Ecological site R025XY071NV
MAHOGANY SAVANNA 14-16 P.Z.

Last updated: 4/25/2024
Accessed: 11/21/2024

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

MLRA notes

Major Land Resource Area (MLRA): 025X–Owyhee High Plateau

MLRA Notes 25—Owyhee High Plateau
This area is in Nevada (56 percent), Idaho (30 percent), Oregon (12 percent), and Utah (2 percent). It makes up about 27,443 square miles. MLRA 25 is characteristically cooler and wetter than the neighboring MLRAs of the Great Basin. The western boundary is marked by a gradual transition to the lower and warmer basins of MLRA 24. The boundary to the south-southeast, with MLRA 28B, is marked by gradual changes in geology marked by an increased dominance of singleleaf pinyon and Utah juniper and a reduced presence of Idaho fescue. The boundary to the north, with MLRA 11, is a rapid transition from the lava plateau topography to the lower elevation Snake River Plain.
Physiography:
All of this area lies within the Intermontane Plateaus. The southern half is in the Great Basin section of the Basin and Range province. This part of the MLRA is characterized by isolated, uplifted fault-block mountain ranges separated by narrow, aggraded desert plains. This geologically older terrain has been dissected by numerous streams draining to the Humboldt River.
The northern half of the area lies within the Columbia Plateaus province. This part of the MLRA forms the southern boundary of the extensive Columbia Plateau basalt flows. Most of the northern half is in the Payette section, but the northeast corner is in the Snake River Plain section. Deep, narrow canyons draining into the Snake River have been incised into this broad basalt plain. Elevation ranges from 3,000 to 7,550 feet on rolling plateaus and in gently sloping basins. It is more than 9,840 feet on some steep mountains. The Humboldt River crosses the southern half of this area
Geology:
The dominant rock types in this MLRA are volcanic. They include andesite, basalt, tuff, and rhyolite. In the north and west parts of the area, Cretaceous granitic rocks are exposed among Miocene volcanic rocks in mountains. A Mesozoic igneous and metamorphic rock complex dominates the south and east parts of the area. Upper and Lower Paleozoic calcareous sediments, including oceanic deposits, are exposed with limited extent in the mountains. Alluvial fan and basin fill sediments occur in the valleys.
Climate:
The average annual precipitation in most of this area is typically 11 to 22 inches. It increases to as much as 49 inches at the higher elevations. Rainfall occurs in spring and sporadically in summer. Precipitation occurs mainly as snow in winter. The precipitation is distributed fairly evenly throughout fall, winter, and spring. The amount of precipitation is lowest from midsummer to early autumn. The average annual temperature is 33 to 51 degrees F. The freeze-free period averages 130 days and ranges from 65 to 190 days, decreasing in length with elevation. It is typically less than 70 days in the mountains.
Water:
The supply of water from precipitation and streamflow is small and unreliable, except along the Owyhee, Bruneau, and Humboldt Rivers. Streamflow depends largely on accumulated snow in the mountains. Surface water from mountain runoff is generally of excellent quality and suitable for all uses. The basin fill sediments in the narrow alluvial valleys between the mountain ranges provide some ground water for irrigation. The alluvial deposits along the large streams have the most ground water. Based on measurements of water quality in similar deposits in

adjacent areas, the basin fill deposits probably contain moderately hard water. The water is suitable for almost all uses. The carbonate rocks in this area are considered aquifers, but they are little used. Springs are common along the edges of the limestone outcrops.
Soils:
The dominant soil orders in this MLRA are Aridisols and Mollisols. The soils in the area dominantly have a mesic or frigid temperature regime and an aridic, aridic bordering on xeric, or xeric moisture regime. Soils with aquic moisture regimes are limited to drainage or spring areas, where moisture originates or runs on and through. These soils are of a very limited extent throughout the MLRA. They generally are well drained, clayey or loamy, and shallow or moderately deep. Most of the soils formed in mixed parent material. Volcanic ash and loess mantle the landscape. Surface soil textures are loam and silt loam with ashy texture modifiers in some areas. Argillic horizons occur on the more stable landforms. They are exposed nearer the soil surface on convex landforms, where ash and loess deposits are more likely to erode. Soils that formed in carbonatic parent material in areas that receive less than 12 inches of precipitation are characterized by calcic horizons throughout the profile, while soils in areas that receive more than 12 inches of precipitation do not have calcic horizons in the upper part of the profile. Soils that formed on stable landforms at the lower elevations are dominated by ochric horizons. Soils that formed at the middle and upper elevations are characterized by mollic epipedons. Soils in drainage areas at all elevations that receive moisture running on or through them are characterized by thicker mollic epipedons.
Biological Resources:
This MLRA supports shrub-grass vegetation. Lower elevations are characterized by Wyoming big sagebrush associated with bluebunch wheatgrass, western wheatgrass, and Thurber's needlegrass. Other important plants include bluegrass, squirreltail, penstemon, phlox, milkvetch, lupine, Indian paintbrush, aster, and rabbitbrush. Black sagebrush occurs but is less extensive. Singleleaf pinyon and Utah juniper occur in limited areas. With increasing elevation and precipitation, vast areas characterized by mountain big sagebrush or low sagebrush/early sagebrush in association with Idaho fescue, bluebunch wheatgrass, needlegrasses, and bluegrass become common. Snowberry, curl-leaf mountain mahogany, ceanothus, and juniper also occur. Mountains at the highest elevations support whitebark pine, Douglas-fir, limber pine, Engelmann spruce, subalpine fir, aspen, and curl-leaf mountain mahogany.
Major wildlife species include mule deer, bighorn sheep, pronghorn, mountain lion, coyote, bobcat, badger, river otter, mink, weasel, golden eagle, red-tailed hawk, ferruginous hawk, Swainson's hawk, northern harrier, prairie falcon, kestrel, great horned owl, short-eared owl, long-eared owl, burrowing owl, pheasant, sage grouse, chukar, gray partridge, and California quail. Reptiles and amphibians include western racer, gopher snake, western rattlesnake, side-blotched lizard, western toad, and spotted frog. Fish species include bull, red band, and rainbow trout.

Ecological site concept

This site occurs on gently rolling to very steep mountain sideslopes. Slopes range from 15 to 50 percent, but slope gradients of 15 to 50 percent are most typical. Elevations are 6500 to 9100 feet.
The soils associated with this site are shallow to moderately deep to bedrock and are well drained. These soils are modified by high volumes of rock fragments throughout the profile. There is usually a surface cover of cobbles, stones or boulders. Available water holding capacity is moderate. Runoff is high to very high and the potential for sheet and rill erosion is moderate to severe depending on slope.

The reference state is the interpretative state for this site. The representative plant community is dominated by curlleaf mountain-mahogany. Other important species are mountain big sagebrush, Idaho fescue, bluebunch wheatgrass and needlegrasses. Total overstory canopy cover is less than 50 percent (±35%). Understory vegetation comprises about 20% of the total site production. Potential vegetative composition for the understory is about 55% grasses, 10% forbs and 35% shrubs. Total annual air-dry production for all trees, shrubs and herbaceous plants in the understory to a height of 4.5 feet is 600 pounds for an unfavorable year, 800 pounds for a normal years and 1000 pounds for a favorable year. Overstory trees and tree-like shrub composition is about 80% of the total site production. Approximate ground cover (basal and crown) is 40 to 60 percent. Total for all trees, shrubs and herbaceous plants in the understory to a height of 4½ feet:LBs/AC
Favorable years 1000, Normal years 800, Unfavorable years 600.

Associated sites

R025XY012NV	**LOAMY SLOPE 12-16 P.Z.**

R025XY027NV	**LOAMY 12-14 P.Z.**
R025XY030NV	**MAHOGANY THICKET**
R025XY042NV	**SHALLOW LOAM 14-16 P.Z.**

Similar sites

R025XY031NV	**STONY MAHOGANY SAVANNA** Less productive site; associated with rock outcrop; overystory canopy less than or equal to 25 percent
R025XY075NV	**MAHOGANY SAVANNA 16+ P.Z.** FEID dominant understory grass; PSSPS minor species; higher elevations
R025XY030NV	**MAHOGANY THICKET** More productive overstory canopy; overstory canopy greater than or equal to 50 percent

Table 1. Dominant plant species

Tree	(1) *Cercocarpus ledifolius*
Shrub	(1) *Artemisia tridentata subsp. vaseyana*
Herbaceous	(1) *Festuca idahoensis* (2) *Pseudoroegneria spicata subsp. spicata*

Physiographic features

This site occurs on gently rolling to very steep mountain sideslopes. Slopes range from 15 to 50 percent, but slope gradients of 15 to 50 percent are most typical. Elevations are 6500 to 9100 feet.

Table 2. Representative physiographic features

Landforms	(1) Mountain slope
Runoff class	Low to very high
Flooding frequency	None
Ponding frequency	None
Elevation	1,981–2,774 m
Slope	15–50%
Water table depth	152 cm
Aspect	Aspect is not a significant factor

Climatic features

The climate associated with this site is semiarid, characterized by cold, moist winters and warm, dry summers. The average annual precipitation ranges from 14 or more inches. Mean annual air temperature is typically <45 degrees F. The average growing season is about 60 to 90 days.

Mean annual precipitation across the range in which this ES occurs is 18.58".

Monthly mean precipitation: January 1.65”; February 1.68”; March 1.98”; April 2.43”; May 2.41”; June 1.62”; July 0.61”; August 0.63”; September 0.84”; October 1.41”; November 1.51”; December 1.79”.

*The above data is averaged from the Jarbridge 4N and Lamoille PH WRCC climate stations.

Table 3. Representative climatic features

Frost-free period (average)	84 days
Freeze-free period (average)	114 days

Precipitation total (average)	483 mm

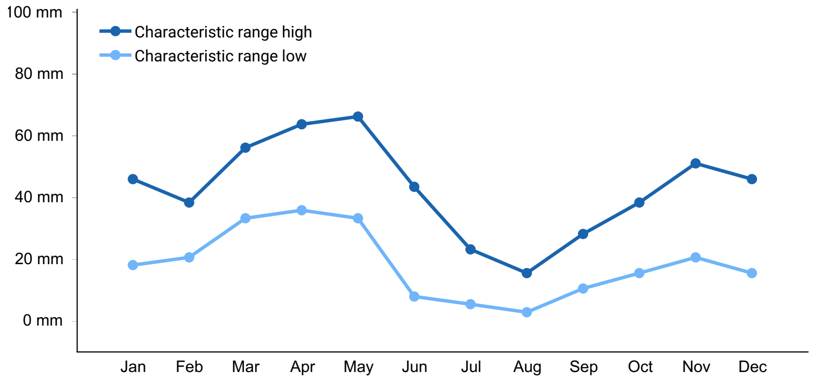

Figure 1. Monthly precipitation range

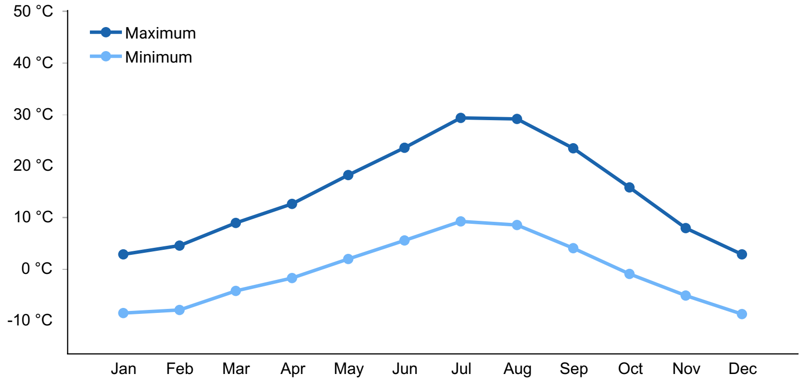

Figure 2. Monthly average minimum and maximum temperature

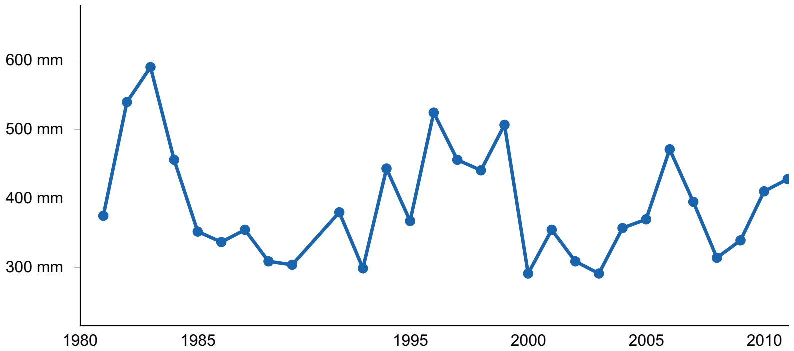

Figure 3. Annual precipitation pattern

Climate stations used

- (1) JARBIDGE 7 N [USC00264039], Jackpot, NV
- (2) LAMOILLE YOST [USC00264394], Spring Creek, NV

Influencing water features

There are no influencing water features associated with this site.

Soil features

The soils associated with this site are shallow to moderately deep to bedrock and are well drained. These soils are modified by high volumes of rock fragments throughout the profile. There is usually a surface cover of cobbles, stones or boulders. Available water holding capacity is moderate. Runoff is high to very high and the potential for sheet and rill erosion is moderate to severe depending on slope.

The soil series correlated with this site includes: Haunchee, Mahogee, Rozara, and Udelope.

A representative soil series is Udelope, classified as a loamy, mixed, superactive Lithic Haplocryoll. These soils are shallow and very shallow and well drained. They were formed in residuum and colluvium derived from andesite and other volcanic rocks. Reaction is moderately acid through neutral. Diagnostic features include a mollic epipedon that occurs from the soil surface to 18 inches. Clay content in the particle-size control section is 8 to 18 percent. Rock fragments range from 0 to 35 percent, dominantly andesite or other volcanic rocks.

Table 4. Representative soil features

Parent material	(1) Residuum (2) Colluvium
Surface texture	(1) Gravelly sandy loam (2) Very cobbly loam (3) Very gravelly loamy coarse sand
Family particle size	(1) Loamy (2) Loamy-skeletal
Drainage class	Well drained
Permeability class	Moderate to moderately rapid
Depth to restrictive layer	20–102 cm
Soil depth	20–102 cm
Surface fragment cover <=3"	30–40%
Surface fragment cover >3"	0–20%
Available water capacity (0-101.6cm)	2.29–5.08 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–13
Soil reaction (1:1 water) (0-101.6cm)	5.6–9
Subsurface fragment volume <=3" (Depth not specified)	20–38%
Subsurface fragment volume >3" (Depth not specified)	0–22%

Ecological dynamics

An ecological site is the product of all the environmental factors responsible for its development and has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation and temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration and runoff), 4) soils (depth, texture, structure, and organic matter), 5) plant communities (functional groups and productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The Great Basin vegetative communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The moisture resource supporting the greatest amount of plant growth is usually the water stored in the soil profile during the winter. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition. It can also increase resource uptake via the decomposition of dead plant material following disturbance. The invasion of cheatgrass has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007). Dobrowolski et al. (1990) cite multiple authors on the extent of the soil profile exploited by the competitive exotic annual cheatgrass. Specifically, the depth of rooting is dependent on the size of the plant, and in competitive environments, cheatgrass roots were found to penetrate only 15 centimeters whereas isolated plants and pure stands were found to root at least 1 meter in depth, with some plants rooting as deep as 1.5 to 1.7 m.

This ecological site is dominated by the long-lived curl-leaf mountain mahogany, deep-rooted cool season perennial bunchgrasses, and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 meters. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992). The perennial bunchgrasses typically have shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 meters. General differences in root depth distributions between grasses and shrubs results in resource partitioning in this system.

Curl-leaf mountain mahogany is a multi-branched, evergreen shrub or tree extending from 3 to over 20 feet in height. The rooting of mountain mahogany is spreading and limited by the depth to bedrock. Youngberg and Hu (1972) reported in an Oregon study that curl-leaf mountain mahogany produces nitrogen-fixing root nodules. They also reported that nodulated plants had the highest amounts of nitrogen in the leaves. It is the most widely distributed species of Cercocarpus and is the only species of the genus that extends as far north and west as Washington. Most often, curl-leaf mountain mahogany stands occur on warm, dry, rocky ridges or outcrops where fire would be an infrequent occurrence (USDA 1937). Dealy (1975) and Scheldt (1969) found that mahogany trees were larger and older on fire-resistant rocky sites and were the seed source if fire destroyed the non-rocky portion of the site.

Curl-leaf mahogany plants are long-lived and can reach 1,300+ years of age (Schultz 1987, Schultz et al. 1990). As mahogany stands increase in average age, average canopy volume and height of the individuals present also increases. As average canopy height and volume increase, stand density declines (Schultz et al 1991). Stands with a closed or nearly-closed canopy often have few to no young curl-leaf mahogany (i.e., recruitment) in the understory (Schultz et al. 1990, 1991) despite high seed density beneath trees (Russell and Schupp 1998, Ibanez and Schupp 2002). Intraspecific competition reduces the growth rates of all age classes below the potential growth rates for the species. Competition may also increase mortality in the younger plants.
Curl-leaf mahogany plants are very self-compatible for pollination and most developing seed matures and is viable (Russell et al. 1998). The deep litter throughout stands with high canopy cover appears to facilitate seed germination but retards seedling survival due to poor contact between the root and the soil (Schultz et al. 1996, Ibanez and Schupp 2001). Reproduction in large stands with high canopy cover occurs most often in canopy gaps where a tree has died and an increase exposure of bare ground occurs, or around the perimeter of the stand under sagebrush plants where there is less, typically shallow litter cover (Schultz 1987, Schultz et al. 1991).

Mahogany seeds require bare mineral soil to germinate; litter depths over 0.25 inches can impede recruitment (Gruell 1985, Schultz et al. 1991, Ibáñez et al. 1998, Ibáñez 2002). Cheatgrass thus affects mahogany growth by competing for water resources and reducing the amount of bare soil in an area (Ross 1999). Multiple sources (Schultz et al. 1996, Ibáñez et al. 1998) found that mahogany seedlings germinate abundantly under the canopy of adult plants but rarely successfully establish there due to shading and higher litter amounts. In addition, Schultz et al. (1996) found that seedlings had significantly higher long term success in areas dominated by sagebrush canopy than in areas under mahogany canopy or in interspaces. Some hypothesize that the light shading and hydraulic lift provided by sagebrush may create a microsite that facilitates mahogany recruitment (Gruell 1985, Ibáñez et al. 1998).

Mountain big sagebrush is generally long-lived; therefore it is unnecessary for new individuals to recruit every year for perpetuation of the stand. Simultaneous low, continuous recruitment and infrequent large recruitment events are the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

The perennial bunchgrasses present on this site generally have shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 meters but taper off more rapidly than shrubs. Differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems. Muttongrass may be more shade tolerant than other perennial bunchgrasses and will persist in the understory as the canopy closes (Erdman 1970).
Mahogany stands are susceptible to drought, frost, and invasion by non-native species, especially cheatgrass (*Bromus tectorum*). Cheatgrass affects mahogany seedling growth by competing for water resources and nutrients in an area (Ross 1999).

In western and central Nevada communities in which curlleaf mountain-mahogany occurs, large-scale disturbance was infrequent in presettlement times. However, evidence of small-scale disturbance from lightning, low-severity fire, insects, wind, and snow is abundant. Small disturbances often create canopy gaps in dense stands of curlleafmountain-mahogany. Gaps allow for the release of young curlleaf mountain-mahogany.

The successional role of curlleaf mountain-mahogany varies with community type. Mountain brush communities in which curlleafmountain-mahogany is either dominant or codominant are generally stable. Changes in relative abundance of codominant species may occur; however, succession rates are extremely slow because vegetation changes depend on soil development which is also slow.

As ecological condition declines, understory grasses and forbs are reduced as mountain big sagebrush, snowberry, and rabbitbrush increase. Heavy utilization by livestock and wildlife will result in most of the foliage of the mountain-mahogany growing above the reach of browsing animals and will severely limit production. Cheatgrass is the species most likely to invade this site.

This ecological site has moderate to high resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, precipitation, and nutrient availability. Long-term disturbance response may be influenced by small differences in landscape topography. Three possible alternative stable states have been identified for this site.

Fire Ecology
The presettlement fire regime of curlleaf mountainmahogany communities probably varied with community type and structure. The fire return interval in curl-leaf mountain mahogany-dominated sites is not well documented, however Arno and Wilson (1986) suggested sites of curl-leaf mountain mahogany with ponderosa pine (*Pinus ponderosa*) had fire return intervals of 13-22 years before 1900. Curlleaf mountainmahogany may depend on fire to reduce conifer competition and produce favorable soil conditions for seedling establishment Most often curl-leaf mountain mahogany stands occur on warm, dry, rocky ridges or outcrops where fire would be an infrequent occurrence (USDA Forest Service 1937). Dealy (1974) and Scheldt (1969) found that mahogany trees were larger and older on fire-resistant rocky sites and were the seed source if fire destroyed the non-rocky portion of the site. Mahogany will persist longest in rocky areas where it is protected from fire. Because of their thicker bark, mature trees can often survive low-severity fires (Gruell 1985). Individual curlleaf mountainmahogany are severely damaged by fire. Because many dead branches persist in the crown and leaves are slightly resinous, curlleaf mountainmahogany is probably very flammable. Curl-leaf mountain mahogany is considered a weak sprouter after fire and is usually moderately to severely damaged by severe fires. Recovery time of these sites is variable; some measurements show that stands lack recruitment for up to 30 years post-fire (Gruell 1985).

Mountain big sagebrush is highly susceptible to injury from fire. It is often top-killed by fire and will not resprout. Mountain big sagebrush is killed by fire (Neuenschwander 1980, Blaisdell et al. 1982) and does not resprout (Blaisdell 1953). Post-fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). It may return to pre-burn density and cover within 15-20 years following fire, but establishment after severe fires may proceed more slowly (Bunting et al. 1987).

Antelope bitterbrush is moderately fire-tolerant (McConnell and Smith 1977). If cheatgrass is present, bitterbrush seedling success is much lower. The factor that most limits establishment of bitterbrush seedlings is competition for water resources with cheatgrass, an invasive species (Clements and Young 2002). Bitterbrush regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), though sprouting ability is highly variable (Blaisdell et al. 1982). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low-intensity fires may allow bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site, coupled with seasonality and intensity of the fire factor into individual species' responses. For most forbs and grasses, the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

Idaho fescue's response to fire varies with condition and size of the plant, season and severity of fire, and ecological conditions. Mature Idaho fescue plants are commonly reported to be severely damaged by fire in all seasons (Wright et al. 1979). Initial mortality may be high (in excess of 75%) on severe burns, but usually varies from 20 to 50% (Barrington et al 1988). Rapid burns have been found to leave little damage to root crowns, and new tillers are produced with onset of fall moisture (Johnson et al. 1994). However, Wright and others (1979) found the dense, fine leaves of Idaho fescue provided enough fuel to burn for hours after a fire had passed, thereby killing or seriously injuring the plant regardless of the intensity of the fire (Wright et al. 1979). Idaho fescue is commonly reported to be more sensitive to fire than the other prominent grass on this site, bluebunch wheatgrass (Conrad and Poulton 1966). Robberecht and Defosse (1995) suggested the latter was more sensitive, however. They observed culm and biomass reduction with moderate fire severity in bluebunch wheatgrass, whereas a high fire severity was required for this reduction in Idaho fescue. Given the same fire severity treatment, post-fire culm production was initiated earlier and more rapidly in Idaho fescue (Robberecht and Defosse 1995).

Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Bluebunch wheatgrass is generally favored by burning. Burning stimulates flowering and seed production. However, season and severity of the fire will influence plant response. Plant regeneration will vary depending on post-fire soil moisture availability.

Sandberg bluegrass, a minor component of this ecological site, has been found to increase following fire, likely due to its low stature and productivity (Daubenmire 1975, Rau et al. 2008). Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion and/or cheatgrass and other invasive species to occupy interspaces, leading to increased fire frequency and potentially an annual plant community. Repeated frequent fire in this community will facilitate the establishment of an annual weed community with varying amounts of Sandberg bluegrass and rabbitbrush.

Depending on fire severity, rabbitbrush and snowberry (Symphoricarpos spp.) may increase after fire. Rubber rabbitbrush is top-killed by fire, but can resprout after fire and can also establish from seed (Young 1983). Yellow rabbitbrush (*Chrysothamnus viscidiflorus*) is top-killed by fire, but sprouts vigorously after fire (Kuntz 1982, Akinsoji 1988). Snowberry is also top-killed by fire, but resprouts after fire from rhizomes (Leege and Hickey 1971, Noste and Bushey 1987). Snowberry has been noted to regenerate well and can exceed pre-burn biomass in the third season after a fire (Merrill et al. 1982). If balsamroot (Balsamorhiza spp.) is common before fire, these plants will increase following a fire or with heavy grazing (Wright 1985). As cheatgrass increases, fire frequencies also increase to frequencies between 0.23 and 0.43 times a year; then, even sprouting shrubs such as rabbitbrush will not survive (Whisenant 1990).

State and transition model

MLRA 25
Mahogany Savanna 14-16"
025XY071NV

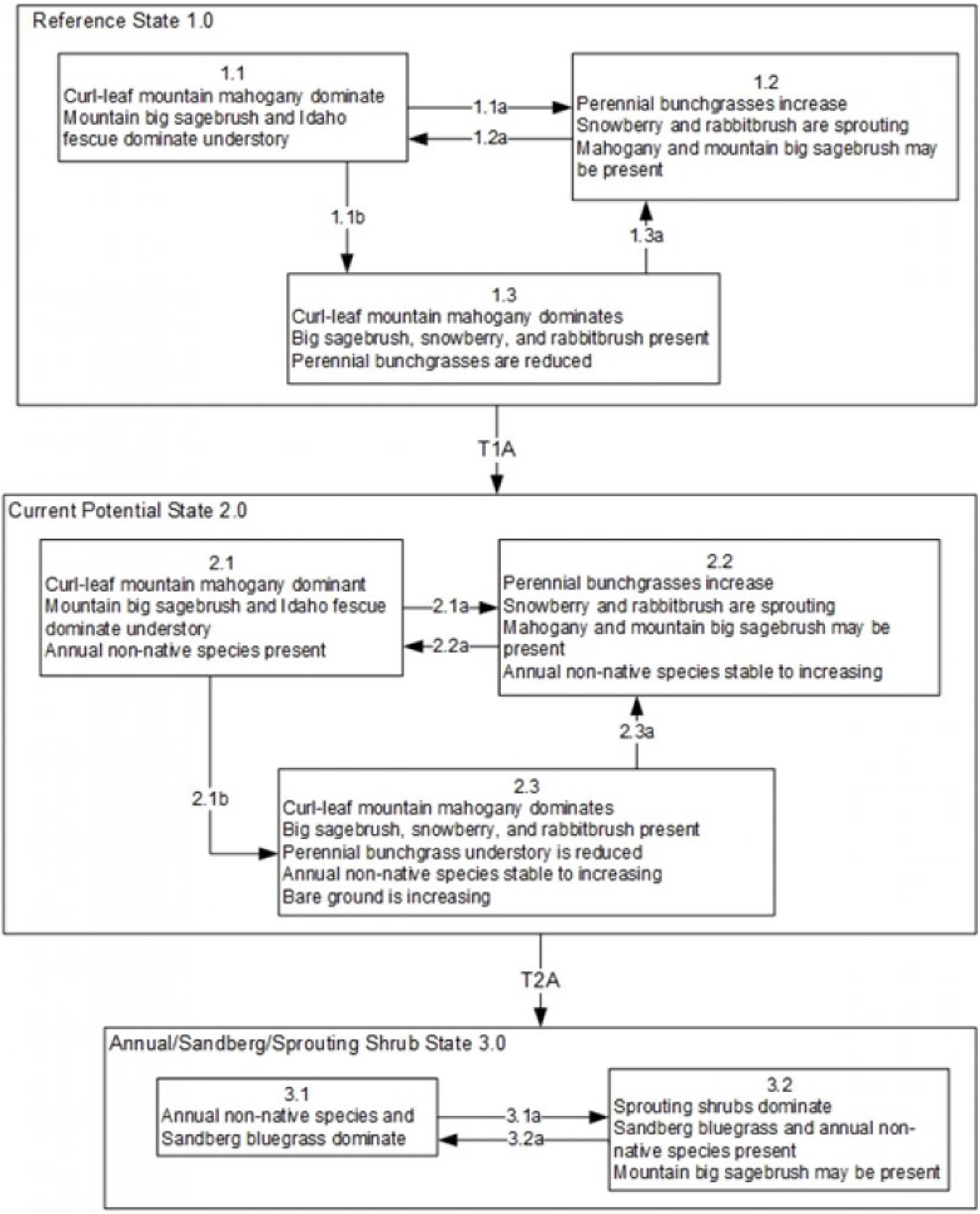

Figure 5. T. Stringham 3/2015

MLRA 25
Mahogany Savanna 14-16"
025XY071NV
Legend

Reference State 1.0 Community Pathways
1.1a: Low severity fire creates mosaic of grass/sagebrush/mahogany. A low severity fire may only affect the understory.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also decrease perennial understory.
1.3a: Low severity fire creates mosaic of grass/sagebrush/mahogany. A low severity fire may only affect the understory.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Pathways
2.1a: Low severity fire.
2.1b: Time and lack of disturbance such as fire or drought. Inappropriate grazing management may also decrease perennial understory.
2.2a: Time and lack of disturbance such as fire or drought. Inappropriate grazing management may also decrease perennial understory.
2.3a: Low severity fire.

Transition T2A: High-severity fire removes mahogany component.

Annual/Sandberg/Sprouting Shrub State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire or drought. Inappropriate grazing management may also decrease perennial understory.
3.2a: Fire.

Figure 6. Legend

State 1
Reference State

The Reference State 1.0 represents the natural range of variability under pristine conditions. The reference state has three general community phases: a tree-shrub dominant-phase, a sprouting shrub and perennial grass-dominant phase, and a shrub-dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic long-term drought, and/or insect attack.

Community 1.1
Community Phase

The reference state is the interpretative state for this site. The representative plant community is dominated by curlleaf mountainmahogany. Mountain snowberry is principal understory shrub. Columbia needlegrass is the most prevalent understory grass. Total overstory canopy cover exceeds 45 percent (=50%). Potential vegetative composition for the understory is about 55% grasses, 15% forbs and 30% shrubs. The overstory of curlleaf mountainmahogany is about 90% of the total site production. Understory vegetation comprises less than 10% of the total site production. Total annual air-dry production for all trees, shrubs and herbaceous plants in the understory to a height of 4.5 feet is 150 pounds for unfavorable years, 350 pounds for normal years and 600 pounds for favorable years. Approximate ground cover (basal and crown) is 50 to over 75 percent.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Tree	1765	2012	2259
Grass/Grasslike	251	457	664
Shrub/Vine	233	390	547
Forb	45	90	135
Total	**2294**	**2949**	**3605**

Community 1.2
Community Phase

This community phase is characteristic of a post-disturbance, early-seral community. If resulting from fire, mahogany will be present in patches. Snowberry and rabbitbrush are sprouting or increasing in burned areas. Perennial bunchgrasses may dominate.

Community 1.3
Community Phase

Mahogany density will increase in the absence of disturbance. Shrubs and deep-rooted perennial bunchgrasses will be shaded out by the dense mahogany. Muttongrass is more shade tolerant, however, and will still be found in the understory. Mahogany in dense stands will lose lower branches due to shading and/or herbivory, resulting in a more tree-like appearance. Scattered Utah juniper trees may be present and increasing on the site.

Pathway a
Community 1.1 to 1.2

Low-severity fire can reduce the mahogany overstory and allow for the understory species to dominate the site. Due to low fuel loads, fires will typically be low severity, resulting in a mosaic pattern.

Pathway b
Community 1.1 to 1.3

Time and lack of disturbance such as fire allows the mountain mahogany to increase. The shrub and herbaceous understory components decline due to increased shading from the trees. Excessive herbivory may also decrease the perennial grass understory.

Pathway a
Community 1.2 to 1.1

Time and lack of disturbance such as fire allows the mountain mahogany to increase. The shrub and herbaceous understory components decline due to increased shading from the trees. Excessive herbivory may also decrease the perennial grass understory.

Pathway a
Community 1.3 to 1.2

A low-severity fire, snow loading, or insect damage will decrease the overstory and allow for the herbaceous plants in the understory to increase.

State 2
Current Potential State

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. These non-natives can be highly flammable, and can promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community 2.1
Community Phase

Figure 8. Mahogany Savanna 14-16" (R025XY071NV) Phase 2.1 T. Stringham, August 2011

Figure 9. Mahogany Savanna 14-16" (R025XY071NV) Phase 2.1 P.Novak-Echenique, August 2011

This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. This community is dominated by curl-leaf mountain mahogany. Mountain big sagebrush, mountain snowberry, and antelope bitterbrush dominate the understory. Idaho fescue, bluebunch wheatgrass, and mountain brome make up the perennial bunchgrasses. Forbs and other grasses are a small component of the understory. Utah juniper may be present. There are minor amounts of non-natives species in the understory.

Community 2.2
Community Phase

This community phase is characteristic of a post-disturbance, early seral community where annual non-native species are present. Perennial bunchgrasses dominate the site. Snowberry and rabbitbrush are sprouting or increasing. Mahogany and sagebrush are present in trace amounts. Annual non-native species are stable or increasing within the community.

Community 2.3
Community Phase

Figure 10. Mahogany Savanna 14-16" (R025XY071NV) Phase 2.3 T. Stringham, August 2011

Curl-leaf mountain mahogany dominates the overstory. Big sagebrush and rabbitbrush are reduced due to shading, but snowberry may remain in the understory. Perennial bunchgrass understory is reduced. Muttongrass will likely increase in the understory and may be the dominant grass on the site. Mahogany may have a "hedged" or tree-like appearance from many years of browsing by deer. Annual non-native species are stable to increasing. Scattered Utah juniper trees may be present and increasing on the site.

Pathway a
Community 2.1 to 2.2

Fire reduces the overstory and allows for the understory species to dominate the site. Due to low fuel loads, fires are typically low severity resulting in a mosaic pattern. A fire may be more severe following an unusually wet spring or a change in management favoring an increase in fine fuels. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Pathway b
Community 2.1 to 2.3

Community Phase

Community Phase

Time and lack of disturbance allows the mountain mahogany component to increase. The shrub and herbaceous understory components decline due to increased shading from the trees. Inappropriate grazing management may also decrease the perennial understory.

Pathway a
Community 2.2 to 2.1

Time and lack of disturbance and/or grazing management that favors the establishment and growth of woody species allows curl-leaf mountain mahogany and understory shrubs to re-establish. Inappropriate grazing management may also decrease the perennial understory.

Pathway a
Community 2.3 to 2.2

Low-severity fire, damage from snow loading, or insects will reduce the overstory and allow for the perennial bunchgrasses in the understory to increase. A fire may be more severe following an unusually wet spring or a change in management favoring an increase in fine fuels. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

State 3
Annual/Sandberg/Sprouting Shrub State

This state has two community phases a grass-dominated phase and a sprouting shrub-dominated phase. The primary characteristic of this state is a lack of mountain mahogany resulting from a severe wildfire. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Sandberg bluegrass will increase with a reduction in competition from deep rooted perennial bunchgrass and become the dominant grass. Annuals, Sandberg bluegrass, and sprouting shrubs dominate site resources such that soil water, nutrient capture, nutrient cycling, and soil organic matter are temporally and spatially redistributed.

Community 3.1
Community Phase

Annual non-native species and Sandberg bluegrass dominate this community phase. Cheatgrass and mustards are most likely to to invade this site. Sprouting shrubs such as yellow rabbitbrush may be present. Mountain mahogany and mountain big sagebrush are no longer present.

Community 3.2
Community Phase

Snowberry and/or rabbitbrush dominate overstory. Understory is comprised of Sandberg bluegrass and likely cheatgrass. Mountain big sagebrush may be present.

Pathway a
Community 3.1 to 3.2

Time without disturbance allows sprouting shrubs such as snowberry and rabbitbrush to recover. Though unlikely, mountain big sagebrush may also return with adequate precipitation and lack of disturbance. Inappropriate grazing management may also decrease perennial understory.

Pathway a
Community 3.2 to 3.1

Initially after fire, the shrubs are reduced and Sandberg bluegrass and/or non-native annual species to dominate the site.

Transition A
State 1 to 2

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, mustards, and thistle. Slow variables: Over time annual non-native species increase within the community. Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Transition A
State 2 to 3

Trigger: High-severity or stand-replacing fire that significantly reduces or eliminates mountain mahogany and sagebrush. Bunchgrass plants significantly damaged by the fire may be further reduced or eliminated with inappropriate post-fire grazing management. Sandberg bluegrass becomes the dominant grass. Slow variable: Cover and production of Sandberg bluegrass and/or annual non-natives will increase. Reduction of soil organic matter input, resulting in decreased soil water. Threshold: Loss of mahogany overstory, sagebrush, and deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter. Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Primary Perennial Grasses**			233–520	
	Idaho fescue	FEID	*Festuca idahoensis*	135–224	–
	bluebunch wheatgrass	PSSPS	*Pseudoroegneria spicata ssp. spicata*	45–135	–
	mountain brome	BRMA4	*Bromus marginatus*	18–90	–
	bluegrass	POA	*Poa*	18–72	–
	milkvetch	ASTRA	*Astragalus*	9–28	–
	arrowleaf balsamroot	BASA3	*Balsamorhiza sagittata*	10–28	–
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	9–28	–
	buckwheat	ERIOG	*Eriogonum*	9–28	–
	geranium	GERAN	*Geranium*	9–28	–
	ragwort	SENEC	*Senecio*	10–28	–
	western needlegrass	ACOC3	*Achnatherum occidentale*	9–26	–
	Thurber's needlegrass	ACTH7	*Achnatherum thurberianum*	9–26	–
2	**Secondary Perennial Grasses/Grasslikes**			18–72	
	sedge	CAREX	*Carex*	20–118	–
	basin wildrye	LECI4	*Leymus cinereus*	20–118	–
Forb					
3	**Perennial**			45–135	
	arrowleaf balsamroot	BASA3	*Balsamorhiza sagittata*	20–118	–
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	20–118	–
	buckwheat	ERIOG	*Eriogonum*	20–118	–
	sedge	CAREX	*Carex*	4–27	–
Shrub/Vine					
4	**Primary Shrubs**			215–457	
	mountain big sagebrush	ARTRV	*Artemisia tridentata ssp. vaseyana*	179–314	–
	antelope bitterbrush	PUTR2	*Purshia tridentata*	18–72	–
	mountain snowberry	SYOR2	*Symphoricarpos oreophilus*	18–72	–
	arrowleaf balsamroot	BASA3	*Balsamorhiza sagittata*	4–27	–
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	4–27	–
	buckwheat	ERIOG	*Eriogonum*	4–27	–
5	**Secondary Shrubs**			18–90	
	Utah serviceberry	AMUT	*Amelanchier utahensis*	39–118	–
	rubber rabbitbrush	ERNAS	*Ericameria nauseosa ssp. nauseosa var. salicifolia*	39–118	–
	creeping barberry	MARE11	*Mahonia repens*	39–118	–
Tree					
6	**Evergreen**			1766–2259	
	curl-leaf mountain mahogany	CELE3	*Cercocarpus ledifolius*	1765–2158	–
	antelope bitterbrush	PUTR2	*Purshia tridentata*	18–72	–

	mountain snowberry	SYOR2	*Symphoricarpos oreophilus*	18–72	–
	Utah serviceberry	AMUT	*Amelanchier utahensis*	4–27	–
	rubber rabbitbrush	ERNAS	*Ericameria nauseosa ssp. nauseosa var. salicifolia*	4–27	–

Animal community

Livestock/Wildlife Grazing Interpretations:
This site is suited for livestock grazing. Considerations for grazing management include timing, intensity and duration of grazing.

Overgrazing by livestock and/or wildlife will cause a reduction in deep-rooted perennial bunchgrasses in the understory. Bluebunch wheatgrass and needlegrasses may be particularly affected. As perennial grass cover declines, the potential for invasion by annual non-native species is increased. Reduction in competition from these grasses allows shallower rooted grasses such as Sandberg bluegrass and forbs to increase (Smoliak et al. 1972). Bare ground also increases in this scenario. With annuals present in the understory, a fire in this community can cause a transition to a state dominated by annuals and Sandberg bluegrass with some sprouting shrubs such as rabbitbrush and snowberry in the overstory.

Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer, and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

Serviceberry branches and leaves are consumed by both domestic livestock and wildlife, particularly in late winter and early spring. Serviceberry can tolerate moderate to heaving browsing when adequate precipitation is received.

Mountain big sagebrush is eaten by domestic livestock but has long been considered to be of low palatability, and a competitor to more desirable species.

Antelope bitterbrush is an important shrub species to domestic livestock (Wood 1995). Antelope bitterbrush is most commonly found on soils which provide minimal restriction to deep root penetration such as coarse textured soil, or finer textured soil with high stone content (Driscoll 1964, Clements and Young 2002). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953).

Idaho fescue provides important forage for many types of domestic livestock. The foliage cures well and is preferred by livestock in the late fall and winter. Idaho fescue tolerates light to moderate grazing (Ganskopp and Bedell 1980) and is moderately resistant to trampling (Cole 1987). Heavy grazing may lead to replacement of Idaho fescue with non-native species such as cheatgrass (Mueggler 1984).

Mountain brome is ranked as excellent forage for both cattle and horses and good for domestic sheep, though domestic animals will graze mountain brome only when it is fairly succulent. Mountain brome increases with grazing (Leege et al. 1981). A study by Mueggler (1967) found that with clipping, mountain brome increased in herbage production when clipped in June. When clipped in July, mountain brome increased due to reduced competition from forb species. The study also found that after three successive years of clipping, mountain brome started to exhibit adverse effects.

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975, Britton et al. 1990). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990). Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards. 1995). Mueggler (1975) estimated that low-vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife (Anderson and Scherzinger 1975, Britton et al. 1990).

Stocking rates vary over time depending upon season of use, climate variations, site, and previous and current management goals. A safe starting stocking rate is an estimated stocking rate that is fine-tuned by the client by adaptive management through the year and from year to year.

Wildlife Interpretations:
This site provides breeding and hunting grounds for mountain lions, Puma concolor (Steele et al. 1981, Gucker 2006). Lions used curl-leaf mountain mahogany vegetation as an important site for caching kills. In a study conducted by Logan and Irwin (1985), 33 percent of noted lion caches (52 total) were located in curl-leaf mountain mahogany vegetation.

Bird species utilize mountain mahogany habitat types heavily. Virginia's warblers (Oreothylypis virginae) were recorded in their second-highest densities in the state in mountain mahogany habitats. This habitat type also provides important nesting sites for dusky flycatchers (Empidonax oberholseri), rock wrens (Salpinctes obsoletus), and American kestrels (Falco sparverius) (Wildlife Action Plan Team 2012).

Curl-leaf mountain mahogany is an important cover and browse species for big game such as elk (Cervus canadensis), mule deer (Odocoileus heminous), pronghorn antelope (Antilocarpra americana), and bighorn sheep (Ovis canadensis) (Lanner 1983, Furniss 1988, Sabo et al. 2005). Sampson and Jespersen (1963) state that curl-leaf mountain mahogany is excellent browse for mule deer, and domestic livestock will browse this plant to varying degrees in all seasons except summer. It is not uncommon for these trees to develop a “hedged” appearance after years of regular browsing by wildlife. Curl-leaf mountain mahogany is consumed widely by mule deer throughout the year (Olsen 1992); mule deer fecal pellets were observed to contain curl-leaf mountain mahogany year-round, with the highest frequency of leaves found in winter (Gucker 2006). Mule deer will also utilize curl-leaf mountain mahogany for cover (Steele et al. 1981). A variety of small mammals consume curl-leaf mountain mahogany seeds (Gucker 2006, Wildlife Action Plan Team 2012). Curl-leaf mountain mahogany leaves and fruits have also been found in bushy-tailed woodrat (Neotoma cinerea) middens (Gucker 2006).

Serviceberry berries provide excellent forage for small animals and birds. Birds also utilize the shrub for nesting and cover.

Antelope bitterbrush is critical browse for mule deer, antelope, and elk (Wood 1995).

Despite low palatability, mountain big sagebrush is eaten in small amounts by sheep, cattle, goats, and horses. Mountain big sagebrush is a highly preferred winter forage for mule deer: In a study by Personius et al. (1987), mountain big sagebrush was the most preferred sagebrush species. Fecal samples from ungulates in Montana showed that bighorn sheep, mule deer, and elk all consumed mountain big sagebrush in small amounts in winter, while cattle showed no sign of sagebrush use. Chemical analysis indicates that the leaves of big sagebrush equal alfalfa meal in protein, have a higher carbohydrate content, and yield twelvefold more fat (USDA Forest Service 1937). Reliance on the big sagebrush ecosystem by many wild animals for both food and cover has been documented and reviewed extensively. Sagebrush-grassland communities provide critical sage-grouse breeding and nesting habitats. Meadows surrounded by sagebrush may be used as feeding and strutting grounds. Sagebrush is a crucial component of their diet year-round, and sage-grouse select sagebrush almost exclusively for cover. Sage-grouse prefer mountain big sagebrush and Wyoming big sagebrush communities to basin big sagebrush communities.

Idaho fescue is an important source of forage for pronghorn and deer in ranges of northern Nevada.

Mountain brome seedheads and seeds provide food for many birds and small mammals. Pronghorn antelope will consume mountain brome primarily in the spring. The palatability of mountain brome is excellent for deer, particularly during the late spring and early summer.

Common snowberry is considered important browse for many types of wildlife. Bighorn sheep use common snowberry regularly during the summer. Forage value to elk is fair. Common snowberry is important as both cover and food for bird and small mammal populations. These include sharp-tailed, ruffed, and blue grouse, wild turkey and, several non-game species of bird including the kingbird, western flycatcher, and western bluebird. Among small mammals that rely on common snowberry are fox squirrels, desert cottontails, and pocket gopher.

Hydrological functions

Runoff is medium to rapid. Permeability is moderate to moderately rapid.

Recreational uses

Aesthetic value is derived from the diverse floral and faunal composition and the colorful flowering of wild flowers and shrubs during the spring and early summer. This site offers rewarding opportunities to photographers and for nature study. This site is used for camping and hiking and has potential for upland and big game hunting.

Other products

Native peoples used big sagebrush leaves and branches for medicinal teas, and the leaves as a fumigant. Bark was woven into mats, bags and clothing.

Other information

Curlleaf mountainmahogany may be planted to help stabilize soil in disturbed areas such as roadcuts and mine spoils.

Inventory data references

Soils and Physiographic features were gathered from NASIS.

Type locality

Location 1: Elko County, NV	
Township/Range/Section	T47N R63E S16
General legal description	About 8 miles west of Jackpot, Brown's Bench area, Elko County, Nevada.

Location 2: Elko County, NV	
Township/Range/Section	T34N R60E S6
General legal description	About 2 miles west of Secret Pass on trail leading to Secret Peak, Ruby Mountains, Humboldt-Toiyobe NF, Elko County, Nevada.

Other references

Akinsoji, A. 1988. Postfire vegetation dynamics in a sagebrush steppe in southeastern Idaho, USA. Vegetatio 78: 151-155.

Anderson, E. W. and R. J. Scherzinger. 1975. Improving quality of winter forage for elk by cattle grazing. Journal of Range Management: 120-125.

Arno, S. F. and A. E. Wilson. 1986. Dating past fires in curlleaf mountain-mahogany communities. Journal of Range Management: 241-243.

Barrington, M., S. C. Bunting, G. Wright, C. P. S. Unit, and I. Moscow. 1989. A Fire Management Plan for Craters of the Moon National Monument. Cooperative Park Studies Unit.

Blaisdell, J. P. 1953. Ecological effects of planned burning of sagebrush-grass range on the Upper Snake River Plains. US Dept. of Agriculture.

Blaisdell, J. P. and W. F. Mueggler. 1956. Sprouting of bitterbrush (Purshia tridentata) following burning or top removal. Ecology 37:365-370.

Blaisdell, J. P., R. B. Murray, and E. D. McArthur. 1982. Managing intermountain rangelands - sagebrush-grass ranges. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 46.

Blaisdell, J. P. and J. F. Pechanec. 1949. Effects of herbage removal at various dates on vigor of bluebunch wheatgrass and arrowleaf balsamroot. Ecology 30: 298-305.

Britton, C. M., G. R. McPherson, and F. A. Sneva. 1990. Effects of burning and clipping on five bunchgrasses in eastern Oregon. Western North American Naturalist 50: 115-120.

Bunting, S. C., B. M. Kilgore, and C. L. Bushey. 1987. Guidelines for prescribed burning sagebrush-grass rangelands in the northern Great Basin. US Department of Agriculture, Forest Service, Intermountain Research Station Ogden, UT, USA.

Busse, D., A. Simon, and M. Riegel. 2000. Tree-growth and understory responses to low-severity prescribed burning in thinned *Pinus ponderosa* forests of central Oregon. Forest Science 46: 258-268.

Busso, C. A. and J. H. Richards. 1995. Drought and clipping effects on tiller demography and growth of two tussock grasses in Utah. Journal of Arid Environments 29: 239-251.

Caudle, D., J. Dibenedetto , M. Karl , H. Sanchez , and C. Talbot. 2013. Interagency Ecological Site Handbook for Rangelands. http://jornada.nmsu.edu/files/InteragencyEcolSiteHandbook.pdf. Accessed 11/14/2014.

Chambers, J. C., B. A. Bradley, C. S. Brown, C. D’Antonio, M. J. Germino, J. B. Grace, S. P. Hardegree, R. F. Miller, and D. A. Pyke. 2013. Resilience to stress and disturbance, and resistance to *Bromus tectorum* L. invasion in cold desert shrublands of western North America. Ecosystems: 1-16.

Chambers, J. C., B. A. Roundy, R. R. Blank, S. E. Meyer, and A. Whittaker. 2007. What makes Great Basin sagebrush ecosystems invasible by *Bromus tectorum*? Ecological Monographs 77:117-145.

Clements, C. D. and J. A. Young. 2002. Restoring Antelope Bitterbrush. Rangelands 24: 3-6.

Comstock, J. P. and J. R. Ehleringer. 1992. Plant adaptation in the Great Basin and Colorado plateau. Western North American Naturalist 52: 195-215.

Conrad, C. E. and C. E. Poulton. 1966. Effect of a wildfire on Idaho fescue and bluebunch wheatgrass. Journal of Range Management:138-141.

Daubenmire, R. 1970. Steppe vegetation of Washington. Technical Bulletin. Washington Agricultural Experiment Station. 131 p.

Daubenmire, R. 1975. Plant succession on abandoned fields, and fire influences in a steppe area in southeastern Washington. Northwest Science 49: 36-48.

Dealy, J. E. 1974. Ecology of curlleaf mountain-mahogany (Cercocarpus ledifolius Nutt.) in eastern Oregon and adjacent areas. Unpublished dissertation. Oregon State University, Corvallis, OR.

Dobrowolski, J. P., M. M. Caldwell, and J. H. Richards. 1990. Basin hydrology and plant root systems. Pages 243-292 in C. B. Osmond, L. F. Pitelka, and G. M. Hidy, editors. Plant biology of the basin and range. Springer-Verlag, New York.

Eckert, R. E., Jr. and J. S. Spencer. 1987. Growth and reproduction of grasses heavily grazed under rest-rotation management. Journal of Range Management 40:156-159.

Fire Effects Information System (online http://www.fs.fed.us/database/feis)

Furniss, M. M., D. C Ferguson, K. W Voget, J. W. Burkhardt, A.R. Tiedemann, J. L. Oldemeyer. 1988. Taxonomy, life history, and ecology of a mountain-mahogany defoliator, Stamnodes animata (Pearsall), in Nevada. Fish and Wildlife Research 3. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. 26.

Gaffney, W. S. 1941. The effects of winter elk browsing, South Fork of the Flathead River, Montana. The Journal of Wildlife Management 5:427-453.

Garrison, G. A. 1953. Effects of clipping on some range shrubs. Journal of Range Management 6:309-317.

Gruell, G., S. C. Bunting, and L. Neuenschwander. 1985. Influence of fire on curlleaf mountain-mahogany in the intermountain west.Pages 58-72 in Fire's Effects on wildlife habitat - symposium proceedings. General Technical Report INT-186, Missoula, Montana. USDA Forest Service, Intermountain Research Station.

Gucker, C. L. 2006. Cercocarpus ledifolius. Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory http://www.fs.fed.us/database/feis/. Accessed 3/10/2015.

Houghton, J.G., C.M. Sakamoto, and R.O. Gifford. 1975. Nevada’s weather and climate, special publication 2. Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno, NV.

Johnson, C. G., R. R. Clausnitzer, P. J. Mehringer, and C. Oilver. 1994. Biotic and abiotic processes of eastside ecosystems: The effects of management on plant and community ecology, and on stand and landscape vegetation dynamics. PNW-GTR-322. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 76.

Kerns, B. K., W. G. Thies, and C. G. Niwa. 2006. Season and severity of prescribed burn in ponderosa pine forests: Implications for understory native and exotic plants. Ecoscience 13: 44-55.

Kuntz, D. E. 1982. Plant response following spring burning in an Artemisia tridentata subsp. vaseyana/Festuca idahoensis habitat type. Dissertation, University of Idaho, Moscow, ID.

Lanner, R. M. 1983. Trees of the Great Basin: A Natural History. University of Nevada Press, Reno, NV. 215 p.

Laycock, W. A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. Journal of Range Management 20: 206-213.

Leege, T. A. and W. O. Hickey. 1971. Sprouting of northern Idaho shrubs after prescribed burning. The Journal of Wildlife Management: 508-515.

Logan, K. A. and L. Irwin. 1985. Mountain lion habitats in the Big Horn Mountains, Wyoming. Wildlife Society Bulletin 13: 257-262.

McArthur, E. D., A. Blaner, A. P. Plummer, and R. Stevens. 1982. Characteristics and hybridization of important intermountain shrubs: 3. Sunflower family. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Research Paper INT-177 43.

McConnell, B. R. and J. G. Smith. 1977. Influence of grazing on age-yield interactions in bitterbrush. Journal of Range Management 30: 91-93.

Merrill, E. H., H. Mayland, and J. Peek. 1982. Shrub responses after fire in an Idaho ponderosa pine community. The Journal of Wildlife Management 46: 496-502.

Mueggler, W. F. 1975. Rate and pattern of vigor recovery in Idaho fescue and bluebunch wheatgrass. Journal of Range Management 28: 198-204.

Murray, R. B. 1983. Response of antelope bitterbrush to burning and spraying in southeastern Idaho. Pages 142-152 in Proceedings: Research and management of bitterbrush and cliffrose in western North America, Salt Lake City. General Technical Report INT-152. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

National Oceanic and Atmospheric Administration. 2004. The North American Monsoon. Reports to the Nation.

National Weather Service, Climate Prediction Center. Available online: http://www.weather.gov/

Neuenschwander, L. 1980. Broadcast burning of sagebrush in the winter. Journal of Range Management: 233-236.

Noste, N. V. and C. L. Bushey. 1987. Fire response of shrubs of dry forest habitat types in Montana and Idaho. Page 22 General Technical Report INT-239. USDA Forest Service, Intermountain Research Station., Ogden, UT.

Olsen, R. 1992. Mule deer habitat requirements and management in Wyoming. B-965. University of Wyoming, Cooperative Extension Service, Laramie, WY.

Rau, B. M., J. C. Chambers, R. R. Blank, and D. W. Johnson. 2008. Prescribed fire, soil, and plants: Burn effects and interactions in the central Great Basin. Rangeland Ecology & Management 61: 169-181.

Richards, J. H. and M. M. Caldwell. 1987. Hydraulic lift: Substantial nocturnal water transport between soil layers by Artemisia tridentata roots. Oecologia 73:486-489.

Robberecht, R. and G. Defossé. 1995. The relative sensitivity of two bunchgrass species to fire. International Journal of Wildland Fire 5: 127-134.

Sabo, J. L., R. Sponseller, M. Dixon, K. Gade, T. Harms, J. Heffernan, A. Jani, G. Katz, C. Soykan, J. Watts, and J. Welter. 2005. Riparian zones increase regional species richness by harboring different, not more, species. Ecology 86: 56-62.

Sampson, A. W. and B. S. Jespersen. 1963. California range brushlands and browse plants. University of California, Division of Agricultural Sciences, California Agricultural Experiment Station, Extension Service, Berkeley, CA. 162 p.

Scheldt, R. S. 1969. Ecology and utilization of curl-leaf mountain mahogany in Idaho. Unpublished thesis. University of Idaho, Moscow, ID.

Smoliak, S., J. F. Dormaar, and A. Johnston. 1972. Long-term grazing effects on Stipa-Bouteloua prairie soils. Journal of Range Management 25: 246-250.

Steele, R., R. D. Pfister, R. A. Ryker, and J. A. Kittams. 1981. Forest habitat types of central Idaho. Gen. Tech. Rep. INT-114. U. S. Department of Agriculture, Forest Service, Intermountain Research Station.

Tisdale, E. W. and M. Hironaka. 1981. The sagebrush-grass region: A review of the ecological literature. Bulletin 33, Moscow, ID: University of Idaho Forest, Wildlife and Range Experiment Station.

USDA Forest Service. 1937. Range Plant Handbook. Dover Publications, New York, NY. 816.

USDA-NRCS Plants Database (online http://plants.usda.gov/)

Whisenant, S. G. 1990. Changing fire frequencies on Idaho's Snake River Plains: Ecological and management implications. In Proceedings - Symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management April 5-7, 1989, Las Vegas, NV. Gen. Tech. Rep. INT-GTR-276. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT 351 p.

Wildlife Action Plan Team. 2012. Nevada Wildlife Action Plan. Nevada Department of Wildlife, Reno, NV.

Wood, M. K., B. A. Buchanan, and W.Skeet. 1995. Shrub preference and utilization by big game on New Mexico reclaimed mine land. Journal of Range Management 48: 431-437.

Wright, H. A. 1985. Effects of Fire on Grasses and Forbs in Sagebrush-Grass Communities. Pages 12-21 in Rangeland Fire Effects; A Symposium: Boise, ID, USDI-BLM.

Wright, H. A., C. M. Britton, and L. F. Neuenschwander. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: A state-of-the-art review.Intermountain Forest and Range Experiment Station, Forest Service, US Department of Agriculture.

Young, R. P. 1983. Fire as a vegetation management tool in rangelands of the intermountain region. Pages 18-31 in Managing Intermountain Rangelands - Improvement of Range and Wildlife Habitats: Proceedings; 1981 September 15-17; Twin Falls, ID; 1982 June 22-24; Elko, NV Gen. Tech. Rep. INT-GTR-157. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Ogden, UT. 194 p.

Contributors

RK
T. Stringham
P NovakEchenique

Approval

Kendra Moseley, 4/25/2024

Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	11/21/2024
Approved by	Kendra Moseley
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

---

7. **Amount of litter movement (describe size and distance expected to travel):**

---

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

---

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

---

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

---

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

---

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

---

14. **Average percent litter cover (%) and depth (in):**

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

---

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state**

for the ecological site:

17. **Perennial plant reproductive capability:**