smaller and smaller pieces, but it is not transformed chemically into another type of mineral.[19] Physical weathering in the form of extreme rainfall is recognized as one factor driving erosion and creating differing soils on slopes and flood plains.[54]

The other defining characteristic of soils in arid and semiarid environments is that regular precipitation events do very little leaching of minerals from the soils. This can leave layers within the soil with high concentrations of salts. "The most striking feature of desert soils is the presence of layers of accumulation of calcium carbonate [or lime], gypsum, sodium chloride or other salts."[9:17] At times these salt layers become so cemented that they inhibit the growth of plant roots. In arid and semiarid environments the development of salt concentrations is normally a factor of soil age.[9] Layers of sodium chloride and calcium carbonate (know locally as caliche) are commonplace in deeper soils. After rainfall, the water percolates through the soil to a depth determined by the amount of precipitation. In deep soils with semiarid climate, the water stops percolating before moving through all the soil. In lower low lying parts of the Owyhee drainage that were converted to irrigated agriculture, especially flood plains, caliche and salt layers had to be broken and dispersed by deep plowing to allow crop production. Many desert soils not suited to agriculture also have layers of caliche. Examples include deep soils of the YP desert and on Tuscarora’s alluvial fans. Where caliche exists, rain and snow melt water can not enter deep aquifers.

a. Factors in desert soil formation

Soil formation does not occur in isolation from other ecosystem processes. Climate, vegetation and geology all influence soil. And, soil in turn influences the growth of vegetation and the break down of bedrock.

"The scarcity of vegetation limits the amount of residue available for soil organic matter production in arid climates. Since nitrogen is carried in soil organic matter, it is low in desert soils."[19:40] In addition, temperature controls the rate of decomposition of organic matter. In warm, moist climates, organic matter decomposition takes place year round, in colder climates decomposition only occurs in the warmer months. In semiarid climates decomposition only occurs during brief periods of warm and wet soil conditions. The cycling of organic material is dependent upon microorganisms in the soil that break leaf litter and branches into their component parts.[15,19]

In deserts most rain "falls rapidly. Soil washing, erosion and runoff are intense. The high runoff rate further reduces the rain's effectiveness for plant growth except along stream channels, arroyos, and valleys were water accumulates. Shrubs and trees grow more densely along these water drainageways, and soils show the effect of more organic matter."[19:40] "The consequences of the high-intensity rain are rapid runoff and accelerated erosion."[15:208] Low topographic areas accumulate soil while the high plateaus and slopes lose soil to erosion.[50]

While erosion of desert soils is often high, topography, vegetation, and storms play into how erosion actually works. Soil loss is greater when either the steepness or length of a slope increases. "Longer slopes are more susceptible to erosion on the lower end because more water accumulates on long than on short slopes. Vegetation directly affects the erosion hazard in two ways: (1) plant canopies and residues reduce the impact of raindrops on the soils surface; and (2) anchored vegetation slows water movement across the land"[15:208] Another aspect of erosion is the duration of rainfall; the longer the duration the more likely that the soil's maximum water infiltration rate will be exceeded. It is when infiltration rates are exceeded that water runs across the surface of the ground because it can not be absorbed. This is more likely if the rain is very intense or lasts for a long time.[15,38]

Soil moisture is controlled by infiltration rates (the rate at which soil can absorb rainfall) and the soil water holding capacity. The water holding capacity of a soil is based on the type and quantity of pores it has and its depth. "Rain in the arid regions tends to come in high-intensity storms in which the rainfall rate greatly exceeds the infiltration rate."[15:208] After rainfall, the water held within the soil will be depleted as atmospheric evaporation and plant transpiration use the water. "Water storage is greatest when the initial evaporation rate is high and a dry surface soil is formed rapidly."[15:211] This means that the flow of water between pores in the soil does not continue to bring deeper water to the surface where it will be evaporated. A study on water retention in semiarid soils of New Mexico showed that "moisture conditions most favorable for plants occurred in areas where: (1) the landscape was level or nearly level, with little or no evidence of erosion; (2) there was a thin coarse-textured surface horizon to permit maximum infiltration of moisture; and (3) the subsoil was fine textured and/or indurated [had a hardened layer] to prevent deep moisture movement. A coarse-textured surface soil not only permits rapid infiltration of water but also [the surface] dries rapidly and protects subsoil water from evaporation losses."[15:212]

b. Soil nutrients

Certain types of desert vegetation alter the soil in which they live by accumulating soluble minerals, normally salts. "The soil located under and in close proximity to these plants may take on a wholly different physical character."[19:40-41]

The availability of soil nutrients to plant life is dependent upon the organic material produced by vegetation growing on the soil which is subsequently deposited as litter from leaves, seeds and wood.[50] Plants need nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and micronutrients.[18] Normally these nutrients become available for plant uptake from chemical weathering of the soil such that it is broken into component minerals. Because chemical weathering rates are reduced in desert soils, there are less nutrients available for plant use. Additionally, plants need a certain balance between nitrogen, phosphorus, potassium, and other nutrients. In desert soils, generally nitrogen and phosphorous levels are often insufficient for maximum growth.[18]

Desert soils are also known for their spotty distribution of nutrients. The areas around shrubs where organic litter is greatest generally have higher quantities of phosphorus, potassium and nitrogen.[40,41] This patchy distribution of nutrients is very good for the shrubs, but can have long lasting effects on fertility even after shrublands have been turned to grass.[41] The processes that lead to the development of shrub patches with high quantities of nutrients are still unknown.[41] Schlesinger and Pilmanis suggest that the formation of these islands of fertility may be due, in part, to the collection of a soil mound around the base of the shrubs, the sediment coming from wind erosion of the open spaces between shrubs.[40] The formation of nutrient rich zones around desert shrubs allows for the continuation of shrub vegetation. And, the replacement of grassy deserts with shrub deserts generates an increase in the amount of dust, and hence the patchy nature of the soil.[40]

3. Soil classification system

The United States has developed a classification system to describe all soils. The classification has orders, suborders, great groups, subgroups, families and series. Each stage of the classification process describes the soil profile in greater detail.[314,388]

The United States Geological Service (USGS) surveys show that most soils in the upper Owyhee subbasin fall into the orders of Aridisols, Entisols, or Mollisols.

"Aridisols are mineral soils of the arid regions. They have a low organic-matter content. During most of the time when temperature range is favorable for plant growth, the soils are dry or salty, with consequent restrictions on growth. During the warm season, there is no period of three months or more when soil moisture is continually available to plants, except in places where a water table is close to the surface."[15:42] Common aspects of aridisols are a layer of pebbles on the surface of the ground and a subsurface zone where salts have accumulated to form a hard or cemented layer. However, for soils to form distinctive layers throughout their depth they must be on relatively stable landforms, where erosion is minimal. On some desert tablelands with resistant geological layers, such as basalt, clay rich soils will form when the tableland is "isolated for tens or hundreds of thousands of years."[15:49]

Entisols have no development of layers within the soil that show distinctive physical or chemical modification to the parent material and, as such, are lacking layers referred to by soil scientists as pedogenic horizons. "Entisols are mineral soils showing little or no development of pedogenic horizons. . . . Pedogenic horizons have not formed because, primarily, the soils are too young due to recent deposition of fresh material or to [the natural] eroding away of the previous surface."[15:43] An example of an entisol would be a sand dune, where the is no differentiation between sand at the top where plants are growing and the mineral sand that formed the dune. Other entisols occur in areas of recent deposition such as flood plains and areas of ongoing erosion such as hill slopes.[15] Shallow stony soils over bedrock also fall in this category, including some soils of the basalt landscape of the upper Owyhee subbasin.

Mollisols are soils that generally develop under grasslands and steppe vegetation. They have a high content of organic matter that darkens the color of the soil and they are relatively fertile. The climate regimes where they develop vary from semiarid to semi-humid. Common parent materials are loess, sand, and limestone. The majority of the world's mollisols are used for agriculture.[6,52] In semiarid areas there is a subgroup of mollisols (xerolls) that develop on sites that are generally dry. "Those occurring in the United states have native vegetation of bunchgrass (e.g., *Festuca*, *Agropyron*, and *Pseudoroegnera* spp.) and shrubs (e.g., *Artemisia* spp. and *Purshia*), or savannas of grass with scattered trees. The xerolls are extensive in the Palouse loess region of Washington, Idaho, and Oregon and are widely scattered throughout the states west of the continental divide."[7:327]

4. Data on soils in the upper Owyhee subbasin

Soils in the upper Owyhee subbasin in Idaho and Nevada have been surveyed. The soil survey includes maps that break down every field into specific named soil series. The soil series are based upon physical and chemical characteristics and subsequently each series is divided by soil texture and slope. This detail can be overwhelming, but is very useful for planning purposes such as choosing appropriate locations for road construction or the installation of waste treatment facilities.[5,6,14,20]

Soils vary significantly across landscape features so that the soils found on flood plains, plateaus, and in the mountains are different. Generally areas where agriculture is productive have soils that are deeper, with less rock, and greater quantities of nutrients. Some of the soils found in the upper Owyhee subbasin are described below (Figure 9.1).

a. Agricultural soils

i. Around Riddle

The agricultural soils around Riddle are found in bottom lands and have deep deposits of fine grained sediments. The sediment derives from alluvium that has been transported by the creeks. The soil is classified as a mollisol.[20,48]

Properties and qualities
* Slope: 0 to 1 percent
* Depth to restrictive feature: More than 80 inches
* Drainage class: Poorly drained
* Depth to seasonally high water table: About 12 to 18 inches
* Available water capacity: High (about 11.2 inches)

Parent material: Loamy alluvium

Typical profile
* 0 to 9 inches: Loam
* 9 to 60 inches: Stratified sandy loam to silty clay loam

Runoff: Very slow

Hazard of erosion: Slight by water or wind

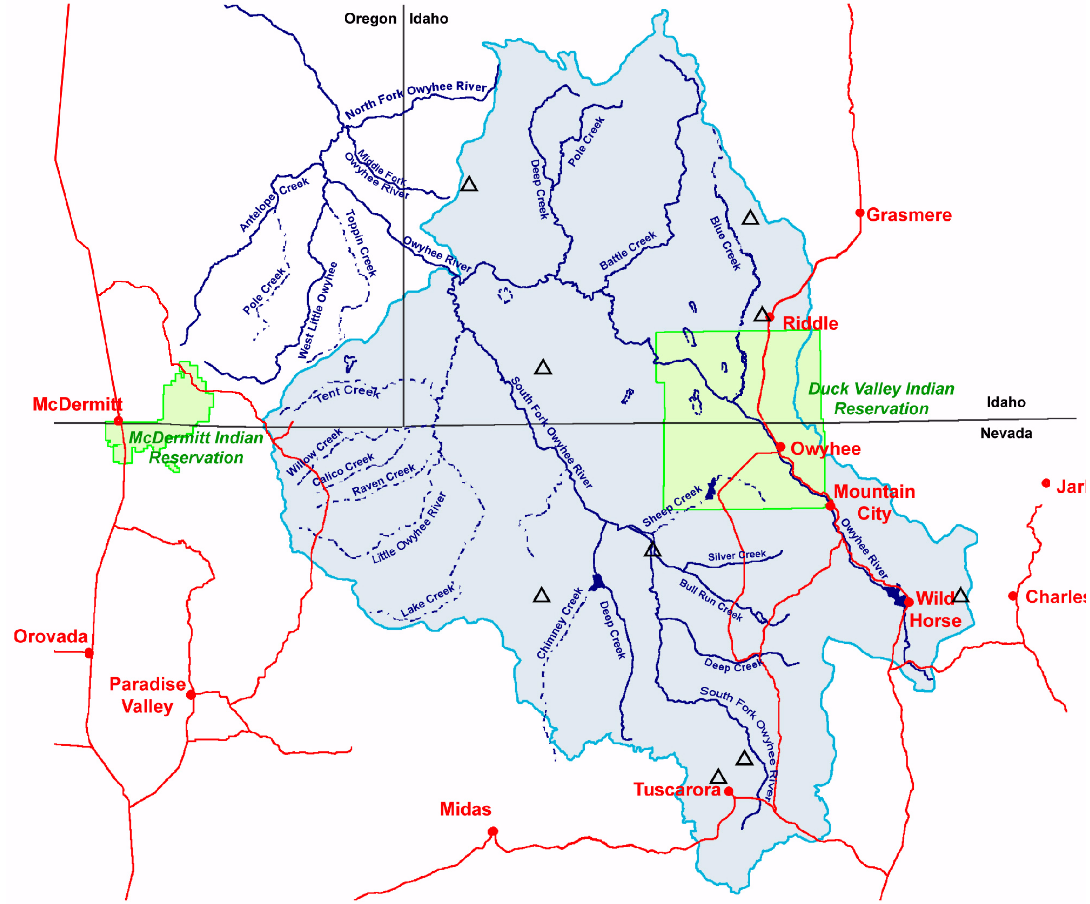

Figure 9.1. Soils from the upper Owyhee subbasin discussed below are indicated with triangles on this map.

ii. Flood plain sediments along the South Fork Owyhee River and tributaries

Along flat creek courses in wider valleys flood plains can form. The soils found along the flood plains in the upper Owyhee subbasin are very important economically. These are areas where better stands of vegetation can survive the dry summers. The flood plains with productive soils are found outside the entrenched portions of stream channels. They are generally used for hay land and pasture. Locations in the subbasin where these soils can be found include some areas along the South Fork Owyhee River, Sheep Creek, Bull Run Creek, and Silver Creek.[6,48] In technical terms these flood plain soils are classified in the mollisol order.[7]

Properties and qualities
* Slope: 2 to 4 percent
* Depth to restrictive feature: More than 60 inches
* Depth to seasonal high water table: 48 to 72 inches
* Available water capacity: 9.6 to 13 inches (high)

Parent material: Alluvium derived from mixed rocks and volcanic ash

Typical profile
* 0 to 9 inches: Loam
* 9 to 61 inches: Stratified sandy loam to silty clay loam

Runoff: Very slow
Hazard of erosion: Slight by water or wind

Photo 9.1. The greater availability of water and grassy vegetation on flood plains in the upper Owyhee subbasin led to the formation of soils distinct from those in surrounding uplands.

Another type of flood plain is that immediately adjacent to the stream channels. It is composed of the same materials as the other flood plains, but it is more frequently flooded, of more recent deposition, and at greater risk for erosion from floods. Flood plains immediately adjacent to stream channels are often considered to be riparian areas. Along the South Fork Owyhee River and tributaries these sediments are more frequently, naturally eroded and deposited. The scientific evidence for this is that these soils are of more recent deposition.

In other locations along the creek corridors where the water course is steeper or confined to a narrow channel the recent erosive and depositional events are not recorded in the soil surveys. Beaches, gravel bars, and similar unconsolidated materials that are deposited naturally along the banks of steeper stretches of creeks are not considered to be soils for the purpose of survey (they can change and move quickly).

iii. Independence Valley

The flood plains of Independence Valley have very deep, poorly drained, and slowly permeable soils.[14] The soils are composed of fine grained materials that have

Photo 9.2. Gravel bars deposited along river courses are not considered to be floodplain soils because they frequently change location.

been transported into the valley by the creeks.[5,6,48] These soils have developed with grassland cover and are classified in the mollisol order.

Properties and qualities:
* Slope: 0 to 2 percent
* Depth to restrictive feature: More than 80 inches
* Drainage class: Poorly drained
* Depth to water table: About 12 to 18 inches
* Frequency of flooding: Frequent
* Available water capacity: High (about 10.6 inches)

Parent material: Mixed alluvium

Typical profile:
* 0 to 4 inches: Silty clay loam
* 4 to 37 inches: Silty clay
* 37 to 60 inches: Silty clay loam

Runoff: Slow

Hazard of erosion: Slight by water or wind

Much of Independence Valley is used to grow hay and pasture grass.

The soils in the upper Owyhee subbasin that are currently used for agriculture and irrigated along rivers and streams are loams. The soils have a high available water capacity, are often poorly drained and are periodically flooded by the nearby creeks.

The agricultural soils are classified in the mollisol soil order. The properties of the soil that led to this classification are the result of a long time of soil formation. The soils were formed by the deposition of clay and silt sized particles during flood events. These materials originated from erosion upstream. Soil formation also included the accumulation of organic debris and nutrients from grassland/shrub vegetation cover and periodic flooding.[7]

b. Upland soils

Upland soils are found across the wide expanses of the upper Owyhee subbasin. In area covered, these are the predominate soils. Comparatively, these soils support less vegetation and hold less moisture than those used for agriculture. Below are two examples of upland soils.

i. YP Desert between Lookout Butte and the South Fork Owyhee River

Soils of the tablelands of the YP Desert are derived from volcanic ash, loess and/or welded tuff.[20,48] A sample soil profile from this area comes from between Lookout Butte and the South Fork Owyhee River. It has a duripan between 20 and 40 inches in depth and a moderate hazard of erosion. In shallow excavations, the sides of a hole will cave in as the particles are not strongly held together.

Properties and qualities
* Slope: 2 to 8 percent
* Depth to restrictive feature: 20 to 40 inches to duripan
* Depth to water table: More than 80 inches
* Available water capacity: Low (about 4.4 inches)

Parent material: Volcanic ash, loess, and/or mixed alluvium derived from welded tuff and basalt
Typical profile
* 0 to 3 inches: Silt loam
* 3 to 20 inches: Clay loam
* 20 to 30 inches: Gravelly sandy loam
* 30 to 38 inches: Cemented material
* 38 to 60 inches: Very gravelly loamy sand
Runoff: Slow or medium
Permeability: Moderately slow
Hazard of erosion: Moderate by water and wind.

ii. Between Blue Creek Reservoir and Turner Table

Soils in the upland area between Blue Creek Reservoir and Turner Table are very shallow ending in bedrock. There are many cobbles and rock fragments within the soil.[20,48]

Properties and qualities:
* Slope: 1 to 20 percent
* Depth to restrictive feature: 20 to 40 inches to lithic bedrock
* Depth to water table: More than 80 inches
* Available water capacity: Very low (about 2.4 inches)
Parent material: Volcanic ash and slope alluvium over bedrock derived from tuff breccia
Typical profile:
* 0 to 11 inches: Stony sandy loam
* 11 to 25 inches: Very cobbly sandy clay loam
* 25 to 28 inches: Extremely cobbly sandy clay loam
* 28 to 38 inches: Unweathered bedrock
Runoff: Slow to Rapid
Hazard of erosion: Water - slight to moderate, Wind - moderate

Where the bedrock is closer to the surface, 10 to 20 inches, the soil is stonier. These shallower soils are more common near hill summits.[20,48] The bed rock of volcanic origin provides all of the minerals found in the soil.

Parent material: Volcanic ash and colluvium over bedrock derived from volcanic rock
Typical profile:
* 0 to 5 inches: Stony loam
* 5 to 12 inches: Cobbly clay loam
* 12 to 19 inches: Very cobbly clay
* 19 to 29 inches: Unweathered bedrock

Photo 9.3. A stony upland soil.

Photo 9.4. The shallow soils of the uplands in the upper Owyhee subbasin are subject to more erosion where they are disturbed by unimproved roads than where they are covered by vegetation.

Across the uplands of the upper Owyhee subbasin the soils are similar to the examples above. They are typically stony and shallow. Many times the sediments are poorly held together so they can erode more easily than the agricultural soils. Where cut by road banks or excavation these soils lose the natural protection from erosion that is provided by the shallow slope of the plateaus. Plant growth is limited in these soils. The soils have bedrock or duripans close to the surface that restrict the depth to which plant roots can grow and the depth of soil that can hold useable water for plants. The soils are nutrient poor and dry for long portions of the year. They are classified in the Aridisol soil order.

c. Playa lake bed soils

Playa lake beds are unique features in the landscape of the upper Owyhee subbasin. They occupy very little of the total region but are included here because their soils are significantly different from surrounding upland regions.

Playas are locations where water accumulates and evaporates. These are the end of the line for the sediment that water is carrying. The sediment in a dry lake bed is the smallest sized particles, clays and silts, that erode easily. The modern playa lakes in the upper Owyhee subbasin are fairly small and are only flooded occasionally. As flooding is occasional, the lake beds are ranked as only fair habitats for shallow water areas and wetland wildlife.[6,48]

Properties and qualities
* Slope: 0 to 2 percent
* Depth to restrictive feature: More than 80 inches
* Drainage class: Very poorly drained (percolation is slow)
* Depth to temporary water table: About 6 to 18 inches
* Frequency of flooding: Occasional
* Available water capacity: High (about 9.1 inches)

Photo 9.5. Playa lake beds accumulate recent deposits of fine sediment with some rocks on the surface.

Parent material: Alluvium derived from mixed rocks, loess and volcanic ash
Typical profile
* 0 to 4 inches: Silt loam
* 4 to 60 inches: Clay

Photo 9.6. The recently deposited, fine grained sediments at reservoirs are similar to those found at playa lakes and, likewise, are at risk for erosion.

During the last glaciation the climate was wetter and lots of clay sized particles were deposited over larger areas where the lakes from that era existed. The older playa surface has rock fragments over clay.[6,48] Differences in soil for a remnant playa include:

Properties and qualities:
* Depth to water table: More than 80 inches
* Frequency of flooding: Rare

Typical profile
* 0 to 5 inches: Cobbly silt loam
* 5 to 60 inches: Clay

Soils from playa lake beds were formed out of alluvium, derived from the local rocks, that was transported in runoff from the region. They are deep deposits of fine grained sediments with no structure holding them together. The soils are classified as entisols. They are the result of recent deposition and erode easily.

Playa lake bed sediments are the product of years of the same processes that are now going on around reservoirs in the upper Owyhee subbasin. Fine grained sediments derived from the loess and volcanic rocks in the subbasin are transported by water and deposited where the water accumulates and later the soil dries. Over time the clay particles deposited at reservoirs will form thick clay soils. The recently deposited sediments of clay and loam sized particles do not have a strong soil structure and erode easily.

d. Mountain soils

Mountains by definition are high point on the landscape with steep slopes. At these high locations the soils are derived from immediately adjacent bedrock. By contrast, a flood plain will be composed of a mix of sediments derived from throughout the drainage basin above it. The steep slopes of mountains are at a greater risk of sediment erosion from rock fall and surface runoff. The hazard of erosion can be reduced by plant cover. Plant cover, however, will not stop all erosion. In some very steep mountainous regions there is no soil due to frequent rock fall and avalanche events. These areas are termed scree or talus slopes.[55]

i. Juniper Mountain

The east side of Juniper Mountain in Idaho is within the upper Owyhee subbasin. The soils are derived from the volcanic rocks prevalent in the area.

Properties and qualities
* Slope: 5 to 25 percent
* Depth to restrictive feature: 40 to 60 inches to lithic bedrock
* Depth to water table: More than 80 inches
* Available water capacity: Low (about 5.3 inches)

Parent material: Volcanic ash and colluvium over bedrock derived from basalt, tuff breccia and/or welded tuff

Typical profile
* 0 to 1 inches: Slightly decomposed plant material
* 1 to 10 inches: Stony loam
* 10 to 25 inches: Very gravelly loam
* 25 to 57 inches: Extremely gravelly sandy loam
* 57 to 67 inches: Unweathered bedrock

Runoff: Slow to moderate

Hazard of Erosion: Slight by water and wind

The mountain soils of Juniper Mountain are generally deep with a high quantity of rock. The vegetation cover is good because it contributes a layer of decomposed plant material to the soil surface, however, when the soil dries it can not hold much available water for plants.

In some of the mountainous terrain the rocks are closer to the surface and the soils are shallower. Where soils are shallower, less vegetation grows, runoff is moderate to rapid and there is a greater hazard of erosion.

ii. Wild Horse

East of Wild Horse the side of Haystack mountain has very rocky soils on steep slopes. This mountain is of the identical geological formation as the Bull Run and Independence Mountains. The soils generally end at unweathered bedrock. The suitability of these soils for wild herbaceous plants and shrubs is rated as fair and they are poorly suited to range seeding operations. Rapid runoff on these steep mountain slopes presents a high hazard of sediment erosion.[5,48]

Photo 9.7. The steep talus slope of this peak in the Independence Mountains does not support soil.

Properties and qualities
* Slope: 50 to 75 percent
* Depth to restrictive feature: 20 to 40 inches to lithic bedrock
* Drainage class: Well drained
* Depth to water table: More than 80 inches
* Available water capacity: Very low (about 2.8 inches)

Parent material: Residuum and colluvium derived from mixed rocks, loess, and volcanic ash

Typical profile
* 0 to 6 inches: Very gravelly loam
* 6 to 27 inches: Very gravelly clay loam
* 27 to 31 inches: Unweathered bedrock

Runoff: Rapid

Hazard of erosion: High by water, slight by wind

Photo 9.8. The rubble left from historic mining operations around Tuscarora is unconsolidated.

iii. Tuscarora

The hillsides around Tuscarora have been heavily impacted by mining and travel of recreationists. On aerial photos it is possible to see the scars left on the landscape. In the immediate mine areas the original soils have been completely removed. The rubble left from mining is unconsolidated, has not been reclaimed, and has few soil properties. Loose rubble has a great erosion hazard. The majority of the visible mining scars are located on the hill slopes. The characteristics of soils from the hills of Tuscarora from spots not directly impacted by mining are discussed below.[6,48]

The landscape can be divided into hill slope soils with bedrock close to the surface and soils on alluvial fans closer to the valley floor.[6,48] Characteristics of a hill slope soil follow:

Properties and qualities
* Slope: 8 to 15 percent
* Depth to restrictive feature: 14 to 20 inches to lithic bedrock
* Depth to water table: More than 80 inches
* Available water capacity: Very low (about 1.6 inches)

Parent material: Residuum derived from volcanic rocks

Typical profile
* 0 to 12 inches: Very gravelly loam
* 12 to 17 inches: Very gravelly clay
* 17 to 21 inches: Unweathered bedrock

On the hill slopes the bedrock is very close to the surface of the soil. Even under undisturbed natural conditions the sediment is not held well in place and has little water holding capacity to support vegetation.

On the alluvial fans a duripan affects water movement. The duripan restricts the permeability and is restrictive to plant root growth. The soil has a hazard of erosion by water and blowing soil. Furthermore the soil is not suited for paths and trails because it erodes easily.[6] An alluvial fan soil description follows.[6,48]

Properties and qualities
* Slope: 2 to 15 percent
* Depth to restrictive feature: 20 to 36 inches to duripan
* Depth to water table: More than 80 inches
* Available water capacity: Low (about 4.9 inches)

Parent material: Alluvium derived from mixed rocks, loess and volcanic ash

Typical profile
* 0 to 10 inches: Gravelly loam
* 10 to 30 inches: Clay
* 30 to 48 inches: Indurated
* 48 to 60 inches: Stratified extremely gravelly sandy loam to gravelly sandy clay loam

Soils of both the hill slopes and fans around Tuscarora were susceptible to sediment erosion before mining. The intensive use of this area, building of trails, and piling of mining waste rock are additional human factors promoting erosion.

5. Soils summary

Most of the soils in the upper Owyhee subbasin have not been substantially modified by human occupation. Very little of the upper Owyhee subbasin has been developed. The soils in the region, as would be expected, share many characteristics with soils in other arid areas. Landform is a major component contributing to characteristics of soils, such as their depth, ability to support plant life, erodability, and particle size.

Soils in the mountains are generally shallow, support little vegetation growth, have lots of gravel, and are susceptible to erosion. The soils described above for mountainous regions of the upper Owyhee subbasin are xerolls, a subgroup in the mollisol soil order. These soils are rich in organic matter from the bunch grass and shrub vegetation that grows on them, but are dry for much of the year. Limitations to plant growth come from the semiarid climatic conditions and shallow soil depths.

Soils from the expanses of plateau are generally shallow, rocky and have a cemented layer close to the surface. These soils hold little moisture and fall within the aridisol order. Soils within the aridisol order were expected for this region because of the semiarid environment.

Soils from the flood plains and valley bottoms are classified in the mollisol order. From this we know that these areas have long been covered in organic rich grassland and/or shrub vegetation. The soil characteristics that will lead to this classification have formed over time and with specific vegetation.

On the playa lake beds the sediments are composed of very fine particles, clay and silt. These fine particles have been deposited recently. The soils are at a great hazard for erosion. Playa lake beds have soils similar to what would be expected to form at human made reservoirs that are seasonally flooded and dry.

Soils in the upper Owyhee subbasin are mostly composed of the weathering products of volcanic rocks. From particles of fine silt to cobble sized fragments in the soil derived from volcanic rock. The volcanic rock and its weathering products are of recent geological origin and the erosion products are largely fine silt.

The mineral content in soils of the upper Owyhee subbasin originates from minerals in the volcanic rocks. Predominately the minerals carried in erosion and runoff from the upper Owyhee subbasin come from the soils that came from the underlying rocks. These are not point sources. Some naturally occurring minerals of concern include mercury, antimony, uranium, and radon. The elevated concentrations of these minerals in the bedrock led and continues to lead to their natural occurrence in soils and water ways. Minerals are carried across state lines by rivers, but the non point sources are not very amenable to management solutions. There are very few point sources of mineral or chemical pollution in the upper Owyhee subbasin. Some concentrations of cyanide and mercury may be associated with abandoned, historical mining operations.[56] The pollution at mining sites could be cleaned up.

Many of the soils in the upper Owyhee subbasin can be at risk for erosion. While soils have erosion hazards or risks, the actual amount of erosion that occurs is based upon substantial rain or snow events, storms that bring heavy rainfall, and human activities that expose the sediments.

B. Erosion

The sediment load transported by a river is obvious to most observers. Crystal clear stream water is not carrying substantial amounts of sediment, while murky brown waters are a result of a large sediment load within the river. The sediments in rivers come from erosion of soil and rock. Water carrying diatoms and algae that grow in the river water will appear to be hazy from carrying sediment but the suspended particles are created by plant life. The soils within the upper Owyhee subbasin are discussed above and the rocks are discussed in the geology section of the background component of this assessment. Wind erosion contributes a very minor amount of sediment directly to the rivers.

“Erosion is an intrinsic natural process but in many places it is increased by human land use.”[51] All of the river canyons and gullies we see as scenic locations today were created by natural erosion. The goal of assessing sediment sources and erosion is not to halt the movement of sediments, but to understand, and where possible, mitigate the effects of modern human activities on soil loss.

Management of sediment losses requires an understanding of how erosion functions naturally, what creates surface runoff within the upper Owyhee subbasin, and what cultural practices are management options.

1. Forms taken by erosion

When looking at the landscape to see where erosion is happening, there are three types of soil movement.[13,37] Sheet erosion moves sediment off the surface of a large area of ground and is generally more common in flat areas. Rill erosion consists of more or less parallel erosion paths across sloping ground. Gully erosion cuts through sediments in low areas where water accumulates during runoff events, creating features we call gullies.

Identification of what type of erosion has occurred will suggest the types of actions which can be taken to prevent erosion. In nature the quantity and speed of runoff water determine the form taken by erosion, and slopes will show a progression from sheet erosion at the top where they are nearly flat, to rill erosion on the slope, and finally gully erosion along the steepest incline.[13] On furrow irrigated fields the erosion occurring is analogous to rill erosion.

Erosion at a rate which has occurred historically in areas little impacted by human activity may not be amenable to any form of management. Similarly erosion where human activity has not significantly changed the composition of the soils or the nature of vegetative cover will be difficult to alter with human intervention.

a. Management of sheet erosion

> "Sheet erosion can be prevented by maintaining plant cover and maximising infiltration of ponded water through the maintenance of soil structure and organic matter. Organic matter acts as a glue, stabilising pore spaces which transmit surface water deeper into the soil and thus reduce the volume of ponded water available for erosion."[12]

b. Management of rill erosion

> "Once runoff has been initiated, rill erosion can be prevented by either reducing flow velocity, or hardening the soil to erosion. . . . Flow velocity can be reduced by either reducing the flow volume or roughening the soil surface. Increasing surface roughness through the use of grassed waterways and grassed filter strips causes entrained soil particles to fall out of suspension. Flow volume can be reduced by not allowing sheet flow to accumulate. Techniques such as ripped mulched lines and contour drains prevent runoff building up enough volume and speed to detach and entrain soil particles. . . . Where options to reduce runoff volume or velocity are limited, surface soils may be protected from scouring by hardening the surface."[11]

c. Management of gully erosion

> "Once established, gully erosion can be difficult to control. In most cases a combination of approaches, including the use of vegetation, fencing, diversion banks and engineering structures are required. . . . Vegetation is the primary, long-term means by which gully erosion can be controlled. All gullies need to be fenced from stock and revegetated along the gully floor, sidewalls and surrounding areas. Establishing vegetation on gully sidewalls is often difficult due to moisture stress."[10]

Suggestions from Tasmania, Australia include, revegetating the gully floor with rapidly growing grasses and the sidewalls with trees, revegetating the catchment above the gully, and using irrigation hydroseeding and mulching.[10] In areas where the gully erosion can not be controlled with vegetation, “gully erosion may be able to be controlled if runoff can be diverted and safely disposed of.”[10] However this requires engineering expertise and carries the, “risk of transferring instability from one area to another.”[10] While we may think of Tasmania as being a world away, similar erosion problems are found in many semiarid regions of the world and their solutions are similar. At some sites the construction of upstream stock ponds can reduce runoff pressure aggravating gullies.

2. Erosion on rangelands

The effects of grazing on sediment erosion were examined in southwestern Idaho in the Reynolds Creek watershed. Reynold’s Creek is close to the upper Owyhee subbasin and has similar vegetation and rainfall patterns. Expected sediment losses were calculated on the basis of observable factors such as the percentage of ground covered by leaf litter and plant canopy, soil type, slope, and rainfall. The equation used, Universal Soil Loss Equation (USLE), is widely accepted as a predictor of erosion.[57,58] Nine locations were monitored from 1972 to 1978 with ungrazed and grazed range plots. Cattle grazed at moderate (2 plots), heavy (6 plots), and severe (1 plot) intensities, meaning the utilization of, respectively, 41-60%, 61-80%, and 81-100% of key forage species. Each grazed plot of rangeland was compared to an adjacent ungrazed plot to determine effects of grazing on sediment erosion. Reduction in plant cover and leaf litter that could lead to more sediment production was observed in only two plots. Both plots were on steeper slopes and one was grazed severely and the other heavily. The remaining seven locations did not experience significant changes in cover, these included two other steep locations with a heavy grazing regime.[57] Increased sediment production on rangeland would not be predicted for areas with standard practices of grazing management.

In the study of the Reynolds Creek watershed, it was not possible for the researchers to directly measure the sediment lost from the studied plots. However four of the drainages with test plots had measurements of actual sediment yield. The actual sediment yield was only 25 percent of the soil losses calculated from the plots. The difference between actual and calculated losses indicates that less soil is eroding across the surface of the rangelands than is predicted by the standard management equation USLE.[57] The authors of this assessment also found it interesting to note that the actual soil losses in four creek drainages in southwestern Idaho were 0.22, 0.29, 0.31, and 0.43 metric tonnes / ha / year, sediment yields significantly lower than the USDA soil loss tolerance for the shallowest soils, 2.24 metric tonnes / ha / year (1 ton / acre / year).[58]

3. What increases the amount of erosion during storms and snow melt?

a. Surface erosion

Erosion is the natural process by which sediment is moved down slope. Gravity is the major force in action, as in a rock fall. But, gravity is assisted in creating erosion by water both loosening and carrying material. Two major factors contributing to how much erosion occurs are the slope of the land and type of precipitation. The greater the slope of the land, the more likely it is to undergo erosion. Steep slopes will lose more sediment than flat plains. High intensity and volumes of precipitation also increase the amount of erosion.[28] When heavy rains occur, the soil can not absorb all of the water and so some of the water starts running across the surface of the ground. Snow melt can also result in a large amount of water on the surface running across the ground, especially when the ground is still frozen. If the ground is frozen it will not absorb the water from the snow melt. If there is a large amount of surface runoff or the surface runoff is across a steep slope, this water will begin scouring the ground it is moving over and pick up sediment. Individual particles of sediment are small enough to be carried in the water and moved off of the land.[28]

Very large weather events have the power to dislodge both large particles and those which are held together firmly by forces in the soil. The influx of this sediment to the river system occurs over a short time period as the additional moving water has the force to carry these particles.[28]

Erosion is greater in areas where the landscape is in its early stages of formation. Many areas of the upper Owyhee subbasin are geologically recent (geology section of the background component of this assessment). These “new” rocks and the “new” landscape have not been smoothed from eons of erosion. Steep slopes increase erosion risks. Another implication of recent formation is that soils have only started to form, limiting the ability of the landscape to support vegetation and exposing the newly formed soils to erosion.

Soils vary in the amount of clay, silt and sand they contain. A soil composed of sand and silt particles is more likely to undergo erosion than one with a clayey surface. Soils of more recent origin have a tendency to have silt and sand particles near the surface. These particles can be dislodged more readily than clay particles. The large areas of basalt and volcanic ash in the subbasin weather to silt that is easily dislodged.

b. Stream channel erosion

Storms and snow melt can cause large runoff events.[8] This water reaches stream courses. The greatest amounts of water flowing in a creek are recorded as peak flows. In the upper Owyhee subbasin the peak river flows occur with the runoff from snowmelt (see the hydrology section of this assessment). A large quantity of fast moving water in a creek can cause scouring of the stream bed and gully erosion of the stream banks.

> “Seasonal variations in stream flow are a major determinant of the structure and seasonality of ecosystem processes in streams and rivers. Periods of high flow in small streams, for example, scour stream channels, removing or redistributing sediments, algae, and detritus. In larger rivers, high flow events may lead to predictable patterns of bank erosion and deposition.”[8:94-95]

Researchers have documented characteristics of streams that are associated with greater erosion and scouring during floods. These characteristics include flashy changes in water flow, high channel gradient, abundant coarse material in the stream bed, relatively low bank cohesion (from less structured soils and/or fewer plant roots),

 

Photo 9.9. The contrast between stream channels with (left) and without (right) bank erosion. On left a stream channel draining into the East Fork of the Owyhee River in Nevada. On right the East Fork of the Owyhee River above Wild Horse reservoir.

and narrow channels that enable faster deep flowing flood water.[27] Arid and semiarid streams are known for rapid changes in flow, rocks in stream beds, and less structured soils in channel banks. In the upper Owyhee subbasin, these flashy water flows can carry sediment great distances so the sediment from one state can be carried into the next state downstream.

Floods can change the shape and composition of a river. In the Colorado River, for example, "The annual cycle of scour and fill had maintained large sandbars along the river banks, prevented encroachment of vegetation onto these bars, and limited bouldery debris deposits from constricting the river at the mouths of tributaries".[35] The increase in riparian vegetation along the Colorado River resulting from the removal of flooding after dam construction has been detrimental to aquatic life in the river.[35]

Floods are complicated from a management perspective. While they result in erosion and scouring, the effects of erosion and scouring can increase aquatic species diversity and the diversity of aquatic habitats.[35] For example, scouring can clean fine sediment out of gravel that fish use for spawning and natural flash floods can periodically reduce exotic and lake fishes that have been introduced to the streams.[35] In free-flowing rivers with episodic high flows, the plants in the riparian area are regulated by flood scour. Scour will remove plants.[35]

4. What will decrease the amount of erosion during storms?

Two factors important to decreased erosion during storms are the soil surface cover and the permeability of the soil to water. Soil surface cover can help hold sediment in place. Greater soil infiltration allows more water to be absorbed into the soil before it begins running across the surface of the ground.

The amount of erosion which occurs is largely controlled by the vegetative cover and type of soil. Vegetation and plant litter hold soils in place.[13,38] Soil that is being held in place is much harder to erode and will only be influenced by much more intense storm events. Soils covered in rock fragments also produce less sediment from rain based erosion.[45] Rocky cover leaves less sediment available for transport by runoff and slows the speed and power of run off water.

"Infiltration is the term applied to the process of water entry into the soil. The rate of this process, relative to the rate of water supply determines how much water will enter the root zone, and how much, if any, will run off. Hence, the rate of infiltration affects . . . the amount of surface runoff and the attendant danger of erosion."[38:382] Soils high in clay or covered in rocks do not absorb water quickly and can produce more surface run off in rapid downpours. Soils with a predominance of sand or coarser particles tend to absorb water very quickly.[8] The more water that is absorbed by the soil, the less water will become surface run off.

Revegetation of stream banks is the general management practice utilized to mitigate the effects of scouring and gully erosion during high water events.[10,35] This practice is necessary where human modification of the environment has been extreme. However, vegetation can only hold stream banks together up to the point where the floods have the power to remove the plants.[35]

Not all erosion can be controlled. The portion that management practices can address is the portion that is related to cultural practices.

5. Cultural practices related to soil losses

Erosion on rangeland has not been scientifically studied in the upper Owyhee subbasin. However, erosion can be observed by those who use the same areas year after year. People downstream can observe the muddied waters of rivers carrying sediment from upstream erosion. Large sediment loads delivered to the rivers are the result of either extreme storms or other problems.

a. Sources of problems and concerns

Human land use, particularly related to vehicle travel is seen as a major source of sediment being delivered to waterways in the upper Owyhee subbasin.

i. Unimproved roads

Unimproved roads through rangelands create problems with erosion. Often the placement of dirt roads has developed as a matter of convenience, with no planning to minimize their effects on soil loss. Unimproved roads can erode more than improved roads. Improved roads will have runoff ditches along the sides which funnel water off the road and onto the range.

Unimproved roads erode in the tire tracks, collecting water running off the landscape and acting as sediment sources.[39] This happens because once water is in the wheel ruts, it can not escape. Water often flows within the wheel ruts for great distances, eroding deeper and deeper gullies into the land. Over time the erosion along one set of wheel tracks will lead drivers to move off of the existing road to drive on adjacent land. Those who use the range on a frequent basis notice that this problem becomes more pronounced with the steepness of the slope. Steep slopes have greater need of cuts designed to direct water off of the road at regular intervals.

Photo 9.10. Erosion in the tire tracks of an unimproved road across the plateau in the upper Owyhee subbasin.

Simple gutter improvements creating ways for water to escape from the wheel ruts of unimproved roads will decrease erosion.[39] Extensive descriptions for rural home owners, ranchers and rangeland managers on how to care for and improve rural roads are provided in the online publication "A Ditch in Time".[39] Many of the unimproved dirt roads in the upper Owyhee subbasin are already acting as gullies and will likely continue to do so even without vehicle traffic because the gullies will not magically grow plants to hold the soil in place.

ii. ATV tracks and off road recreation

Off road recreation by both small 4 wheelers and large 4x4 vehicles disturbs the surface of the soil. Repeated use of an area or paths for off road recreation kills vegetation. Soil compaction, which results from vehicles driving over the soil, greatly increases the chance of precipitation flowing across the surface of the land.[13] These factors leave areas used for off road recreation extremely susceptible to erosion from rainstorms or snow melt. Areas which have been used repeatedly for off road recreation contribute disproportionately larger amounts of sediment to the rivers.

iii. Stream bank erosion

Steam bank scouring can be a natural process. This scouring can also be aggravated by excessive animal pressure on riparian vegetation, leaving stream banks excessively vulnerable to erosion.

iv. Irrigation-induced erosion

There is very little irrigation in the upper Owyhee subbasin, so there is little runoff from irrigation. The concern with irrigation water is that runoff will be returned to the river. This runoff can carry sediment, nutrients, and animal wastes. Cattle are fed over winter on some pastures in the upper Owyhee subbasin and flood irrigation can carry material from these pastures.

v. Confined animal feeding operations

In some regions, concern has been expressed that sediments at confined animal feeding operations are extremely susceptible to erosion and that during storm events the sediment might be lost into the rivers, carrying with it a high concentration of animal wastes. This is not a widespread concern in the upper Owyhee subbasin.

vi. Urban areas

Urban areas can significantly increase the amount of runoff water. Urban areas have less soil area to absorb rain water. Large amounts of fine sediment are produced in construction areas.[32] The upper Owyhee subbasin has few urban areas so this is not expected to contribute much sediment to the waterways.

vii. Timber harvest

Timber harvest is associated with the addition of fine sediments to streams.[32] Large scale timber harvesting is uncommon in the upper Owyhee subbasin.

6. Erosion in the upper Owyhee subbasin.

There have been few evaluations of erosion in the upper Owyhee subbasin. The Idaho Association of Soil Conservation Districts and the Idaho Soil Conservation Commission conducted stream channel inventories on privately owned land in the upper Owyhee subbasin. The conclusion was that areas upland from the stream channel contributed little excessive erosion or deposition to the stream channels. The primary sources of erosion for the stream channel came from the stream channel and riparian areas themselves.[23]

a. Possible solutions to current problems

i. Unimproved roads

Unimproved roads through rangelands eventually need to be repaired or replaced. Simply prohibiting vehicle traffic will not halt erosion which is already carrying sediment off the road. As replacement and repairs are necessary, minimal design considerations can be implemented to divert water strategically from the roadway at reasonable intervals. In some places, routes can be chosen with less erosive potential.

ii. ATV tracks and off road recreation

Education of ATV and other off road vehicle users needs to be both more energetic and effective.

iii. Stream bank protection

Where stream banks are accessible to animals and people, maintenance of good riparian cover can diminish erosion. In many places in the upper Owyhee subbasin, the streams run in deep canyons with little livestock access and all erosion along the streams is natural.

iv. Irrigation-induced erosion

It is not known how much sediment or animal wastes are lost from irrigated fields and pastures in the upper Owyhee subbasin.

In the upper Owyhee subbasin, most irrigation is of hayfields and pasture. The traditional method of irrigating hayfields has been surface flood irrigation. This irrigation method is usually inefficient in water use for the crop. In some areas, central pivot irrigation systems have been adopted. Central pivot irrigation systems use water more efficiently.[Section XI, Agriculture, this document]

More efficient water use means less runoff. Efficient water use practices are being adopted and further adoption will result in less sediment loss from fields. Possibly the best way to deal with concerns with runoff water from agricultural fields is to eliminate the runoff altogether. This can be done with controlled water application. If all of the irrigation water applied to a field stays on the field, there will be no run-off and no worry of accompanying sediment, nutrients, and bacteria entering creeks.[47] Both sprinkler irrigation and drip irrigation systems can be designed to eliminate runoff from agricultural fields.[26,42,43,44] For hayfields and pasture, sprinkler irrigation is more cost effective than drip irrigation systems.

Other improvements to limit sediment losses include leveling and settling ponds. Leveling makes fields flatter, and flatter fields are less subject to erosion because the water in furrows is moving slowly. Slower water has less power to pick up and move sediment. An additional method to eliminate most sediment and water returning to the rivers is through the use of settling ponds in constructed wetlands or catchment ponds with pump-back systems. Settling ponds allow the sediment to fall out of suspension in the water and gather on the bottom of the pond.[44] After sediment has settled, water is returned clean to tail ditches and creeks.

7. Questions that need to be answered about soil losses

How much vegetation is needed on the rangeland to avoid erosion related to thunderstorm events? Do different types of vegetation have different amounts of sediment losses? Is the amount of vegetation needed possible within the constraints of semiarid environmental conditions?

What is the difference in sediment loss between rangeland on a flat plain and that on the slope of a hill? How does grazing affect sediment losses?

How is the amount of soil erosion changing with invasive weeds? With expanding juniper cover?

How much vegetation is needed along a stream bank for stabilization? What species of vegetation that are adapted to local environmental conditions would grow in these places? How often is this vegetation lost to natural scour?

To what extent are there soil loss problems following wildfires and controlled burning of rangeland?

There is no survey of locations with active erosion within the upper Owyhee subbasin to document the erosion rate and study whether the current rate is what would be expected to occur naturally or is being aggravated by human activities. Only the latter would be amenable to remediation. Naturally occurring erosion has been substantial and is responsible for much of the beauty and incredible landscape of the upper Owyhee subbasin.

To what extent has legacy historic overgrazing on upper Owyhee subbasin rangelands altered soil properties that influence modern sediment production? (Changes to surface cover, infiltration rates, and sediment production have been documented in other arid historically overgrazed areas.[38]) To what extent has the past legacy of overgrazing been overcome by range management practices during the last half century?

C. Sediments in waterways

One of the TMDL concerns about erosion is that increased amounts of sediment are entering the river systems. A background on how sediment enters waterways, how it is measured, and how sediment is transported by creeks and streams is presented below. This is followed by a general discussion of stream biota, the fish and macroinvertebrates that live in the water ways and may be affected by sediment in the water. The data on sediments in the water ways of the upper Owyhee subbasin and data gaps close the section.

1. Sources of runoff water

The sources of water entering the rivers in the upper Owyhee subbasin have not been delineated. The water flow in the subbasin depends upon the flow of the various perennial, intermittent and ephemeral streams. In addition, the amount of sediment carried by runoff and streams varies based upon the source. This is a data gap.

Sediments entering streams can be discussed in terms of their origin: that coming from springs and seeps, that originating in storm events, that from urban areas, and that being transported in return water from irrigation.

Water from underground aquifers, such as springs and seeps will carry little to no sediments. However this water may carry mineral concentrations picked up from the natural elements in the rocks the water has passed through.

Thunderstorms and rapid snow melt can produce massive surface runoff. This runoff will likely carry sediment from the area it passes over. The floods that may result in narrow stream channels also have the potential to scour sediments from the banks of the channels. Storms are natural and some erosion will always accompany them. Human management of sediment entering streams from storm events can only address man made sources of loose sediments.

Agricultural lands that are barren during rain storms may have greater sediment erosion.[32] In addition, these lands are deliberately irrigated. Irrigation tail ditches will carry sediments from the fields that the irrigation water ran across. This is of concern to water quality since the soil may contain high quantities of phosphorus, nitrogen, bacteria, and pesticides.

2. Sediment transport in rivers

Limiting human provoked soil losses can limit the sediment entering a river system. However not all sediment comes from human actions. The amount and types of sediment within river systems in the past are poorly known.

Erosion is a natural process by which sediments are added to the streams and rivers, and likewise rivers are the natural way that these sediments are transported to lakes and seas. While river systems carry eroded sediments, they “can also be depositional, accumulating sediment within channels and floodplains.”[31:129] How river systems transport and deposit sediment is dependent upon a number of factors including sediment supply, the river gradient, total river discharge, bed sediment size, and seasonal variations in flow.[31,36]

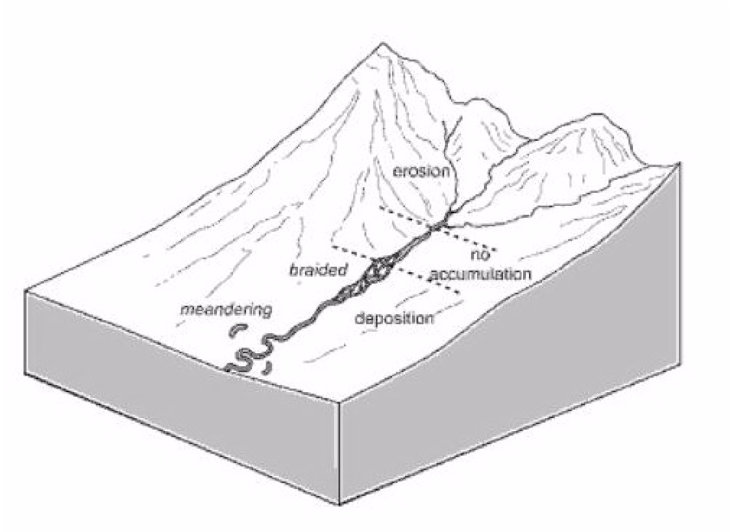

Figure 9.2. Schematic locations of erosional, transfer, and depositional zones. Adapted from 31, Figure 9.1

Gradient will determine if a portion of a river system is within the erosional, transfer, or depositional zone (Figure 9.2). "In the erosional zone the streams are actively downcutting, removing bedrock from the valley floor and from the valley sides via downslope movement of material into the stream bed. In the transfer zone the gradient is lower, streams and rivers are not actively eroding, but nor is this a site of deposition. The lower part of the system is the depositional zone, where sediment is deposited in the river channels and on the floodplains."[31:129] When looking at a river system within a landscape, the more mountainous portions will undergo erosion while rivers running across flat lands will be subject to deposition of sediments.

The gradient and water flow are related to **bed sediment size**. Bed sediments can range is size from boulders to fine silts. The size of sediment found in a given location is based upon ease of transport. Smaller particles are more easily moved by water. The sediments that a creek or river can carry within the water are termed the suspended load.[31] Those particles that can be moved along the bed of a creek by rolling are termed bed load. The suspended sediment load that water can carry is based upon its power. A greater suspended load can be carried by a creek with a steeper gradient and thus greater power of the flowing water. The greater the sediment load that can be carried in the water the more fine sediments will be preferentially removed. Creeks with more gravel in the beds tend to have higher gradients where water is moving quickly. Creeks with lower gradients and where water is moving more slowly will have finer sediments in the bed.[31] As water slows down, the sediment load it can carry is less and fine sediments settle out of suspension. For example, when the suspended load carries both silt and clay sized particles, the heavier silt particles will settle out before and upstream of where the clay is deposited. Creeks are dynamic systems with many different types of beds that are not necessarily all rock or all fine sediment.

Photo 9.11. The Jack Creek canyon shows how gradient changes from erosional slopes to transitional zones near the valley bottom.

Many physical characteristics in a river system alter sediment transport and bed sediment size, some examples are the erosion of parent material, the confluence of tributaries, and dams.[36] Rock can be introduced anywhere along a stream where the local rock deposits are breaking up. Rock introduced locally will be more angular as the transport of rocks by the stream tends to round off the edges. Where tributaries join a major channel there is an increase in the volume of water that is moving. This increased power can move more sediment and stream beds will have larger particle sizes.[36] Dams alter sediment transport as the water slows down and loses sediment that it has been carrying. The bed sediment in reservoirs and upstream of the reservoir where the water has already slowed is often fine.

Floods change sediment transport in rivers. The increase in water flow increases the power of the creek or river. With greater flow and power, more and larger particles can be moved as suspended and bed load. Sediment transport as suspended load increases during a flood. Visually this can be seen as murkier water. Floods also have the power to move larger material as part of the bed load. The rolling of rocks during a flood is the movement of bed load that, over time, leads to rounded cobbles and rounded gravel. Greater transport of sediments by flood waters is natural.[31] The greater water flow during flooding also carries the suspended sediments further downstream, sometimes for great distances.

Less pronounced seasonal variations in water flow will also change the ability of a creek to transport sediment. The lowest sediment transport can be predicted for times of the year with the lowest flows. Meanwhile the peak flows during spring snow melt would likely correspond with high levels of sediment transport.

The highest flows may account for almost all sediment movement in creeks. Singh and Durgunoglu state that, "80-90% of the sediment load is carried during the highest 10-15% of the flows."[59:199]

3. Measuring sediment in water

To the naked eye water that has suspended sediment looks murky. The haziness results from very small particles that remain suspended in the water. Suspended sediment is frequently measured in terms of this haziness, or turbidity.[53] While it is easiest to see the sediment transported in suspension, creeks and rivers also move sediment as part of the bed load. These particles move by tumbling along in the bed. They are pushed along but are too heavy to be held within the water.

a. Suspended sediment

Suspended sediment is measured based on how clear the water is (turbidity) or the amount of sediment found within the water (suspended sediment concentration).

Turbidity is related to how much light will pass through the murky water. One rough estimate can be made from recording the depth at which a black and white disk can no longer be seen. The common laboratory measure of turbidity is based on the scattering of light in water. The Nephelometric Turbidity Unit (NTU) is higher for murky water and lower for water with no particulate matter (Figure 9.3). The treated drinking water in your home is not permitted by the EPA to exceed 1 NTU.[16] "A turbidity of 3000

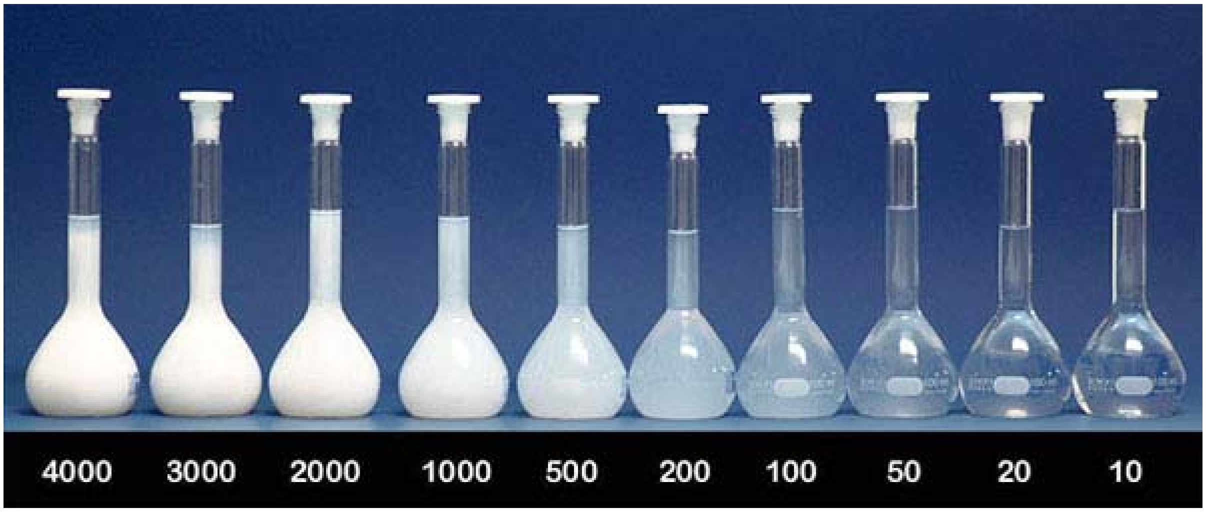

Figure 9.3. Examples of water turbidity measured in NTU.[33]

NTU typically corresponds to a suspended sediment concentration of 3 g/l but this will vary depending on the characteristics of the particles in suspension."[25:14] When a water sample is taken to measure turbidity it must be analyzed in a timely manner.

Turbidity is measured on the basis of all particles in water. Sediment, while often a major factor in high turbidity, is not the only source of haziness in water. Turbidity "is caused by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms, organic acids, and dye."[49:TBY-3] Turbidity measurements also are effected by particle size, "for a given sediment concentration a reduction in particle size results in an increase in turbidity."[25:14]

Manual water sampling is the oldest method of obtaining measurements of suspended sediment concentration. "Manual sediment sampling is highly time-consuming and cumbersome but is reliable and accurate and remains a reference (and so used for calibration of other methods) as it is the most widely and often used and allows the determination of the size distribution. The sampling can be done manually (grab sample) or using a pump."[25:1] Sediment is then separated from water and weighed. The total suspended sediment measured in this manner is generally expressed in the units milligrams per liter (mg/l). The Federal Interagency Sedimentation Project provides information on sampling methodologies.[17]

When examining the sediment carried by streams and rivers, the scale of measurement is important. The flux of sediment is more variable in smaller watersheds than in larger ones due to localized, short duration events like landslides or flash floods. "Larger watersheds integrate the stochastic pulses of sediment occurring within their smaller subcatchments and thus dampen the variability of sediment fluxes through reaches that drain large areas."[32:2748] Measurements of turbidity and suspended sediment load naturally vary between creeks, between years, and between seasons. Large fluctuations are expected in smaller creeks due to local events.

There are very few turbidity measurements for streams and rivers in the upper Owyhee subbasin. There are very few measurements of suspended sediment concentration. Measurements have not been collected systematically (such as by week) to provide data on seasonal river changes. These are a data gaps. The contributions of algae and diatoms to the turbidity of upper Owyhee subbasin water is unknown, another data gap.

b. Bed load

The sediment and gravel that move along the bottom of a creek is the bed load. The amount of material that is moved along will be based on the power of the water flowing in a creek and the creek gradient. This means that more of these materials will move during high flow events and far less during low flows. During high flow events the large scale movement of bed sediments can cause scouring.

> "Bed-load transport is even more difficult to estimate in alluvial streams than suspended sediment and poses a particular problem in high-energy bedrock rivers. So far, no sediment-monitoring agencies have been able to devise a standard sampler that can be used without elaborate field calibration or that can be used under a wide range of bedload conditions. The samplers used are giving quite different results depending on river characteristics so a combination of sampling methods should be used."[25:2-3]

The most widespread method for measuring bed load is with traps for the materials that are moving. Portable bed load traps can be installed at riffles to measure the movement of particles larger than 4 mm size.[25] Particles of this size are small gravel. The traps would not measure movement of sediment that is a major concern in discussions of stream characteristics.

Measurements of sediment and gravel moved as bed load are not available for the upper Owyhee subbasin. This is a data gap.

The suspended and bed loads of creeks are moving continually downstream and inevitably cross state boundaries.

Photo 9.12. The stream bed of this intermittent creek in the upper Owyhee subbasin is covered with sediment. This creek would only move sediment in its bed load.

4. Sediments and stream biota

Streams are home to many organisms. The complexity of stream habitats has a positive influence on the diversity of macroinvertebrates and fish that inhabit them.[36,46] Complex habitats have many different types of cover, slow and fast moving water, different stream beds, variation in water temperatures, and variation in aquatic vegetation.

a. Macroinvertebrates

Macroinvertebrate fauna are known to respond to the physical characteristics of streams.[36] The aquatic insects found on stream bottoms are benthic macroinvertebrates. They are important in water quality assessments because they have short life cycles, are generally sedentary, are a primary source of food for fish, and are easy to sample.[21]

Where stream flows change and the type of stream beds are diverse more types of macroinvertebrates can be found. "Species diversity is generally higher in heterogeneous environments, and positive relationships between sediment sorting and taxa diversity have been reported."[36:831] Within a stream the macroinvertebrate populations will vary based upon the location they are sampled. Variation can occur on a small scale. "Species diversity is likely to decline downlink and increase at significant LSSs [Lateral Sediment Sources]"[36:831] The influx of more water and sediment at a tributary, for example, will increase local macroinvertebrate species diversity.

Some macroinvertebrate populations are intolerant of sediment in the creek bed. "Macroinvertebrates (Plecoptera) intolerant to sediment are mostly found where substrate cover is less than 30% (<6mm). More sediment tolerant macroinvertebrates (Plecoptera) are found where the substrate cover is greater than 30% (<6mm)."[22:48] The specific populations that prefer different bed sediment sizes are used in some assessments of aquatic habitat to indicate the type of creek bed.

i. Stream Macroinvertebrate Index

Since sediment can impair creek bed habitat for macroinvertebrates, samples of these populations are used to classify the stream habitats. The stream macroinvertebrate index (SMI) is a measure commonly used in assessments of water quality. The index includes measures of the macroinvertebrate population that are predicted to increase or decrease with increasing perturbation. Measures include richness, composition, pollution tolerance, diversity, feeding group, and habit.[21]

According to the Idaho Department of Environmental Quality (DEQ), "The SMI is a direct biological measure of cold water aquatic life."[21:6-4] The index is based upon measures of the macroinvertebrate populations in streams that are 'unimpaired' within a bioregion. The distribution of index scores, calculated 'unimpaired' macroinvertebrate populations in a given bioregion, is determined. From this distribution, if a population falls below the 10th percentile of the reference collection (the 'unimpaired' macroinvertebrate populations) then it is given a condition rating of 1, and if it falls between the 10th and 25th percentile the rating is 2. Above this the rating of 3 is assigned. According to the Idaho DEQ, this distribution accurately assigned approximately 85% of 'impaired' streams to rating 1 and 90-97% of 'impaired' streams to rating 2.[21]

Unimpaired streams should receive a condition rating of 3, the best. However, the authors of this assessment would like to point out that the way the rating system has been constructed, approximately 25% of the ‘unimpaired’ reference streams would fall into the condition ratings of 1 and 2. The SMI values for some ‘unimpaired’ streams, those below the 25th percentile, overlap numerically with the SMI values of ‘impaired’ streams. Caution must be exercised in the interpretation of the SMI index given that there is a substantial overlap between values for the ‘unimpaired’ and ‘impaired’ streams that were used to establish the condition ratings.

The stream macroinvertebrate index is based upon populations within a specific bioregion.[21] This means that there are various SMI bioregions for Idaho, including the ‘Snake River Basin’ bioregion.

The SMI is used in some assessments to determine if sediment is impairing existing beneficial uses of a creek for fish.[22]

Local baseline data on macroinvertebrate populations in the upper Owyhee subbasin are needed since the SMI is based upon macroinvertebrate populations in healthy local streams. The macroinvertebrate populations in the Owyhee River drainage may be distinct from those in the larger Snake River Basin bioregion. Filling this data gap is imperative if the SMI index is going to be used to classify the health of stream systems. Designation of a stream as ‘impaired’ must be based on a large body of scientific knowledge and accurate assumptions about the natural temperature regimes of streams.

b. Fish

Fish communities are part of complex aquatic ecosystems. The complexity of these systems makes management decisions very complicated. Some elements of these ecosystems include creek structure, cover, temperature, nutrients, suspended sediment, seasonality, depth, velocity, geographic region, other species present, amount of available habitat, temperature refugia, and the life stage of the fish.[46] One major goal in the management of fish habitats is to maintain the productive capacity of these habitats, a goal that requires knowledge of the productive capacity prior to development.[46] This knowledge is a data gap for the upper Owyhee subbasin.

i. Fish known to be in the upper Owyhee subbasin in Idaho

In 1974 a fishery survey was conducted of Big Blue Reservoir on Blue Creek, Little Blue Reservoir on Little Blue Creek, Paine Creek Reservoir on Paine Creek, Juniper Basin Reservoir on Juniper Creek, Squaw Creek Reservoir on Squaw Creek, and Bybee Reservoir on Shoo-fly Creek. The survey was conducted to evaluate the potential of the reservoirs for stocking with game fish. In Big Blue Reservoir they collected suckers, shiners, and squawfish. Upstream they also found sculpins. In Little Blue Reservoir suckers and shiners were gathered. Paine Creek Reservoir had shiners but “was apparently stocked in the 40s and early 50s and produced large trout up to 4 to 6 pounds.” The fish populations of Juniper Basin, Squaw Creek and Bybee Reservoirs were “unknown”.[34]

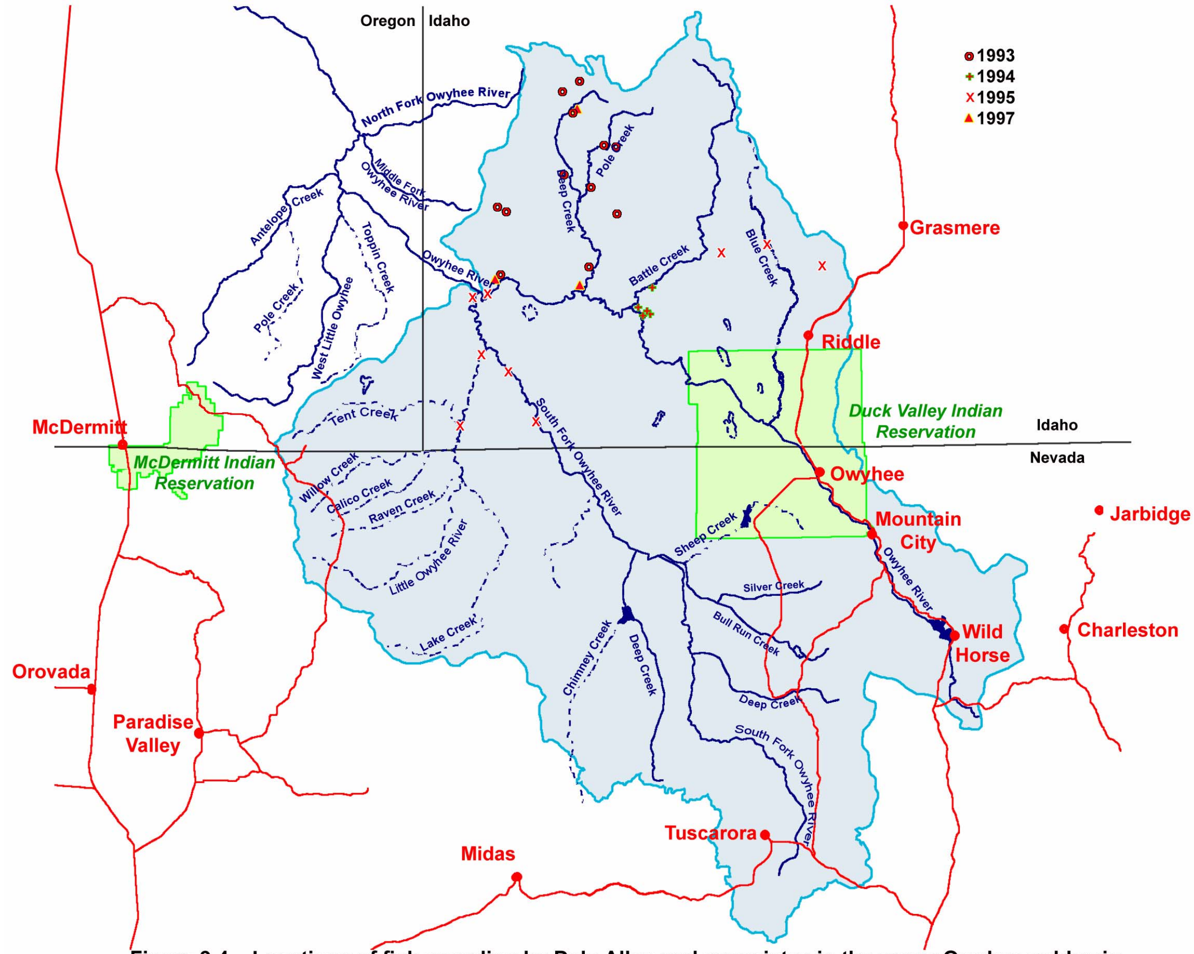

Figure 9.4. Locations of fish sampling by Dale Allen and associates in the upper Owyhee subbasin in Idaho

Surveys for redband trout (*Oncorhynchus mykiss gairdneri*), the only salmonid in the upper Owyhee subbasin, have been conducted by Dale B. Allen and associates on different stream reaches in the upper Owyhee subbasin in Idaho (Figure 9.4). In 1993 stream segments at least 200 feet long were sampled in the Red Canyon Creek and Deep Creek drainages. Redband trout were found in three of the four reaches sampled in the Red Creek drainage. Eight of the nine stream segments in the Deep Creek drainage had no redband trout. The section sampled on Nip and Tuck Creek had a high density of redband compared to other sections sampled both in these drainages and in the Jordan Creek drainage outside the upper Owyhee subbasin. Other fish species collected during the 1993 surveys were longnose dace (*Rhinichthys cataractae*), leopard dace (*Rhinichthys falcatus*), speckled dace (*Rhinichthys osculas*), redside shiner (*Richarsoniuis balteatus*), mountain sucker (*Catostomus platyrhynchus*), chiselmouth (*Acrocheilus alutaceus*), northern squawfish (Ptychocheilus oregonensis), smallmouth bass (*Micropterus dolomieui*), and sculpin species (*Cottus* spp.).[4]

In 1994 surveys were conducted on reaches of Battle Creek and Owyhee River. No redband trout were found in either of these watercourses. Other fish identified in at least one of the sampled stream segments were smallmouth bass, redside shiner, speckled dace, bridgelip sucker (*Ptychocheilus oregonensis*), longnose dace, mottled sculpin (*Cottus bairdi*), chiselmouth, mountain whitefish (*Prosopium williamsoni*) and northern squawfish.[1]

The 1995 fish surveys were conducted on stream reaches of Little Owyhee River, South Fork Owyhee River, Owyhee River, Blue Creek, Little Blue Creek, and Shoofly Creek. The survey for redband trout found no redband in the Little Owyhee River, the South Fork Owyhee River, or the three creeks. In a segment of the Owyhee River just above Crutchers Crossing four redband were found by electrofishing. Other nongame species collected on South Fork Owyhee River and Owyhee River were small mouth bass, bridgelip sucker, longnose dace, northern squawfish, sculpin species and

Photo 9.13. Fish observed at Wiley Ranch along the East Fork of the Owyhee River, July 2010.

largescaled sucker (*Catostomus macrocheilus*). No fish were found in the Little Owyhee River or Shoofly Creek as they were dry.[2]

In 1997 a survey was conducted of the redband trout population at two sites on Deep Creek and one site on Red Canyon Creek. There were no redband at either of the Deep Creek sampling sites. The Red Canyon site contained a low density of redband trout. Other fish species present at the sampling sites were bridgelip sucker, chiselmouth, longnose dace, redside shiner, sculpin species, smallmouth bass, speckled dace, and sucker species.[3]

During July 1997, five biologists floated the Owyhee River for a week. During that time only one redband was collected by angling the river; it was caught just below the confluence with Deep Creek. Redband were observed but not caught or sampled near the mouth of Red Canyon Creek. No other redband were observed. The conclusion of the participants was that “redband trout were almost entirely absent in these reaches of the Owyhee River.” The angling catch consisted of smallmouth bass and northern squawfish.[3]

On the South Fork Owyhee River a study in 1995 found no redband trout. Electrofishing at the 45 Ranch on the South Fork Owyhee in 1999 also found no redband but located smallmouth bass, northern squawfish (pikeminnow), mottled sculpin, and largescaled sucker.[24]

Within the Upper Owyhee HUC, spawning of salmonid species has not been documented. Thus the 2003 TMDL for this area of the upper Owyhee subbasin does not designate spawning as a beneficial use for any water body.[23]

ii. Redband trout in the Snake River and Owyhee River drainages

Meyer and colleagues studied the occurrence of redband trout in waterways of the Snake and Owyhee River drainages.[29] Their work examined the occurrence of redband trout (*Oncorhynchus mykiss gairdneri*) in relationship to environmental factors and stream characteristics at sample locations. They do not provide data on the specific sample locations. This means that the creeks in the Owyhee River drainage are not singled out. The major division in Meyer and colleagues’ study was between desert and montane streams. Data from sites in the upper Owyhee subbasin are included in the group of samples from desert streams south of the Snake River. The majority of studied desert streams sites are in the Owyhee River, Bruneau River, and Salmon Falls Creek drainages. By contrast the montane streams are from north of the Snake River in the drainages of the Boise River, Payette River, Big Wood River, and Weiser River.

The locations sampled for this study were randomly chosen. However, when these locations were visited between late June and early October, samples were only taken if the stream had enough water to support fish life, was less than 25 meters wide (114 ft), and averaged less than 0.7 meters (27 inches) deep.

Redband trout were found in greater densities in desert streams:

> “Of the 615 sites that contained [enough water to support] at least one species of fish, redband trout were found at 384 (62%) of the sites, including 176 (65%) of the 273 study sites in desert streams and 208

> (61%) of the 342 study sites in montane streams. For sites that contained redband trout, mean density was 21 redband trout · 100 m^{-2} (95% CI 17–26) for desert streams and 11 redband trout · 100 m^{-2} (95% CI 10–13) for montane streams."[29:82]

Using the map published with Meyer's study, the authors of this assessment counted at least 20 sample locations on streams within the upper Owyhee subbasin. It is not known if trout were encountered in these locations or not (97 of the surveyed desert creek sites had no trout).

Meyer and colleagues statistically analyzed their large data set. Some of the environmental and stream characteristics of the sampled areas are related to the occurrence of redband trout. In desert streams redband trout were found where there was a greater percent of cobble-boulder stream bed, a lower percentage of fine sediment stream bed, greater amounts of stream shading, lower populations of pikeminnow and smallmouth bass, and greater stream gradient. In montane streams redband trout were found in streams at lower elevations, where there was more stream bed in cobble/boulder sized particles, and in lower gradient steams. Variables that did not contribute statistically to explaining redband trout occurrence in either desert or montane streams included the percent unstable stream banks, density of nonnative trout (not including the hatchery rainbow trout numbers as they were eliminated from analysis), stream width, water conductivity, and the percent gravel sized particles in the stream beds.[29]

Further analysis was conducted to better understand the population density of redband trout where there were redband trout. For desert streams these models can account for 43% of the variation in density based on stream order (smaller streams have more fish), stream shading (more fish in streams with more shading), percentage of cobble/boulder substrate (more fish where there are more cobbles), and either unstable banks (more fish where the banks were less stable) or width:depth ratio of the stream (deeper, narrower creeks have more trout). The best models for montane creeks only explained 17% of the variation in the density of redband trout. This means that the environmental variables and stream characteristics analyzed do not describe why the densities of redband trout vary in mountain creeks.[29]

Water temperature data was recorded at 51 arbitrarily selected study sites over the summer (June-August). In the montane streams, the mean summer water temperatures (<18°C, 64°F) had no relationship to redband trout density. In the desert streams, the mean water temperatures varied between approximately 11 and 22°C (52-72°F) and streams with higher temperatures had lower redband trout population densities.[29] The high maximum water temperatures did not mean there were no trout. Meyer and colleagues "captured redband trout at 6 sites with maximum water temperatures >28 °C and at 2 sites with >30 °C. These results concur with Zoellick's (1999) finding of redband trout in stream reaches with maximum stream temperatures of 29 °C. These temperatures exceed the thermal tolerance reported for other native salmonids that occupy arid climates in the western United States"[29:86] Meyer and colleagues suggest that with higher stream temperatures, some of the trout may move to cooler streams or find pockets of cooler water.

The study "results suggest that, in general, environmental conditions were more suitable for redband trout in desert streams than in montane streams."[29:87] Limiting factors to the range and density of redband trout populations in arid streams include summer stream temperatures and the presence of piscivorous fish. In the case of the latter, it is unknown if the of piscivorous fish (pikeminnow and smallmouth bass) prefer different habitats or if they prey on redband trout.

Meyer and colleagues' work highlights the complex relationships between fish and their environment. Redband trout do not live in all of the desert streams and characteristics of their preferred environments have been given as the factors associated with their occurrence. The authors of this assessment would like to highlight that factors that are related to the occurrence and density of redband trout in desert streams are predominantly natural environmental characteristics. Stream gradient, creek depth to width ratio, percent cobble/boulder substrate, percent fine sediment substrate, and occurrence of native pikeminnow are related to the local geography, type of bed rock under the stream, type of rock being weathered upstream, and native fish species. Meanwhile, the occurrence of smallmouth bass is a product of sport fishing. The other element that enters into preferred habitat locations is stream shading which is a product of the local vegetation and frequency of stream scour.

Meyer and colleagues' study demonstrates that redband trout prefer to live in specific types of natural stream environments and, in their preferred desert stream locations, the population densities are higher than in mountain streams. Whether streams in the upper Owyhee subbasin sampled in the study contained redband trout is unknown.

iii. Stream beds

Stream beds generally have a mix of material of different sizes from fine sediments, like silt, up to boulders. Different fish have different habitat preferences.

Stream bed structure is a factor in the fish that use a creek system. For example:

> "Salmonids have been shown to have a preference for larger and varied substrates, and to avoid sand or other fine substrates. On the other hand, some species, such as prairie river cyprinids or the Eastern sand darter (*Ammocrypta pellucida*), may be most abundant over fine substrates, avoiding gravel and large rocky substrate. Substrate composition has been implicated as a factor in fish growth, varying by species."[46:21]

While the species mentioned in the above quote are not found in the upper Owyhee subbasin, it is important to note that there is no one perfect type of stream bed for all fish. In the upper Owyhee HUC some of the fish species preferences are as follows:

> "The small mouth bass species (*Micropeterus dolomieui*), found throughout the Upper Owyhee River Watershed, require adequate substrate for nest building. This substrate could be sand or gravel. The sucker species found in the area (*Catostomus macrohelus*) prefers gravel

> to rocky substrate. Northern pikeminnow (*Ptychocheilus oregonensis*) uses streams and rivers for spawning activity, but is more of a broadcast spawner than nest builder. Sculpin (*Cottus baird*) are also known to inhabit waters in the Upper Owyhee Watershed. Sculpin prefer clean water and clean gravel for habitat."[22:48-49]

> Different fish live, spawn and feed in different types of stream beds.

- *Sediments on stream beds as a pollutant*

Erosion adds sediments to the rivers. The addition of fine sediments to a stream by human induced erosion can fill in pools and the spaces between cobbles. This changes the stream bed.

The addition of fine sediment to stream beds is seen as a pollutant because of its detrimental effects to fish populations. "Bedload sediment can disturb habitat for macroinvertebrates, fill in interstitial spaces required for spawning and rearing areas, and fill in pools needed for refuge."[22:48]

Sediment in stream beds has been identified as a deterrent to spawning and as a possible limiting factor to populations of salmonids. "Sedimentation has been identified as one possible agent degrading freshwater ecosystems and limiting the persistence and recovery of salmonid populations. High levels of fine sediment (<2 mm diameter) in spawning gravels are correlated with low survival of salmonid eggs and alevins*."[32:2740-2741]

Gravel is discussed as the best stream bed type in many habitat restoration projects and management reports, in large part due to the desire to increase fish spawning habitat:

> "Many valued fish species use gravel for spawning, and therefore the restoration of spawning gravel has frequently been an objective of habitat enhancement projects where gravel is assumed to be limiting. Placement of instream structures may trap gravel and improve spawning habitat, and the addition of large cobble and boulder habitat can increase localized densities of salmon and trout but the effect may be temporary if fines inundate interstitial spaces over time. Demonstration of increased spawning activity in newly created spawning habitat does not necessarily translate to an increase in total egg deposition or adult abundance.[46:22]

Gravels in creeks and rocky areas in lakes are both used more frequently as spawning areas. However this does not necessarily change the population numbers. The creation of new rock areas in lakes, while attracting more fish, shows no apparent change in fish productivity or biomass.[46]

Stream beds low in sediment and high in gravel are necessary for the spawning of some fish species. It is not known what portion of a stream needs to have a gravel bed for fish to spawn in the stream. It is not known whether human activity has

* Alevins are tiny fish carrying a food supply (a sac of egg yolk) attached to their bellies.

increased or decreased the amount of fine sediment in the rivers and streams of the upper Owyhee subbasin.

iv. Suspended sediments in fish habitat

Sediment is considered to be a pollutant because of the haziness that it introduces to the water where fish live. “Suspended sediment can impair sight feeding fish by reducing their capability to find food. It may also aggravate gills and reduce oxygen intake.”[22:48] “Most studies have demonstrated that turbidity levels exceeding 25-30 NTUs will impair aquatic life use by causing reduced fish growth, reduced survival, reduced abundance, respiratory stress, and increased ventilation. Avoidance, reduced energy intake and displacement can occur at turbidity levels of 22 to greater than 200 NTUs.”[22:48] It is not known if human activity in the upper Owyhee subbasin has increased or decreased the NTU of waterways.

5. Sediment data for the upper Owyhee subbasin

TMDL studies of streams and rivers in parts of the upper Owyhee subbasin have identified sediment as a pollutant in some streams and reservoirs within the upper Owyhee subbasin. Sediment measurements have been taken during these studies and these data are summarized below.

a. South Fork Owyhee River

In 1999 a TMDL study was carried out for the South Fork Owyhee River. “Turbidity/suspended sediment samples were taken at eight sites during the May reconnaissance trip. Except for the two sites in Nevada, all turbidity results were below 25 Nephelometric Turbidity Units (NTUs). Suspended sediments results varied from 50 to 77 mg/l in Idaho, to 24 to 75 mg/l in Nevada.”[24:27]

Turbidity measurements below 25 NTUs are favorable because these levels do not impair aquatic life. Yet with less than 10 samples for the South Fork Owyhee River, there is a great data gap:

> “Turbidity information is limited. During a five day monitoring trip on the South Fork Owyhee River, turbidity samples were collected at sites in Nevada and in Idaho. However, due to the limited holding time for turbidity samples, all samples collected exceeded the recommended holding time for submittal to the laboratory. The data is still important, but may be more of an indicator of inorganic material than organic material. The information obtained in May is also important to determine water quality conditions originating from Nevada.”[24:30]
>
> “Obtaining “background” turbidity information may even pose a larger problem. Without long term temporal information, the background levels needed to compare to State of Idaho standards may not be obtainable.”[24:30]

Macroinvertebrate populations were measured in 1999 in the upper Owyhee subbasin at the El Paso Pipeline Crossing and 45 Ranch. Measurements taken in July and August at both locations indicate the abundance and expected species for the type of river.[24] In fact, the El Paso Pipeline Crossing sample from July received the maximum possible score, 23, using the Idaho River Index for macroinvertebrates.

The riparian areas of the South Fork Owyhee River on the 45 Ranch allotment have been assessed. Alongside this, the river channel has been documented. "The upstream segment [of the South Fork] had a greater percentage of channel bottom covered with coarse material (cobbles and gravel) than the lower segment. This may reflect sediment input from the Little Owyhee system that would tend to dump sand and silt into the South Fork during flash floods."[30:10] In discussing the South Fork, Moseley states, "it appears to me that the erosional and depositional processes are in balance. The terraces are actively being degraded to a moderate degree and contribute to the sediment load of the river, including both bed load and suspended load. Bed load deposits are being laterally accreted (minimal vertical accretion) in the deeply entrenched floodplain and are colonized by the sandbar willow communities. Some of the suspended load settles out within the channel below bankfull stage. If it's deposited in slack water or eddies, it creates the fine-textured substrates colonized by the sharp bulrush community. Cattle have virtually no effect on these processes on the 45 Allotment."[30:14-15]

b. Upper Owyhee HUC

According to a 1998 Idaho DEQ report five streams and two reservoirs in the Upper Owyhee HUC within Idaho were polluted by sediment (Table 9.1).[22]

Table 9.1. 1998 DEQ listed water quality limited segments (§303(d) listed streams) in the Upper Owyhee HUC, Idaho. (CWAL = cold water aquatic life, SS = salmonid spawning, PCR = primary contact recreation).[22]

Stream	**Pollutants of Concern**	**Stream Miles**	**Impaired Uses**
Blue Creek Reservoir	Sediment	185 Acres	CWAL, SS
Juniper Basin Reservoir	Sediment	750 Acres	CWAL, SS
Deep Creek	Sediment, Temperature	46.1	CWAL, SS
Pole Creek	Sediment, Temperature, Flow Alteration	24.0	CWAL, SS
Castle Creek	Sediment, Temperature	11.5	CWAL, SS
Battle Creek	Bacteria	62.3	PCR
Shoofly Creek	Bacteria	22.9	PCR
Red Canyon Creek	Sediment, Temperature, Flow Alteration	5.2	CWAL, SS
Nickel Creek	Sediment	2.8	CWAL, SS

These water bodies have been described in the 2003 *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load Owyhee County, Idaho* and the 2004 *Upper Owyhee Watershed TMDL Implementation Plan for Agriculture.*[22,23]

While Sediment has been identified as a pollutant in some creeks, the quantity of sediment in the waters of Deep Creek, Pole Creek, Castle Creek, Red Canyon Creek, and Nickel Creek is not known. It is not known if monitoring of these creeks for the TMDL report included sampling for sediment.

In the following discussion it is important to note that there is a difference between 'designated beneficial uses' and 'existing uses'.

i. Reservoirs

The two reservoirs discussed in the reports have single measurements of sediments. It is not known if measurements were made when livestock were grazing in the allotment. Livestock watering or substantial runoff events can increase the amount of sediment suspended in water.

- *Blue Creek Reservoir*

The Blue Creek Reservoir is used to store irrigation water. "The listed pollutant of concern is sediment. Biological monitoring conducted in 2001 indicated sediment is impairing the biological communities."[22:xviii] The major biological community within the reservoir is stocked fish. "In 2000, the Idaho Department of Fish and Game introduced domestic Kamloops trout in the reservoir. With the stocking of the Kamloops, the reservoir has been determined to have cold water aquatic life as an existing use and criteria to support this existing use therefore applies."[22:xviii] Prior to the introduction of Kamloops trout the designated beneficial uses of the reservoir were listed as water supply, aesthetics, and wildlife habitat. "There is no indication that these uses are impaired."[22:32]

There is one measurement of sediment within Blue Creek Reservoir. On July 7, 2001 the turbidity was measured at 67 NTUs at the reservoir surface (0.5 meters) and 64 NTUs at the reservoir bottom (3.2 meters).[22] At the same time the total suspended solids were measured at 23 mg/l at the surface and 25 mg/l at the bottom. Representative sediment and NTU data is a data gap for this water body.

- *Juniper Basin Reservoir*

"Juniper Basin Reservoir constructed in 1923, was designed as a storage reservoir for irrigation water. It has since fallen into disrepair. The reservoir is mainly used for livestock watering."[22:11] The reservoir has a depth of 2 meters below the outlet (6.5 feet) and 5 meters (16 feet) at full capacity. The sediment on the bottom of the reservoir is fine grained. At present the only agricultural use may be livestock watering as it is unknown if the reservoir release valve is capable of functioning.

"Juniper Basin Reservoir does not have designated beneficial uses except for water supply, aesthetics and wildlife habitat (IDAPA§ 58.01.02140.04.). There is no indication that these uses are impaired. Existing uses include PCR [Primary Contact Recreation] or SCR [Secondary Contact Recreation]. The listed pollutant is sediment. It is not clear how Juniper Basin Reservoir was placed on the 1998 §303(d) list."[22:32]

There is one measurement of sediment within Juniper Basin Reservoir. On July 6, 2001 turbidity was measured at 72 NTUs at the reservoir surface (0.5 meters) and bottom (1.2 meters).[22] Total suspended solids for the same day were 11 mg/l at the surface and 14 mg/l at the bottom of the reservoir.

Although the Idaho DEQ did not find the reservoir in 2003 to have impaired uses, the authors of this assessment noticed that the use of Juniper Basin Reservoir for watering of cattle had resulted in an extreme concentration of cattle around the reservoir in 2010 at the expense of the aesthetic appearance and all other uses.

Photo 9.14. Cattle using the Juniper Basin Reservoir as a water source in July 2010.

ii. Creeks

Sediment has been identified as a pollutant in five creeks within the Upper Owyhee HUC. The suspended sediment concentration and turbidity in these creeks have not been directly measured. The Stream Macroinvertebrate Index was used as an indirect measure of sediment pollution. The SMI rates the health of a creek's macroinvertebrate community in comparison to reference collections from 'unimpaired' creeks. The SMI scores used to designate sediment as a pollutant in these creeks are given in Table 9.2. The dates of the sample collections are not known.

Table 9.2. Stream Macroinvertebrate Index scores for five creeks in the Upper Owyhee HUC between 1995 and 1999. Higher numbers indicate better health of the macroinvertebrate population.[22:34]

Creek	1995	1996	1997	1998	1999
Deep Creek (location 1)	22.33, 24.33	65.82	50.73	60.57	
Deep Creek (location 2)	45.55, 41.78	48.5	46.48	51.46	62.17
Pole Creek					50.55
Castle Creek		34.49, 21.58			
Red Canyon Creek					63.36
Nickel Creek	9.97				

* >58 Condition Rating 3 (best); 49-57 Condition Rating 2; 31-48 Condition Rating 1; <31 Minimum Threshold

The creeks were revisited in 2000 and 2001 for the 2003 Idaho DEQ assessment, "macroinvertebrates and periphyton* samples were collected on those systems listed as being impaired by sediment. Two sets of samples were collected in 2000 and two sets in 2001."[22:49] SMI scores were not calculated. No comparison was made with the macroinvertebrate population data from previous years. Instead, the presence and absence of species known to be tolerant or intolerant to sediment was used as an indirect measure of sediment pollution. In addition a siltation index was calculated. Of the five creeks where sediment was listed as a pollutant, three did not show sediment pollution in the 2000 and 2001 samples. Sediment was not a limiting factor to fish populations in Pole Creek, Red Canyon Creek, or Nickel Creek. Castle Creek and the upper course of Deep Creek were impaired by sediment.[22] While Nickel

* Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems.

Creek did not show signs of sediment pollution, the general lack of macroinvertebrate and periphyton species in the creek (maybe due to metal toxicity), put sediment back on the pollutant list. Data and recommendations from the 2003 assessment were set aside in the subsequent summary report with no explanation. Both Pole Creek and Red Canyon Creek are listed as polluted with sediment in the 2004 report.[23]

iii. Feasibility of addressing the Upper Owyhee HUC TMDL

Resolving the sediment pollution in suspended and bed load of creeks is one goal of the TMDL. Flooding, or high water flow episodes are a major contributor to suspended sediment. During a flood there is more water moving with greater power. This results in greater turbidity and thus more sediment in the running water. Floods also move a greater amount of bed load.

Other factors that influence the amount of sediment within water vary between still and running water bodies.

- *Reservoirs*

As water in reservoirs and lakes tends to be calm, the sediment carried by a stream will settle on the bottom of reservoir or lake. This fine grained sediment can be remixed with the water due to disturbances such as higher than normal water flows, stock watering, or wind.

The Juniper Basin Reservoir is currently used for watering stock. As the majority of the reservoir is shallow the entrance of stock into the reservoir may result in significant disturbance of the lake bed and reintroduction of sediment into suspension. All riparian vegetation around the reservoir has been consumed.

Exclusion of stock from the Juniper Basin Reservoir would limit disturbance of the water and fine sediments on the reservoir bed and would allow the establishment of riparian vegetation. Stock exclusion from reservoirs is a good management practice that can be implemented by the development of off reservoir water sources for stock. Whether stock exclusion will meet the pollution requirements of the TMDL reports is unknown.

The TMDL report from 2003 stated that, "It is not clear how Blue Creek Reservoir was placed on the 1998 §303(d) list."[22:32] However, this placement indicates that sediment was recorded for the reservoir in 1998, prior to stocking of domestic Kamloops trout in 2000.[22] These fish are considered to be at risk from this sediment. The actual sediment pollution and the factors contributing sediment pollution at Blue Creek Reservoir are unknown.

It is unknown how much new sediment is introduced to the reservoirs each year.

- *Creeks*

Some creeks have sediment exceeding that desired for salmonid fish habitat. Limiting human made sources of sediment erosion will limit additional silting in of the creek beds if it is a factor. Improvement of fords should be considered as vehicle traffic and erosion of the road bed can contribute sediment to a creek. The sediment which would occur in the absence of anthropomorphic activities is not open to amelioration.

The fine sediments that are already in creek beds will be best removed naturally by successive high flow events that scour and remove the fine sediments. The speed with which fine sediments are removed is outside of human control.

The majority of the region has not been heavily impacted by humans. Erosion of sediment off of the rangelands and erosion of the stream channels during weather events and high water flows will continue.

Direct measurements of sediment in suspension and on the creek beds are needed to understand some of the natural variation.

Future monitoring of the creeks should include observation and sampling at various locations along the stream as changes in topography and the location of tributaries impact the stream bed's properties. The health of a stream system should be assessed from multiple points of data collection. The lack of this extent of information is a data gap as is the understanding of the stream system which would result from having the information.

Whether the goals for sedimentation of the TMDL can be met is unknown. Stream bank erosion is assumed to be a major contributor of sediment to the creeks and reservoirs with sediment pollution. The TMDL sets limitations on streambank erosion rates.[22] There is no current implemented way to measure streambank erosion rates. Calculating streambank erosion requires measuring the tons of sediment lost per mile per year. Another limitation has been placed on the total sediment load in tons per year. It is unknown how much sediment is actually moving through the creeks each year so it is unknown if the sediment load allocation figures can be met.

6. Sediment standards

a. Idaho

"The state of Idaho utilizes narrative sediment criteria and numeric turbidity criteria to determine if there are violations of WQS [Water Quality Standards]".[22:47]

> "With an absence of a numeric criterion for sediment, some TMDLs in Idaho have set targets for total suspended solids (TSS), suspended sediment and/or substrate embeddedness or percent fines. Once impairment to the beneficial uses has been determined, as described in IDAPA§ 58.01.02.200.08, an interpretation or an extrapolation is made with the use of literature values. These values can either define a water column allocation, substrate targets and/or both."[22:47]

> "Section 250 of the WQS describes applicable turbidity levels. IDAPA§ 58.01.02.250.02.d. states 'Turbidity, below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than fifty (50) Nephelometric Turbidity Units (NTUs) instantaneously or more than twenty-five (25) NTU for more than ten (10) consecutive days.'"[22:47]

Determining the background turbidity level for the WQS requires an area where there are no anthropogenic sources that would affect the water quality. These levels would also be creek specific. The lack of this information is a data gap.

b. TMDL of Upper Owyhee HUC

Limits for suspended sediment concentrations, turbidity, and particle size in the channel beds have been delineated by the EPA for the Idaho portion of the upper Owyhee watershed:

> "A draft Subbasin Assessment and TMDL for the Upper Owyhee Watershed was completed by IDEQ and approved by the EPA in March 2003. Pollution load allocations were included for the 303(d) listed stream segments as well as other non-listed stream segments within the Upper Owyhee Watershed and ranged as follows: 87-100 percent shading for temperature; 50 mg/L monthly average and 80 mg/L durational targets for suspended sediment; 25 NTUs target for reservoirs; 27 percent fine material reduction for channel substrate; and stream bank erosion targets ranging from 3.4 to 43.5 tons/mile/year."[23:9-10]

There are no plans for monitoring sediment in association with the limits set within the TMDL.[23:35-37] The natural background of sediment load and for channel shading are unknown data gaps.

7. Sediment transport

A major data gap is an understanding of how sedimentation of upstream rivers and creeks affects the amount of sediment downstream.

How much of all the sediment transport is accounted for by unusually high flow events?

Will direct measurements of sediments in creeks agree with the conclusion drawn from the populations of macroinvertebrates?

How much of a stream course would naturally have a gravelly bed for fish to find desirable habitat? How do short periods of increased water turbidity (such as those associated with storm and runoff events) affect fish health? Are fish moving between stream segments over the course of the year with fluctuations is water flow, temperature, and bed habitat?

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Upper Owyhee Watershed Assessment

X. Riparian

Contents

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

X. Riparian

A. What is a riparian zone?

A riparian zone is an area that supports vegetation requiring more moisture than the adjacent uplands. In arid and semiarid regions, riparian areas exist in the narrow strip of land along the borders of creeks, rivers, or other bodies of water where surface water influences the surrounding vegetation.[7,18,27,39]

Riparian ecosystems exist between the uplands where there is seldom standing water and the stream, river, or lake where free flowing or standing water is common. They may also exist on intermittent streams where plants have access to the water table. Riparian zones have widely varied hydrology, soil, and vegetation types. There are different interactions between the topography, soil, geology, elevation, hydrology, vegetative cover, evapotranspiration, animal use, and alterations by people. Consequently riparian zones vary considerably and may be difficult to delineate.[7,18,32,38,39]

Because of the proximity of riparian zones to water, the plant species are considerably different from those of the drier surrounding areas. Riparian zones are generally more productive in terms of plant biomass and are a critical source of diversity in rangelands. They create well-defined habitat zones but make up a minor proportion of the overall area in arid-land watersheds. Riparian plant communities are disproportionately important in the upper Owyhee subbasin, but there is "probably less known about them"[7] than other plant communities. Riparian zones represent an extremely significant component of the overall landscape.[7,18,27,32,33] "Wetlands and riparian zones generally cover only a small percentage of the landscape in arid regions, but in the Owyhee Uplands ecoregion the percentage is even smaller than that of the Great Basin. Again, the reason for this is the lack of large playa lakes or internal basins . . . that are often comprised almost solely of alkaline wetlands."[26]

Photo 10.1. A riparian section of vegetation along an intermittent stream coming out of the Independence Mountains.

B. Why are riparian areas important?

The vegetation in riparian areas affects the hydrology of the ecosystem. During high stream flows, water can be stored in the adjacent soil and in ponds, lessening the destructive effects of downstream flooding. The stored water can be a source of groundwater recharge, helping maintain stream flows later into the season.[18,38] Where willows grow along the stream banks, passing water fills the soil profile to the sides of the stream. The water is released slowly back into the stream, helping stabilize the flow in the channel.

Stream banks with well developed riparian vegetation are less prone to erosion. The roots of riparian vegetation stabilize the soil. Water slowed by riparian vegetation has less power to erode the stream bank. Also, slower water will carry less sediment and sediments from floodwaters may be deposited in riparian vegetation.[18]

Riparian vegetation filters water both before and after it reaches a stream, removing sediments and nutrients, providing clean water and building up the soil.[18,32]

Abundant forage, water, and wildlife habitat attract a greater amount of use of riparian zones by wildlife than proportional for their small land area. In addition to providing habitat for fish and wildlife, riparian areas in the upper Owyhee subbasin provide scenic beauty. They are disproportionately important for many other uses. They provide opportunities for hunters, fishermen, and birdwatchers. Recreationists concentrate their use in and along such areas. Riparian zones tend to have relatively gentle topography which makes them attractive locations for roads or housing. Frequently, stream margins are highly productive forage sites. Cattle concentrate in

Photo 10.2. The green of the riparian area along Tent Creek contrasts with the grey-green vegetation of the hillside

riparian areas not only to drink, but because of the shade, relatively gentle topography and vegetation that remains green after upland forage dries.[18,32,33,39,40]

1. Importance to wildlife

The riparian zone is the most important wildlife habitat type in managed rangelands and is used more than any other type of habitat. Of course aquatic species such as fish and amphibians use the water in these zones, but many other semi-aquatic animals, such as waterfowl and muskrats, are found only in riparian zones. Riparian areas are critical to the life cycles of many other wildlife species.[18,33]

Stream side vegetation is also extremely important in the food chain. The organic detritus from the vegetation is a food source for aquatic organisms. The vegetation is an important habitat for terrestrial insects that form part of the diet of many bird and fish species.[18]

In the upper Owyhee subbasin most non-bird wildlife species are directly dependent on riparian zones or use these areas more than other habitats. Wildlife habitat consists of food, cover, and water. Riparian areas offer water. Many riparian zones also provide an unusually large part of forage for big game as well as livestock.[32,33]

Because riparian zones are a transitional zone, there are often several changes in vegetation between the wetland and the land with no subsurface water. This provides a number of different microhabitats so that there is a large diversity of breeding and forage sites. Some of these microhabitats tend to be more humid with more shade. Some wildlife species including deer and elk are attracted by the microclimate produced by the vegetation.[18,33,38]

Every riparian zone has different site attributes, but riparian zones are important to wildlife for many reasons.

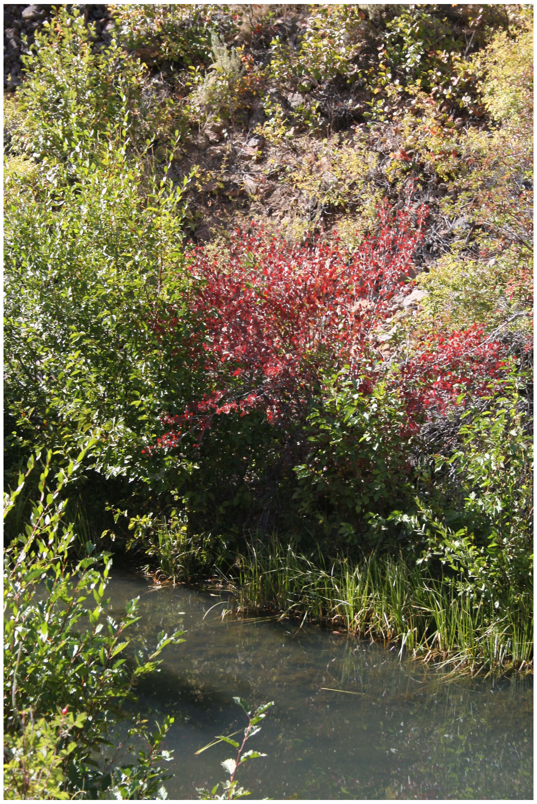

Photo 10.3. Changing types of vegetation in a riparian zone along a small creek in the upper Owyhee subbasin.

C. Vegetation

Riparian plant communities are complex and highly variable in structure, number of species, species composition, productivity, and size. Plant species adapted to the upland may be unable to grow near river channels because they can't tolerate continuously wet soil and similarly species adapted to the river environment usually will not tolerate drier, less frequently flooded sites. Many riparian species must survive complete inundation some years or soil that may dry out completely other years, and sometimes both within the same year. [7,13,32,39]

Stream conditions vary considerably over the course of a year and from year to year. Vegetation in riparian zones is even more variable than streams. There is not only a greater availability of water to plants, but frequently there are deeper soils. This leads to a great diversity of plant species. Riparian communities include many combinations of grasses, forbs, shrubs, and even trees. The density of the vegetation varies considerably.[7,9,13,32,33]

Riparian and wetland natural communities in the Owyhee Uplands are generally assumed to be similar to those present in the Great Basin except that there are few large, high elevation aspen groves and the extent of alkaline wetland habitats is limited.[26]

Photo 10.4. Coyote willows reflected in Hurry Back Creek in the upper Owyhee subbasin.

Willows are the common woody riparian species in the upper Owyhee subbasin. The coyote willow is an upright, deciduous shrub which is generally about 12 feet tall and about 15 feet wide. It grows along creek bottoms, both on the shoreline and sometimes in the water. Coyote willow forms dense thickets of pure, even-aged shrubs. Short-lived, they are threatened by both fire and drought. They can not survive long if the water table becomes too low.[6,5]

Sedges and rushes are common herbaceous riparian species.

These species are well adapted to riparian areas. Numerous growing points and stems allow water to flow over and through a plant. A high density of roots or underground stems (rhizomes) which form a dense mat protect the stream bank from erosion and contribute to steam bank stability during high water.[3,32,38]

The dramatic contrasts between the plant communities of the riparian zone and the general surrounding upland range vegetation adds to the visual appeal.

D. Proper functioning

A properly functioning riparian area will have adequate vegetation to filter sediment, to stabilize the stream bank, to protect the stream bank from erosion, to store and release water, and to recharge the aquifer. A properly functioning riparian area along a perennial stream would result in some of the following characteristics: late summer stream flows, high forage production, good water quality, and vegetation and roots that protect and stabilize the banks. It could provide shade, cooler water, good fish habitat, and a high diversity of wildlife habitats.[2,15,27] In order to determine whether a riparian area is functioning properly, it is necessary to examine site-specific characteristics. The potential vegetation for that spot is based on the interaction of geology, soil, and the physical processes and attributes of the stream.[4,25]

E. Historical use

Some of the earliest use of riparian areas in the upper Owyhee subbasin by Euro-Americans was for wintering cattle. Since the cattle remained close to the existing water supplies, they would completely consume the nearby forage, mainly winterfat, and Indian ricegrass. In the dry upper Owyhee basin, the wetter riparian areas were the first areas farmed, mostly for hay. In 1901 north of Winnemucca, David Griffiths listed alkali bullrush, cattail tine, and spike rush which grow in freshwater marshes and seasonal lakes as important hay species. The floodplains adjacent to creeks were the first areas used to plant hay and other domestic plants.[10,41]

Photo 10.5. The Wiley Ranch on the Owyhee River. Counterclockwise from upper left: the site looking towards the river, the old farm house, the Owyhee River, abundant riparian vegetation.

To provide enough water and irrigable land to grow hay to feed their herd through the winter, ranchers acquired tracts of private property. During the summer the herds drank from streams and springs on the public lands where they were grazing, but established water rights were crucial for the success of a ranch.[31,11] Since the riparian areas were the most productive lands, they were used for farming and ranching. Irrigated lands are usually located within the historic floodplains of stream and river corridors which expanded the riparian areas.[11] Meadows were enlarged on private land by diverting water by gravity flow along the lateral edges of the floodplains and using surface irrigation.[41] Today it is difficult to distinguish natural wetlands and pastures from the areas that have been continually expanded through human intervention.

In the Nevada section of the upper Owyhee subbasin, the agricultural lands have been irrigated from the streams running out of the Independence and Bull Run mountains. The channelization and spread of irrigation water has largely transformed the native riparian areas in the few agricultural areas (see Agriculture section of this assessment).

In the upper Owyhee subbasin in Idaho, only 4% of the area is riparian. The historical acquisition of waterways and associated riparian areas in this section of the subbasin is evidenced by 18% of the stream miles being on private land although only 6.5% of the land is privately held. Some of the old wet meadow riparian areas have been converted to irrigated pasture or hay fields.[12,11] "All privately owned stream segments assessed during the 2003 [Idaho TMDL] Riparian Assessment . . . still have active riparian livestock grazing."[12]

F. Fragility

Since riparian zones occupy relatively small areas, they should be considered vulnerable to severe alteration. The distinctive vegetative community is important to the ecology of the whole region. There are many activities that can impact riparian areas.[2,33,39]

Indiscriminate recreational use can seriously disturb or destroy habitat in riparian zones. In riparian zones, recreational use per unit area is many times that for other vegetative communities. Campgrounds in riparian zones increase the opportunity for viewing wildlife but decrease the effectiveness of the riparian zone as wildlife habitat due to the "disturbance by humans, trampling, soil erosion, compaction, and loss of vegetation."[2,33]

The increased presence of vehicles and people on existing roads along riparian zones affects how wildlife use the area. New road construction in riparian zones would alter the size of the zone and of the vegetative community. It may impact water quality and alter the microclimate, destroying wildlife habitat. Road maintenance can disturb riparian areas.[2,33]

The U.S. Forest Service has identified the major factors affecting riparian areas in the Owyhee River basin as livestock grazing, floods, and dams.[39] There are some areas of the upper Owyhee subbasin where livestock grazing continues to affect riparian areas. Continuous or intensive grazing of riparian zones may alter vegetation with a reduction in plant productivity, a change in the plant community, or the encroachment of dry land vegetation. The change may result in a lack of adequate vegetation for bank protection and sediment filtering. The resulting erosion may lower the streambed and change the adjacent water table. Cattle in an eroded streambed may create further bank erosion with "hoof shear".[2,7,33,38]

Management actions such as fire suppression may also alter riparian areas.[38]

G. Riparian areas in the upper Owyhee subbasin

Photo 10.6 Hoof shear beginning to affect a stream bank.

Since riparian areas only exist where there is some connection to the water table, these will primarily be along perennial streams (see Figure 5.13 in the hydrology component of this assessment). Some intermittent streams may also have riparian areas. However, the majority of the non-perennial stream reaches in the upper Owyhee subbasin have not been evaluated as to whether they are ephemeral or intermittent.

Sagebrush dies when flooded. Sagebrush does not tolerate saturated soil, and if the soil stays saturated for two weeks, the sagebrush dies. Spreading water across sagebrush land for two weeks is a well known method of sagebrush control, since the root systems die from lack of aeration.[24] Stream channels that have well developed sagebrush growing directly in the bottom of the wash are not connected to the water table and are ephemeral and will not support riparian vegetation. However, sagebrush seedlings can germinate and begin growing where they can't survive subsequent flooding.

1. Landsat imagery

Using Landsat data, maps have been developed showing the probable plant associations in the upper Owyhee subbasin. Sensors aboard the Landsat satellites measure both visible and infrared wavelengths coming from small sections of the earth. The resolution of the pictures generated from these measurements is about 30 meters (98 feet) by 30 meters.[34] Details smaller than 30m by 30m will not be apparent. The Gap Analysis Program is designed to map vegetation using the Landsat spectral bands. The upper Owyhee subbasin lies within two of the completed projects: the Northwest Regional Gap project and the Southwest Regional Gap Analysis projects completed in 2004 and 2007. In the rangeland section of this assessment on Figure 7.1, plant associations mapped by the Northwest Regional Gap project and the Southwest Regional Gap project, it is possible to locate the course of many of the perennial streams and rivers in the upper Owyhee subbasin by the light green coloration indicating *intermountain basins semi-desert grassland* plant associations (Figure 7.2). "These grasslands occur in lowland and upland areas and may occupy swales, playas, mesa tops, plateau parks, alluvial flats, and plains, but sites are typically xeric [dry]."[22] A similar, but slightly more olive, green denotes mesic [with a well-balanced supply of moisture] meadows in the mountainous area.

The blue-green adjacent to the drier *intermountain basins semi-desert grassland* plant associations is the *Great Basin foothill and lower montane riparian woodland and shrubland* plant association which also exists along streams in the mountains*. The plant association designated by a slightly darker blue green is called *Columbia Basin riparian woodland and shrubland*. Other riparian and wetland plant associations in the upper Owyhee subbasin are less widely spread. Streams draining into the basin from South Mountain and a number of the intermittent streams draining into the Little Owyhee River from the east side of Capitol Peak have *Rocky Mountain lower-montane riparian woodland and shrubland, Rocky Mountain subalpine-montane riparian shrubland* or *Rocky Mountain subalpine-montane riparian woodland* plant associations along their banks, indicated by the turquoise areas.[19,22,35,36,20] Descriptions of these riparian plant associations are found in Appendix J.

There are also plant associations of wetlands or seasonal wetlands identified by Landsat analysis in the subbasin. These include *Columbia Plateau silver sagebrush seasonally flooded shrub-steppe*, *North American arid west emergent marsh*, *Rocky Mountain subalpine-montane mesic meadow*, *Rocky Mountain subalpine mesic meadow*, and *Rocky Mountain alpine-montane wet meadow* (Appendix J).[19,22,35,36,20]

2. 45 Ranch

The Gap analysis project provides a broad description of the probable vegetation of an area. A more detailed classification system has been adopted by the Environmental Protection Agency and the US Geological Survey (USGS) and focuses on existing vegetation actually growing at a site. The lowest level in this classification system, the National Vegetation Classification System, is delineated by the association of two or more species and called a community.[37,Rangeland component]

The only extensive survey of riparian plant communities in the upper Owyhee subbasin was conducted by the Nature Conservancy on the 45 Ranch and the associated BLM allotment. The Nature Conservancy's survey showed riparian communities existed along the floodplains of the South Fork Owyhee River and the Little Owyhee River, in the spring systems of the canyons, and in intermittent lakes and creeks. In addition to the riparian communities in and along the perennial and intermittent streams, the terrace communities were also assessed. Although the reports of the inventory and assessment are specific to a particular location, to a certain extent the results summarized below can serve as an indication of the types of riparian vegetation which might be found in other areas of the plateau lands of the upper Owyhee subbasin. The South Fork Owyhee River may be considered representative of deeply incised perennial streams, the Little Owyhee River of intermittent streams, and the intermittent lakes and pools of similar pools throughout the plateau region.

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* Although montane means inhabiting mountain areas, the area specifically referred to as *montane* “is the highland area located below the subalpine zone. Montane regions generally have cooler temperatures and often have higher rainfall than the adjacent lowland regions, and are frequently home to distinct communities of plants and animals.”[16]

The assessment identified 275 riparian species (Appendix E) and 21 riparian and wetland plant communities (Table 10.1).[17] Plant communities are named by the dominant specie found within them and a forward slash (/) separates this from a specie in a different tree, shrub, or plant group.[21]

Table 10.1. Riparian and terrace plant communities identified on the 45 allotment.[17]

Common name	Scientific name	Principal location
Woodlands		
Western juniper/California oatgrass	*Juniperus occidentalis/Danthonia californica*	Intermittent creek
Tall Shrub		
Sandbar willow*/Barren	*Salix exigua/*Barren	South Fork
Sandbar willow*/Mesic graminoid	*Salix exigua/*Mesic graminoid	South Fork
Low Shrub		
Silver sagebrush/Dry graminoid	*Artemisia cana/*Dry graminoid	Little Owyhee, intermittent creek
Silver sagebrush/Mat muhly	*Artemisia cana/Muhlenbergia richardsonis*	Intermittent lake
Owyhee sagebrush shrubland comm.	*Artemisia papposa* shrubland comm.	Intermittent creek
Graminoid		
Nebraska sedge	*Carex nebrascensis*	Intermittent creek
California oatgrass	*Danthonia californica*	Intermittent creek
Creeping spike-rush - vernal pool	*Eleocharis palustris* (vernal pool)	Intermittent lake
Creeping spike-rush - palustrine	*Eleocharis palustris* (palustrine)	Little Owyhee
Wandering spike-rush	*Eleocharis rostellata*	South Fork, intermittent creek
Baltic rush	*Juncus balticus*	Little Owyhee, intermittent creek
Common reed	*Phragmites australis*	South Fork, intermittent lake
Threesquare bulrush	*Scirpus americanus*	South Fork
Sharp bulrush	*Scirpus pungens*	South Fork
Forb		
Prairie sage	*Artemisia ludoviciana*	Little Owyhee, intermittent lake
Cut-leaved water-parsnip	*Berula erecta*	Intermittent creek
Davis peppergrass vernal pool	*Lepidium davisii* vernal pool community	Intermittent lake
Transition zone communities		
Smooth scouring rush	*Equisetum laevigatum*	
Smooth brome	*Bromus inermis*	
Non-riparian river terrace communities		
Basin big sagebrush/basin wildrye	*Artemisia tridentata* ssp. *tridentata/Elymus cinereus*	South Fork terrace
Greasewood/Sandberg bluegrass	*Sarcobatus vermiculatus/Poa secunda*	South Fork terrace
Basin big sagebrush/needle-and -thread grass	*Artemisia tridentata* ssp. *tridentata/Stipa comata*	South Fork terrace
Wyoming big sagebrush/Thurber's needlegrass	*Artemisia tridentata* ssp. *wyomingensis/Stipa thurberiana*	South Fork terrace

* Sandbar willow is also commonly called Coyote willow

a. South Fork Owyhee River

The plant communities occurring in the floodplain of the South Fork Owyhee River were not diverse and were very different from those on the adjacent stream terraces. The principal communities were identified: Sharp bulrush (*Scirpus pungens*) which tolerates prolonged flooding but has poor palatability for big game and livestock; Common reed (*Phragmites australis*), a tall perennial stand which floods annually; and Sandbar or Coyote willow (*Salix exigua*) communities containing the only woody species with significant cover in the floodplain.[17]

Photo 10.7. The Owyhee River on the 45 Ranch.

The assessment concludes that the "riparian vegetation of the South Fork floodway [sic] is represented by communities in high ecological condition. The sharp bulrush community, especially, armors most of the river banks along the South Fork. The maintenance and condition of these communities is more affected by the larger fluvial (river) processes of the watershed than by local livestock grazing."[17] "Most of the South Fork's flow originates in the mountains of Nevada, where snow accumulates in the winter. This snow accumulation zone constitutes a small percentage of the South Fork basin, however, with most of it being arid lowlands of the plains. There is virtually no snowpack on the plains and streams tend to be intermittent and ephemeral, largely flowing during winter and spring and in summer only during storms. This makes for a very flashy hydrologic regime where the river rises rapidly and dramatically in response to spring snow melt patterns and episodic storm events, quickly returning to near base flow."[17]

Between the floodplain communities and the terrace communities there is a narrow transition zone on the river banks with species which may withstand at least some flooding. The Smooth scouring rush (*Equisetum laevigatum*) and Smooth brome (*Bromus inermis*) appear to stabilize steep banks during floods. [17]

Considered by the assessment to be important and unique, the "river terrace communities never flood and are marginally riparian, but their distribution is restricted to valley bottoms along the South Fork and Little Owyhee rivers because of alluvial substrates and higher water table than surrounding uplands."[17] "On the 45 Allotment nearly all terraces support the basin big sagebrush/basin wildrye plant community."[17]

The Basin big sagebrush/basin wildrye (*Artemisia tridentata* ssp. *tridentata/Elymus cinereus*) plant community, with few exceptions, occupies all of the terraces along the South Fork Owyhee River. Greasewood/Sandberg bluegrass *(Sarcobatus vermiculatus/Poa secunda*) community was observed on a few terraces. On slightly higher terrace surfaces there were upland communities of Basin big sagebrush/needle-and-thread grass (*Artemisia tridentata* ssp. *tridentata*/*Stipa comata*) and Wyoming big sagebrush/Thurber's needlegrass (*Artemisia tridentata* ssp. wyomingensis/*Stipa thurberiana*).[17]

The assessment concluded that 57 percent of the terraces were in good to excellent condition. The "concentration of high quality examples of the basin big sagebrush/basin wildrye community is the greatest of anywhere in Idaho."[17]

b. Little Owyhee River

The Little Owyhee River is intermittent, probably flowing only during spring runoff and summer storm events. The large size of the drainage area into the Little Owyhee River is unusual for an intermittent stream. There are some perennially wet habitats in the floodplain although the surface flow is intermittent. There are open-water pools in the channel with aquatic species growing in them. The floodplain riparian communities are quite varied. [17]

The last flood event my have scoured the floodplain surface and deposited a new layer of sand, gravel or cobble. The gravel and cobble deposits are mostly devoid of plants. However, new sand deposits may contain a suite of annual plants if the deposits remain moist. "Where the water table is at or near the surface, the channel can be dominated by lush graminoid wetland communities"[17] (Table 10.1). Sharp bulrush and willow species are less common than on the South Fork Owyhee River. The willow occur in the channel or along its edge. The high cobble bars in the middle of the channel are covered by prairie sage and a high diversity of associated species. Silver sagebrush can dominate small bars on the edge of the dry channel. At high flows, this silver sage/dry graminoid community is clearly under water, probably for only short periods of time.[17]

The terrace plant communities were similar to those along the South Fork with basin big sagebrush/basin wildrye community types and greasewood. However, the perennial understory species were uniformly replaced by exotic annuals “as a legacy of past livestock grazing.”[17] "The big terraces along the lower Little Owyhee are easily accessible and have been grazed hard since settlement."[17]

c. Canyon spring systems

Although numerous, all of the canyon spring systems are small. Most of them are isolated sources of perennial water. The associated riparian habitats of the springs contain very different riparian plant communities.[17]

d. Intermittent lakes and creeks

On the upper Owyhee subbasin plateau there are both intermittent creeks and internally drained basins that have an intermittent lake or small pool at the lowest point. Across the subbasin these intermittent creeks, natural lakes and pools are widespread.

Vegetation in these habitats is different than that in the surrounding uplands. Although they have water in them only part of the year and sometimes not every year, they are influenced by high water tables or standing or flowing water. "Little is known about the succession, disturbance, and management of these communities."[17]

i. Intermittent pools

The intermittent wetland basins, locally called playas, are defined by Keeley and Zedler as vernal pools. They "define vernal pools as precipitation-filled seasonal wetlands inundated during periods when temperature is sufficient for plant growth, followed by a brief waterlogged-terrestrial stage and culminating in extreme desiccating soil conditions of extended duration."[14] In the 45 allotment the basin areas vary in size from a few acres to several hundred acres. The principal plant communities of the intermittent lakes and pools of the allotment are silver sagebrush/matmuhly (*Artemisia cana/Muhlenbergia richardsonis*), creeping spike-rush - vernal pool (*Eleocharis palustris*), and Davis peppergrass vernal pool (*Lepidium davisii*). In small pools Davis peppergrass is often the only plant.[17]

ii. Intermittent creeks

Although the Little Owyhee River is intermittent and shares some of the same communities as intermittent creeks, its size makes it a special case. Within the 45 allotment there were five community types on the intermittent creeks. Prairie sage (*Artemisia ludoviciana*) communities were common in intermittent drainages and along the Little Owyhee. Silver sagebrush/dry graminoid community was also found along the Little Owyhee. California oatgrass communities are common in the Owyhee uplands. However, both the Western juniper/California oatgrass *(Juniperus occidentalis/Danthonia californicus*) and Owyhee sagebrush (*Artemisia papposa*) communities were uncommon in the 45 allotment.[17]

e. Weeds

Although 17 percent of the riparian flora consisted of non-native species, only four of the 48 non-native plants were deemed to be of concern by the author of the 45 Ranch assessment. White-top was widespread, usually in the transition zone between the wetter floodplain and the drier terrace, frequently on the upper edge of river banks. Canada thistle and Scotch thistle were growing in small patches of the terraces. There were five mature tamarisk (*Tamarix* sp.) plants mapped along the South Fork Owyhee River floodplain.[17]

Although there were no new plants of tamarisk (salt-cedar) observed, the authors of this upper Owyhee watershed assessment consider this to be a major potential threat to riparian areas. Tamarisk is known to replace native vegetation, use prolific amounts of water and dry out riparian areas. It has a habit of mining salts from the soil profile and exuding them on the surrounding soil, rendering those areas unable to support plant species that cannot tolerate saline conditions. Salt cedar is at or near the top of the list of noxious invasive weeds for all agencies. There is a high probability that established salt cedar will limit the ground flow of water to an extent that it may affect fish and wildlife. Tamarisk has very prolific seed production and can out compete native riparian trees and shrubs. [1,27,23]

H. Invasive species.

Tamarisk (or salt cedar) is a major potential invasive species of riparian areas in the upper Owyhee subbasin (Figure 7.3). A single tamarisk plant can use up to 200 gallons per day of water in the summer time. Tamarisk has very prolific seed production, grows very rapidly, and sends roots down deep. It provides very poor stream bank stabilization and erosion control.[23,30,28]

Tamarisk could be controlled today, but it is poised to replace native riparian vegetation. There is a high probability that expanded salt cedar could limit the flow of ground water which will obviously affect water for wildlife and push some species toward extinctions.[23,28] Insects which rely on vegetation which has been replaced by tamarisk will disappear and species which feed off the insects will lose a food source. Larger wildlife which frequent the wetter spots of intermittent streams to obtain water may be pushed out of the habitat due to lack of water availability.

Other invasive species in the upper Owyhee subbasin which adversely affect riparian areas include perennial pepperweed, white top, poison hemlock, houndstongue, and purple loosestrife (see invasive species discussion in the rangeland component of this assessment).

I. Upper Owyhee Agricultural TMDL

The 2003 *Upper Owyhee Watershed TMDL Implementation Plan for Agriculture* assesses riparian zones in the Idaho section of the upper Owyhee subbasin. The authors, the Idaho Soil Conservation Commission (ISCC) and the Idaho Association of Soil Conservation Districts (IASCD), determined that many best management practices (BMPs) "have already been established by producers within the watershed. The BMPs included watering facilities developed away from streams (watering troughs and tanks), spring development, heavy use area protection, fencing, and prescribed grazing (shorter duration grazing and moving livestock to prevent overgrazing). With proper installation and maintenance these BMPs can improve water quality and help restore stream function. Most of the riparian areas that were evaluated during the 2003 Upper Owyhee Riparian Assessment displayed an upward trend. This indicates that existing BMPs have already provided water quality improvements on the stream segments with TMDL targets within privately owned parcels."[12]

"According to some ranchers in the area, there has already been a change in grazing duration. This has greatly improved stream channel condition and riparian health along several stream reaches. The primary reason to reduce duration and adjust timing is to increase and protect riparian vegetation. Allowing new vegetation growth each year will create multiple age classes, which increases both the quantity and quality of stabilizers along the stream bank and ensures long-term bank stability."[12]

All of the areas assessed by the ISCC and IASCD were riparian areas on privately owned stream reaches (Figure 10.1). The assessment determined that there were several privately owned parcels with riparian areas that needed site-specific changes, primarily in grazing management. The authors felt that these improvements could be made without "the use of structural components such as fencing; however, additional pasture fencing and water developments in these areas would certainly make it easier to control livestock distribution and grazing intensity."[12]

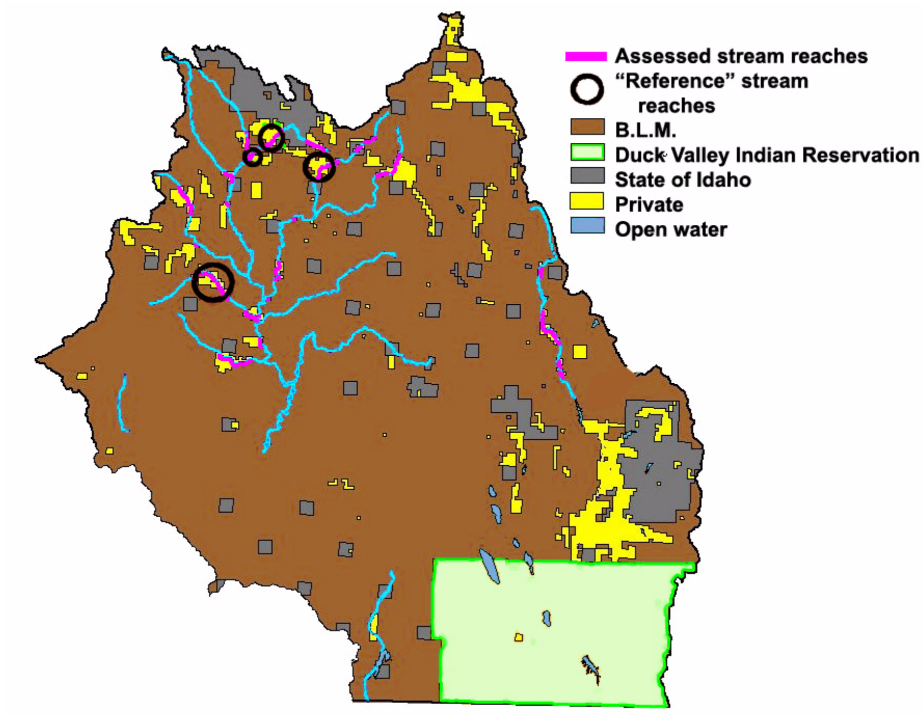

Figure 10.1. Riparian areas of stream reaches assessed in the Idaho section of the upper Owyhee subbasin.[12]

The base materials of the stream channels next to the majority of the riparian areas surveyed by the ISCC and IASCD consisted mostly of gravel, sand, and silt. These channels had an average slope (gradient) of 0.7% with the largest gradient being 2.1%. The channels are important to the development of riparian vegetation since the "upland areas above streams have minimal impact on riparian function and stream conditions. The upland area begins at the outside edge of the riparian area along a stream and continues upward to the subwatershed boundary. There was little evidence of excessive erosion or deposition within stream channels from upland areas within each of the evaluated subwatersheds. The primary sources of erosion and deposition are within the stream channel and riparian areas themselves."[12]

The ISCC and IASCD assessment rated the "outward floodplain development" as adequate on 73% of the stream reaches assessed. However, the "inward floodplain development" into the stream channel was rated as adequate in only 15% of the assessed stream segments. A trapezoidal stream channel was considered to indicate adequate inward floodplain development while a dish shaped channel indicated needed improvements in inward floodplain development.[12]

The assessment found that certain stream reaches of Camas Creek, Castle Creek, Deep Creek and Pole Creek represented "potential riparian stability, vegetation health, and diversity within the stream." These streams were deemed to be "reference" streams for the subbasin with good to excellent riparian conditions (Figure 10.1). All of these stream reaches are near the headwaters of the respective creeks. Considering the diversity of geological, hydrological and physical aspects of riparian zones, these stream reaches may not be representative of what can be achieved elsewhere in the subbasin, especially downstream where streams may be highly confined or subject to great natural fluctuations in high and low flows.

J. Discussion

The management of riparian areas is a vital environmental and economic issue. Although riparian zones in the upper Owyhee watershed are extremely limited, there are many different groups who feel the areas should be managed in different fashions and this poses the potential for conflicts. Riparian resources are utilized by livestock, wildlife, fish, vegetation, invertebrate animals, river rafters, hunters, fishermen, hikers, campers, boaters, birdwatchers, homesteaders and others. As a result, riparian zones are critical zones for multiple-use planning.

Some riparian areas are obviously not subject to management such as those in deep canyons inaccessible except by boat.

All ecosystems are dynamic and change over time. Riparian systems are probably more dynamic than the surrounding uplands.[32] Planning for riparian zones needs to consider their dynamic nature and attempt to maintain them as fully functioning ecosystems.[18] These ecosystems will vary from what they were during other climatic periods, from what they were before the Spanish introduced horses to the new world, and from what they were at the turn of the 19th century or the turn of the 20th century. There is no going back to some "pristine condition." Invasive species have affected riparian zones. Recreational use of riparian areas in the upper Owyhee subbasin is increasing as the urban population in the western United States grows.

Photo 10.8. Riparian areas along an inaccessible stretch of the Owyhee River.

It is extremely important to consider all uses of riparian zones. No one use is inherently detrimental or beneficial.

Cattle grazing is sometimes cited as a primary negative factor in riparian areas. Although many riparian areas in the United States were mismanaged and degraded by improper livestock grazing, modern livestock grazing practices are substantially different from those of early in the last century. The negative effects of grazing can be minimized or eliminated with proper management.[18,33,40,15,8]

Management decisions about livestock grazing need to be made on a case by case basis since there are site factors that change from one riparian community to another. Techniques that attract livestock away from riparian areas, that promote avoidance of riparian areas, or that exclude livestock from riparian areas can all diminish the impact of grazing in one location. Grazing systems may also limit the duration or time of year when livestock graze in or near a riparian area. With livestock exclusion, consideration must also be given to the effect on wildlife.[7,15,33,40,15,8]

Water developments for livestock away from riparian areas may also benefit wildlife. Proper placement and design of water impoundments can create new wildlife habitat as well as providing water for cattle. "Small, wet meadows can also be created by piping overflow water from livestock troughs into fenced areas thereby creating and maintaining such meadows."[33]

Because of the greater moisture in riparian areas and generally a deeper soil, riparian zones generally have a high rate of recovery of vegetation when they are appropriately managed and protected.

K. Unknowns

How will the expansion of tamarisk into many of the riparian areas of the upper Owyhee subbasin affect the hydrology and vegetation of the area? How would the hydrology and vegetative changes affect wildlife? Will public agencies respond before drastic losses occur?

Not all the riparian areas in the upper Owyhee subbasin have been identified or characterized. In the upper Owyhee subbasin, the potential of riparian areas based on physical, biological, and chemical conditions is not known. The site specific physical, biological, and chemical conditions of riparian areas have not been surveyed. Due to the variability in factors influencing riparian zones and the resulting diversity, a small sample can not necessarily be taken as representative of the whole.

The relative impacts of different uses of riparian areas in the upper Owyhee subbasin are not known. What impacts are river rafters having on riparian areas? There are limited camping areas along the Owyhee River rafting corridor and these tend to be in riparian areas.

What are the actual impacts of livestock on riparian areas? What reaches are not affected and what reaches are affected? An inventory of heavily impacted riparian sites or reaches has not been made. Information on how grazing systems may be used to accomplish such goals as maintenance of woody stream bank vegetation and the prevention of bank crumbling and soil compaction is being developed by experience and research.[33] The management that will result in maintaining, restoring, improving, or expanding riparian areas in the upper Owyhee subbasin is poorly defined.

Information on the site potential for riparian vegetation is lacking.[12] "Studies have shown [that following restoration activities] the improvement to stream morphology, riparian conditions, streambank stability and stream hyporheic conditions may take anywhere from 20 to 100 years."[12]

What are the cultural resources of riparian zones? The same attributes that lead to a high intensity of modern use in riparian zones have been present for millennia. A greater number of archaeological sites have been reported near water sources than in adjacent uplands.[29] These areas should also have sites of historical significance. River terraces are nice places to live. Where are these sites and which, if any, of them should be protected or preserved.

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Upper Owyhee Watershed Assessment

XI. Watershed Condition Evaluation

Contents

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

XI. Watershed condition evaluation

To evaluate the condition of the upper Owyhee subbasin, it is necessary to look at all of the interacting factors within the ecosystem. The subbasin has changed since the first Native Americans took up residence here at least 13,000 years ago. There have been changes in climate, changes in population densities, and changes in the effects of humans on the ecosystem.

Native American inhabitants of the region modified the environment. The pre-European land use practices affected the abundance of game and promoted the propagation of economically important plant species. With the arrival of Euro-Americans and with advances in technology, the types of modifications to the environment have changed and are continuing to change. These more recent modifications can be considered both beneficial and harmful.

Ecosystems are dynamic. The ecosystems of the upper Owyhee subbasin have changed from what they were before the Spanish introduced horses and European diseases to the western hemisphere. They have changed from what they were at the time of Euro-American contact, and they have changed from what they were at the turn of the last century.

Some things have remained relatively constant over the last two hundred years. The upper Owyhee subbasin is still an arid to semi-arid desert with little water and less runoff. The land is geologically very young so soils are not well developed. The combination of poor or nonexistent soils with a lack of water has meant that the human population of the area has remained low.

The tremendous geological and erosive forces which shaped the landscape in the more distant past have been relatively inactive in the recent past. Unchanged by bulldozers and subdivisions, the natural beauty of the landscape has not been spoiled.

A. Evaluation of watershed condition

The upper Owyhee subbasin occupies a large, sparsely populated area. There is a paucity of data about many aspects of the region, both as it may have existed before Euro-American entry into the region and as it exists now. Many of the unknowns, or data gaps, have been enumerated in the other sections of this assessment.

There are some conclusions which can be made from the data which is available.

The upper Owyhee subbasin has complex geography. It varies in elevation from 4,800 feet to over 10,000 feet. The parent materials are from widely different geological origins. There is a resulting diversity across the subbasin in local hydrology, native vegetation, land use, and other characteristics.

A landscape that was devoid of trees except in the Bull Run and Independence Mountains at the time of Euro-American contact now has trees growing along parts of many of the streams and rivers.

Large game, extremely scarce at the time of Euro-American contact, now roam the Owyhee uplands.

Over grazing in the late 1800s and early 1900s left broad expanses of rangeland largely denuded and unprotected from erosive events. Grazing management has led to renewed vegetative cover on most of these rangelands.

Hundreds of species of native plants still grow in the upper Owyhee subbasin. Native animal species can be observed in all areas.

Water developments throughout the subbasin have increased the availability of water to both livestock and wildlife.

The potential expansion of tamarisk poses one of the greatest threats to the continued availability of water originating within the upper Owyhee subbasin. This would affect wildlife, riparian areas, and downstream uses. Additional weed species and juniper are poised to expand within the watershed.

Further off-stream water developments are needed to remove livestock from some riparian areas during times when the riparian vegetation would be sensitive to grazing pressure.

The expansion of agriculture on the western side of the Bull Run and Independence Mountains in Nevada has led to the channelization of streams in the area, including long reaches of Bull Run Creek.

B. Discussion

We cannot know what the condition of the watershed would be in the absence of humans. The geology and climate affecting the area would be little different, although even the climate may be changing due to the activities of people elsewhere in the world.

1. Invasive species

In comparison with other areas of the Owyhee watershed, the upper Owyhee subbasin has a lower incidence of invasive species.

Evolution occurs slowly over time. The native plant stands of the rangelands and riparian areas in the upper Owyhee subbasin evolved with grazing pressure,[1] without nonnative invasive species, and with periodic fires. Now there are invasive species, a low fire frequency, and in some areas the absence of grazing. Native plants are not adapted to compete well under the changed conditions.

Major efforts are needed to halt and reverse the spread of invasive species. Many of the invasive species are just obtaining a toehold and need to be stopped while treating them is still relatively easy. Newer, less dangerous herbicides with shorter half lives are being successfully used by ranchers cooperating with the Jordan Valley Cooperative Weed Management Area. The continued spread of invasive weed species will result in a degraded, non native environment without the vegetative community which was (and in many places still is) an important component of the ecosystem. The whole web of native insect and higher animal life depends on the continued vigor of native plant species both on the rangeland and in riparian areas.

Tamarisk is known to be present along both the South Fork Owyhee River and the east fork Owyhee River (Figure 7.3). It is still relatively infrequent. These isolated occurrences pose a serious threat by providing a source of seed which can both spread and expand the population around the existing plants and disseminate seed downstream where it can establish new colonies along the banks of the river. A program now to eliminate the existing plants could significantly avert undesirable effects resulting from decreased water production. The use of biological controls of tamarisk has been severely limited by court cases.

Photo 11.1. Tamarisk in bloom.

Although halogeton occupies large stretches of the center of the road in the southwest corner of Owyhee county, it has obviously been in the area for quite some time since the area to the east of the Little

Photo 11.2. Halogeton on the left hand side of the road. Little Owyhee River Canyon in the background.

Photo 11.3. A well established halogeton plant.

Owyhee River is named Halogeton Flats. And yes, the flats are contaminated with halogeton.

Management of invasive species may be the most time sensitive issue for maintaining healthy watershed conditions.

2. Rangeland

The rangeland of the upper Owyhee is extensive. Some of the range is in great shape with a mix of perennial forbs, grasses, and shrubs. There are large areas that have sparse vegetation but have about as much vegetation as the climate and soil will support.

There is an area of the upper Owyhee subbasin in southeast Malheur County and southwest Owyhee County along the border with Nevada which is overstocked with woody vegetation. There are very few forbs or grasses, either native or introduced, in the understory. In July 2010, there were no signs of grazing. The excessive growth of sagebrush may be the result of a long period with systematic fire suppression or with no fires.

Photo 11.4. Rangeland overstocked with woody vegetation in southwest Owyhee County

3. Riparian

The riparian areas in the steep-sided, deeply incised canyons of the Owyhee River and the South Fork Owyhee River are in close to pristine condition. There is limited access to these areas for large wildlife, cattle, or most humans.

The elimination of most of the beaver by trappers in the early 1800s changed the hydrology of the upper reaches of streams. We do not know the extent of changes in the associated riparian vegetation. The early trappers noted that much of the riparian system in the upper Owyhee subbasin was useless for trapping beaver. The confined nature of the streams and their routine scouring rendered them inappropriate for support of beaver.

Photo 11.5. Looking down from steep canyon walls on riparian vegetation along the Owyhee River.

4. Hydrology

The river flows in the upper Owyhee subbasin vary significantly from year to year. Occasionally there may be a larger volume of flow in one day than the total volume for the driest years. The upstream water impoundments have had a slight mitigating effect on the “flashy” nature of the flows.

Exceptionally large flows, especially when accompanied by ice, are responsible for removing riverside vegetation, transporting sediment, and causing stream bank erosion.

5. Mercury and other legacy mining minerals

Much of the mining activity in the upper Owyhee subbasin ended at the end of the nineteenth century or early in the twentieth century. The individuals or companies responsible for any lingering pollutants are no longer around and can not be held accountable for cleanup. Private individuals and local governments do not have the economic resources to contain the sources of any legacy pollutants which continue to flow into the streams of the upper Owyhee subbasin. Federal and state agencies need to be actively involved in preventing the ongoing and future contamination and eliminating this threat to the water quality.

6. Federal ownership of the land

The major portion of land in the upper Owyhee subbasin is federal land. With a small tax base, it is a hardship on the counties and other local agencies to provide services to this vast area.

The BLM has served as the steward of much of the land in the upper Owyhee subbasin. Much of the past recuperation of degraded areas of rangeland was accomplished with BLM support and oversight. However, the public land is managed by bureaucracy and bureaucracies are frequently slow in responding or unresponsive to local needs.

7. Recreation

Growing population in SW Idaho and elsewhere is increasing the use of the area for recreation. This use today tends to be concentrated in the more easily reached areas. Recreationists do not necessarily have conservation ethics and may leave behind trash, human waste, and scars upon the landscape. New roads appear where recreationists don't respect the fragility of the landscape. Some individuals lack respect for private property and fences, especially during hunting season.

Some recreationists may not be prepared for the conditions in the high desert. A lack of experience may result in catastrophic ends to a trip. Inexperience may lead to not realizing how unmaintained roads may have become impassable or to being unprepared for unexpected delays in a remote area with no cell phone access and carrying inadequate provisions such as water, jackets, and spare tires. Counties or other public agencies can be forced to expend huge resources looking for lost individuals who have failed to leave clear indications of where they are going.

Despite the increased use of some areas, a large portion of the beautiful places within the subbasin are seldom visited.

8. Private ownership

Although only 6.5% of the land in the Idaho section of the upper Owyhee subbasin is private, 18% of the total stream miles are on private property. These private lands "are usually the most productive areas".[2] The private land water rights are essential to being able to productively use the federally owned rangeland.

The land in the upper Owyhee subbasin in Idaho is not particularly attractive to investors to hold speculatively. However, the purchase of these holdings by entities intending to acquire the associated grazing rights can have detrimental consequences if the purpose is to leave the BLM land ungrazed. Land removed from use will have less management and day-to-day oversight with a greater potential for the spread of invasive weeds and juniper.

Speculative investments in land can raise the price of property and greatly restrict attempts by young people to maintain the traditions of family farming and ranching.

C. Large gaps in data

Much basic information about the conditions within the upper Owyhee subbasin is lacking and there is a very poor understanding of the ecological interactions in the subbasin. These data gaps and unknowns have been enumerated in the other sections of this assessment. A few of these are highlighted here.

1. Hydrology

There is a popular misconception that published maps showing flow lines are showing streams.

There has been no ground verification of which streams in the upper Owyhee subbasin are ephemeral, intermittent, or perennial. Since the USGS maps do not distinguish between intermittent and ephemeral streams, ground surveys are necessary to make these determinations. In the upper Owyhee subbasin this information is not available for most drainages. The three stream types can not be evaluated in the same fashion and have dissimilar responses to restoration efforts. Intermittent streams are those which flow for only certain times of the year, when they receive water from springs or runoff. During dry years they may cease to flow entirely or they may be reduced to a series of separate pools. Ephemeral streams only carry water during and immediately after runoff events.

2. Rangeland

We do not understand the impact of juniper expansion on watershed function and water resources. Likewise, we don't know how watershed function and water resources are affected by the conversion of rangeland vegetation to invasive annuals.

What effect will rangeland overstocked with woody shrubs have on watershed function?

Studies are needed on ways to restore native perennial vegetation to rangelands. Is there an acceptable ratio of cheatgrass to native plants where the ecological processes of rangeland still function? We have little information on the response of different vegetative communities to livestock grazing, timing of the grazing, or removal of grazing. Can the removal of livestock accelerate conversion of rangeland to cheatgrass or other invasive species?

Has a lack of fire resulted in overstocking of some areas with sagebrush and a concomitant decrease in grass and forbs essential to wildlife and grazing? Does a predominant sagebrush cover change runoff and erosion processes?

3. Riparian

In the upper Owyhee subbasin, the potential of riparian areas based on physical, biological, and chemical conditions is not known. The site specific physical, biological, and chemical conditions of riparian areas have not been surveyed. The management practices that will result in maintaining, restoring, improving, or expanding riparian areas in the upper Owyhee subbasin are poorly defined.

Some areas identified as lakes with wetlands appear to only occasionally become temporary lakes. Although they may support special sage species more tolerant to water scarcity, they are not wetland bird habitat (e.g. Lookout Lake).

Seasonal observations of suspected and known riparian habitats will be necessary to learn about fluctuations in the natural water flows from floods to intermittently available water. Understanding seasonality in available water will be essential to management decisions and expectations of rehabilitation.

4. Fish

There have been no studies of the interactions between the species of fish in the upper Owyhee subbasin. Little is known about the distribution of each specie within the subbasin. There is extremely little information on the non-game fish populations, fluctuations in their populations, or reasons for the fluctuations.

There are many introduced fish species in the upper Owyhee subbasin. How do the nonnative fish compete for food and habitat with the native fish? What effects are the hatchery trout stocked into the subbasin having on the native redband trout populations?

5. Water quality

In the upper Owyhee subbasin, the relative contribution to stream heating from solar radiation, from the air, from the ground, and from cliffs have not been described.

Even though water quality criteria are in place, the basic information is lacking on site response to climate, hydrology, geology, soil, slope, plant and animal communities, and other environmental features needed to develop water quality criteria for the upper Owyhee subbasin.

There are no data or models that show that the current water quality temperature criteria are consistent with the thermal potential of the streams in the upper Owyhee subbasin. How will new water rights in Idaho and Nevada which will reduce stream flows affect probable, but unknown, increases in downstream temperatures?

No comprehensive survey has been done to precisely locate possible sources of mercury, arsenic, or other pollutants in the upper Owyhee subbasin nor to identify geologic locations in the upper Owyhee subbasin that have mercury or arsenic concentrations which might contribute to mercury or arsenic in the river system if the sites become disturbed in the future.

6. Wildlife

The interactions between different wildlife species, introduced wild horse populations, and cattle are poorly understood including forage preferences and usage over the year. Few studies are available pertinent to the upper Owyhee subbasin on the effects of specific ranching practices on forage for wildlife.

How many cougar and wolves are actually in the upper Owyhee subbasin? At what level do these predator populations significantly affect wildlife populations and ranching?

How are wildlife populations being influenced by the expansion of weeds? How would wildlife populations be affected by the elimination of any of the stock ponds?

7. Wilderness areas

We do not know how designation of wilderness areas will affect fire management, watering sites, or the control of invasive species. Have some of the invasive species already become widespread and established enough that, without management, they will continue to spread, eliminating the very diversity of native vegetation that should exist in a preserved area?

Will uncontrolled burns, typical management of wilderness areas, or controlled burning, possible in managed range, best promote native vegetation and limit erosion?

D. Conclusion

The people who made their living in the upper Owyhee subbasin through the 1930s were exceedingly poor. They utilized whatever resources they could. The stewardship of the land, both private and public, has greatly improved since the 1930s.

Valuable information developed in other regions can be applied to some extent to future decision making processes affecting the upper Owyhee subbasin. However, because of the relative isolation and low potential productivity, much of the specific information necessary to make informed decisions about future actions has not been developed. Generalizing from other areas without the locally developed information can lead to decisions guided by misinformation resulting in possibly disastrous consequences to the ecological integrity of the upper Owyhee subbasin.

Local information needs to be developed so that future choices can be based on facts and the best scientific knowledge available. Decisions need to be guided by what is best for the ecology of the subbasin and the people that it supports, not by a political agenda. Uncontrolled increased exploitation of resources or complete abandonment of use are both ecologically untenable.

The upper Owyhee subbasin contains many areas of natural beauty. The people of the area have been able to work together to solve many problems. The coming changes in climate and the world economy can not be foreseen, but the upper Owyhee subbasin contains individuals who will continue to cooperate to solve local challenges.

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Upper Owyhee Watershed Assessment

Appendix A. Notes on mapping

1. Description of how maps were created

The information included as maps in this assessment came from many different sources. The earth's surface is part of a sphere. Maps are flat. There are many different ways of orienting and shaping, "projecting", the spherical surface onto the flat plane. Our brains are capable of taking the landmarks which we recognize and correctly interpreting how the other features are related. However, for comparative purposes it is nice to have all data on paper in a similar projection.

The projection used for the base map is a Universal Transverse Mercator projection optimized for this region of the globe (UTM 11N), using the North American Datum of 1927 (NAD27) as a coordinate system for the placement of objects. The rivers, highways and outline of the upper Owyhee subbasin make up the base map. This is the map that serves as the background on which other information like vegetation can be charted.

There are computer programs to create maps using available "coverages", digitized information about where features are located. The programs used in this assessment were Adobe Photoshop 7.0 for Windows, QGIS 0.11.0 for Linux, and GRASS 6.3.0 for Linux. The original projections of a coverage (map of one characteristic) can be "reprojected" so they match the orientation of the base map.

All data were reprojected into the NAD27 (North American Datum of 1927), UTM11N (Universal Transverse Mercator Zone 11 North) projection. Although NAD83 (North American Datum of 1983) might be a more appropriate choice, the decision was made early in the project. The maximum difference between these data is approximately 82 meters in the area being assessed, but this difference is reduced to a few meters using GIS software with an appropriate mapping between the data. The ultimate mapping resolution is 1:960,000, representing exactly 100mx100m per pixel. The resolution was dictated by the limitations of the software approach used. Alignment error accounts for at most one pixel, meaning the data are aligned to within 182m (1/9 mile) of the correct NAD83 locations.

QGIS was used to view and export GRASS data to image files, which were imported into Adobe Photoshop. Adobe Photoshop 7.0 was used to combine maps from different sources. Some of the maps in this assessment contain information which was originally only available as an image. In that case the original map has been overlaid on the base map using the rivers to orient the information to the base map using Adobe Photoshop 7.0. All maps created in GRASS and QGIS were imported into Adobe Photoshop for final editing.

2. Sources of map data

Coolbaugh M. 2004. Major roads in the state of Nevada.

Major roads in the state of Nevada are represented by this digital line graph (vector map layer). The data were reprojected into the UTM11N NAD27 projection using QGIS.

Daly C, Taylor G. 2000. United States Average Annual Precipitation, 1961-1990. 2000.

"This map layer shows polygons of average annual precipitation in the contiguous United States, for the climatological period 1961-1990. Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created. PRISM is an analytical model that uses point data and a digital elevation model (DEM) to generate gridded estimates of annual, monthly and event-based climatic parameters."

Precipitation is represented at a scale of 1:2,000,000 by this polygonal graph (vector map layer with areal data) corresponding to the PRISM rainfall model. The data were reprojected into the UTM11N NAD27 projection using QGIS.

Department of Commerce/National Oceanic and Atmospheric Administration/Western Regional Climate Center. 2009. Western Regional Climate Center SNOTEL Station Data. NRCS National Water and Climate Center. Accessed 7/10/2009.

"The Natural Resources Conservation Service (NRCS) installs, operates, and maintains an extensive, automated system to collect snowpack and related climatic data in the Western United States called SNOTEL (for SNOwpack TELemetry). The system evolved from NRCS's Congressional mandate in the mid-1930's 'to measure snowpack in the mountains of the West and forecast the water supply.' The programs began with manual measurements of snow courses; since 1980, SNOTEL has reliably and efficiently collected the data needed to produce water supply forecasts and to support the resource management activities of NRCS and others.

Climate studies, air and water quality investigations, and resource management concerns are all served by the modern SNOTEL network. The high-elevation watershed locations and the broad coverage of the network provide important data collection opportunities to researchers, water managers, and emergency managers for natural disasters such as floods."

All SNOTEL sites within the subbasin were identified. Locations of sites were manually entered as a latitude-longitude map layer in the QGIS Geographic Information System.

Department of Commerce/National Oceanic and Atmospheric Administration/Western Regional Climate Center. 2009. Western U.S. Climate Historical Summaries. Accessed 7/10/2009.

"The Regional Climate Centers (RCC) deliver climate services at national, regional and state levels working with NOAA partners in the National Climatic Data Center, National Weather Service, the American Association of State Climatologists, and NOAA Research Institutes. This successful effort resulted in jointly developed products, services, and capabilities that enhance the delivery of climate information to the American public, and builds a solid foundation for a National Climate Service. As NOAA and Congress work to help society adapt to climate change, these collaborative efforts form a framework for the service, data stewardship, and applied research components of the National Climate Service."

All weather stations within the subbasin were identified. Locations of sites were manually entered as a latitude-longitude map layer in the GRASS Geographic Information System.

Department of the Interior/Bureau of Land Management/Idaho State Office/Geographic Sciences. 2009. Surface Management Agency for Idaho (Federal, State, and Private Lands). Version 1. Accessed 7/11/2009.

"This spatial data contains Surface Management Agency (SMA, also sometimes called Land Status) information for Idaho. It shows categories for Federal and State agencies as well as Private lands in Idaho.

For government land, this data displays the MANAGING AGENCY of the land, which may or may not be the same as the "owning agency" of the land. SMA is sometimes referred to as "ownership", although this term is inaccurate when describing public lands.

The Bureau of Land Management (BLM) in Idaho creates and maintains this spatial data. This dataset is derived by dissolving based on the "owner_type" field from the master SMA GIS dataset (which is edited often) kept by the BLM Idaho State Office.

Originally, the primary source of the GEOMETRY of the features was the BLM Geographic Coordinate Database (GCDB). In areas where GCDB records are unavailable, the spatial features are taken from a variety of sources including the BLM Idaho Resource Base Data collection, US Geological Survey Digital Line Graphs (DLGs), and US Forest Service Cartographic Feature Files (CFFs), among others (see Process Steps). It should be stressed that the geometry of the data may NOT be GCDB-based, and the GCDB-based features are not necessarily being edited to match improved GCDB, therefore this data should NOT be considered actual "GCDB data". For the latest GCDB spatial data, please download it from http://www.geocommunicator.gov

The source of the ATTRIBUTE information is an ongoing effort to coordinate between the BLM Master Title Plats (MTPs), the BLM case files and Realty Staff, the BLM LR2000 database, cooperation with other government agencies that own or manage land parcels, and users of the data. The data for other agencies may not be accurately represented if the information was not provided to the BLM by the managing agency. BLM gives its best effort to attribute the parcels properly, but when errors are found, please contact the BLM Idaho State Office Geographic Sciences department at 208-373-3950.

Please get a fresh copy of this data a couple times a year as the SMA data is constantly changing. Official actions that affect the managing agency are finalized each day, and changes to correct found errors are always being updated.

Nevada SMA data was acquired from the BLM Nevada web site and clipped to the area that is managed by Idaho BLM Boise District.

Purpose: This layer is intended to be a source of surface management agency spatial information in Idaho. Uses of this data include spatial analysis and cartographic products. This data will be made available to all users as BLM corporate data.

The surface management agency data (land "ownership") should be used as a general guide only. Official land records, located at the Bureau of Land Management (BLM) and other offices, should be checked for up-to-date information concerning any specific tract of land. Roads crossing public lands may be used unless closed by signs or notice by the land management agency. Public domain lands surrounded by private land may not be accessible. Permission is required from private landowners to cross private land, unless access is provided by a Federal, State, or County road or a BLM road with legal access."

This digital polygon model digitized at 1:100,000 resolution indicates federal, state, and private management of lands within the state of Idaho. The model was reprojected to the standard UTM11N NAD27 projection using GRASS and subsequently accessed with QGIS.

Department of the Interior/USGS. 2009. National Elevation Dataset. Accessed 7/10/2009.

"The National Elevation Dataset (NED) is the primary elevation data product of the USGS. The NED is a seamless dataset with the best available raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands. The NED is updated on a nominal two month cycle to integrate newly available, improved elevation source data. All NED data are public domain. The NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure. NED data are distributed in geographic coordinates in units of decimal degrees, and in conformance with the North American Datum of 1983 (NAD 83). All elevation values are in meters and, over the conterminous United States, are referenced to the North American Vertical

Datum of 1988 (NAVD 88). The vertical reference will vary in other areas. NED data are available nationally (except for Alaska) at resolutions of 1 arc-second (about 30 meters) and 1/3 arc-second (about 10 meters), and in limited areas at 1/9 arc-second (about 3 meters). In most of Alaska, only lower resolution source data are available. As a result, most NED data for Alaska are at 2-arc-second (about 60 meters) grid spacing, Part of Alaska is available at the 1- and 1/3-arc-second resolution, and plans are in development for a significant improvement in elevation data coverage of the state.

The NED serves as the elevation layer of The National Map, and provides basic elevation information for earth science studies and mapping applications in the United States. Scientists and resource managers use NED data for global change research, hydrologic modeling, resource monitoring, mapping and visualization, and many other applications.

The Seamless Data Distribution System (SDDS) offers seamless data for a user-defined area, in a variety of formats, for online download or media delivery.

Historic Digital Elevation Models (DEMs) are now available."

The National Elevation Dataset was used at a resolution of 1 arc-second. The files for four separate sectors were patched into a seamless dataset. Contours as digital line graphs at 500-ft, 1,000-ft, 2,500-ft, and 5,000 ft intervals were created using the GRASS contour function. The data were reprojected into the UTM11N NAD27 projection using GRASS.

Department of the Interior/USGS. 2009. National Hydrography Dataset.

"The National Hydrography Dataset (NHD) is the surface water component of The National Map. The NHD is a comprehensive set of digital spatial data representing the surface water of the United States using common features such as lakes, ponds, streams, rivers, canals, and oceans. These data are designed to be used in general mapping and in the analysis of surface-water systems using geographic information systems (GIS). In mapping, the NHD is used with other data themes such as elevation, boundaries, and transportation to produce general reference maps. Customized maps can be made to meet specific needs of the user by emphasizing certain aspects of the data. A map emphasizing hydrography can be produced by displaying more of the content embedded in hydrography.

The NHD often is used by scientists, specifically in surface-water analysis using GIS technology. This takes advantage of a rich set of embedded attributes that can be processed by a computer system to generate specialized information. This information can then be portrayed in specialized maps to better understand the results. These analyses of hydrography are possible largely because the NHD contains a flow direction network that traces the water downstream or upstream. It also uses an addressing system to link specific information about the water such as water discharge, water quality, and fish population. Using the basic water features, flow network, linked information, and other characteristics, it is possible to study cause and affect relations, such as how a source of poor water quality upstream might affect a fish population downstream."

The National Hydrography Dataset was used to create data for water bodies, flowlines, and perennial streams. This dataset contains in vector format artificial flowlines, connectors, canals/ditches, flows through lakes and ponds, flows through playas, flows through swamps and marshes, and perennial streams. The artificial flowlines and perennial streams were used to generate digital line graphs of the flows in the Upper Owyhee subbasin.

Also included in the National Hydrography Dataset are polygon maps of the lakes, reservoirs, ponds, playas, swamps, and marshes in the Upper Owyhee subbasin. These maps were used for mapping of major water bodies in the subbasin.

All data were imported into GRASS and reprojected into the UTM11N NAD27 projection using GRASS.

Department of the Interior/USGS. 2009. USGS Water-Data Site Information for the Nation. Accessed 7/10/2009.

"The Site Inventory System contains and provides access to inventory information about sites at stream reaches, wells, test holes, springs, tunnels, drains, lakes, reservoirs, ponds, excavations, and water-use facilities.

About 300 components make up the descriptive elements of the site inventory. The retrieval program can be used for retrieving information about sites in summary lists, in detailed tables, or a file suitable for input to other programs."

USGS Water-Data Site Information for the Nation comprises all streamflow gages. The latitude-longitude data for these sites (in NAD27) were used to place the gages on the corresponding map. This was done via direct latitude-longitude entry of points in QGIS.

Department of the Interior/USGS/U.S. Board on Geographic Names. 2009. Geographic Names Information System (GNIS). Accessed 7/10/2009.

"The Geographic Names Information System (GNIS) is the Federal and national standard for geographic nomenclature. The U.S. Geological Survey developed the GNIS in support of the U.S. Board on Geographic Names as the official repository of domestic geographic names data, the official vehicle for geographic names use by all departments of the Federal Government, and the source for applying geographic names to Federal electronic and printed products.

The GNIS contains information about physical and cultural geographic features of all types in the United States, associated areas, and

Antarctica, current and historical, but not including roads and highways. The database holds the Federally recognized name of each feature and defines the feature location by state, county, USGS topographic map, and geographic coordinates. Other attributes include names or spellings other than the official name, feature designations, feature classification, historical and descriptive information, and for some categories the geometric boundaries.

The database assigns a unique, permanent feature identifier, the Feature ID, as the only standard Federal key for accessing, integrating, or reconciling feature data from multiple data sets. The GNIS collects data from a broad program of partnerships with Federal, State, and local government agencies and other authorized contributors, and provides data to all levels of government, to the public, and to numerous applications through a web query site, web map and feature services, file download services, and customized files upon request."

GNIS was used for determination and placement of both populated places and mine sites. Direct latitude-longitude entry was used to bring the data into QGIS.

Department of the Interior & Department of Agriculture/GeoMAC (Geospatial Multi-Agency Coordination). 2009. Historic Fire Data. Accessed 7/10/2009.

"The Geospatial Multi-Agency Coordination Group or GeoMAC, is an internet-based mapping application originally designed for fire managers to access online maps of current fire locations and perimeters in the conterminous 48 States and Alaska. Using a standard web browser, fire personnel can view this information to pinpoint the affected areas. With the growing concern of western wildland fires in the summer of 2000, this application has also become available to the public. We hope that you find this important information both timely and helpful."

Historic fire data are available on an annual basis and on a multi-annual basis. The data were reprojected into the UTM11N NAD27 projection using QGIS.

Environmental Protection Agency/Office of Water/OST. 1998. Counties and County Equivalents Boundaries in the United States for BASINS. Accessed 7/10/2009.

"This coverage is of the county boundaries of the conterminous United States. It was derived from the U.S. Geological Survey State Boundaries, which were derived from Digital Line Graph (DLG) files representing the 1:2,000,000-scale map in the National Atlas of the United States."

BASINS was used to generate boundaries both within QGIS and within GRASS for reference purposes and to generate baseline reference data. BASINS was used to generate basemaps for both systems in the native UTM11N NAD27 projection.

Environmental Protection Agency/Office of Water/OST. 1998. Hydrologic Unit Boundaries of the Conterminous United States in BASINS. Accessed 7/10/2009.

"This metadata describes various delineations of watershed boundaries being stored in the EPA Spatial Data Library System (ESDLS). These delineations are based on the Hydrologic Unit Maps published by the U.S. Geological Survey Office of Water Data Coordination, together with the list descriptions and name of region, subregion, accounting units, and cataloging units. This metadata set describes the spatial data sets as they exist after downloading the data from ESDLS.

The changes made to the data sets from ESDLS are as follows:

1) Reprojected the ARC/INFO coverages to a geographic projection.

2) Derived accounting unit and cataloging unit layers only from original data.

3) Convertted ARC/INFO coverages to Arcview Shapefiles with ARCSHAPE

command in Environmental Systems Research Institute (ESRI) GIS software."

BASINS was used to generate boundaries both within QGIS and within GRASS for reference purposes and to generate baseline reference data. BASINS was used to generate basemaps for both systems in the native UTM11N NAD27 projection.

Geographic Information Services Unit, Oregon Department of Transportation (ODOT). 2006. Highways. 2006. Accessed 7/11/2009.

"This statewide file represents an annual snapshot and includes all state owned or maintained highways, spurs, connections, frontage roads, temporary traveled routes (TTR) and located lines."

Oregon publishes all GIS data in the Oregon Lambert Projection, a conical projection base on the NAD83 datum. These data were reprojected into the UTM11N NAD27 projection in GRASS, and then imported into QGIS. One road from north of McDermitt, OR to the Nevada border was manually projected with a linear transformation from the ODOT county map system in Oregon Lambert to the UTM11N NAD27 coordinate sytem.

GRASS Development Team. 2009. Geographic Resources Analysis Support System (GRASS) Software. Open Source Geospatial Foundation.

GRASS software was used for sophisticated reprojection and data analysis problems, including creating contours from the NED (National Elevation Dataset) and counting census data. GRASS represents the state-of-the-art in open-source geographic information systems.

Idaho Transportation Department, GIS Section. 2004. Idaho State Highways. 2004. Accessed 7/11/2009.

"Idaho State Highway System (US Highways, State Highways, Interstate Highways and Rest Areas/POEs)."

Idaho's state highway map is published in a GIS-friendly format. The data were reprojected with minimal error from UTM11N NAD83 into the UTM11N NAD27 projection using QGIS.

Multi-Resolution Land Characteristics Consortium (MRLC). 2008. National Land Cover Database (NLCD) 1992/2001 Retrofit Land Cover Change.

"New developments in mapping methodology, new sources of input data, and changes in the mapping legend for the 2001 National Land Cover Database (NLCD 2001) will confound any direct comparison between NLCD 2001 and the 1992 National Land Cover Dataset (NLCD 1992). Users are cautioned that direct comparison of these two independently created land cover products is not recommended. This NLCD 1992/2001 Retrofit Land Cover Change Product was developed to offer users more accurate direct change analysis between the two products.

The NLCD 1992/2001 Retrofit Land Cover Change Product uses a specially developed methodology to provide land cover change information at the Anderson Level I classification scale (Anderson et al., 1976), relying on decision tree classification of Landsat imagery from 1992 and 2001. Unchanged pixels between the two dates are coded with the NLCD 2001 Anderson Level I class code, while changed pixels are labeled with a "from-to" land cover change value (Change Code Table). Additional detail is available in the metadata included in the multizone downloadable zip file. This product is designed for regional application only and is not recommended for local scales.

The 65 CONUS mapping zones (excluding Alaska) have been grouped into 14 larger zonal areas to facilitate distribution and download. A mouse click on an area of interest will follow the link to the multizone download site. A shapefile with the standard NLCD zone attributes and multizone attributes is also available."

This 30-meter-resolution product classifies land cover and land cover change over a nine-year period between 1992 and 2001. Data were reprojected from the Albers conical equal-area projection to UTM11N NAD27 using GRASS GIS software.

Multi-Resolution Land Characteristics Consortium (MRLC). 2008. National Land Cover Database 2001 (NLCD 2001).

"New developments in mapping methodology, new sources of input data, and changes in the mapping legend for the 2001 National Land Cover Database (NLCD 2001) will confound any direct comparison between NLCD 2001 and the 1992 National Land Cover Dataset (NLCD 1992). Users are cautioned that direct comparison of these two independently created land cover products is not recommended. This NLCD 1992/2001 Retrofit Land Cover Change Product was developed to offer users more accurate direct change analysis between the two products.

The NLCD 1992/2001 Retrofit Land Cover Change Product uses a specially developed methodology to provide land cover change information at the Anderson Level I classification scale (Anderson et al., 1976), relying on decision tree classification of Landsat imagery from 1992 and 2001. Unchanged pixels between the two dates are coded with the NLCD 2001 Anderson Level I class code, while changed pixels are labeled with a "from-to" land cover change value (Change Code Table). Additional detail is available in the metadata included in the multizone downloadable zip file. This product is designed for regional application only and is not recommended for local scales.

The 65 CONUS mapping zones (excluding Alaska) have been grouped into 14 larger zonal areas to facilitate distribution and download. A mouse click on an area of interest will follow the link to the multizone download site. A shapefile with the standard NLCD zone attributes and multizone attributes is also available."

This 30-meter-resolution product classifies land cover in the calendar year 2001. Data were reprojected from the Albers conical equal-area projection to UTM11N NAD27 using GRASS GIS software.

National Atlas of the United States. 2006. Federal Lands of the United States.

"This map layer consists of federally owned or administered lands of the United States, Puerto Rico, and the U.S. Virgin Islands. Only areas of 640 acres or more are included. There may be private inholdings within the boundaries of Federal lands in this map layer. This is a revised version of the December 2005 map layer."

National Atlas of the United States. 2006. Indian Lands of the United States.

"This map layer shows Indian lands of the United States. Only areas of 640 acres or more are included. Federally-administered lands within a reservation are included for continuity; these may or may not be considered part of the reservation and are simply described with their feature type and the administrating Federal agency. This is an updated version of the December 2005 map layer."

This map layer was used to map the boundaries of the Duck Valley Indian Reservation.

National Atlas of the United States. 2004. Cities and Towns of the United States. Accessed 7/10/2009.

"This map layer includes cities in the United States, Puerto Rico and the U.S. Virgin Islands. These cities were collected from the 1970 National Atlas of the United States. Where applicable, U.S. Census Bureau codes for named populated places were associated with each name to allow additional information to be attached. The Geographic Names Information System (GNIS) was also used as a source for additional information. This is a revised version of the December 2003 map layer."

This map is a point map (vector map without lines). The map was dynamically reprojected in QGIS to the standard UTM11N NAD27 projection used for this project.

National Atlas of the United States. 2005. Streams and Waterbodies of the United States. Accessed 7/10/2009.

"This map layer shows areal and linear water features of the United States, Puerto Rico, and the U.S. Virgin Islands. The original file was produced by joining the individual State hydrography layers from the 1:2,000,000- scale Digital Line Graph (DLG) data produced by the USGS. This map layer was formerly distributed as Hydrography Features of the United States. This is a revised version of the January 2003 map layer."

The map layer was edited in QGIS to remove all but principal water courses outside of the Upper Owyhee subbasin. The map was dynamically reprojected in QGIS to the standard UTM11N NAD27 projection used for this project. The map forms the basis for hydrological mapping within this project.

National Atlas of the United States. 2006. Major Dams of the United States Accessed 7/10/2009.

"This map layer shows areal and linear water features of the United States, Puerto Rico, and the U.S. Virgin Islands. The original file was produced by joining the individual State hydrography layers from the 1:2,000,000- scale Digital Line Graph (DLG) data produced by the USGS. This map layer was formerly distributed as Hydrography Features of the United States. This is a revised version of the January 2003 map layer."

This map is a point map (vector map without lines). The map was dynamically reprojected in QGIS to the standard UTM11N NAD27 projection used for this project.

Quantum GIS Development Team. 2009. Quantum GIS Geographic Information System. Open Source Geospatial Foundation.

QGIS is the most user-friendly open-source GIS application.

USDA Service Center Agencies. 2004. National Coordinated Common Resource Area.

"A CRA map delineation is defined as a geographical area where resource concerns, problems, or treatment needs are similar. It is considered a subdivision of an existing Major Land Resource Area (MLRA) map delineation or polygon. Landscape conditions, soil, climate, human considerations, and other natural resource information are used to determin the geographic boundaries of a CRA (Title 450, Technology, General Manual, Part 401, Technical Guides, Section 401.21, Definitions).

The National Coordinated CRA Geographic Database, Version 1.1, provides:

1) A consistent CRA geographic database;

2) CRA geographic data compatible with other Geographic Information System (GIS) data digitized from 1:250,000 scale maps, such as land use/land cover, political boundaries, Digital General Soil Map of the U.S. (updated STATSGO), and ecoregion boundaries;

3) A consistent (correlated) geographic index for Conservation Management Guide Sheet information and the electronic Field Office Technical Guide (eFOTG); and

4) A geographic linkage with the national MLRA framework."

Polygon maps at a resolution of 1:250,000 were imported into GRASS and reprojected into the standard UTM11N NAD27 projection used for this project. They were subsequently accessed with QGIS.

3. USGS topographic maps

Inside Idaho. Idaho USGS 1:24,000-scale digital raster graphic (DRG) collection search and download. Accessed 2/10/2009. http://maps.insideidaho.org/WebMapping/Search/DownloadDRG/index.asp

This interactive map was used to identify the USGS 7.5' quadrangles in the Idaho and Oregon sections of the upper Owyhee subbasin.

Idaho Geospatial Office. 2009. DRG: 24K UTM with collar. In: Gail Eckwright, Director. *Inside Idaho:Interactive Numeric & Spatial Information Data Engine.* Accessed 2/20/2009. http://inside.uidaho.edu/asp/drgnameUTM.asp?Letter=A

A Digital Raster Graphic (DRG) is a georeferenced raster image of a scanned USGS topographic map. A DRG is useful as a source or background layer in a GIS, as a means to perform quality assurance on other digital products, and as a source for the collection and revision of other data.

This site was the source of the topographic maps of Idaho retrieved for reference while writing this assessment.

W. M. Keck Earth Sciences and Mining Research Information Center. 2001. 1:24,000 scale topos clickable map. Accessed 2/11/2009. http://keck.library.unr.edu/data/drg/nv24k_clickable.html

This interactive map was used to identify the USGS 7.5' quadrangles in the Nevada section of the upper Owyhee subbasin.

W. M. Keck Earth Sciences and Mining Research Information Center. 2003. USGS topographical maps (DRGs). Retrived 2/20/2009. http://keck.library.unr.edu/data/drg/drgs.html

Digital raster graphic (DRGs) are scanned images (minimum resolution of 250 dots per inch) of USGS standard series topographic maps, including all collar information. The image is georeferenced and fit to the Universal

Transverse Mercator projection. Most DRGs on this site are North American Datum (NAD) 1927_UTM_Zone11. Exceptions are the 1:24000 clipped/no collar files which are NAD 83 and the California DRG's which are NAD_1927_California_Teale_Albers.

This site was the source of the topographic maps of Nevada retrieved for reference while writing this assessment.

Oregon USGS Digital Raster Graphics (DRG) Index. Accessed 7/21/2009. http://libremap.org/data/state/oregon/drg/

The sources of topographic maps have changed over time. Oregon no longer has a state web site with the maps. However, as of July 21, 2009 the topographic maps for all the states of the United States were available from the Libre Map Project at http://libremap.org/

The USGS 1:24,000 scale topographic quadrangles in the upper Owyhee subbasin:

In Idaho:

Battle Creek Lakes
Bedstead Ridge
Big Springs Ranch
Brace Flat
Bull Basin Camp
Bull Camp Butte
Castro Table
Clover Mountain
Coyote Hole
Crab Spint Butte
Defeat Butte
Dickshooter Ridge
Flying H Ranch
Four Corners
Frying Pan Basin
Grassy Ridge
Hat Peak
Hurry Up Creek
Indian Meadows
Jarvis Pasture
Juniper Basin
Juniper Basin SE
Little Blue Table
Lost Valley
Mountain View Lake
Nadine Butte
Nichol Flat
Piute Basin East
Piute Basin West
Pleasant Valley
Red Basin
Riddle
Ross Lake
Rubber Hill
Shoofly Springs
Slack Mountain
Smith Creek
Snow Creek
Spring Creek Basin
Star Valley
Star Valley Knoll
Star Valley Ridge East
Star Valley Ridge West
State Line Camp
Turner Table
Wagon Box Basin
Wickiup Creek

In Nevada:

Badger Creek
Big Cottonwood Canyon
Bull Run Reservoir
Burner Hills
Button Lake
Button Lake Well
Calico Butte
Capitol Peak
Chicken Creek Summit
Cornucopia Ridge
Cornwall Mountain
Corral Lake
Cottonwood Peak
Deep Creek
Desert Ranch
Dry Creek Reservoir
Fourmile Butte
Greeley Flat
Greeley Flat SE
Groundhog Reservoir
Haystack Peak
Hicks Mountain
Humboldt Hill
I-L Ranch
Jacks Peak
Lake Mountain
Maggie Summit

Maiden Butte	Red Cow Creek	Tuscarora
Maiden Butte SE	Rodear Flat	Twelvemile Flat
McAfee Peak	Sheep Creek Reservoir	Twelvemile Flat SE
McCleary Wells	Silver Lake	Ungina Wongo
Merritt Mountain	Soldier Cap	Water Pipe Canyon
Middle Draw Reservoir	Star Valley Ridge SE	Wild Horse
Mountain City	Star Valley Ridge SW	Wilson Reservoir
Mount Blitzen	Sugarloaf Butte	Winter Ridge
Owyhee	Tennesee Mountain	Winters Ranch Reservoir
Peterson Table East	The Point	

In Oregon:

Defeat Butte	Lookout Lake
Oregon Butte	Star Valley Knoll

Figure A.1. USGS 1:24,000 scale topographic quadrangles in the upper Owyhee subbasin.

Upper Owyhee Watershed Assessment

Appendix B. Mining Districts.

Aura		
	Other names:	Bull Run, White Rock, Centennial, Columbia, Blue Jacket, Edgemont
	Discovered:	1867
	Organized:	1869
	Period Active:	1869-1879; 1899-1919; 1934-37
	Commodities:	gold, silver, copper, lead, zinc, antimony
	Comments:	The Aura district covers the east slope of the Bull Run Mountains, formerly the Centennial Range, north of the site of Aura in Bull Run Basin and extends east to include the drainages of Trail, Badger, and Doby George Creeks in the northern Independence Range. This is the eastern portion of the original Bull Run district which also included the present Edgemont district. Bull Run was later changed to White Rock, then to Centennial. The Aura name dates from about 1906 when the town of Aura grew on Columbia Creek, below the old town of Columbia.
Burner		
	Other names:	Burner Hills
	Period Active:	Early 1880s to 1893
	Commodities:	silver, lead, zinc, arsenic
	Comments:	District covers the Burner Hills, an isolated group of hills about 2 by 3 miles across which rise out of the Owyhee Desert. The district is about 16 miles north of Midas and 10 miles west of Good Hope.
Cornucopia		
	Discovered:	1872
	Organized:	1872
	Commodities:	silver, gold, copper, lead, antimony
	Comments:	Located about 15 miles north of Tuscarora, north of the South Fork of the Owyhee River in low mountains bordering the southeast margin of the Owyhee Desert. The main mines are located in sections 18-19, T42N, R51E.
Divide		
	Other names:	Rock Creek
	Discovered:	1916
	Period Active:	1916-1929
	Commodities:	silver, gold, antimony

	Comments:	This district is located at the head of Dry Creek, about 8 miles northwest of Tuscarora, and covers the drainage divide northeast of McCann Creek Mountain. The district is sometimes included in the adjacent Rock Creek district.	
Edgemont			
	Other names:	Bull Run, White Rock, Centennial	
	Discovered:	1890s	
	Commodities:	gold, silver, lead, copper, zinc, tungsten, molybdenum, uranium, arsenic	
	Comments:	This district covers the west slope of the Bull Run (Centennial) Mountains and includes the western portion of the original Bull Run district. The site of the early town of White Rock is located in the northwest corner of the district and the town of Edgemont was located near the west center. The Edgemont name came into use for the western part of the historic Bull Run district following activity in the 1890s. The eastern part of the old Bull Run district is now within the Aura district.	
Good Hope			
	Other names:	Aurora, Amazon	
	Discovered:	1873, 1875	
	Commodities:	silver, antimony, gold, arsenic	
	Comments:	Located about 25 miles northwest of Tuscarora in T41N, R49E. Two historic districts, Amazon and Aurora, are included in the present Good Hope district; Amazon (1873) was in the northeast corner of the township, Aurora (1875) was in the west half of the township. According to Smith (1976), the area was renamed Good Hope, probably in 1878.	
Independence Mountains			
	Other names:	Jerritt Canyon, Jerritt, Burns Basin, Big Springs, Gance Creek	
	Commodities:	gold, silver, antimony, mercury, barite, titanium	
	Comments:	The Independence Mountains district was defined by LaPointe and others (1991) to include all of the Independence Mountains north of Taylor Canyon and south of the Aura district, including the old Burns Basin antimony district and the gold-mining areas of Jerritt Canyon (Jerritt), Big Springs, and Gance Creek. The Wood Gulch Mine area at the north end of the Independence Mountains is included in the separate Aura district.	
Island Mountain			
	Other names:	Gold Creek, Bruno, Bruneau, Wyoming, Penrod	
	Organized:	1869	
	Commodities:	silver, lead, zinc, antimony, copper, gold, tungsten, uranium, barite, arsenic	

	Comments:	Organized in 1869 as the Wyoming district which included what is presently known as Martin Creek (Crystal Creek), Penrod Creek, west of Cornwall Mountain, and the town of Bruno, on "Crystal Creek." The present district extends northeast and southwest from Island Mountain to include most of the drainage basin of Penrod Creek. The district occupies the southeastern flank of Tennessee Mountain and the area to the south, including Cornwall Mountain, Cornwall Basin, and Rosebud Mountain.
Lime Mountain		
	Other names:	Deep Creek, Independence
	Commodities:	copper, silver, gold
	Comments:	Includes all of Lime Mountain, a ridge about 6 miles long extending northward from Deep Creek toward Bull Run Creek. Smith (1976) used Independence and Deep Creek as alternate names for this district.
Mountain City		
	Other names:	Cope, Rio Tinto, Fairweather, Fair Weather, Murray, Murrey, Sooner, Marseilles, Van Duzer, Van Duzen, Van Duyser, Vanduser
	Discovered:	1869
	Organized:	1869
	Commodities:	copper, silver, gold, lead, zinc, antimony, uranium, tungsten, molybdenum, arsenic
	Comments:	Located on the Owyhee River, 7 miles south of the Idaho state line. The original district name was Cope. The district now includes the old districts of Cope, covering California Creek, Hansen Gulch, Grasshopper Gulch, and Mill Creek; Murray, to the northwest; Sooner, about 10 miles to the east; Marseilles, in section 21, T45S, R53E; the Van Duzer placer district on Van Duzer and Cobb Creeks; and the Rio Tinto Mine area, southwest of Mountain City. The Van Duzer placers are sometimes considered to be a separate district.
Tuscarora		
	Organized:	1867
	Commodities:	gold, silver, lead, copper, mercury, arsenic
	Comments:	The Tuscarora district is at the town of Tuscarora on the southeastern slope of Mount Blitzen in the Tuscarora Range. The district was organized to include placers along McCann Creek below Beard Hill in the western part of the present district. The district was enlarged to include lode mines in and north of the present town of Tuscarora and now also includes Berry Basin, west of McCann Creek.

Upper Owyhee Watershed Assessment

Appendix C. Descriptions of the ecoregions in different systems of classification

All descriptions are from the identified source. Some descriptions may have material edited out, but no material has been added.

A. Description of the NRCS common resource areas in the upper Owyhee subbasin (see Figure 2.5)

25.2 – Owyhee High Plateau - Dissected High Lava Plateau: This unit consists of alluvial fans, rolling plains, and shear-walled canyons that are cut into extrusive rock. Sagebrush grassland is common, and scattered areas of woodland are on the rocky uplands. This unit supports cooler season grasses than do the valleys to the south, and it does not support saltbush and greasewood. Frigid and mesic Aridisols and Mollisols are in this unit. Grazing is the primary land use. Cropland is less common on this unit than it is on the Snake River Plain. High-quality water and native fish assemblages are in isolated canyons.[3]

25.3 – Owyhee High Plateau - Owyhee Uplands and Canyons: This unit contains deep, precipitous river canyons, barren lava fields, badlands, and tuffaceous outcroppings that are riddled by caves. The unit supports sagebrush grassland.[4]

25.4 - Owyhee High Plateau - High Desert Wetlands: The High Desert Wetlands ecoregion is critical habitat for nesting and migratory birds. Sedges, meadow barley, creeping wildrye, and Nevada bluegrass are found in wetter areas. Water levels in its lakes and wetlands fluctuate seasonally and annually.[4]

25.6 - Owyhee High Plateau - Semiarid Uplands : The disjuct semiarid uplands ecoregion includes mid-elevation zones in the Bull Run and Independence mountains and volcanic cones, buttes and rocky outcrops that rise out of neighboring, drier lava plains. Mountain sagebrush, western juniper, mountain brush and grasses grow in the ecoregion. The density and extent of juniper woodland varies with long term climate changes, grazing pressure, and fire suppression.[3]

25.8 - Owyhee High Plateau - Upper Humboldt Plains: This unit consists of broad fans and rolling tuffaceous hills and plains. Isolated low mountains and hills also occur. Soil temperature regime is mostly mesic and frigid. Soil moisture regime is mainly aridic bordering xeric. Common vegetation includes Wyoming big sagebrush, basin big sagebrush, low sagebrush, bluebunch wheatgrass and basin wildrye.[3]

B. EPA (See Figure 2.6)

80a - Northern Basin and Range - Dissected High Lava Plateau ecoregion: The Dissected High Lava Plateau ecoregion is a broad to gently rolling basalt plateau cut by deep, sheer-walled canyons, with perennial and intermittent streams draining to the Snake River. Elevation varies from 4,000 to 7,300 feet. Potential natural vegetation is mostly sagebrush steppe; Wyoming big sagebrush and black sagebrush are abundant, as well as Douglas rabbitbrush, Idaho fescue, bluebunch wheatgrass, western wheatgrass, Thurber's needlegrass, bottlebrush squirreltail, Great Basin wildrye, Sandberg's bluegrass, Indian ricegrass, and cheatgrass. Juniper-pinyon woodlands grow on rocky and gravelly uplands.[2]

80e - Northern Basin and Range - High Desert Wetlands ecoregion: The nearly level High Desert Wetlands ecoregion consists of high desert lakes and surrounding wetlands that provide critical habitat for nesting and migratory birds and associated upland birds and mammals. Elevation varies from 4,000 to 5,200 feet (1,219 to 1,646 m). The fine-textured soils are poorly-drained, and basins collect water seasonally. Water levels fluctuate from year to year. Sedges, rushes, black greasewood, tufted hairgrass, mat muhly, meadow barley, creeping wildrye, and Nevada bluegrass occur in wetter areas. Drier areas support basin big sagebrush, Wyoming big sagebrush, silver sagebrush, bluebunch wheatgrass, basin wildrye, Idaho fescue, Thurber's needlegrass, and cheatgrass.[2]

80f - Northern Basin and Range - Owyhee Uplands and Canyon ecoregion: The Owyhee Uplands and Canyons ecoregion is a sagebrush steppe containing deep river canyons, barren lava fields, badlands, and tuffaceous outcrops that are riddled by caves. Elevation varies from 2,500 to 6,600 feet (762 to 2,012 m). Although the region's climate and vegetation are similar to the Dissected High Lava Plateau, its lithology is more varied, stream density is higher, and water availability is greater. These attributes, combined with its remote location, make the region a particularly valuable refuge for wildlife. The steppe is characterized by Wyoming big sagebrush, basin big sagebrush, Douglas rabbitbrush, bluebunch wheatgrass, Idaho fescue, bottlebrush squirreltail, Sandberg's bluegrass, and cheatgrass. Rocky areas support scattered western juniper. Cheatgrass has replaced depleted bunchgrasses in overgrazed areas.[2]

80j - Northern Basin and Range - Semiarid Uplands ecoregion: The disjunct Semiarid Uplands ecoregion includes scattered hills, low mountains, volcanic cones, buttes, and rocky outcrops that rise out of the drier Dissected High Lava Plateau and High Lava Plains. Elevation varies from 4,800 to 9,700 feet (1,463 to 2,957 m). Finely textured soils support big sagebrush, low sagebrush, antelope bitterbrush, serviceberry, snowberry, mountain-mahogany, and associated grasses, such as Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass, Nevada bluegrass, Great Basin wildrye, bottlebrush squirreltail, mountain brome, and Thurber needlegrass. Aspen and chokecherry are found in protected snow pockets, with willow and chokecherry in riparian areas. Rockier soils support juniper steppe woodlands. The density and extent of juniper varies over time and is dependent on long-term climate fluctuations, grazing pressure, and fire suppression.[2]

80k - Northern Basin and Range - Partly Forested Mountains ecoregion: The Partly Forested Mountains ecoregion occupies the elevational belt above the Semiarid Uplands the Independence mountains, from 6,500 to 10,900 feet. These are partially glaciated, high, rugged mountains with glacial features including moraines, cirques, and tarn (lake)s. Perennial or intermittent, high gradient, cold streams are fed by snowmelt and springs. Riffle segments have cobble or boulder substrates. Annual precipitation is sufficient to support a Great Basin pine forest community of Douglas-fir, subalpine fir, ponderosa pine, and limber pine, with whitebark pine near the tree line, and aspen stands in riparian meadows, moist draws, and wet depressions. The understory features low juniper, mountain big sagebrush, mountain brush, serviceberry, snowberry, mountain-mahogany, Idaho fescue, sheep fescue, rough fescue, bottlebrush squirreltail, prairie lupine, mountain brome, bluebunch wheatgrass, and Sandberg bluegrass. Small areas of tundra and alpine meadows are found at the highest elevations.[2]

13m - Central Basin and Range - Upper Humboldt Plains ecoregion: The Upper Humboldt Plains ecoregion is an area of rolling plains punctuated by occasional buttes and low mountains. It is mostly underlain by volcanic ash, rhyolite, and tuffaceous rocks. Low sagebrush is common in extensive areas of shallow, stony soil, as are cool season grasses, such as bluebunch wheatgrass, Idaho fescue, and Sandberg bluegrass. Lightning fires are common and a post-fire monoculture of cheatgrass tends to replace the native grasses and shrubs. Grazing is the major land use.[2]

C. USDA Forest Service

Section 342B--Northwestern Basin and Range - This section has nearly level basins and valleys bordered by long gently sloping alluvial fans with linear mountain ranges. Soils are formed mostly from rocks of volcanic origin. Vegetation consists of sagebrush and desert shrub cover types.[1]

> Geomorphology. This area occurs within the Basin and Range physiographic province. Northwestern Basin and Range Section is located in the northern portion of Nevada, southeastern Idaho, and south-central Oregon. It extends into northern Utah also. Nearly level basins and valleys are bordered by long, gently sloping alluvial fans. North-south trending mountain ranges and few volcanic plateaus rise sharply above the valleys. Large alluvial fans have developed at the mouths of most canyons. Elevation ranges from 4,000 to 7,200 ft (1,200 to 2,200 m).[5]
>
> Lithology and Stratigraphy. Pliocene volcanic and shallow intrusive igneous rocks occur, along with andesite, breccias, and basalt flows. Alluvial deposits, playas, marshes, and flat deposits occur in the valleys.[5]
>
> Soil Taxa. There are Aridisols in combination with frigid and mesic soil temperature regimes, along with xeric and aridic soil moisture regimes. Large areas have saline-sodic affected soils.[5]
>
> Potential Natural Vegetation. Kuchler vegetation types include sagebrush steppe. The Soil Conservation Service identifies the potential natural vegetation as shrub-grass with saltbush-greasewood vegetation.[5]
>
> Fauna. A major migration route for waterfowl crosses this Section. It is characterized particularly by tundra swans, lesser snow geese, American widgeons, and pintail, canvasback, and ruddy ducks, which use the wetlands around interior basin lakes. Sandhill cranes, western snowy plovers, and white-faced ibis nest here. California bighorn sheep and California quail

characterize the uplands. Small bands of bison once roamed the margin of Malheur Lake but disappeared prior to white settlement. Rare kit foxes live in the desert lowlands. Pronghorn and mule deer are present. Wolverines are occasionally found. Gray flycatchers, Townsend's solitaires, northern sage sparrows, and broad-tailed hummingbirds are characteristic. Spotted frogs and Malheur shrews are uncommon riparian species. Antelope ground squirrels occupy areas of pale desert soils. Sharptail grouse, once common, are no longer present. Warner Lake suckers, Alvord chubs, and Soldier Meadows desertfish are endemic fishes of interior basin lakes and springs. Lahontan cutthroat trout also characterize this Section.[5]

Climate. Precipitation ranges from 4 to 20 in (100 to 790 mm) annually; mountains receive as much as 20 in annually. Precipitation is evenly distributed throughout fall, winter, and spring, but is low in the summer. Summers are hot and dry and winters are cold and dry. Temperature averages 41 to 50°F (5 to 10°C). The growing season ranges from 30 to 140 days.[5]

Surface Water Characteristics. Water is scarce except at higher elevations. Few streams and little water storage occurs in this Section. Large ground water supplies have been untapped. Pyramid Lake is the major lake in this Section.

Disturbance Regimes. Short duration and low intensity brush fires occur due to summer thunderstorms. Water and wind erosion is also occurring.[5]

Land Use. Livestock production is the primary use, with little farming. Some mining has also occurred.[5]

Section 342C--Owyhee Uplands- This section consists largely of a nearly flat, deeply dissected plateau where block-faulted mountain ranges are less pronounced than in other parts of the Basin and Range physiographic province to the south. Annual rainfall averages from 4 to 8 inches. Unlike the Basin and Range province, however, drainage is not internal and erosion by surface streams has formed steep-walled canyons. Rock formations are mostly volcanic tuffs and basalts, with some granites. Soils on plains are generally shallow and clayey, but are deeper and loamy on slopes. The main vegetation consists of sagebrush and pinyon-juniper cover types.[1]

Geomorphology. This area occurs within the Columbia Plateau physiographic province, also known as the Columbia Intermontane province. The Owyhee Uplands Section is part of southwest Idaho, southeast Oregon, and northern Nevada. This area is an uplifted region with doming and block-faulting common. It is deeply dissected from erosional processes. Lavas are older than that of the Snake River Plains. The Owyhee Mountains are made of granite; however, most of the uplands are rhyolites and welded tuffs with silicic volcanic flows, ash deposits, and wind-blown loess. Elevation ranges from 4,000 to 8,000 ft (1,200 to 2,500 m).[5]

Lithology and Stratigraphy. Miocene basalt rocks occur here. Rhyolites, welded tuffs, and silicic volcanic flows are also found in this Section. Columbia basalts occur along the Snake River.[5]

Soil Taxa. Aridisols, Entisols, Alfisols, Inceptisols, and Mollisols occur in combination with mesic and frigid soil temperature regimes, and xeric and aridic soil moisture regimes. Cryic temperature regimes occur at higher elevations.[5]

Potential Natural Vegetation. Kuchler vegetation types are sagebrush steppe with *Artemisia* and *Agropyron* and small areas of wheatgrass-bluegrass. The Soil Conservation Service identifies the area as having a sagebrush-grass potential natural vegetation.[5]

Fauna. A major migration route for geese crosses this Section, and it is used particularly by the intermountain population of Canada geese. This Section also is a major wintering area for mallards and common mergansers. California bighorn sheep live in rocky canyons. Gray flycatchers, northern sage sparrows, and mountain quail live in the sagebrush and juniper uplands. Wolverine once lived here but have not been seen for decades. Once common, sharptail grouse are scarce in grasslands and sagebrush foothills. Spotted frogs have been found here. Small bands of elk roam the uplands year-round, and elk from surrounding Sections winter here. Pronghorn, mule deer, and sage grouse inhabit this Section. Remnant bull trout populations are found in cold headwater streams. Other Columbia and Snake River system species include northern squawfish, biglip sucker, bridgelip sucker, Utah sucker, and Columbia redside shiners.[5]

Climate. Precipitation ranges from 7 to 15 in (200 to 400 mm) annually; it is close to evenly distributed throughout the year, but is low from mid summer to early autumn. Precipitation is only 20 percent of the evaporation potential during the frost-free period. Summers are dry with low humidity. Temperature averages 35 to 45 °F (2 to 8 °C). The growing season ranges from 90 to 120 days but is less than 60 days at higher elevations.[5]

Surface Water Characteristics. Water supply from precipitation and streamflow is small and unreliable, except along the Owyhee, Bruneau, and Humboldt Rivers. Snow accumulation at the higher elevations contributes to streamflow. Few small lakes and reservoirs are found in this Section.[5]

Disturbance Regimes. After fire, grasses and forbs replace higher seral species. Water and wind erosion is also occurring.[5]

Land use. Livestock grazing, and dryland and irrigated farming are the major land uses. Recreation is also important.[5]

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Upper Owyhee Watershed Assessment

Appendix D. Reservoirs

There are many dams on small reservoirs and stock ponds in the upper Owyhee subbasin. This appendix provides a brief description of only the larger reservoirs.

Idaho

The information for the reservoirs in the Idaho section of the upper Owyhee subbasin is taken from a 1974 survey by the Idaho Fish and Game Department. The information on fish has been removed since it would no longer be timely, but the other information is printed verbatim.

Big Blue Reservoir

Big Blue Reservoir is located at an elevation of 5,400 feet in Sections 2 & 11, T13S, R2E, Boise Meridian and is fed by Blue Creek. Surface area (full) is 131 acres, volume (full) is 1,131 acre-feet and the maximum depth (full) is 29 feet. Watershed condition and cover: This is a sagebrush-grass watershed. Cattle were observed all around the reservoir (August 15, 1972). In June, there were about 60 resident nesting Canada geese on this reservoir. The Blue Creek watershed and vegetative cover is in fair condition. Source and Quality of Water: Fed by Blue Creek which flows year-round. Access: It is necessary to go through private land to get to this reservoir and the present owner would like to have it posted. This access problem needs to be resolved. Ownership is by BLM. Used for irrigation with an annual maximum drawdown of about 8 feet. Built in 1914.[3]

Little Blue Reservoir

Little Blue Reservoir is located at an elevation of 5,400 feet in Section 17 and the reservoir extends into Section 16, T13S, R3E, Boise Meridian. Surface area (full) is 188 acres, volume (full) is 800 acre-feet, the maximum depth (full) is 33 (down about 10 feet, August 15, 1972). Watershed condition and cover: Is about the same type of watershed and terrain as Big Blue Reservoir. Watershed and vegetative cover is in fair condition. Source and quality of water: Just a little bit of algae on the water back of the dam. Fed by Little Blue Creek which is intermittent in summer. Access: Same as Big Blue Reservoir. Ownership is by BLM.[3]

Paine Creek Reservoir

Paine Creek Reservoir is located at an elevation of 5,500 feet in the Riddle Ranch complex, Sections 27 and 34, T13S, R3E, Boise Meridian. Surface area (full) is 55 acres, volume (full) is 2,120 acre-feet and the maximum depth is 29 feet and there is an average drawdown of about 8-12 feet. Height of the dam is 40 feet. Watershed condition and cover: The watershed doesn't look large and is mostly sagebrush-grass. Range is in good shape. Source and quality of water: Fed by Paine Creek, a small stream which flows all summer with some nice springs up the creek 1-2 miles. The upper half of the reservoir is shallow. The entry into it with one exception either state or BLM land. Construction and relocation of the 4.1 miles of the present road would be required to provide public access. The reservoir is used for irrigation of the Riddle Ranch meadows and was constructed in 1930.[3]

Juniper Basin Reservoir

Juniper Basin Reservoir is located at an elevation of 5,100 feet in Sections 4 & 5, T16S, R1W, Boise Meridian, 4 miles west of Duck Valley Indian Reservoir, 4 miles north of the Nevada line and entirely on public land. Approximately 200 surface acres when full, volume (full) unknown, and maximum depth reported as 25 feet. The dam height is 35 feet. Watershed condition and cover: Sage and grassland, moderately grazed. Source is Juniper Creek. Access: Poor, 4-wheel-drive roads through Nevada are the only access.[3]

Squaw Creek Reservoir

Squaw Creek Reservoir is located at an elevation 5,400 feet in Section 22, T14S, R3E, Boise Meridian 1 mile northeast of Riddle on private land. Surface area (full) is estimated at 80 acres, volume (full) 1,200 acre-feet, and maximum depth, 35-40 feet. Source of water is Squaw Creek which carries water from Squaw Reservoir on the Indian Reservation. Squaw Reservoir is on upper Squaw Creek and filled by water diverted from Mary's Creek. Access: About 1/2 mile of gravel road through private land and the state gravel pit off Idaho Highway 51 near Riddle. Drawdown doesn't occur until upstream reservoir is empty.[3]

Bybee Reservoir

Bybee Reservoir is located at an elevation of 5,350 feet in Section 31, T13S, R2E, Boise Meridian on BLM land. Surface area is approximately 70 acres when full, and the maximum depth is estimated at 30 feet. Source of water is Shoo-fly Creek. Big Blue Creek Reservoir is 5 miles to the northeast. Access: By fair dirt roads 14 miles west of Idaho Highway 51 at Riddle.[3]

Nevada

The State of Nevada Division of Water Resources of the Department of Conservation and Natural Resources maintains an inventory of the dams in the state with their IDs, names, heights, location, storage capacity, tributary area, owner and last date inspected.

In the upper Owyhee subbasin there are four dams owned by the Petan Company of Nevada, Inc. Wilson Reservoir is the largest with a storage capacity of 8,000 acre-feet. The 37 foot tall dam impounds water from Wilson Creek which drains about 26 square miles. The Dry Creek Dam is on Dry Creek. It is 50 feet tall. The reservoir has a capacity of 1,940 acre-feet draining an area of 10.36 square miles. There are two reservoirs on Bull Run Creek, Bull Run Reservoir and Rawhide Reservoir. Bull Run Reservoir is further upstream with 60.3 mi^2 of tributary area. It holds 1,000 acre-feet of water. Rawhide Dam downstream holds 1,500 acre feet of water with 129.4 mi^2 draining into it. Both Bull Run Dam and Rawhide Dam are 37 feet tall.[4] Although the dams are primarily to provide irrigation water, Wilson Reservoir is also used for recreation by the public. The campground and boating are operated by the Bureau of Land Management.[3]

The Agri-beef Company has two dams in the upper Owyhee subbasin, Chimney Creek Dam and Deep Creek Dam. Chimney Creek Dam can impound up to 5,000 acre feet of water from Chimney Creek in Desert Ranch Reservoir. The 22 foot tall dam captures water draining off of 345.7 square miles of watershed. The Deep Creek Dam on Deep Creek collects water from 71.2 mi^2 of drainage. When full, the reservoir can hold 1,410 acre-feet of water behind a 42 foot tall dam.[4]

The largest dam in the upper Owyhee subbasin is the Wild Horse Dam owned by the United States Department of the Interior, Bureau of Indian Affairs. The stored irrigation water is for agriculture in the Duck Valley Indian Reservation. The original dam was found to be weak and a new one was constructed in 1969. This doubled the size of the reservoir. When full, the reservoir has a surface area of 2,830 acres and holds 73,500 acre feet of water. The spillway elevation is 6,205 feet above sea level.[1] The dam is 101 feet tall and holds water from a 60 mi^2 watershed.[4]

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Upper Owyhee Watershed Assessment

Appendix E.

A non exhaustive list of plants identified in the upper Owyhee subbasin with species names, common names, and source of information.

Although a species is not listed in the following table, it does not indicate that the species is absent from the upper Owyhee subbasin. The species included here are those that have been positively identified as being within the subbasin. There are undoubtedly numerous species which have been omitted, particularly since the personal observations were mostly made following the flowering season for most of the wildflowers so that they would not have been very obvious.

A. Species found on the 45 Ranch[2]
B. Atlas of Nevada Conifers[1]
P. Personal observations
M. Pictures available on the Mid-Snake River Watershed Vegetation Database[3]

Scientific name	Common name[*]	Source
	Grasses	
Achnatherum hymenoides	indian ricegrass	A P M
Agropyron cristatum	crested wheatgrass	A P
Agropyron intermedium	intermediate wheatgrass	A
Agropyron repens or *Elymus repens*	quackgrass	A
Agropyron smithii	bluestem wheatgrass, western wheatgrass	A P
Agropyron spicatum	bluebunch wheatgrass	A
Agropyron trachycaulum or *Elymus trachycaulum*	slender wheatgrass	A
Agrostis exarata	spike bentgrass	A
Agrostis stolonifera	creeping bentgrass	A M
Alopecurus aequalis	little foxtail, shortawn fescue	A
Alopecurus geniculatus	water foxtail, water fescue	A
Alopecurus pratensis	meadow foxtail, field meadow-foxtail	A P M
Apera interrupta	interrupted apera, dense silkybent	A
Beckmannia syzigachne	American sloughgrass	A
Bromus inermis	smooth brome, pumpelly's brome	A
Bromus japonicus	Japanese brome	A
Bromus tectorum	cheatgrass, downey brome	A P M
Calamagrostis inexpansa	narrow-spiked reedgrass	A
Crypsis alopecuroides	foxtail pricklegrass	A
Dactylis glomerata	orchardgrass	A
Danthonia californica	California oatgrass	A
Deschampsia cespitosa	tufted hairgrass	A
Deschampsia danthonoides	annual hairgrass	A
Distichlis spicata	desert saltgrass	A P

Echinochloa crus-galli	barnyard grass	A		
Elymus cinereus or *Leymus cinereus*	great basin wildrye, giant wildrye, basin wildrye	A	P	M
Elymus elymoides	squirreltail		P	M
Elymus triticoides	creeping wildrye	A		
Eremopyrum triticeum	annual wheatgrass	A		
Festuca arundinacea	tall fescue	A		
Festuca idahoensis	Idaho fescue	A		
Glyceria elata	tall mannagrass, fowl mannagrass	A		
Glyceria grandis	American mannagrass	A		
Hordeum brachyantherum	meadow barley	A		
Hordeum jubaturm	squirrel-tail, foxtail barley	A		M
Koeleria cristata or *Koeleria nitida* or *Koeleria macrantha*	Prairie Koeler's grass, prairie Junegrass	A		
Muhlenbergia asperifolia	scratchgrass muhly	A		
Muhlenbergia richardsonis	mat muhly	A		
Panicum capillare	witchgrass, old witchgrass	A		
Phalaris arundinacea	reed canarygrass	A	P	
Phleum pratense	timothy	A		
Phragmites australis	common reed	A		
Poa ampla	big bluegrass	A		
Poa bulbosa	bulbous bluegrass	A	P	M
Poa compressa	Canada bluegrass	A		
Poa cusickii	Cusick’s bluegrass	A		
Poa interior	inland bluegrass	A		
Poa nevadensis	Sandberg bluegrass, Nevada bluegrass	A		
Poa pratensis	Kentucky bluegrass	A		
Poa sandbergii or *Poa secunda*	Sandberg's bluegrass, curly blue grass	A		
Puccinellia nuttalliana	Nuttall’s alkaligrass	A		
Sitanion hystrix	bottlebrush squirreltail	A	P	
Spartina gracilis	alkali cordgrass	A		
Sphenopholis obtusata	wedgegrass, prairie wedgescale	A		
Stipa comata or *Hesperostipa comata*	needle-and-thread	A		
Stipa thurberiana or *Achnatherum thurberianum*	Thurber's needlegrass	A		
Stipa webberi or *Achnatherum webberi*	Webber’s needlegrass	A		
Taeniatherum caput-medusae	medusahead rye		P	M
Vulpia bromoides	brome fescue, barren fescue	A		
	Grasslikes			
Carex athrostachya	slender-beaked sedge	A	P	
Carex douglasii	Douglas’s sedge	A		
Carex lanuginosa	wooly sedge	A		
Carex nebrascensis	Nebraska sedge	A		
Carex praegracilis	clustered field-sedge	A		
Cyperus aristatus	awned flatsedge	A		
Eleocharis palustris	creeping spike-rush, common spikerush	A		
Eleocharis rostellata	beaked spikerush	A		
Juncus balticus or *Juncus arcticus*	mountain rush, Baltic rush	A		
Juncus ensifolius	swordleaf rush, dagger-leaf rush	A		
Juncus longistylis	long-styled rush	A		
Juncus nevadensis	Sierra rush	A		
Juncus orthophyllus	straight-leaved rush	A		

Schoenoplectus americanus or *Scirpus americanus*	chairmaker's bulrush, Olney threesquare	A		
Schoenoplectus fluviatilis or *Scirpus fluviatilis*	river bulrush	A	P	
Schoenoplectus pungens or *Scirpus pungens*	common threesquare	A		
Schoenoplectus tabernaemontani or *Scirpus validus*	softstem bulrush	A		
Sparganium emersum	simplestem bur-reed	A		
	Forbs			
Achillea millefolium	white yarrow	A	P	M
Acroptilon repens	Russian knapweed		P	M
Agastache urticifolia	horse mint, nettle-leaf horse-mint	A	P	M
Agoseris glauca	pale agoseris, short beaked agoseris	A		M
Agoseris heterophylla	annual agoseris	A		
Agoseris sp.	Agoseris	A		
Aliciella leptomeria or Gilia leptomeria	sand gilia	A		
Alisma plantago-aquatica	water-plantain	A		
Allium acuminatum	tapertip onion	A		M
Allium lemmonii	Lemmon's onion	A		
Allium nevadense	Nevada onion	A		
Allium parvum	dwarf onion, small onion		P	M
Allium tolmiei	Tolmie's onion	A		
Alyssum desertorum	desert madwort, desert alyssum	A		
Amaranthus albus	prostrate pigweed, white pigweed	A		
Amaranthus blitoides	prostrate pigweed		P	M
Amaranthus californicus	California amaranth	A		
Amsinckia lycopsoides	tarweed fiddleneck		P	
Amsinckia menziesii	common fiddleneck, Menzies' fiddleneck	A	P	
Amsinckia retrorsa	rigid fiddleneck	A	P	M
Angelica kingii	King's angelica, Nevada angelica	A		
Antennaria dimorpha	low pussytoes, cushion pussytoes	A		
Antennaria luzuloides	woodrush pussy-toes	A		
Antennaria microphylla	littleleaf pussytoes, rosy pussytoes	A		
Apocynum cannabinum	Indianhemp, common dogbane	A	P	
Arabis holboellii	Holboell's rockcress	A		M
Arabis microphylla	littleleaf rockcress	A		
Arabis puberula	silver rockcress, hoary rockcress	A		
Arabis sp.	rockcress	A		
Arabis sparsiflora	sicklepod rockcress, elegant rockcress	A		
Arenaria congesta	ballhead sandwort	A		M
Arenaria kingii	King's sandwort	A		
Arnica longifolia	spearleaf arnica, seep-spring arnica	A		
Arnica sororia	twin arnica	A		
Artemisia biennis	binennial wormwood	A		
Artemisia dracunculus	dragon sagewort, tarragon	A	P	M
Artemisia ludoviciana	prairie sage, silver wormwood	A	P	M
Artemisia packardiae	Packard's wormwood, Packard's mugwort	A		
Asclepias incarnata	swamp milkweed	A		
Asclepias speciosa	showy milkweed	A		M
Aster ascendens or *Symphyotrichum ascendens*	western aster	A		

Aster eatonii	Eaton's aster	A		
Aster frondosus	alkali aster, short-rayed aster	A		
Aster hesperius or *Symphyotrichum lanceolatum*	white panicle aster, western lined aster	A		
Aster scopulorum	lava aster,crag aster	A		
Astragalus atratus	mourning milkvetch	A		
Astragalus calycosus	matted milkvetch, Torrey's milkvetch	A		
Astragalus convallarius	lesser rushy milkvetch	A		
Astragalus curvicarpus	curvepod milkvetch, sickle milkvetch	A		M
Astragalus eremiticus	hermit milkvetch	A		
Astragalus filipes	threadstalk milkvetch	A	P	M
Astragalus kentrophyta	spiny milkvetch, thistle milkvetch	A		
Astragalus lentiginosus	freckled milkvetch	A		
Astragalus newberryi	Newberry's milkvetch	A		
Astragalus obscurus	arcane milkvetch	A		
Astragalus purshii	wooly-pod milk-vetch	A		
Astragalus sp.	milkvetch	A	P	
Astragalus tetrapterus	fourwing milkvetch	A		
Atriplex patula	spear saltbush, spear orache	A		
Balsamorhiza hookeri	Hooker's balsamroot	A	P	M
Balsamorhiza sagittata	arrowleaf balsamroot	A	P	M
Bassia hyssopifolia	fivehorn smotherweed	A		
Bassia scoparia or *Kochia scoparia*	burningbush	A		M
Berula erecta	cutleaf waterparsnip	A		
Blepharipappus scaber	blepharipappus	A		
Brickellia microphylla	littleleaf brickelbush	A	P	M
Brickellia grandiflora	tasselflower brickelbush, largeflower brickellia	A		
Brickellia oblongifolia	Mojave brickelbush, narrow-leaved brickellia	A		
Callitriche hermaphroditica	northern water-starwort, autumnal water-starwort	A		
Calochortus bruneaunis	Bruneau mariposa lily	A		
Calochortus eurycarpus	white mariposa lily, wide-fruit mariposa	A		M
Calochortus macrocarpus	sagebrush mariposa lily	A		
Camassia quamash	camas		P	M
Camelina microcarpa	littlepod falseflax, hairy falseflax	A		
Camissonia boothii	Booth's evening primrose, alyssum evening primrose	A		M
Camissonia claviformis	browneyes, club fruit evening primrose	A		M
Camissonia pterosperma	wingfruit suncup	A		
Camissonia tanacetifolia	tansyleaf evening primrose	A	P	
Capsella bursa-pastoris	shepherd's-purse	A	P	M
Cardaria chalapensis	chalapa hoarycress		P	M
Cardaria draba	heart podded hoarycress, hoary whitetop	A	P	M
Castilleja chromosa or *Castilleja angustifolia*	desert paintbrush, violet desert paintbrush, Northwest paintbrush	A		
Castilleja linariifolia	Wyoming Indian paintbrush	A		
Castilleja minor or *Castilleja exilis*	annual paintbrush, lesser Indian paintbrush	A		
Castilleja pallescens	pale Indian paintbrush	A		
Castilleja sp.	Indian paintbrush	A	P	M
Caulanthus crassicaulis	thickstem wild cabbage	A		
Centaurea maculosa	spotted knapweed		P	M
Centaurium exaltatum	Great Basin centaury, desert centaury	A		
Ceratophyllum demersum	coon's tail, hornwort	A		
Chaenactis douglasii	hoary false-yarrow, hoary chaenactis	A		M
Chamaesyce serpyllifolia	thymeleaf sandmat, thyme leafed spurge	A		

Chenopodium album	lambsquarters	A	P	
Chenopodium botrys	Jerusalem oak goosefoot, Jerusalem-oak	A	P	
Chenopodium fremontii	Fremont's goosefoot	A	P	
Chenopodium glaucum	oakleaf goosefoot	A		
Chenopodium leptophyllum	narrowleaf goosefoot, slimleaf goosefoot	A		
Chorispora tenella	crossflower, blue mustard, chorispora	A	P	M
Chorizanthe watsonii	fivetooth spineflower, Watson's spineflower	A		
Cicuta douglasii	western water hemlock			M
Cicuta maculata	spotted water hemlock	A		
Cirsium arvense	Canada thistle	A	P	M
Cirsium canovirens	greygreen thistle	A		
Cirsium subniveum	intermountain thistle		P	
Cirsium utahense	Utah thistle		P	M
Cirsium vulgare	bull thistle	A	P	M
Clarkia pulchella	pink fairies, ragged robin		P	M
Claytonia lanceolata	spring beau ty		P	M
Claytonia perfoliata or *Montia perfoliata*	miner's lettuce	A		M
Clematus lingusticifolia	western clematis, virgin's bower	A	P	M
Cleome serrulata	rocky mountain beeplant		P	M
Collinsia parviflora	small flowered blue-eyed Mary	A		M
Conyza canadensis	Canadian fleabane, horseweed	A		
Cordylanthus ramosus	bushy bird's beak	A		
Crepis acuminata	long-leaved hawksbeard	A		M
Crepis atrabarba	hawksbeard	A	P	
Crepis occidentalis	largeflower hawksbeard	A		
Crepis spp.	hawksbeard	A	P	
Cryptantha circumscissa	cushion cryptantha, matted cryptantha	A		M
Cryptantha echinella	prickly cryptantha	A		
Cryptantha sp.	cryptantha	A		M
Cryptantha spiculifera	Snake River cryptantha	A		
Cryptantha watsonii	Watson's cryptantha, Watson's cat's eye	A		
Cymopterus longipes	longstalk springparsley	A		
Cymopterus petraeus or *Pteryxia petraeus*	rockloving wavewing, rockloving cymopterus	A		
Cymopteris spp.	springparsley		P	M
Cystopteris fragilis	brittle bladderfern	A		
Damasonium californicum or Machaerocarpus califonicus	fringed waterplantain, california damsonium	A		
Delphinium andersonii	Anderson's larkspur, desert larkspur	A		
Delphinium sp.	larkspur	A	P	M
Descurainia incana or Descurainia richardsonii	mountain tansymustard	A		
Descurainia sophia	flixweed	A	P	M
Dodecatheon jeffreyi	Sierra shootingstar, Jeffrey's shooting star	A		
Downingia insignis	calicoflower, harlequin calicoflower	A		
Downingia laeta	Great Basin calicoflower, Great Basin downingia	A		
Draba douglasii or *Cusickiella douglasii*	alkali cusickiella, Douglas' draba	A		
Draba verna	spring whitlow grass	A	P	M
Eatonella nivea	white false tickhead	A		
Epilobium brachycarpum	tall annual willowherb, panicled willowherb	A		M
Epilobium ciliatum	fringed willowherb, American willowherb	A		

Epilobium pygmaeum	smooth spike-primrose	A		
Epilobium torreyi	Torrey's spike-primrose, Torrey's willowherb	A		
Epilobium spp.			P	M
Epipactis gigantea	stream orchid, giant heelborine	A		
Equisetum arvense	common horsetail, field horsetail	A	P	M
Equisetum laevigatum	smooth scouringrush, smooth horsetail	A		M
Equisetum variegatum	variegated horsetail, variegated scouringrush	A		
Eriastrum sparsiflorum	Great Basin woollystar	A		
Erigeron aphanactis	rayless shaggy fleabane, basin raylee daisy	A		M
Erigeron bloomeri	scabland fleabane	A		
Erigeron chrysopsidis	dwarf yellow fleabane	A		
Erigeron compositus	dwarf mountain fleabane, cutleaved	A		
Erigeron latus	broad fleabane	A		
Erigeron linearis	desert yellow daisy, lineleaf fleabane	A		
Erigeron lonchophyllus	shortray fleabane, spearleaf fleabane	A		
Erigeron poliospermus	purple cushion fleabane, cushion fleabane	A		
Erigeron pumilus	shaggy fleabane	A		
Eriogonum caespitosum	matted buckwheat	A		
Eriogonum heracleoides	parsnipflower buckwheat, Wyeth buckwheat	A		M
Eriogonum microthecum	slenderbush buckwheat	A		
Eriogonum ovalifolium	cushion backwheat, oval-leaved eriogonum	A		M
Eriogonum sphaerocephalum	round-headed eriogonum, rock buckwheat	A		
Eriogonum strictum	Blue Mountain buckwheat	A		M
Eriogonum umbellatum	sulfur-flower buckwheat	A	P	M
Eriogonum vimineum	wickerstem buckwheat, broom buckwheat	A		
Eriogonum spp.			P	M
Eriophyllum lanatum	woolly sunflower, Oregon sunshine	A	P	M
Erodium cicutarium	filaree	A		M
Euthamia occidentalis	western goldentop, western goldenrod	A		
Fritillaria pudica	yellow bell	A		M
Galium aparine	stickywilly, goose-grass cleavers	A		M
Galium multiflorum	shrubby bedstraw	A		
Gayophytum Juss. spp.	groundsmoke	A		
Gayophytum ramosissimum	pinyon groundsmoke, hairstem groundsmoke	A		
Gerannium carolinianum	Carolina cranesbill, Carolina geranium	A		
Geranium viscosissimum	sticky geranium		P	M
Geum triflorum	old man's whiskers, prairie smoke avens	A		
Gilia aggregata or *Ipomopsis aggregata*	scarlet gilia, skyrocket gilia		P	M
Gilia inconspicua	shy gilia	A		
Gilia sinuata	rosy gilia			
Glycyrrhiza lepidota	wild licorice, American licoriceroot	A	P	M
Gnaphalium palustre	western marsh cudweed, lowland cudweed	A		
Grindelia sp.	gumweed		P	M
Hackelia ophiobia	Owyhee River stickseed	A		
Halogeton glomeratus	saltlover, halogeton	A	P	M
Helianthus nuttallii	Nuttall's sunflower	A		
Hesperochiron pumilus	false strawberry		P	M
Heuchera parvifolia	littleleaf alumroot, common alumroot	A		
Heuchera rubescens	pink alumroot, red alumroot	A		
Hydrophyllum capitatum	ballhead waterleaf		P	M
Iva axillaris	poverty sumpweed	A	P	M
Ivesia baileyi	Bailey's ivesia	A		

Kochia scoparia	kochia	A	P	M
Lactuca tatarica or *Lactuca pulchella*	blue lettuce	A		
Lactuca serriola	prickly lettuce	A	P	M
Lappula redowshi	western stickseed	A		
Layia glandulosa	whitedaisy tidytips	A		
Lemna minor	common duckweed	A		
Lepidium campestre	field pepperweed, pepperwort	A		
Lepidium davisii	Davis's pepperweed	A		
Lepidium latifolium	perennial pepperweed		P	M
Lepidium perfoliatum	clasping pepperweed, clasping peppergrass	A	P	M
Leptosiphon septentrionalis or *Linanthus septentrionalis*	northern linanthus	A		
Lesquerella kingii	King's bladderpod	A		
Lesquerella sp	bladderpod		P	
Leucocrinum montanum	sandlily	A		M
Lewisia rediviva	bitterrooot	A		M
Lilaea scilloides	flowering quillwort, awl-leaf lilaea	A		
Limosella aquatica	water mudwort	A		
Lepidium perfoliatum	perfoliate pepperweed		P	M
Leptosiphon septentrionalis or *Linanthus septentrionalis*	northern linanthus	A		
Linum lewisii	wild blue flax, prairie flax		P	M
Lithophragma glabrum	bulbous woodland-star, smooth prairiestar	A		
Lithophragma tenellum	slender woodland-star, slender prairiestar	A		
Lomatium spp.	desertparsley	A	P	M
Lomatium cous	cous biscuitroot, cous desertparsley	A		M
Lomatium dissectum	fernleaf biscuitroot, fern-leafed desert parsley	A	P	M
Lomatium grayi	Gray's lomatium, Gray's desert parsley		P	M
Lomatium leptocarpum	gumbo lomatium	A		
Lomatium macrocarpum	bigseed biscuitroot, large-fruit desert-parsley,	A		
Lomatium nudicaule	barestem biscuitroot, barestem lomatium	A	P	M
Lupinus argenteus	silvery lupine, tailcup lupine	A		
Lupinus brevicaulis	shortstem lupine, sand lupine	A		
Lupinus lepidus	dwarf lupine, prairie lupine	A		
Lupinus spp.	lupine	A	P	M
Lupinus uncialis	inch-high lupine	A		
Lygodesmia spinosa	spiny skeletonweed	A		
Machaeranthera canescens	hoary aster	A		M
Madia exigua	little tarweed, threadstem madia, little tarplant	A		
Madia gracilis	grassy tarweed, common tarweed	A		
Maianthemum racemosum or *Smilacina racemosa*	false spikenard, feathery false lily of the valley	A		
Malacothrix torreyi	Torrey's desertdandelion	A		
Marrubium valugare	horehound		P	
Marsilea vestita	hairy cloverfern, hairy waterclover	A		
Medicago lupulina	black medic, hop clover	A		M
Medicago sativa	alfalfa	A	P	M
Melilotus alba	white sweet clover	A	P	M
Melilotus officinalis	yellow sweet clover		P	M
Melilotus sp.	sweetclover	A		
Mentha arvensis	field mint	A		
Mentzelia albicaulis	whitestem blazingstar	A	P	M
Mentzelia laevicaulis	smooth-skin blazingstar, blazing star	A		M

Mertensia oblongifolia	sagebrush bluebells	A P	
Microseris nutans	nodding microseris	A	M
Microseris troximoides	false-agoseris	A	
Microsteris gracilis	pink microsteria	A	
Mimulus floribundus	Mayflowered monkeyflower	A	
Mimulus guttatus	seep monkeyflower	A	
Mimulus nanus	dwarf monkeyflower, dwarf purple monkeyflower	A	M
Mimulus suksdorfii	Suksdorf’s monkeyflower, miniature monkey-flower	A	
Monardella odoratissima	mountain monardella	A P	M
Monolepis nuttalliana	patata, Nuttall's povertyweed	A	
Montia chamissoi	water miner’s lettuce, water montia	A	M
Myosurus aristatus	bristly mousetail	A	
Myosurus minimus	tiny mousetail	A	
Nama densum	leafy fiddleleaf, leafy nama, matted nama	A	
Navarretia intertexta	Great Basin navarretia, needleleaf navarretia	A	
Nemophila breviflora	Great Basin baby-blue-eyes	A	
Nestotus stenophyllus or *Haplopappus stenophyllus* or *Stenotus stenophyllus*	narrowleaf mock goldenweed	A	
Nicotiana attenuata	coyote tobacco	A P	
Oenothera caespitosa	rock-rose, desert evening primrose	A	M
Oenothera elata	Hooker’s evening primrose	A	
Oenothera villosa	hairy evening primrose, common evening primrose	A P	
Onopordum acanthium	Scotch thistle	A P	M
Orobanche sp.	broomrape	A	M
Orobanche corymbosa	flat-top broomrape	A	
Orobanche fasciculata	clustered broomrape	A	
Orthocarpus luteus	golden-tongue owl-clover, yellow owl’s-clover	A P	M
Pectocarya setosa	moth combseed	A	
Pediocactus simpsonii	mountain ball cactus	A	
Penstemon deustus	scabland penstemon, hot-rock penstemon	A P	M
Penstemon gairdneri	Gairdner’s beardtongue	A	M
Penstemon humilis	low beardtongue, lowly penstemon	A	
Penstemon janishiae	Antelope Valley beardtongue	A	
Penstemon sp.	penstemon	A	M
Penstemon speciosus	showy penstemon, royal penstemon	A P	M
Perideridia gairdneri or Perideridia montana	common yampah	A	M
Phacelia glandulifera	sticky phacelia, glandular-hair scorpion-weed	A	
Phacelia hastata	whiteleaf or silverleaf phacelia	A	M
Phacelia heterophylla	varileaf phacelia	A	
Phacelia linearis	threadleaf phacelia	A	M
Phacelia rattanii	Rattan’s phacelia	A	
Phlox hoodii	Hood's phlox	A	M
Phlox longifolia	long-leafed phlox	A	M
Phlox spp.		P	
Phoenicaulis cheiranthoides	daggerpod	A	M
Plagiobothrys leptocladus	firebranched popcornflower,slenderbranch popcornflower	A	
Plagiobothrys scouleri	Scouler's popcornflower	A	
Plantago major	common plantain	A	
Plectritis macrocena	longhorn plectritis, white plectritis	A	
Polygonum aviculare	doorweed, prostrate knotweed,	A P	

Polygonum confertiflorum	fruitleaf knotweed, closeflowered knotweed	A		
Polygonum heterosepalum	oddsepal knotweed,dwarf desert knotweed	A		
Polygonum hydropiperoides	common waterpepper, swamp smartweed	A		
Polygonum lapathifolium	curlytop ladysthumb, pale smartweed, curlytop knotweed	A		
Polygonum persicaria	spotted ladysthumb, redshank	A		
Potamogeton nodosus	longleaf pondweed	A		
Potamogeton pectinatus or *Stuckenia pectinata*	sago pondweed	A		
Potamogeton pusillus	small pondweed	A		
Potentilla anserina or *Argentina anserina*	silverweed cinquefoil	A	P	
Potentilla glandulosa	sticky cinquefoil	A		
Potentilla gracilis	slender cinquefoil	A		
Potentilla recta	sulfur cinquefoil		P	
Potentilla rivalis	brook cinquefoil	A		
Pseudognaphalium stramineum or *Gnaphalium chilense*	cottonbatting plant, cudweed	A		
Psilocarphus brevissimus	short woollyheads, dwarf woollyheads	A		
Pyrrocoma carthamoide or *Haplopappus carthamoides*	largeflower goldenweed	A		
Pyrrocoma hirta or *Haplopappus hirtus*	tacky goldenweed, sticky goldenweed	A		
Pyrrocoma lanceolata or *Haplopappus lanceolatus*	lanceleaf goldenweed	A		
Pyrrocoma uniflora or *Haplopappus uniflorus*	plantain goldenweed, one-flowered goldenweed	A		
Ranunculus aquatilis	white water crowfoot, water buttercup	A		
Ranunculus cymbalaria	alkali buttercup, shore buttercup	A		
Ranunculus testiculatus or Ceratocephala testiculata	burr buttercup, hornseed buttercup, curveseed butterwort	A	P	M
Rorippa islandica	marsh yellowcress	A		M
Rorippa nasturtium aquaticum	watercress	A		
Rumex acetosella	sheep sorrel		P	M
Rumex crispus	curly dock	A	P	
Rumex aquaticus or *Rumex occidentalis*	western dock	A	P	
Rumex salicifolius	willow dock, narrowleaf dock	A	P	
Rumex venosus	veiny dock	A	P	M
Sagittaria cuneata	wapato, arumleaf arrowhead	A		
Salsola kali	Russian thistle		P	M
Scrophularia lanceolata	lanceleaf figwort	A		
Scutellaria angustifolia	narrowleaf skullcap	A		
Scutellaria antirrhinoides	snapdragon skullcap			
Scutellaria nana	dwarf skullcap	A		
Sedum debile	orpine stonecrop, weak-stemmed stonecrop	A		
Senecio integerrimus	western groundsel	A		M
Sidalcea sp.	checker mallow		P	M
Sisymbrium altissimum	Jim Hill mustard, tumble mustard	A	P	M
Sium suave	hemlock waterparsnip	A		
Solidago canadensis	Canada goldenrod	A		M
Solidago missouriensis	Missouri goldenrod	A		
Sonchus asper	prickly sowthistle, spiny sowthistle	A		

Sphaeralcea munroana	orange globemallow, Munto's globemallow	A	P	M
Stachys palustris	swamp hedgenettle, marsh hedgenettle	A		
Stanleya viridiflora	green princesplume	A	P	
Stenotus acaulis or *Haplopappus acaulis*	stemless mock goldenweed	A		
Stephanomeria minor or *Stephanomeria tenuifolia*	narrowleaf stephanomeria, narrowleaf wirelettuce	A		
Streptanthus cordatus	heartleaf twistflower, heartleaved streptanthus	A		
Taraxacum officinale	common dandelion	A	P	M
Tetradymia canescens	gray horsebrush		P	M
Thelypodium flexuosum	nodding thelypody	A		
Thelypodium laciniatum	thickleaved thelypody	A		M
Thermopsis rhombifolia	mountain yellowpea, prairie golden bean	A	P	
Thlaspi arvense	field pennycress, fanweed		P	M
Tragopogon dubius	yellow salsify, western salsify	A	P	M
Trifolium cyathiferum	cup clover	A		
Trifolium dubium	suckling clover, least hop clover	A		
Trifolium eriocephalum	woollyhead clover	A		
Trifolium fragiferum	strawberry clover	A		M
Trifolium longipes	longstalk clover	A		
Trifolium macrocephalum	big-head clover	A		M
Trifolium repens	white clover	A		M
Trifolium variegatum	whitetip clover	A		
Triglochin palustre	marsh arrowgrass	A		
Typha latifolia	cattail, broadleaf cattail	A	P	M
Urtica dioica	stinging nettle	A	P	M
Veratrum californicum	false helebore, skunk cabbage, corn lily		P	M
Verbascum thapsus	mullein, flannel mullein	A	P	M
Veronica americana	American speedwell	A	P	M
Veronica anagallis-aquatica	water speedwell	A		
Veronica peregrina	purslane speedwell	A		
Viola sp.	violet	A		M
Wyethia amplexicaulis	northern mule's-ears	A	P	M
Xanthium strumarium	cocklebur		P	M
Zannichellia palustris	horned pondweed	A		
Zigadenus elegans	mountain deathcamas		P	M
Zigadenus paniculatus	panicled death-camas, foothill deathcamas	A		M
Zigadenus venenosus	meadow deathcamas	A	P	M
	Shrubs			
Acer glabrum	Rocky Mountain maple	A		M
Amelanchier alnifolia	western service berry	A		M
Artemisia arbuscula	low sagebrush, dwarf sagebrush	A	P	
Artemisia cana	silver sage, silver sagebrush	A	P	M
Artemisia longiloba	early sagebrush	A		
Artemisia papposa	Owyhee sagebrush	A		
Artemisia spinescens or *Picrothamnus desertorum*	bud sagebrush	A	P	
Artemisia tridentata ssp. *tridentata*	basin big sagebrush	A	P	M
Artemisia tridentata var. *vaseyana*	mountain big sagebrush	A	P	
Artemisia tridentata ssp. *wyomingensis*	Wyoming big sagebrush	A	P	
Atriplex canescens	fourwing saltbush		P	M

Atriplex confertifolia	sheepfat, shadscale saltbush	A	P		M
Atriplex nuttalli	saltsage	A			
Ceanothus cuneatus	buckbrush		P		
Cercocarpus ledifolius	curl-leaf mountain mahogany		P		M
Chrysothamnus humilis	Truckee rabbitbrush	A			
Chrysothamnus vicidiflorus	green rabbitbrush	A	P		M
Ericameria nauseosa or Chrysothamnus nauseosus	rubber rabbitbrush, gray rabbit-brush, little rabbitbrush	A	P		M
Grayia spinosa	spiny hopsage	A			M
Gutierrezia sarothrae	broom snakeweed		P		M
Haplopappus nanus	dwarf goldenweed	A			
Holodiscus dumosus	glandular oceanspray, rock spirea	A	P		M
Krascheninnikovia lanata or *Eurotia lanata*	winterfat, white sage	A	P		M
Leptodactylon pungens	granite prickly-phlox, prickly phlox	A			
Philadelphus lewisii	Syringa				M
Prunus virginiana	common chokecherry	A	P		M
Purshia tridentata	bitterbrush, antelope bitterbrush		P		M
Ribes aureum	golden currant	A	P		M
Ribes cereum	wax currant, squaw currant	A	P		M
Ribes inerme	whitestem gooseberry	A			
Ribes velutinum	desert gooseberry	A			
Rosa woodsii	Woods' rose, pearhip rose	A	P		M
Salix exigua	coyote willow, sandbar willow	A			M
Salix lasiandra	Pacific willow	A			
Salix lasiolepsis	arroyo willow	A			
Salix lutea	yellow willow	A			
Salvia dorrii	purple sage, gray ball sage	A			M
Sambucus cerulea or *Sambucus mexicana* or *Sambucus nigra*	blue elderberry	A			M
Sarcobatus vermiculatus	greasewood	A	P		M
Symphoricarpos oreophilus	mountain snowberry	A			M
Tetradymia canescens	gray horse-brush, spineless horse-brush	A	P		M
Tetradymia glabrata	little leaf horse-brush	A	P		
Tetradymia spinosa	cottonthorn horse-brush	A	P		
	Trees				
Abies lasiocarpa	subalpine fir, alpine fir, balsam fir		P	B	M
Juniperus communis	common juniper, dwarf juniper			B	
Juniperus occidentalis	western juniper	A	P	B	M
Juniperus scopulorum	Rocky Mountain juniper, Rocky Mountain red cedar			B	
Pinus albicaulis	whitebark pine		P	B	
Pinus contorta	lodgepole pine, tamarack pine, black pine (planted, expected to naturalize)			B	M
Pinus flexilis	limber pine, Rockyee Mountain white pine		P	B	M
Populus alba	Lombardy poplar	A	P		
Populus tremuloides	quaking aspen		P		M
Pseudotsuga menziesii	Douglas fir		P	B	M
Robinia pseudoacacia	black locust	A			
Salix amygdaloides	peach-leaf willow		P		M
Tamarix parviflora	salt cedar, tamarisk	A			M

Bibliography - Appendix E

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Upper Owyhee Watershed Assessment

Appendix F. Nevada TMDLs

303(d) water bodies listed by the EPA or by the state.

Table F.1. Pollutants of concern for impaired water bodies in Nevada in the upper Owyhee subbasin. Water bodies are included either on the 303(d) federal list, in a TMDL, or in Nevada's administrative regulations.

Reasons for impairment

a. Temperature
b. Sediment
c. Zinc
d. Total dissolved solids
e. Salinity
f. Sulfates
g. Chlorides
h. Arsenic
i. Fluoride
j. Manganese
k. Nickel
l. pH
m Total phosphorus

Nevada waterbody	a	b	c	d	e	f	g	h	i	j	k	l	m
South Fork Owyhee River	x												
Jack Creek			x										
Jerritt Canyon Creek				x	x	x	x						
Snow Canyon Creek				x	x	x	x						
Mill Creek			x	x					x	x	x		
Badger Creek								x					
Owyhee River			x							x			
Tomasina Gulch								x					
Wildhorse Reservoir			x							x		x	x
	a	b	c	d	e	f	g	h	i	j	k	l	m

Nevada TMDLS

Some of the reaches of streams in the upper Owyhee subbasin have had Total Maximum Daily Loads (TMDLs) established by Nevada. These TMDLs are detailed in *Total Maximum Daily Loads for East Fork Owyhee River and Mill Creek*. In addition, a regulation proposed by the state environmental commission sets pollutant levels for the South Fork Owyhee River.

"The TMDLs and load allocations presented in this report are in a form unique for Nevada. Through the use of equations, the defined TMDLs and load allocations vary with flow thereby addressing the EPA requirement to consider seasonal variations and critical flow conditions in the TMDL process."[2] The tables below include the pollutant levels but do not include all of the formulas for changes in flow which are included in the Mill Creek and East Fork Owyhee assessment. The TMDL with formulas for the region can be acquired from the Department of Conservation and Natural Resources and in May 2011 was available at http://ndep.nv.gov/bwqp/owyhee_tmdl.pdf. The statewide formulas for calculating ammonia criteria are included at the end of this appendix.

Nevada considers the potential beneficial uses of a waterbody to be the watering of livestock, water supply for irrigation, habitat for fish and other aquatic life, recreation involving contact with the water, recreation not involving contact with the water, municipal or domestic water supply, industrial water supply, propagation of wildlife and waterfowl, extraordinary ecological or aesthetic value, and enhancement or improvement of water quality in any water which is downstream. In the tables these are labeled respectively livestock, irrigation, aquatic, contact, noncontact, municipal, industrial, wildlife, aesthetic, and enhance. In Tables F.2 through F.5, an x under one of the uses indicates that the use is a designated beneficial use for the waterbody.

Definitions used in the tables:

"S.V." means single value.

"△ T" means change in temperature in Celsius.

"△ pH" means the change in pH.

"NTU" means nephelometric turbidity units, a measure of turbidity that is described in the sediment sources section of this assessment.

"PCU" means platinum cobalt unit, a measure of color.

"No./100ml" means the number of organisms present in 100 milliliters of the water.

"SU" means standard pH units.

"AGM" means annual geometric mean_________.

Table F.2. Nevada TMDL for the Owyhee River from Wildhorse Reservoir to its confluence with Mill Creek.

Parameter	Requirements to maintain existing higher quality	Water quality standards for beneficial uses	Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh
Temperature - °C Maximum	△ T=0	S.V. May-Oct. <21° S.V.Nov.-Apr. <7° △ T<1			X	X							
pH - Units	△ pH ±0.5	6.5 - 9.0			X	X		X					
Total Phosphorous (as P) - mg/l		≤ 0.1			X	X	X	X					
Nitrogen Species (as N) - mg/l	Nitrate S.V. <1.0	Nitrate S.V. ≤ 10 Nitrite S.V. ≤ 0.06			X	X	X	X					
Total Ammonia (as N)- mg/l		See formulas below			X								
Dissolved Oxygen - mg/l		≥ 6.0	X		X	X	X	X		X			
Suspended Solids - mg/l		S.V. ≤ 25			X			X					
Turbidity - NTU		S.V. ≤ 10			X			X					
Total Dissolved Solids - mg/l	S.V. ≤ 200	S.V. ≤ 500	X	X				X					
Chlorides - mg/l	S.V. ≤ 8.0	S.V. <250	X	X				X		X			
Sulfate - mg/l	S.V. ≤ 250							X					
Alkalinity (as CO3) - mg/l		<25% change from natural conditions			X					X			
E. coli - No./100 ml		AGM ≤ 126 S.V. ≤ 410				X	X						
Fecal Coliform - No./100ml		S.V. ≤ 1000	X	X			X	X		X			
Color - PCU		S.V. ≤ 75						X					
			Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh

Table F.3. Nevada TMDL for the Owyhee River from its confluence with Mill Creek to the border of the Duck Valley Indian Reservation.

Parameter	Requirements to maintain existing higher quality	Water quality standards for beneficial uses	Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh
Temperature - °C Maximum	Δ T=0	S.V. May-Oct. <21° S.V. Nov.-Apr. <7° Δ T<1			X	X							
pH - Units	Δ pH ±0.5	6.5 - 9.0			X	X		X					
Total Phosphorous (as P) - mg/l		$\leq$ 0.1			X	X	X	X					
Nitrogen Species (as N) - mg/l	Nitrate S.V. <1.0	Nitrate S.V. $\leq$ 10 Nitrite S.V. $\leq$ 0.06			X	X	X	X					
Total Ammonia (as N)- mg/l		See formulas below			X								
Dissolved Oxygen - mg/l		$\geq$ 6.0	X		X	X	X	X		X			
Suspended Solids - mg/l		S.V. $\leq$ 25			X			X					
Turbidity - NTU		S.V. $\leq$ 10			X			X					
Total Dissolved Solids - mg/l	S.V. $\leq$ 250	S.V. $\leq$ 500	X	X				X					
Chlorides - mg/l	S.V. $\leq$ 8.0	S.V. <250	X	X				X		X			
Sulfate - mg/l	S.V. $\leq$ 250							X					
Alkalinity (as CO3) - mg/l		<25% change from natural conditions			X					X			
E. coli - No./100 ml		AGM $\leq$ 126 S.V. $\leq$ 410				X	X						
Fecal Coliform - No./100ml		S.V. $\leq$ 1000	X	X			X	X		X			
Color - PCU		S.V. $\leq$ 75						X					
			Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh

Table F.4. Nevada TMDL for the South Fork Owyhee River from its origin to the Nevada-Idaho state line.

Parameter	Requirements to maintain existing higher quality	Water quality standards for beneficial uses	Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh
Temperature - °C Maximum	Δ T=0	S.V. May-Oct. <21° S.V. Nov.-Apr. <7° Δ T<1			X	X							
pH - Units	Δ pH ±0.5	6.5 - 9.0			X	X		X					
Total Phosphorous (as P) - mg/l		$\leq$ 0.1			X	X	X	X					
Nitrogen Species (as N) - mg/l	Nitrate S.V. <1.0	Nitrate S.V. $\leq$ 10 Nitrite S.V. $\leq$ 0.06			X	X	X	X					
Total Ammonia (as N)- mg/l		See formulas below			X								
Dissolved Oxygen - mg/l		$\geq$ 6.0	X		X	X	X	X		X			
Suspended Solids - mg/l		S.V. $\leq$ 25			X			X					
Turbidity - NTU		S.V. $\leq$ 10			X			X					
Total Dissolved Solids - mg/l	S.V. $\leq$ 280	S.V. $\leq$ 500	X	X				X					
Chlorides - mg/l	S.V. $\leq$ 15.0	S.V. <250	X	X				X		X			
Sulfate - mg/l	S.V. $\leq$ 250							X					
Alkalinity (as CO3) - mg/l		<25% change from natural conditions			X					X			
E. coli - No./100 ml		AGM $\leq$ 126 S.V. $\leq$ 410				X	X						
Fecal Coliform - No./100ml		S.V. $\leq$ 1000	X	X			X	X		X			
Color - PCU		S.V. $\leq$ 75						X					
			Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh

Table F.5. Nevada TMDL for Taylor Canyon Creek from its origin to its confluence with the South Fork of the Owyhee River.

Parameter	Water quality standards for beneficial uses	Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh
Temperature - °C Maximum	S.V. May-Oct < 21 S.V. Nov-Apr < 13			X	X							
pH - SU	S.V. 6.5 - 9.0			X	X		X					
Total Phosphorous (as P) - mg/l	S.V. ≤ 0.1			X	X	X	X					
Nitrogen Species (as N) - mg/l	Nitrate S.V. ≤ 10 Nitrite S.V. ≤ 0.06			X			X					
Total Ammonia (as N)- mg/l	See formulas below			X								
Dissolved Oxygen - mg/l	S.V. ≥ 6.0	X		X	X	X	X		X			
Suspended Solids - mg/l	S.V. ≤ 25			X			X					
Turbidity - NTU	S.V. ≤ 10			X			X					
Total Dissolved Solids - mg/l	S.V. ≤ 500	X	X				X					
Chlorides - mg/l	S.V. ≤ 250	X	X				X		X			
Sulfate - mg/l	S.V. ≤ 250						X					
E. coli - No./100 ml	A.G.M. ≤ 126 S.V. ≤ 410				X	X						
Fecal Coliform - No./100 ml	S.V. ≤ 1,000	X	X			X	X		X			
Color - PCU	S.V. ≤ 75						X					
		Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh

Ammonia criteria for Nevada

1. Acute water quality criteria

For cold-water fisheries, the 1-hour average concentration of total ammonia, in milligrams of nitrogen per liter, must not exceed the applicable acute criterion for "Cold-Water Fisheries" more than once every 3 years on average.

$$\text{Acute water quality criteria for ammonia (cold-water fisheries)} = \left[\frac{0.275}{1+10^{7.204-pH}}\right]+\left[\frac{39.0}{1+10^{pH-7.204}}\right]$$

For warm-water fisheries, the 1-hour average concentration of total ammonia, in milligrams of nitrogen per liter, must not exceed the applicable acute criterion for "Warm-Water Fisheries" more than once every 3 years on average.

$$\text{Acute water quality criteria for ammonia (warm-water fisheries)} = \left[\frac{0.411}{1+10^{7.204-pH}}\right]+\left[\frac{58.4}{1+10^{pH-7.204}}\right]$$

2. Chronic water quality criteria

The chronic criteria of water quality with regard to the concentration of total ammonia are subject to the following:

The concentration of total ammonia, in milligrams of nitrogen per liter, expressed as a 30-day average must not exceed the applicable chronic criterion more than once every 3 years on average, and the highest 4-day average within the 30-day period must not exceed 2.5 times the applicable chronic criterion.

$$\text{Chronic water quality criteria for total ammonia} = \left[\frac{0.0577}{1+10^{7.204-pH}}\right]+\left[\frac{2.487}{1+10^{pH-7.204}}\right] \times MIN\left[2.85, 1.45 \times 10^{0.028 \times (25-T^{\circ})}\right]$$

A different criterion may be used only where documentation has been accepted showing the absence of freshwater fish in early life stages.

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Upper Owyhee Watershed Assessment

Appendix G. TMDLs in Idaho

Current Idaho

The Idaho Department of Environmental Quality (DEQ) has conducted assessments and developed Total Maximum Daily Loads (TMDLs) for the Upper Owyhee Watershed subbasin and the South Fork Owyhee River subbasin.

Idaho's water quality standards establish the potential beneficial uses of a waterbody to be habitat for aquatic life, recreation, water supply, wildlife habitat, and aesthetics. The first three uses are further divided. Aquatic life includes cold water, salmonid spawning, seasonsal cold water where coldwater aquatic life may be absent or tolerate seasonally warm termperatures, warm water, and modified "with aquatic life limited by one or more conditions that preclude attainment of reference streams or conditions."[Idaho 2010a] Recreational uses are divided into primary contact recreation in the water with a chance of swallowing water and secondary contact recreation with possible occasional ingestion of water. Water supply is further broken down to providing domestic drinking water, providing agricultural water for irrigation or drinking water for livestock, and industrial. Industrial use as well as wildlife habitat and aesthetics are considered to be beneficial uses that apply to all of the surface waters of the state.

A. Upper Owyhee Watershed

The DEQ's *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load, Owyhee, County, Idaho* is a 151 page document. The information in the document is found in a number of different places and sometimes it is difficult to distinguish between existing and recommended designations. An effort has been made to ensure that the data presented here in table format accurately represents the information. There seem to be some discrepancies between these summaries and the summary information of the same document included in the *Upper Owyhee River five year review*.

In the assessment of the Upper Owyhee Watershed, there were no waterbodies with a designated or presumed beneficial use of domestic drinking water.   The agricultural and industrial uses were combined under "water supply".

1. 303(d) waterbodies

Table G.1. Beneficial uses of waterbodies identified or recommended as 303(d) in the Upper Owyhee HUC of Idaho as included in the *Upper Owyhee Watershed Subbasin Assessment*. Only Red Canyon Creek has designated uses. The others are presumed beneficial uses.

e = existing use
x = beneficial use
f = beneficial use fully supported
s = beneficial use no evidence not supported
n = beneficial use not fully supported
i = recommended listing as impaired beneficial use
r = recommended beneficial use

303(d) waterbody*	Cold water aquatic	Salmonid spawning	Modified aquatic	Primary recreation	Secondary recreation	Water supply	Wildlife	Aesthetics
Included in Idaho 2003 assessment					❈			
Blue Creek Reservoir	e, n,i	i		e,f	e,f	f	f	f
Juniper Basin Reservoir	i	i	r	e,f	e,f	s	s	s
Red Canyon Creek	e, n, i	e, n, i		x		x	x	x
Deep Creek	e, n, i	e, n, i		r		s	s	s
Pole Creek	e, n, i	e, n, i		r		s	s	s
Castle Creek	e, n, i	e, n, i		s	s	s	s	s
Battle Creek	e,n	e,n		e,f,i	e,f,i	s	s	s
Shoofly Creek		r		e,f,i	e,f,i	s	s	s
Nickel Creek	e, n, i	e, n, i		e	e	s	s	s
Proposed for next 303(d) list								
Camas Creek	i	i						
Battle Creek	i	i						
Camel Creek	i	i						
Dry Creek	i	i						
Beaver Creek	i	i						
	Cold water aquatic	Salmonid spawning	Modified aquatic	Primary recreation	Secondary recreation	Water supply	Wildlife	Aesthetics

Changes to the TMDL noted in the 2009 Five Year Review

❈ Most streams receive some recreational use by hikers, hunters, and anglers. Secondary contact recreation use should apply to all of these streams.

* Thomas and Smith Creeks are also mentioned as being included in the original TMDL.

2. DEQ identified pollutants

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

Table G.2. DEQ identified pollutants of waterbodies in the Upper Owyhee HUC of Idaho. Pollutants were identified in the 2003 TMDL or in the 2010 integrated report.

303(d) waterbody	Temperature 2003 TMDL	Temperature 2010 integrated report	Sedimentation/ siltation*†	Flow regime alterations*	Escherichia coli*	Mercury*	Metals	Aquatic plant bioassessments*	Organic enrichment	Dissolved oxygen	Combined biota/ habitat bioassessments*
Included in Idaho 2003 assessment											
Blue Creek Reservoir											
Juniper Basin Reservoir					x						
Red Canyon Creek	x	x		x							
Deep Creek	x								x	x	
Pole Creek	x	x		x							
Castle Creek	x	x	x								
Battle Creek											
Shoofly Creek - delist											
Nickel Creek	x	x	x				x	x			
Proposed for next 303(d) list											
Camas Creek		x									
Battle Creek											
Camel Creek		x									
Dry Creek											x
Beaver Creek											
Included in 2010 combined report											
Thomas Creek		x	x					x			
Smith Creek		x	x					x			
Little Blue Creek											x
Shoofly Reservoir						x					
Dry Creek											x
Big Springs Creek											x

† This includes waterbodies listed for sedimentation in either the TMDL or the 2010 combined report.

* From the 2010 303(d) 305(b) combined report.

3. Temperature impaired waterbodies.

In the 2003 TMDL, the DEQ judged Deep Creek, Pole Creek, Castle Creek, and Red Canyon Creek as being water quality limited due to temperature.

Table G.3. The target temperatures for Deep Creek, Pole Creek, Castle Creek, and Red Canyon Creek in the 2003 TMDL for the Upper Owyhee HUC from the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load,*.

Beneficial use	Selected targets
Salmonid spawning	Temperature ≤ 13 °C (55 °F) Maximum daily average ≤ 9°C (48 °F)
Cold water aquatic life	Temperature ≤ 22 °C (72 °F) Maximum daily average ≤ 19°C (66 °F)
Shade component	Shade required to meet targets as determined through the use of the SSTEMP model

The Idaho TMDL for the Upper Owyhee HUC identified temperature impairment as a nonpoint source. The TMDL attempts to assign part of the responsiblity for improving the condition to different contributing factors. These contibuting "loads" are considered to be the different streams and the amount of change which is required in each one, therefore some streams which are not listed as 303(d) have recommended shading requirements.

Table G.4. Shade requirements to achieve load capacity for stream segments in the Upper Owyhee HUC. The stream segment temperature model was used to develop these estimates, from the *Upper Owyhee Watershed Subbasin Assessment and Total Maximum Daily Load*

	June	July	August
	Criteria		
	Salmonid spawning - 9°C % shade	Cold water aquatic life - 22 °C % shade	Cold water aquatic life - 22 °C % shade
Upper Deep Creek	100	52	59
Middle Deep Creek	100	57	57
Lower Deep Creek	100	66	67
Deep Creek below Nickel Creek to Pole Creek	100	58	57
Upper Pole Creek	96	96	58
Lower Pole Creek	100	65	60
Castle Creek	95	95	58

Red Canyon Creek	94	94	57
Nickel Creek	88	88	56
Hurry Back Creek	92	95	54
Nip & Tuck Creek	87	87	54
Current Creek	91	91	53
Camas Creek	98	98	61
Camel Creek	97	97	62
Bull Gulch	98	98	62
Beaver Creek	97	97	59
Upper Dickshooter Creek	100	100	62
Lower Dickshooter Creek	94	65	67

The table above from the *Upper Owyhee Watershed Subbasin Assessment* describes "the required load allocation to address . . . temperature . . . issues in the Upper Owyhee Watershed. All allocations are gross estimates with the belief that once more data is collected by the appropriate land management agencies, and other interested parties, refinements to these allocations can be made."[Idaho 2003]

B. South Fork

The conclusion of the *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load* is that only temperature is impairing beneficial uses. In the assessment, there were no waterbodies with a designated or presumed beneficial use of domestic drinking water. The agricultural and industrial uses were combined under "water supply".

Table G.5. Beneficial uses of waterbodies identified or recommended as 303(d) in the South Fork Owyhee HUC and Idaho DEQ identified pollutants, from the *South Fork Owyhee River Subbasin Assessment and Total Maximum Daily Load*.

303(d) waterbody*	Cold water aquatic	Salmonid spawning	Modified aquatic	Primary recreation	Secondary recreation	Water supply	Wildlife	Aesthetics
South Fork Owyhee River	x	x		x	x	x	x	x
Impaired by temperature	x	x						

Table G.6. Target overall maximum and average temperature reductions necessary at the Nevada - Idaho state line for the South Fork Owyhee River in Idaho to achieve State of Idaho water quality standards.

Beneficial use		Maximum temperature load capacity	Daily average temperature load capacity
Salmonid spawning		13 °C (55 °F)	9°C (48 °F)
	Reduction needed from current temperature	78%	97%
Cold water biota		22 °C (72 °F)	19°C (66 °F)
	Reduction needed from current temperature	27%	28%

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Appendix H. Oregon integrated report

Oregon's integrated report lists waterbodies where not all standards are met. The criteria used for considering the inclusion of a pollutant in the Oregon integrated report that apply to the Owyhee River at the Idaho state line are:

Category 2: Attaining - Some of the pollutant standards are met.
Category 3: Insufficient data to determine whether a standard is met.
3B: Potential concern - Some data indicate non-attainment of a criterion, but data are insufficient to assign another category.
Category 5: The waterbody is water quality limited and a TMDL is needed, Section 303(d) list.

Oregon's integrated report includes data which may support either a stream's impaired condition or properly functioning condition. These data are not differentiated in the table below (e.g. none of the collected samples for alkalinity or ammonia are outside of the accepted standard).

Table H.1. Pollutants included in Oregon's 2010 integrated report for the Owyhee River at mile 200.4, the Idaho state line.

Pollutant	Season	Criteria	Beneficial Uses	Status	Data Source, Supporting Data
Temperature	Year Around (Non-spawning)	Redband or Lahontan cutthroat trout: 20.0 degrees Celsius 7-day-average maximum	Redband or Lahontan cutthroat trout	Water quality limited, 303(d) list, TMDL needed	Previous Data: [DEQ] LASAR 12258 River Mile 109.8: From 6/30/2000 to 10/5/2001, 156 days with 7-day-average maximum > 20 degrees Celsius. DEQ] LASAR 12260 River Mile 130.7: From 7/17/1999 to 9/29/2000, 134 days with 7-day-average maximum > 20 degrees Celsius. [DEQ] LASAR 12262 River Mile 167.7: From 7/17/1999 to 10/5/2001, 217 days with 7-day-average maximum > 20 degrees Celsius.
Arsenic	Year around	Table 20 Toxic	Aquatic life; Human health	Water quality limited, 303(d)	Previous Data: 2004 Data [USGS] Site 13177900 River Mile 165:

		Substances, see below		list, TMDL needed	From 4/17/2001 to 6/25/2001, 2 out of 2 samples > applicable Table 20 criterion
Phosphate Phosphorus	Summer	Total phosphates as phosphorus (P): Benchmark 50 ug/L	Aquatic life	Potential concern, category 3b	Previous Data: [DEQ] LASAR 12262 River Mile 167.7: From 9/11/1996 to 9/9/2003, 2 out of 10 samples > 50 ug/L benchmark criterion in streams to control excessive aquatic growths.
Alkalinity	Year Around	< 20 mg/L (Table 20 criterion).	Aquatic life	Attaining some criteria/uses, category 2	Previous Data: [DEQ/ODA - Salem] LASAR 10729 River Mile 2.8: From 10/15/1996 to 12/10/2003, 0 out of 50 samples < 20 mg/L (Table 20 criterion). [DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 5/21/1996 to 7/13/1999, 0 out of 3 samples < 20 mg/L (Table 20 criterion). [DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 5/24/1994 to 9/9/2003, 0 out of 11 samples < 20 mg/L (Table 20 criterion). [DEQ] LASAR 12260 River Mile 130.7: From 5/25/1994 to 9/9/2003, 0 out of 8 samples < 20 mg/L (Table 20 criterion). [DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 5/25/1994 to 9/9/2003, 0 out of 11 samples < 20 mg/L (Table 20 criterion).
Ammonia	Year Around	Table 20 Toxic Substances, see below	Aquatic life	Attaining some criteria/uses, category 2	[DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 5/25/1994 to 9/9/2003, 0 out of 22 samples > applicable Table 20 criterion. [DEQ/ODA - Salem] LASAR 10729 River Mile 2.8: From 10/15/1996 to 12/10/2003, 0 out of 54 samples > applicable Table 20 criterion. [DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 5/21/1996 to 7/13/1999, 0 out of 8 samples > applicable Table 20 criterion. [DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 5/24/1994 to 9/9/2003, 0 out of 21 samples > applicable Table 20 criterion. [DEQ/ODA - Salem] LASAR 12260 River Mile 130.7: From 5/25/1994 to 9/9/2003, 0 out of 14 samples > applicable Table 20 criterion.
Chloride	Year Around	Table 20 Toxic Substances, see below	Aquatic life	Insufficient data, category 3	Previous Data: [DEQ] LASAR 10730 River Mile 127.7: From 9/30/1998 to 7/13/1999, 0 out of 2 samples > applicable Table 20 criterion. [DEQ] LASAR 12258 River Mile 109.8: From 9/29/1998 to 9/10/2002, 0 out of 3 samples > applicable Table 20 criterion.

					[DEQ] LASAR 12260 River Mile 130.7: From 9/10/2002 to 9/10/2002, 0 out of 1 samples > applicable Table 20 criterion. [DEQ] LASAR 12262 River Mile 167.7: From 9/29/1998 to 9/10/2002, 0 out of 3 samples > applicable Table 20 criterion.
Dissolved Oxygen	Year Around (Non-spa wning)	Cool water: Not less than 6.5 mg/l	Cool-water aquatic life	Attaining some criteria/uses, category 2	Previous Data: [DEQ/ODA - Salem] LASAR 12260 River Mile 130.7: From 5/25/1994 to 9/9/2003, 0 out of 11 samples (0%) < 6.5 mg/l and applicable % saturation. [DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 5/21/1996 to 7/13/1999, 0 out of 5 samples (0%) < 6.5 mg/l and applicable % saturation. [DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 5/25/1994 to 9/9/2003, 0 out of 16 samples (0%) < 6.5 mg/l and applicable % saturation. [DEQ/ODA - Salem] LASAR 10729 River Mile 2.8: From 6/11/1997 to 8/20/2003, 1 out of 14 samples (7%) < 6.5 mg/l and applicable % saturation. [DEQ/ODA - Salem] LASAR 10729 River Mile 2.8: From 10/15/1996 to 12/10/2003, 0 out of 30 samples (0%) < 6.5 mg/l and applicable % saturation. [DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 5/24/1994 to 9/9/2003, 0 out of 16 samples (0%) < 6.5 mg/l and applicable % saturation.
pH	Fall, winter, spring	pH 7.0 to 9.0	Water contact recreation; Resident fish and aquatic life	Attaining some criteria/uses, category 2	Previous Data: [DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 5/25/1994 to 10/9/2001, 1 out of 8 samples (12%) outside pH criteria range 7 to 9. [DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 5/21/1996 to 5/21/1996, 0 out of 1 samples (0%) outside pH criteria range 7 to 9. [DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 5/24/1994 to 10/9/2001, 0 out of 7 samples (0%) outside pH criteria range 7 to 9. [DEQ/ODA - Salem] LASAR 12260 River Mile 130.7: From 5/25/1994 to 10/9/2001, 0 out of 6 samples (0%) outside pH criteria range 7 to 9.
pH	Summer	pH 7.0 to 9.0	Water contact recreation; Resident fish and aquatic life	Attaining some criteria/uses, category 2	Previous Data: [DEQ/ODA - Salem] LASAR 12258 River Mile 109.8: From 9/10/1996 to 9/9/2003, 0 out of 11 s amples (0%) outside pH criteria range 7 to 9.

					[DEQ/ODA - Salem] LASAR 12260 River Mile 130.7: From 9/15/1997 to 9/9/2003, 1 out of 6 samples (17%) outside pH criteria range 7 to 9. [DEQ/ODA - Salem] LASAR 12262 River Mile 167.7: From 9/11/1996 to 9/9/2003, 1 out of 11 samples (9%) outside pH criteria range 7 to 9. [DEQ/ODA - Salem] LASAR 10730 River Mile 127.7: From 9/10/1996 to 7/13/1999, 0 out of 5 samples (0%) outside pH criteria range 7 to 9.

Table H.2. Criteria not to be exceeded in waters of the state of Oregon in order to protect aquatic life and human health. The acute criteria refer to the average concentration for one hour and the chronic criteria refer to the average concentration for 96 hours (4 days) and these criteria should not be exceeded more than once every three years.

	Concentration for protection of aquatic life		
	Fresh acute criteria	Fresh chronic criteria	
Alkalinity		20,000 micrograms/liter	
Ammonia	Criteria are pH and temperature dependent. They are established by the EPA . See example below (Table H.3)		
Arsenic	360 micrograms/liter	190 micrograms/liter	
Chloride	860 mg/L	230 mg/L	

CMC: Mussels Absent, mg N/L										
pH	Temperature, C									
	0	14	16	18	20	22	24	26	28	30
6.5	58.0	58.0	58.0	58.0	43.7	37.0	31.4	26.6	22.5	19.1
6.6	55.7	55.7	55.7	55.7	41.9	35.5	30.1	25.5	21.6	18.3
6.7	53.0	53.0	53.0	53.0	39.9	33.8	28.6	24.3	20.6	17.4
6.8	49.9	49.9	49.9	49.9	37.6	31.9	27.0	22.9	19.4	16.4
6.9	46.5	46.5	46.5	46.5	35.1	29.7	25.2	21.3	18.1	15.3
7.0	42.9	42.9	42.9	42.9	32.3	27.4	23.2	19.7	16.7	14.1
7.1	39.1	39.1	39.1	39.1	29.4	24.9	21.1	17.9	15.2	12.8
7.2	35.1	35.1	35.1	35.1	26.4	22.4	19.0	16.1	13.6	11.5
7.3	31.2	31.2	31.2	31.2	23.5	19.9	16.8	14.3	12.1	10.2
7.4	27.3	27.3	27.3	27.3	20.6	17.4	14.8	12.5	10.6	8.98
7.5	23.6	23.6	23.6	23.6	17.8	15.1	12.8	10.8	9.18	7.77
7.6	20.2	20.2	20.2	20.2	15.3	12.9	10.9	9.27	7.86	6.66
7.7	17.2	17.2	17.2	17.2	12.9	11.0	9.28	7.86	6.66	5.64
7.8	14.4	14.4	14.4	14.4	10.9	9.21	7.80	6.61	5.60	4.74
7.9	12.0	12.0	12.0	12.0	9.07	7.69	6.51	5.52	4.67	3.96
8.0	9.99	9.99	9.99	9.99	7.53	6.38	5.40	4.58	3.88	3.29
8.1	8.26	8.26	8.26	8.26	6.22	5.27	4.47	3.78	3.21	2.72
8.2	6.81	6.81	6.81	6.81	5.13	4.34	3.68	3.12	2.64	2.24
8.3	5.60	5.60	5.60	5.60	4.22	3.58	3.03	2.57	2.18	1.84
8.4	4.61	4.61	4.61	4.61	3.48	2.95	2.50	2.11	1.79	1.52
8.5	3.81	3.81	3.81	3.81	2.87	2.43	2.06	1.74	1.48	1.25
8.6	3.15	3.15	3.15	3.15	2.37	2.01	1.70	1.44	1.22	1.04
8.7	2.62	2.62	2.62	2.62	1.97	1.67	1.42	1.20	1.02	0.862
8.8	2.19	2.19	2.19	2.19	1.65	1.40	1.19	1.00	0.851	0.721
8.9	1.85	1.85	1.85	1.85	1.39	1.18	1.00	0.847	0.718	0.608
9.0	1.57	1.57	1.57	1.57	1.19	1.00	0.851	0.721	0.611	0.517

Table H.3. An example of the interaction of pH with temperature in the determination of ammonia criteria. Values of the acute criterion with mussels absent.

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Upper Owyhee Watershed Assessment

Appendix J. Riparian plant associations

Contents

Riparian plant associations

Inter-mountain basins semi-desert grassland.

This widespread ecological system occurs throughout the Intermountain western U.S. on dry plains and mesas, at approximately 1450 to 2320 m (4750-7610 feet) in elevation. These grasslands occur in lowland and upland areas and may occupy swales, playas, mesa tops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are often well-drained sandy- or loamy-textured soils derived from sedimentary parent materials, but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. When they occur near foothills grasslands they will be at lower elevations. The dominant perennial bunch grasses and shrubs within this system are all very drought-resistant plants. These grasslands are typically dominated or codominated by *Achnatherum hymenoides, Aristida* spp., *Bouteloua gracilis, Hesperostipa comata, Muhlenbergia torreyana, or Pleuraphis jamesii,* and may include scattered shrubs and dwarf-shrubs of species of *Artemisia, Atriplex, Coleogyne, Ephedra, Gutierrezia,* or *Krascheninnikovia lanata*.

Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland

This system occurs in mountain ranges of the Great Basin and along the eastern slope of the Sierra Nevada within a broad elevation range from about 1220 m (4000 feet) to over 2135 m (7000 feet). This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. The variety of plant associations connected to this system reflects elevation, stream gradient, floodplain width, and flooding events. Dominant trees may include *Abies concolor, Alnus incana, Betula occidentalis, Populus angustifolia, Populus balsamifera* ssp. trichocarpa*, Populus fremontii, Salix laevigata, Salix gooddingii, and Pseudotsuga menziesii*. Dominant shrubs include *Artemisia cana, Cornus sericea, Salix exigua, Salix lasiolepis, Salix lemmonii*, or *Salix lutea*. Herbaceous layers are often dominated by species of *Carex* and *Juncus*, and perennial grasses and mesic forbs such *Deschampsia caespitosa, Elymus trachycaulus, Glyceria striata, Iris missouriensis, Maianthemum stellatum*, or *Thalictrum fendleri*. Introduced forage species such as *Agrostis stolonifera, Poa pratensis, Phleum pratense*, and the weedy annual *Bromus tectorum* are often present in disturbed stands. These are disturbance-driven systems that require flooding, scour and deposition for germination and maintenance. Livestock grazing is a major influence in altering structure, composition, and function of the community.

Columbia Basin Foothill Riparian Woodland and Shrubland

This is a low-elevation riparian system found on the periphery of the mountains surrounding the Columbia River Basin, along major tributaries and the main stem of the Columbia at relatively low elevations. This is the riparian system associated with all streams at and below lower treeline, including permanent, intermittent and ephemeral streams with woody riparian vegetation. These forests and woodlands require flooding and some gravels for reestablishment. They are found in low-elevation canyons and draws, on floodplains, or in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff. Underlying gravels may keep the water table just below the ground surface and are favored substrates for cottonwood. Large bottomlands may have large occurrences, but most have been cut over or cleared for agriculture. Rafted ice and logs in freshets may cause considerable damage to tree boles. Beavers crop younger cottonwood and willows and frequently dam side channels occurring in these stands. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Important and diagnostic trees include *Populus balsamifera* ssp. trichocarpa, *Alnus rhombifolia, Populus tremuloides, Celtis laevigata* var. reticulata, *Betula occidentalis*, or *Pinus ponderosa*. Important shrubs include *Crataegus douglasii, Philadelphus lewisii, Cornus sericea, Salix lucida* ssp. lasiandra, *Salix eriocephala, Rosa nutkana, Rosa woodsii, Amelanchier alnifolia, Prunus virginiana*, and *Symphoricarpos albus*. Grazing is a major influence in altering structure, composition, and function of the community.

Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

This ecological system is found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevational range from approximately 900 to 2800 m. This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. It is dependent on a natural hydrologic regime, especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. It can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. In some locations, occurrences extend into moderately high intermountain basins where the adjacent vegetation is sage steppe. Dominant trees may include *Acer negundo, Populus angustifolia, Populus deltoides, Populus fremontii, Pseudotsuga menziesii, Picea pungens, Salix amygdaloides*, or *Juniperus scopulorum*. Dominant shrubs include *Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, Salix drummondiana, Salix exigua, Salix irrorata, Salix lucida, Shepherdia argentea*, or *Symphoricarpos* spp. Exotic trees of *Elaeagnus angustifolia* and *Tamarix* spp. are common in some stands. Generally, the upland vegetation surrounding this riparian system is different and ranges from grasslands to forests. In the Wyoming Basins, the high-elevation *Populus angustifolia*-dominated rivers are included here, including along the North Platte, Sweetwater, and Laramie rivers. In these situations, *Populus angustifolia* is extending down into the sage steppe zone of the basins.

Rocky Mountain Subalpine-Montane Riparian Shrubland

This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana, and also occurs in mountainous areas of the Intermountain region and Colorado Plateau. These are montane to subalpine riparian shrublands occurring as narrow bands of shrubs lining streambanks and alluvial terraces in narrow to wide, low-gradient valley bottoms and floodplains with sinuous stream channels. Generally it is found at higher elevations, but can be found anywhere from 1700-3475 m. Occurrences can also be found around seeps, fens, and isolated springs on hillslopes away from valley bottoms. Many of the plant associations found within this system are associated with beaver activity. This system often occurs as a mosaic of multiple communities that are shrub- and herb-dominated and includes above-treeline, willow-dominated, snowmelt-fed basins that feed into streams. The dominant shrubs reflect the large elevational gradient and include *Alnus incana, Betula nana, Betula occidentalis, Cornus sericea, Salix bebbiana, Salix boothii, Salix brachycarpa, Salix drummondiana, Salix eriocephala, Salix geyeriana, Salix monticola, Salix planifolia*, and *Salix wolfii*. Generally the upland vegetation surrounding these riparian systems are of either conifer or aspen forests.

Rocky Mountain Subalpine-Montane Riparian Woodland

This riparian woodland system is comprised of seasonally flooded forests and woodlands found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Mountains. This system contains the conifer and aspen woodlands that line montane streams. These are communities tolerant of periodic flooding and high water tables. Snowmelt moisture in this system may create shallow water tables or seeps for a portion of the growing season. Stands typically occur at elevations between 1500 and 3300 m (4920-10,830 feet), farther north elevation ranges between 900 and 2000 m. This is confined to specific riparian environments occurring on floodplains or terraces of rivers and streams, in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, and on pond or lake margins. Dominant tree species vary across the latitudinal range, although it usually includes *Abies lasiocarpa* and/or *Picea engelmannii*; other important species include *Pseudotsuga menziesii, Picea pungens, Picea engelmannii X glauca, Populus tremuloides*, and *Juniperus scopulorum*. Other trees possibly present but not usually dominant include *Alnus incana, Abies concolor, Abies grandis, Pinus contorta, Populus angustifolia, Populus balsamifera* ssp. trichocarpa, and *Juniperus osteosperma*.

Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe

This ecological system includes sagebrush communities occurring at lowland and montane elevations in the Columbia Plateau-northern Great Basin region, east almost to the Great Plains. These are generally depressional wetlands or non-alkaline playas, occurring as small- or occasionally large-patch communities, in a sagebrush or montane forest matrix. Climate is generally semi-arid, although it can be cool in montane areas. This system occurs in poorly drained depressional wetlands, the largest characterized as playas, the smaller as vernal pools, or along seasonal stream channels in valley bottoms or mountain meadows. *Artemisia cana* ssp. bolanderi or *Artemisia cana* ssp. viscidula are dominant, with *Artemisia tridentata* ssp. tridentata, *Artemisia tridentata* ssp. wyomingensis, or *Artemisia tridentata* ssp. vaseyana occasionally codominant. Understory graminoids and forbs are characteristic, *with Poa secunda* (= *Poa nevadensis*), *Poa cusickii, Muhlenbergia filiformis, Muhlenbergia richardsonis*, and *Leymus cinereus* dominant at the drier sites; *Eleocharis palustris, Deschampsia caespitosa*, and *Carex* species dominate at wetter or higher-elevation sites.

North American Arid West Emergent Marsh

This widespread ecological system occurs throughout much of the arid and semi-arid regions of western North America, typically surrounded by savanna, shrub steppe, steppe, or desert vegetation. Natural marshes may occur in depressions in the landscape (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Water chemistry may include some alkaline or semi-alkaline situations, but the alkalinity is highly variable even within the same complex of wetlands. Marshes have distinctive soils that are typically mineral, but can also accumulate organic material. Soils have characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of *Scirpus* and/or *Schoenoplectus, Typha, Juncus, Potamogeton, Polygonum, Nuphar*, and *Phalaris*. This system may also include areas of relatively deep water with floating-leaved plants

(*Lemna, Potamogeton*, and *Brasenia*) and submergent and floating plants (*Myriophyllum, Ceratophyllum, and Elodea*).

Rocky Mountain Subalpine-Montane Mesic Meadow

This Rocky Mountain ecological system is restricted to sites from lower montane to subalpine where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. It is found typically above 2000 m in elevation in the southern part of its range and above 600 m in the northern part. These upland communities occur on gentle to moderate-gradient slopes. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as those found in Rocky Mountain Alpine-Montane Wet Meadow (CES306.812). Vegetation is typically forb-rich, with forbs contributing more to overall herbaceous cover than graminoids. Important taxa include *Erigeron* spp., *Asteraceae* spp., *Mertensia* spp., *Penstemon* spp., *Campanula* spp., *Lupinus* spp., *Solidago* spp., *Ligusticum* spp., *Thalictrum occidentale, Valeriana sitchensis, Rudbeckia occidentalis, Balsamorhiza sagittata, Wyethia* spp., *Deschampsia caespitosa, Koeleria macrantha*, and *Dasiphora fruticosa*. Burrowing mammals can increase the forb diversity.

Rocky Mountain Subalpine Mesic Meadow

This Rocky Mountain ecological system is restricted to sites in the subalpine zone where finely textured soils, snow deposition, or wind-swept dry conditions limit tree establishment. It is found typically above 3000 m in elevation in the southern part of its range and above 1500 m in the northern part. These upland communities occur on gentle to moderate-gradient slopes. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as found in Rocky Mountain Alpine-Montane Wet Meadow (CES306.812). Vegetation is typically forb-rich, with forbs contributing more to overall herbaceous cover than graminoids. Important taxa include *Erigeron* spp., *Asteraceae* spp., *Mertensia* spp., *Penstemon* spp., *Campanula* spp., *Lupinus* spp., *Solidago* spp., *Ligusticum* spp., *Thalictrum occidentale, Valeriana sitchensis, Balsamorhiza sagittata, Wyethia* spp., *Deschampsia caespitosa, Koeleria macrantha*, and *Dasiphora fruticosa*. Burrowing mammals can increase the forb diversity.

Rocky Mountain Alpine-Montane Wet Meadow

These are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from montane to alpine (1000-3600 m). These types occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toeslope seeps. They are typically found on flat areas or gentle slopes, but may also occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late-melting snow patches or on snowbeds. Soils of this system may be mineral or organic. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations, often dominated by graminoids, including *Calamagrostis stricta, Caltha leptosepala, Cardamine cordifolia, Carex illota, Carex microptera, Carex nigricans, Carex scopulorum, Carex utriculata, Carex vernacula, Deschampsia caespitosa, Eleocharis quinqueflora, Juncus drummondii, Phippsia algida, Rorippa alpina, Senecio triangularis, Trifolium parryi*, and *Trollius laxus*. Often alpine dwarfshrublands, especially those dominated by *Salix*, are immediately adjacent to the wet meadows. Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding.

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