USDA Natural Resources
Conservation Service

Ecological site R028AY058NV
STONY MAHOGANY SAVANNA

Accessed: 05/13/2025

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.

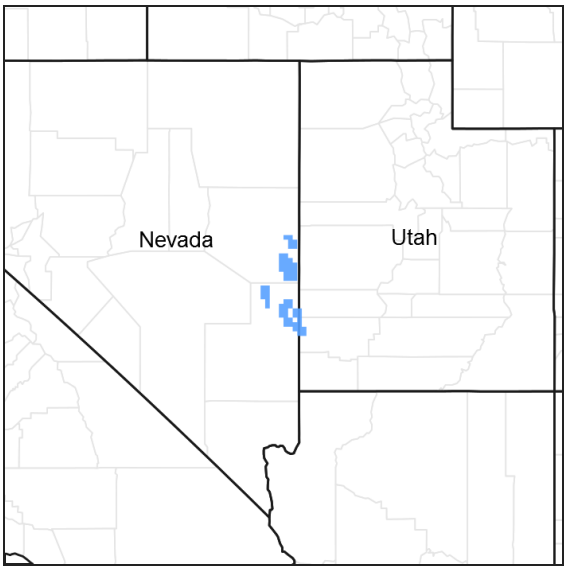

Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 028A–Ancient Lake Bonneville

MLRA 28A occurs in Utah (82%), Nevada (16%), and Idaho (2%). It makes up about 36,775 square miles. A large area west and southwest of Great Salt Lake is a salty playa. This area is the farthest eastern extent of the Great Basin Section of the Basin and Range Province of the Intermontane Plateaus. It is an area of nearly level basins between widely separated mountain ranges trending north to south. The basins are bordered by long, gently sloping alluvial fans. The mountains are uplifted fault blocks with steep side slopes. They are not well dissected because of low rainfall in the MLRA. Most of the valleys are closed basins containing sinks or playa lakes. Elevation ranges from 3,950 to 6,560 ft. in the basins and from 6,560 to 11,150 ft. in the mountains. Most of this area has alluvial valley fill and playa lakebed deposits at the surface. Great Salt Lake is all that remains of glacial Lake Bonneville. A level line on some mountain slopes indicates the former extent of this glacial lake. Most of the mountains in the interior of this area consist of tilted blocks of marine sediments from Cambrian to Mississippian age. Scattered outcrops of Tertiary continental sediments and volcanic rocks are throughout the area. The average annual precipitation is 5 to 12 ins. in the valleys and is as much as 49 ins. in the mountains. Most of the rainfall occurs as high-intensity, convective thunderstorms during the growing season. The driest period is from midsummer to early autumn. Precipitation in winter typically occurs as snow. The average annual temperature is 39 to 53 °F. The freeze-free period averages 165 days and ranges from 110 to 215 days, decreasing in length with elevation. The dominant soil orders in this MLRA are Aridisols, Entisols, and Mollisols. The soils in the area dominantly have a mesic or frigid soil temperature regime, an aridic or xeric soil moisture regime, and mixed mineralogy. They generally are well drained, loamy or loamy-skeletal, and very deep.

Ecological site concept

This site occurs in association with rock outcroppings on mountain summits and sideslopes on all exposures. Slopes range from 8 to 75 percent, but slope gradients of 15 to 50 percent are most typical. Elevations range from approximately 6400 to 10400 feet.

Average annual precipitation is 14 to over 20 inches. Mean annual air temperature is 43 to 45 degrees F. The average growing season is 70 to 100 days.

The soils associated with this site are shallow to moderately deep and well drained. The soils are formed in residuum and colluvium from limestone, calcite, calcareous shale and dolomite. The soil moisture regime is xeric and the soil temperature regime is frigid or cryic. These soils are modified by high volumes of rock fragments throughout the profile, and there is a high amount of cobbles, stones or boulders at the soil surface. Available water capacity is very low to low. Runoff is medium to very high.

The reference state is dominated by curlleaf mountain mahogany. Mountain big sagebrush is the principal understory shrub. Bluebunch wheatgrass, Letterman needlegrass and muttongrass are the most prevalent understory grasses. Total overstory canopy cover is less than 25 percent (±15%). Understory vegetation comprises about 20% of the total site production. Total annual production for all trees, shrubs and herbaceous plants irrespective of height ranges from 600 to 1300 pounds per acre. Total annual production for all trees, shrubs and herbaceous plants in the understory to a height of 4.5 feet ranges from 75 to 300 pounds per acre understory.

Associated sites

F028AY076NV	**PIMO/ARTRV/PSSPS-POFE**
R028AY059NV	**MAHOGANY SAVANNA**
R028AY060NV	**MAHOGANY THICKET**
R028AY065NV	**SHALLOW LOAM 14+ P.Z.**

Similar sites

R028AY059NV	**MAHOGANY SAVANNA** More productive understory; total site productivity is greater; CELE3 canopy cover averages 25 to 35%
R028AY060NV	**MAHOGANY THICKET** Total site productivity is greater; CELE3 canopy cover greater than 35%, usually at least 50%

Table 1. Dominant plant species

Tree	(1) *Cercocarpus ledifolius*
Shrub	(1) *Artemisia tridentata var. vaseyana*
Herbaceous	(1) *Pseudoroegneria spicata subsp. inermis* (2) *Achnatherum lettermanii*

Physiographic features

This site occurs in association with bedrock outcroppings on mountain summits and sideslopes on all exposures. Slopes range from 8 to 75 percent, but slope gradients of 15 to 50 percent are most typical. Elevations range from approximately 6400 to 10,400 feet.

Table 2. Representative physiographic features

Landforms	(1) Mountain (2) Mountain slope
Elevation	1,951–3,170 m

Slope	8–75%
Aspect	Aspect is not a significant factor

Climatic features

Nevada’s climate is predominantly arid, with large daily ranges of temperature, infrequent severe storms, heavy snowfall in the higher mountains, and great location variations with elevation. Three basic geographical factors largely influence Nevada’s climate: continentality, latitude, and elevation. Continentality is the most important factor. The strong continental effect is expressed in the form of both dryness and large temperature variations. Nevada lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that markedly influences the climate of the State. The prevailing winds are from the west, and as the warm moist air from the Pacific Ocean ascend the western slopes of the Sierra Range, the air cools, condensation occurs and most of the moisture falls as precipitation. As the air descends the eastern slope, it is warmed by compression, and very little precipitation occurs. The effects of this mountain barrier are felt not only in the West but throughout the state, with the result that the lowlands of Nevada are largely desert or steppes. The temperature regime is also affected by the blocking of the inland-moving maritime air. Nevada sheltered from maritime winds, has a continental climate with well-developed seasons and the terrain responds quickly to changes in solar heating.
Nevada lies within the mid-latitude belt of prevailing westerly winds which occur most of the year. These winds bring frequent changes in weather during the late fall, winter and spring months, when most of the precipitation occurs. To the south of the mid-latitude westerlies, lies a zone of high pressure in subtropical latitudes, with a center over the Pacific Ocean. In the summer, this high-pressure belt shifts northward over the latitudes of Nevada, blocking storms from the ocean. The resulting weather is mostly clear and dry during the summer and early fall, with scattered thundershowers. The eastern portion of the state receives significant summer thunderstorms generated from monsoonal moisture pushed up from the Gulf of California, known as the North American monsoon. The monsoon system peaks in August and by October the monsoon high over the Western U.S. begins to weaken and the precipitation retreats southward towards the tropics (NOAA 2004).

Average annual precipitation is 14 to over 20 inches. Mean annual air temperature is 43 to 45 degrees F. The average growing season is 40 to 100 days.

Mean annual precipitation at the Great Basin National Park climate station (263340) is 13.33 inches.
Monthly mean precipitation is:
January 1.05; February 1.18; March 1.37; April 1.21; May 1.24; June .87; July .97; August 1.18; September 1.08; October .96; December .96

Table 3. Representative climatic features

Frost-free period (average)	70 days
Freeze-free period (average)	85 days
Precipitation total (average)	432 mm

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 and well drained. The soils are formed in residuum and colluvium from limestone, calcite, calcareous shale and dolomite. The soil moisture regime is xeric and the soil temperature regime is frigid or cryic. These soils are modified by high volumes of rock fragments throughout the profile, and there is a high amount of cobbles, stones or boulders at the soil surface. Available water capacity is very low to low. Runoff is medium to very high. The soil series associated with this site include: Haunchee, Highup, Notellumcreek, and Topeki.

The representative soil series is Haunchee, classified as a Loamy-skeletal, carbonatic Lithic Cryrendolls. Diagnostic

horizons include a mollic epipedon from the soil surface to 14 inches. Identifiable secondary calcium carbonates occur from 2 to 14 inches. Depth to bedrock is 6 to 24 inches. Clay content in the particle control section averages 10 to 20 percent. Rock fragments range from 35 to 70 percent, mainly gravel and cobbles. Reaction is moderately or very strongly alkaline. Effervescence is very slightly effervescent to violently effervescent throughout. Lithology consists of limestone, calcite, calcareous shale and dolomite.

Table 4. Representative soil features

Parent material	(1) Colluvium–limestone (2) Residuum–calcareous shale
Surface texture	(1) Very cobbly loam (2) Extremely stony loam (3) Very stony loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderately slow
Soil depth	15–64 cm
Surface fragment cover <=3"	15–20%
Surface fragment cover >3"	10–20%
Available water capacity (0-101.6cm)	3.05–8.89 cm
Calcium carbonate equivalent (0-101.6cm)	0–50%
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)	5.8–8.1
Subsurface fragment volume <=3" (Depth not specified)	15–35%
Subsurface fragment volume >3" (Depth not specified)	15–35%

Ecological dynamics

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, 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 or can increase resource uptake by 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 the plant achieves and in competitive environments cheatgrass roots were found to penetrate only 15 cm whereas isolated plants and pure stands were found to root at least 1 m in depth with some plants rooting as deep

as 1.5 to 1.7 m.
This ecological site is dominated by the long-lived curlleaf 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 m. (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 generally have somewhat 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.

Curlleaf 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 curlleaf mountain mahogany produces nitrogen-fixing root nodules. They also reported that nodulated plants had the highest amounts of nitrogen in the leaves. Most often curlleaf 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.

Curlleaf 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 or no young curlleaf 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.
Curlleaf 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 retard 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 either canopy gaps where a tree has died and increased exposure of bare ground or around the perimeter of the stand under sagebrush plants, where litter cover is less and seldom deep (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). Once germination occurs, the seedlings exhibit rapid growth in relation to top growth, providing some resistance to drought and competition with invasive species (Dealy 1975). Dealy (1975) reported that curlleaf mahogany seedlings have a mean taproot length of 0.97 m after 120 days. The mean top height was slightly less than 2.5 cm. 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 facilitating mahogany recruitment (Gruell 1985, Ibáñez et al. 1998).

Mountain big sagebrush is generally long-lived; therefore it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

The perennial bunchgrasses that are co-dominant with the shrubs include bluebunch wheatgrass, needlegrasses (Achnatherum spp.) and muttongrass (*Poa fendleriana* ssp. longiligula). These species generally have somewhat 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 m 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.
Mahogany stands are susceptible to drought, frost, insect attack, 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).

Infilling by singleleaf pinyon pine (*Pinus monophylla*) may also occur with an extended fire return interval.

Eventually, singleleaf pinyon will dominate the site and the understory of mountain big sagebrush and grasses will be severely reduced. Muttongrass may remain underneath trees on north-facing slopes.

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. North slopes are more resilient than south slopes because lower soil surface temperatures operate to keep moisture content higher on northern exposures. Four possible alternative stable states have been identified for this site.

Fire Ecology:
The historic fire return interval in curlleaf mountain mahogany stands is not well documented, however, a study by Arno and Wilson (1986) suggested sites of curlleaf mountain mahogany with ponderosa pine had fire return intervals of 13 to 22 years before 1900. Fire frequency most likely depends on surrounding vegetation. Mahogany will persist longest in rocky sites where it is protected from fire. Because of their thicker bark, mature trees can often survive low-severity fires (Gruell 1985). Curlleaf mountain mahogany is considered a weak sprouter after fire. It is usually moderately to severely damaged by severe fires and the recovery time of these sites is variable; some measurements show that stands lack recruitment for up to 30 years post-fire (Gruell 1985). Curlleaf mountain mahogany produces seed crops at very irregular intervals and is difficult to reestablish after fire. Seedlings are sensitive to drought and frost (Plummer et al 1968, Dealy 1975).

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). Mountain big sagebrush may return to pre-burn density and cover within 15 to 20 years following fire, but establishment after severe fires may proceed more slowly (Bunting et al. 1987).

Depending on fire severity, rabbitbrush (Chrysothamnus spp.), mountain snowberry (*Symphoricarpos oreophilus*), Utah serviceberry (*Amelanchier utahensis*), greenleaf manzanita (Arctostaphylus patula) may increase after fire. The majority of research concerning rabbitbrush has been conducted on yellow rabbitbrush. Yellow rabbitbrush has a large taproot root system and is known to be shorter lived and less competitive than sagebrush. Seedling density, flower production, and shoot growth decline as competition from other species increases (McKell and Chilcote 1957, Miller et al. 2013). Yellow rabbitbrush 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). Mountain snowberry has been noted to regenerate well and exceed pre-burn biomass in the third season after a fire (Merrill et al. 1982). 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. However, season and severity of the fire will influence plant response. Plant response will vary depending on post-fire soil moisture availability.

Muttongrass, a minor component on this site, is top killed by fire but will resprout after low to moderate severity fires. A study by Vose and White (1991) in an open sawtimber site, found minimal difference in overall effect of burning on muttongrass.

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.

State and transition model

MLRA 28A
Stony Mahogany Savanna
028AY058NV

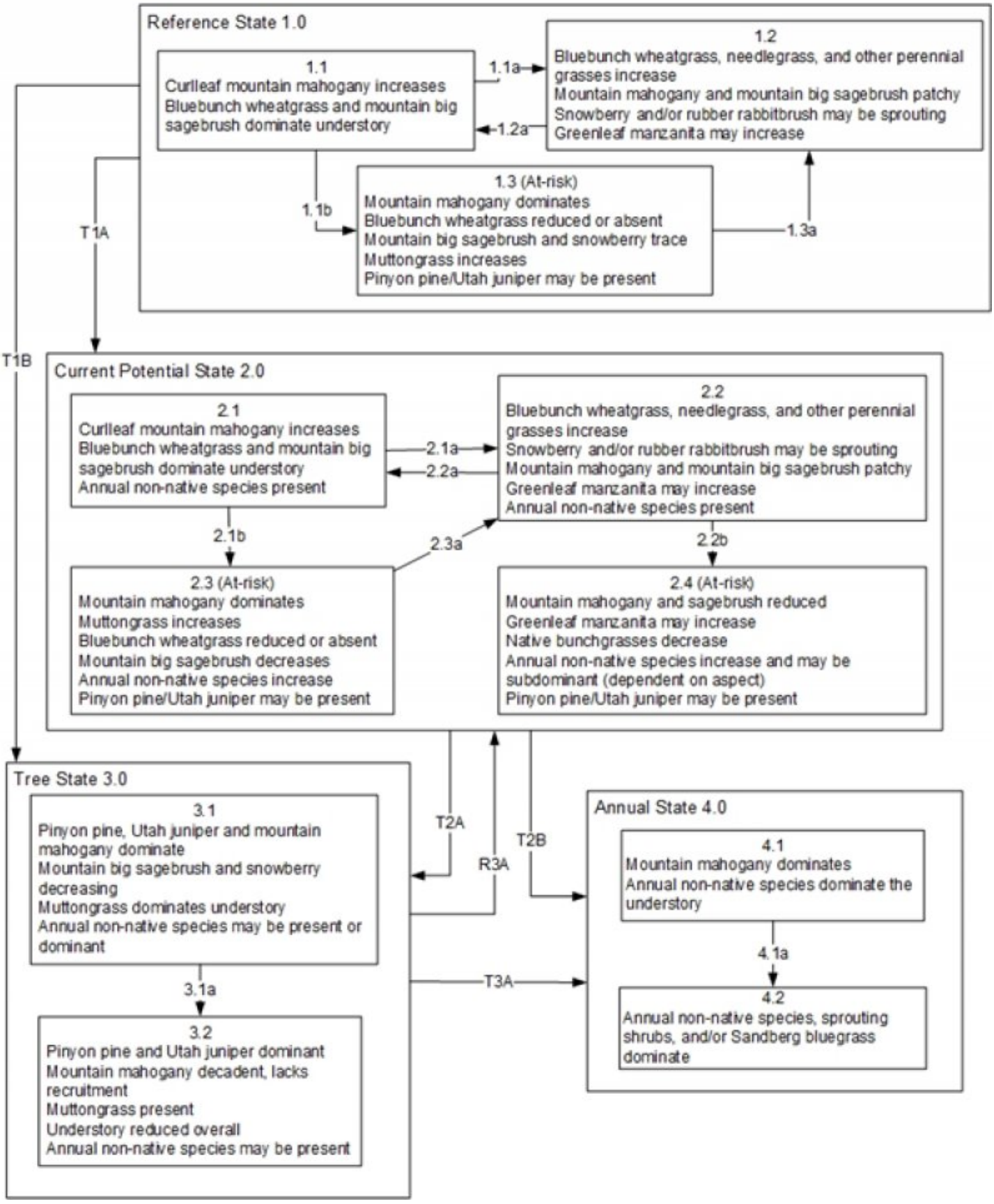

Figure 6. T. Stringham 2/2015

MLRA 28A
Stony Mahogany Savanna
028AY058NV

Reference State 1.0 Community Pathways
1.1a: Low severity fire creates mosaic pattern of shrubs and grasses.
1.1b: Time and lack of disturbance or fire, long-term drought, herbivory, insect damage or combinations of these. Muttongrass increases with more shade.
1.2a: Time and lack of disturbance or fire, long-term drought, herbivory, insect damage or combinations of these.
1.3a: Low severity fire creates mosaic pattern. Greenleaf manzanita will increase after fire.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and lack of disturbance allows pinyon to increase and overtop mahogany. Litter increases while understory plants decrease.

Current Potential State 2.0 Community Pathways
2.1a: Low severity fire.
2.1b: Time and lack of disturbance or fire, long-term drought, inappropriate grazing management, insect damage, or combinations of these. Muttongrass increases because of increased shade from trees.
2.2a: Time and lack of disturbance or fire, long-term drought, inappropriate grazing management, insect damage or combinations of these.
2.2b: Fire in the presence of non-native annuals. Annual species may increase in a year with heavy spring precipitation.
2.3a: Fire. Greenleaf manzanita will increase after fire.

Transition T2A: Time and lack of disturbance allows pinyon to increase and overtop mahogany. Litter increases while understory plants decrease.

Transition T2B: Inappropriate grazing in the presence of non-native annual species (4.1) Catastrophic fire (4.2).

Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance or fire, long-term drought, inappropriate grazing management, or combinations of these allows for maturation of the pinyon/juniper community.

Restoration Pathway R3A: Removal of pinyon and juniper from site will allow mountain mahogany to again become the dominant overstory.

Annual State 4.0 Community Pathways
4.1a: Catastrophic fire.

Figure 7. Legend

State 1
Reference State

The Reference State 1.0 is a representative of 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 drought and/or insect attack.

Community 1.1
Community Phase

This community is dominated by curlleaf mountain mahogany. Mountain big sagebrush and mountain snowberry dominate the shrub understory. Bluebunch wheatgrass and Letterman needlegrass dominate the perennial bunchgrasses. Forbs are a small component of the understory. Utah juniper and singleleaf pinyon are described in the site concept and may or may not be present. Total overstory canopy cover is less than 25 percent (±15%). Understory vegetation comprises about 20% of the total site production. Potential vegetative composition for the understory is about 35% grasses, 5% forbs and 60% shrubs. Overstory trees and tree-like shrub composition is about 80% of the total site production. Approximate ground cover (basal and crown) is 20 to 35 percent. Total annual production for all trees, shrubs and herbaceous plants irrespective of height ranges from 600 to 1300

pounds per acre. Total annual production for all trees, shrubs and herbaceous plants in the understory to a height of 4.5 feet ranges from 75 to 300 pounds per acre understory.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Tree	554	824	1204
Shrub/Vine	66	96	127
Grass/Grasslike	49	80	110
Forb	3	9	17
Total	**672**	**1009**	**1458**

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, Utah serviceberry, green ephedra, wild crabapple, manzanita, and rabbitbrush are sprouting or increasing in burned areas. Perennial bunchgrasses may dominate.

Community 1.3
Community Phase (at risk)

Mountain mahogany density will increase in the absence of disturbance. Shrubs and deep-rooted perennial bunchgrasses will be shaded out by the dense shade. Muttongrass is more shade tolerant, however, and will still be found in the understory. Mountain mahogany in dense stands will lose lower branches due to shading and/or herbivory, resulting in a more tree-like appearance. Scattered singleleaf pinyon trees and Utah juniper may be present and increasing on the site, however the mountain mahogany and shrub understory is intact and is dominating site resources (Miller et al 2008).

Pathway a
Community 1.1 to 1.2

Low-severity lightning fire can reduce the mountain 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 reestablish. The shrub and herbaceous understory components decline due to increased shading from the trees.

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.

Pathway a
Community 1.3 to 1.2

A low-severity or lightning spot 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. It has similar community phases with the addition of the 2.4 at-risk community phase. 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

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 curlleaf mountain mahogany. Mountain big sagebrush and mountain snowberry make up the shrub components of the understory. Bluebunch wheatgrass and needlegrasses make up the perennial bunchgrasses. Forbs and other grasses are a small component of the understory. Utah juniper and singleleaf pinyon may be present.

Community 2.2
Community Phase

This community phase is characteristic of a post-disturbance, early seral community where annual non-native species are present. Mahogany and sagebrush are present in trace amounts. Snowberry, Utah serviceberry, green ephedra, wild crabapple, manzanita, and rabbitbrush are sprouting or increasing; perennial bunchgrasses may dominate the site. Annual non-native species are stable or increasing within the community.

Community 2.3
Community Phase (at risk)

Figure 9. Stony Mahogany Savanna (R028AY058NV) T. Stringham July 2014

Curlleaf mountain mahogany dominates the overstory. Mountain big sagebrush, mountain snowberry, and rabbitbrush decrease. Perennial bunchgrass understory is reduced. Bare ground may be increasing. 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 plants are increasing in the understory. Scattered pinyon trees may be present and increasing on the site, however the mahogany and shrub understory is intact and is dominating site resources (Miller et al 2008).

Community 2.4
Community Phase (at risk)

This community is at risk of crossing into an annual state. Native bunchgrasses dominate the understory; however, annual non-native species such as cheatgrass may be sub-dominant. Annual production and abundance of these

annuals may increase drastically in years with heavy spring precipitation. Mountain big sagebrush and mountain snowberry are minor components. Singleleaf pinyon may be present to increasing. This site is susceptible to further degradation from grazing, drought, insect damage, and fire.

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 or spotting 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

Time and lack of disturbance allows the mountain mahogany component to increase. The shrub and herbaceous understory components eventually decline due to increased shading.

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.

Pathway b
Community 2.2 to 2.4

Tree/shrub removal treatment or prescribed burning in the presence of the non-native annual cheatgrass will reduce shrub canopy and cause a shift to Phase 2.4. A year with heavy spring precipitation in the presence of cheatgrass will accelerate this pathway.

Pathway a
Community 2.3 to 2.2

Low-severity or spotty 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
Tree State

This state has two community phases and is characterized by singleleaf pinyon and/or Utah juniper dominating site resources. Evergreen trees outcompete and overtop the mountain mahogany overstory. The understory is reduced due to shading and competition with tree overstory. This state may be compounded by grazing of livestock and wildlife further reducing perennial understory species. Annual non-native species may be increasing. This state will not occur above the pinyon/juniper tree zone (>9000 ft).

Community 3.1
Community Phase

Singleleaf pinyon, Utah juniper and curlleaf mountain mahogany co-dominate the site. The understory of shrubs and grasses is nearly intact but shows signs of thinning (Miller et al 2008). Mountain big sagebrush and other understory shrubs are starting to show signs of increased competition from tree canopy and are decreasing in the understory. Muttongrass increases with shading and may be the dominant bunchgrass in the understory. Annual non-native species are present and may be increasing.

Community 3.2
Community Phase

Singleleaf pinyon pine and/or Utah juniper dominate the site. Trees dominate site resources and the understory is reduced (Miller at al 2008.) Mountain mahogany is decadent and lack recruitment. Muttongrass is present but reduced in density. The shrub component of the understory is reduced, mountain big sagebrush skeletons may be present. Annual non-native species are present to increasing.

Pathway a
Community 3.1 to 3.2

Time and lack of disturbance allows for pinyon pine and Utah juniper trees to increase.

State 4
Annual State

The primary characteristic of this state is a dominance of non-native annual grasses like cheatgrass. The community may be dominated by sprouting shrubs, annual non-native grass and forbs, and Sandberg bluegrass. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses, and/or severe wildfire or repeated fires. Sandberg bluegrass will increase with a reduction in deep rooted perennial bunchgrass competition 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 4.1
Community Phase

Mountain mahogany dominates the overstory and annual non-native species such as cheatgrass dominate the understory. Perennial bunchgrasses are present in trace amounts. This phase is very at risk of fire and converting to annual grassland.

Community 4.2
Community Phase

Annual non-native species and Sandberg bluegrass dominate the site. Other perennial bunchgrasses may be present in trace amounts. Mountain mahogany and mountain big sagebrush may present in trace amounts. Rabbitbrush, Utah serviceberry, green ephedra and others may be sprouting.

Pathway a
Community 4.1 to 4.2

Catastrophic fire eliminates the mountain mahogany overstory and allows for annual non-native species to dominate. Sprouting shrubs are also present.

State 5
Annual State

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 B
State 1 to 3

Trigger: Time and lack of disturbance such as fire allows for pinyon trees to dominate. Slow variables: Over time abundance and size of pinyon will increase. Threshold: Pinyon pine dominates ecological processes. Trees overtop and outcompete mountain mahogany and shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

Transition A
State 2 to 3

Trigger: Time and lack of disturbance such as fire allows for pinyon and juniper trees to dominate. Slow variables: Over time abundance and size of pinyon will increase. Threshold: Pinyon pine dominates ecological processes. Trees overtop and outcompete mountain mahogany and shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

Transition B
State 2 to 4

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. Cheatgrass becomes the dominant grass. Sandberg bluegrass may be a significant component. Slow variable: Cover and production of annual non-natives and/or Sandberg bluegrass will increase. 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.

Restoration pathway A
State 3 to 2

Removal of singleleaf pinyon and Utah juniper from the site may allow mountain mahogany to reestablish and become dominant in the overstory.

Conservation practices

Brush Management

Transition A
State 3 to 4

Trigger: To community phase 4.1: Overgrazing in the presence of non-native annual species can cause a decrease in perennial bunchgrasses and an increase in annual species. Spring and/or fall moisture may also increase annual species. To community phase 4.2: Catastrophic fire. Slow variables: Cover and production of annual non-native species increase in the understory. Threshold: Loss of mahogany overstory, mountain big sagebrush, and deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter and soil moisture. 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**			46–93	
	bluebunch wheatgrass	PSSPS	*Pseudoroegneria spicata ssp. spicata*	34–59	–
	Letterman's needlegrass	ACLE9	*Achnatherum lettermanii*	9–17	–
	muttongrass	POFE	*Poa fendleriana*	3–17	–
2	**Secondary Perennial Grasses**			3–17	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	1–6	–
	squirreltail	ELEL5	*Elymus elymoides*	1–6	–
	basin wildrye	LECI4	*Leymus cinereus*	1–6	–
	Sandberg bluegrass	POSE	*Poa secunda*	1–6	–
Forb					
3	**Perennial**			3–17	
	milkvetch	ASTRA	*Astragalus*	1–6	–
	bastard toadflax	COUM	*Comandra umbellata*	1–6	–
	mat rockspirea	PECA12	*Petrophytum caespitosum*	1–6	–
	rock goldenrod	PEPU7	*Petradoria pumila*	1–6	–
	phlox	PHLOX	*Phlox*	1–6	–
	stemless mock goldenweed	STAC	*Stenotus acaulis*	2–6	–
Shrub/Vine					
4	**Primary Shrubs**			63–101	
	mountain big sagebrush	ARTRV	*Artemisia tridentata ssp. vaseyana*	59–84	–
	snowberry	SYMPH	*Symphoricarpos*	3–17	–
5	**Secondary Shrubs**			3–26	
	Utah serviceberry	AMUT	*Amelanchier utahensis*	2–9	–
	greenleaf manzanita	ARPA6	*Arctostaphylos patula*	2–9	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	2–9	–
	mormon tea	EPVI	*Ephedra viridis*	2–9	–
	wild crab apple	PERA4	*Peraphyllum ramosissimum*	2–9	–
Tree					
6	**Evergreen**			554–1204	
	curl-leaf mountain mahogany	CELE3	*Cercocarpus ledifolius*	757–857	–
	Utah juniper	JUOS	*Juniperus osteosperma*	6–30	–
	singleleaf pinyon	PIMO	*Pinus monophylla*	6–30	–

Animal community

Livestock Interpretations:
This site has limited value for livestock grazing due to steep slopes and stony surfaces. Despite low palatability, mountain big sagebrush is eaten by sheep, cattle, goats, and horses. 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). 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).

Muttongrass is excellent forage for domestic livestock especially in the early spring. Muttongrass begins growth in late winter and early spring, which makes it available before many other forage plants. Columbia needlegrass provides valuable forage for all classes of livestock. Overall production is generally low in the upper sagebrush and mountain brush zones and at the limits of its range where Columbia needlegrass grows only in scattered patches. It is especially valuable to cattle and horses on summer ranges and to domestic sheep on lambing grounds. It is more often cropped closely by cattle and horses than by sheep. Western needlegrass has a spreading and deeply penetrating root system, which makes it resistant to trampling. Letterman’s needlegrass begins growth early in the year and remains green throughout the relatively long growing season, thus, making it valuable forage for livestock..

Common snowberry is considered important browse for many types of livestock. It is especially important to domestic sheep and cattle. Common snowberry was found to be highly palatable to cattle. It plays a critical role in permitting cattle to meet their protein requirements during the latter half of the growing season. Domestic sheep also utilize common snowberry for browse and it is considered fair to good forage. It is has no forage value for horses. Some livestock (domestic goats, sheep, and cattle) use it in spring, fall, and/or winter but rarely in the summer.

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 valuable habitat for a variety of wildlife species. Curlleaf mountain mahogany is an important cover and browse species for big game such as elk, mule deer, and bighorn sheep (Furniss et al 1988, Lanner 1983). Sampson and Jesperson (1963) states that curlleaf mountain mahogany is excellent browse for mule deer (Odocoileus heminous), 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.

According to Olsen (1992) curlleaf mountain mahogany is consumed widely by mule deer throughout the year. In fact, 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 use curlleaf mountain mahogany for cover as well (Steel et al. 1981).

Mountain big sagebrush is highly preferred and nutritious winter forage for mule deer and elk. Common snowberry is considered important browse for many types of wildlife. Bighorn sheep use common snowberry regularly during the summer. Forage value to elk as 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. Bluebunch wheatgrass is considered one of the most important forage grass species on western rangelands for wildlife. Bluebunch wheatgrass does not generally provide sufficient cover for ungulates, however, mule deer are frequently found in bluebunch-dominated grasslands. Deer and elk make heavy use of muttongrass, especially in early spring when other green forage is scarce. Depending upon availability of other nutritious forage, deer may use mutton grass in all seasons. Muttongrass cures well and is an important fall and winter deer food in some areas. Columbia needlegrass provides valuable forage for many species of wildlife. It is also consumed by mule deer and other wildlife species throughout the growing season. Needlegrasses are a significant component in the diet of pocket gophers. Columbia needlegrass is palatable to many species of wildlife throughout its range. As with most needlegrasses, it is most palatable early in the season before the foliage becomes coarse and wiry. Palatability of Columbia needlegrass is described as "fair" for wildlife overall, becoming nearly unpalatable at maturity. Western needlegrass and Letterman's needlegrass are important forage species for many wildlife species.

Overgrazing by livestock and/or wildlife will cause a reduction in deep-rooted perennial bunchgrasses in the understory with bluebunch wheatgrass and needlegrasses particularly affected. As perennial grass cover declines, the potential for invasion by annual non-native species is increased. With the reduction in competition from these grasses bunchgrasses, shallower rooted grasses such as Sandberg bluegrass and forbs may increase (Smoliak et al. 1972). Bare ground also increases in this scenario.

This site also 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. Loagan and Irwin (1985) noted of 52 mountain lion caches, 33 percent were located in curl-leaf mountain mahogany vegetation (Gucker 2006 and ref. therein).
A variety of small mammals consume curlleaf 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).
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).

Hydrological functions

Permeability is impermeable to moderately slow. Runoff is medium to very high. Hydrologic soil groups are C and D. Rills are none to rare. Occurrence of rills may be more frequent where run-in occurs from adjacent rock outcrops. Water flow patterns are none to rare with occurrence increasing as canopy cover increases. These are typically short <1m) and not connected. Pedestals are none to rare. Occurrence is usually limited to water flow paths. Terracettes typically do not occur. Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., bluebunch wheatgrass, needlegrasses] slow runoff and increase infiltration. Curlleaf mountain mahogany and understory shrubs break raindrop impact and provide opportunity for snow catch and accumulation on site.

Recreational uses

Aesthetic value is derived from the diverse floral and faunal composition. This site offers rewarding opportunities to photographers and for nature study. This site is used for hiking and has potential for upland and big game hunting.

Other products

Native Americans used big sagebrush leaves and branches for medicinal teas, and the leaves as a fumigant. Bark was woven into mats, bags and clothing. The fruits were eaten fresh and also dried for winter use. Common snowberry was used on hair as soap, and the fruits and leaves mashed and applied to cuts or skin sores as a poultice and to soothe sore, runny eyes. Tea from the bark was used as a remedy for tuberculosis and sexually transmitted diseases. A brew made from the entire plant was used as a physic tonic. Arrowshafts and pipestems were made from the stems.

Other information

Curlleaf mountain mahogany may be planted to help stabilize soil in disturbed areas such as roadcuts and mine spoils. Letterman's needlegrass has been used successfully in revegetating mine spoils. This species also has good potential for erosion control.

Type locality

Location 1: White Pine County, NV	
Township/Range/Section	T14N R69E S20
Latitude	39° 4′ 18″
Longitude	114° 15′ 7″
General legal description	About ¾ mile south of Strawberry Creek, Snake Range, Great Basin National Park, White Pine County, Nevada. Also occurs in Lincoln 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.

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

Blaisdell, J.P., R.B. Murray, E.D. McArthur. 1982. Managing Intermountain rangelands--sagebrush-grass ranges. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Gen. Tech. Rep. INT-134. 41 p.

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. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station.

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. Available at: http://jornada.nmsu.edu/sites/jornada.nmsu.edu/files/InteragencyEcolSiteHandbook.pdf. Accessed 4 October 2013.

Chambers, J., B. Bradley, C. Brown, C. D'Antonio, M. Germino, J. Grace, S. Hardegree, R. Miller, and D. 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.

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. Washington Agricultural Experiment Station. Technical Bulletin 62. 131 pp.
Daubenmire, R. 1975. Plant succession on abandoned fields, and fire influences in a steppe area in southeastern Washington. Northwest Science 49:36-48.

Dealy, E.J. 1975. Ecology of curlleaf mountain-mahogany (Cercocarpus ledifolius Nutt) in eastern Oregon and adjacent areas. Unpublished dissertation, Oregon State University, Corvallis.

Dobkin, D.S. and J.D. Sauder. 2004. Shrub steppe landscapes in jeopardy. Distributions, abundances, and the uncertain future of birds and small mammals in the Intermountain West. Bend, OR: High Desert Ecological Research Institute.

Dobrowolski, J.P., Caldwell, M.M. and Richards, J.H. 1990. Basin hydrology and plant root systems. In: Plant Biology of the Basin and Range. New York, NY: Springer-Verlag Pub.,
Driscoll, R. S. 1964. A relict area in the central Oregon juniper zone. Ecology 45:345-353.

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.

Evans, R. A. and J. A. Young. 1978. Effectiveness of rehabilitation practices following wildfire in a degraded big sagebrush-downy brome community. Journal of Range Management 31:185-188.

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. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 26 p.

Ganskopp, D. 1988. Defoliation of thurber needlegrass: herbage and root responses. Journal of Range Management 41:472-476.
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. In J. E. Lotan, J.K. Brown, compilers. Fire's effects on wildlife habitat - symposium proceedings; 1984 March 21; Missoula, MT. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. General Technical Report INT-186. p. 58-72.

Gucker, Corey L. 2006. Cercocarpus ledifolius. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/

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.

Ibáñez, I., and Eugene W. Schupp. 2002.
Effects of litter, soil surface conditions, and microhabitat on Cercocarpus ledifolius Nutt. Seedling emergence and establishment. Journal of Arid Environments 52:209-222.

Ibáñez, I., E. W. Schupp, and J. L. Boettinger. 1998. Successional history of a curlleaf mountain mahogany stand: a hypothesis. McArthur ED, Ostler WK, Wambolt CL (comps) Proceedings: Shrubland Ecotones:12-14.

Koniak, S. 1985. Succession in pinyon-juniper woodlands following wildfire in the Great Basin. The Great Basin Naturalist 45:556-566.

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

Laycock, W. A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. Journal of Range Management: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, Kenneth A. and L. Irwin. 1985. Mountain lion habitats in the Big Horn Mountains, Wyoming. Wildlife Society Bulletin. 13: 257-262.

McKell, C. M. and W. W. Chilcote. 1957. Response of rabbitbrush following removal of competing vegetation. Journal of Range Management 10:228-229.

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.

Miller, R. F., J. C. Chambers, D. A. Pyke, F. B. Pierson, and C. J. Williams. 2013. A review of fire effects on vegetation and soils in the Great Basin Region: response and ecological site characteristics. Fort Collins, CO: U.S.

Department of Agriculture, Forest Service, Rocky Mountain Research Station. Gen. Tech. Rep. RMRS-GTR-308. 126 p.

Miller, R. F., R.J. Tausch, E.D. McArthur, D.D. Johnson, and S.C. Sanderson. 2008. Age structure and expansion of piñon-juniper woodlands: a regional perspective in the intermountain west. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. RMRS-RP-69. 15 p.

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. Gen. Tech. Rep. INT-GTR-239.

Noy-Meir, I. 1973. Desert ecosystems: environment and producers. Annual Review of Ecology and Systematics. 4: 25-51.

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

Plummer, A.P., D.R. Christensen, and S.B. Monsen. 1968. Restoring big-game range in Utah. Publication No. 683. Utah Division of Fish and Game.

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 and Management 61:169-181.

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

Ross, C. 1999. Population dynamics and changes in curlleaf mountain mahogany (Cercocarpus ledifolius Nutt.) in two adjacent Sierran and Great Basin mountain ranges. Ph.D. Dissertation. University of Nevada, Reno.

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

Scheldt, R.S. 1969. Ecology and utilization of curlleaf mountain mahogany in Idaho. Unpublished thesis, University of Idaho, Moscow.

Schultz, B.W., P.T. Tueller, and R.J. Tausch. 1990. Ecology of curlleaf mahogany in western and central Nevada: community and population structure. Journal of Range Management 43(1): 13-20.

Schultz, B. W., R. J. Tausch, and P. T. Tueller. 1991. Size, age, and density relationships to curlleaf mahogany (Cercocarpus ledifolus) populations in western and central Nevada: competitive implications. Great Basin Naturalist 51:183-191.

Schultz, B. W., R. J. Tausch, and P. T. Tueller. 1996. Spatial relationships among young Cercocarpus ledifolius (curlleaf mountain mahogany). Great Basin Naturalist 56:261-266.

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.

Stringham, T.K., P. Novak-Echenique, P. Blackburn, C. Coombs, D. Snyder and A. Wartgow. 2015. Final Report for USDA Ecological Site Description State-and-Transition Models, Major Land Resource Area 28A and 28B Nevada. University of Nevada Reno, Nevada Agricultural Experiment Station Research Report 2015-01. p. 1524.

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

Uresk, D. W., J. F. Cline, and W. H. Rickard. 1976. Impact of wildfire on three perennial grasses in south-central Washington. Journal of Range Management 29:309-310.

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

Vose, J. M. and A. S. White. 1991. Biomass response mechanisms of understory species the first year after prescribed burning in an Arizona ponderosa-pine community. Forest Ecology and Management 40:175-187.

Whisenant, S. G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. In E. D. McArthur, E. M. Romney, S. D. Smith, P. T. Tueller, compilers. Proceedings-symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management; 1989 April 5-7; Las Vegas, NV. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. Gen. Tech. Rep. INT-GTR-276. p 4-10.

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

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. and J. O. Klemmedson. 1965. Effect of fire on bunchgrasses of the sagebrush-grass region in southern Idaho. Ecology 46:680-688.

Young, R.P. 1983. Fire as a vegetation management tool in rangelands of the Intermountain Region. In: Monsen, S.B. and N. Shaw (compilers). 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-157. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. p 18-31.

Youngberg, C.T. and L. Hu. 1972. Root nodules on mountain mahogany. Forest Science 18: 211-212.

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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)	P. NOVAK-ECHENIQUE
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Date	01/11/2016
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rills are none to rare. Occurrence of rills may be more frequent where run-in occurs from adjacent rock outcrops.

2. **Presence of water flow patterns:** Water flow patterns are none to rare with occurrence increasing as canopy cover increases. These are typically short <1m) and not connected.

3. **Number and height of erosional pedestals or terracettes:** Pedestals are none to rare. Occurrence is usually limited to water flow paths. Terracettes typically do not occur.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground 5-10%

5. **Number of gullies and erosion associated with gullies:** none

6. **Extent of wind scoured, blowouts and/or depositional areas:** None - rock fragments armor the surface.

7. **Amount of litter movement (describe size and distance expected to travel):** Fine litter (foliage from grasses and annual & perennial forbs) expected to the distance of slope length during intense summer convection storms or rapid snowmelt events. Persistent litter (large woody material) will remain in place except during large rainfall events. Mat of accumulating leaf or needle litter under mature trees is very stable and shows no obvious movement.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil stability values should be 3 to 6 on most soil textures found on this site.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface structure is subangular blocky, or fine granular. Soil surface colors are grayish browns and soils are typified by a mollic epipedon or an ochric epipedon. Surface textures are loams. An O horizon comprised of slightly decomposed curlleaf mountain mahogany leaves, twigs and grass residue may occur on some pedons. Organic matter of the surface 2 to 4 inches is typically 3 to 5 percent, dropping off quickly below. Organic matter content can be more or less depending on micro-topography.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., bluebunch wheatgrass, needlegrasses] slow runoff and increase infiltration. Curlleaf mountain mahogany and understory shrubs break raindrop impact and provide opportunity for snow catch and accumulation on site.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Compacted layers are none. Platy or subangular blocky sub-surface horizons are not to be interpreted as compacted layers.

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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: Curlleaf mountainmahogany >>

    Sub-dominant: understory shrubs> deep-rooted, cool season, perennial bunchgrasses > deep-rooted, cool season, perennial grasses = shallow-rooted, cool season, perennial forbs = fibrous, shallow-rooted, cool season, perennial forbs = annual forbs

    Other: evergreen trees, succulents

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Overstory trees have little mortality. Dead branches within understory shrubs are common and standing dead shrub canopy material may be as much as 35% of total shrub canopy; mature bunchgrasses (<25%) may have dead centers.

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14. **Average percent litter cover (%) and depth (in):** Herbaceous, or non-persistent, litter within curlleaf mountainmahogany canopy interspaces (± 5%) and litter depth is ± 1 inch. Leaf litter forms a mat 1 to 2 inches thick under the drip line of mature mountainmahogany. Large, persistent, litter from trees (limbs, etc.) variable to 5%.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** Total for all trees, shrubs and herbaceous plants, irrespective of plant height for normal or average growing season (through June) = ± 900 lbs/ac.Favorable years + 1300 lbs/ac and unfavorable years + 600 lbs/ac. For understory vegetation to 4½ feet and normal or average growing season (through June) = ± 500 lbs/ac. Favorable years + 30 lbs/ac and unfavorable years + 75 lbs/ac.

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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:** Potential invaders include cheatgrass. Singleleaf pinyon and Utah junipers may increase and eventually dominate this site.

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17. **Perennial plant reproductive capability:** All functional groups should reproduce in average (or normal) and above average growing season years. Reduced reproduction and growth occur during extreme or extended drought periods.
