

## Ecological site R028BY079NV SHALLOW LOAM 10-14 P.Z.

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### 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.

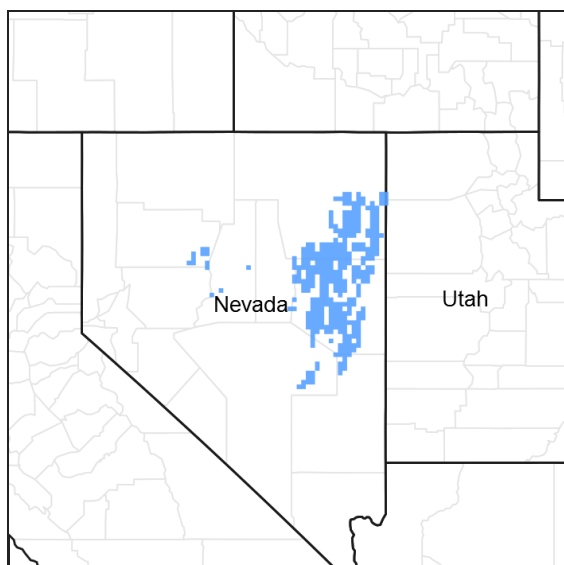


Figure 1. Mapped extent

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): 028B—Central Nevada Basin and Range

MLRA 28B occurs entirely in Nevada and comprises about 23,555 square miles (61,035 square kilometers). More than nine-tenths of this MLRA is federally owned. This area is in the Great Basin Section of the Basin and Range Province of the Intermontane Plateaus. It is an area of nearly level, aggraded desert basins and valleys between a series of mountain ranges trending north to south. The basins are bordered by long, gently sloping to strongly sloping alluvial fans. The mountains are uplifted fault blocks with steep sideslopes. Many of the valleys are closed basins containing sinks or playas. Elevation ranges from 4,900 to 6,550 feet (1,495 to 1,995 meters) in the valleys and basins and from 6,550 to 11,900 feet (1,995 to 3,630 meters) in the mountains.

The mountains in the southern half are dominated by andesite and basalt rocks that were formed in the Miocene and Oligocene. Paleozoic and older carbonate rocks are prominent in the mountains to the north. Scattered outcrops of older Tertiary intrusives and very young tuffaceous sediments are throughout this area. The valleys consist mostly of alluvial fill, but lake deposits are at the lowest elevations in the closed basins. The alluvial valley fill consists of cobbles, gravel, and coarse sand near the mountains in the apex of the alluvial fans. Sands, silts, and clays are on the distal ends of the fans.

The average annual precipitation ranges from 4 to 12 inches (100 to 305 millimeters) in most areas on the valley floors. Average annual precipitation in the mountains ranges from 8 to 36 inches (205 to 915 millimeters) depending on elevation. The driest period is from midsummer to midautumn. The average annual temperature is 34 to 52 degrees F (1 to 11 degrees C). The freeze-free period averages 125 days and ranges from 80 to 170 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 soil temperature regime, an aridic or xeric soil moisture regime, and mixed or carbonatic mineralogy. They generally are well drained, loamy or loamyskeletal, and shallow to very deep.

Nevada's climate is predominantly arid, with large daily ranges of temperature, infrequent severe storms and heavy snowfall in the higher mountains. Three basic geographical factors largely influence Nevada's climate:

continentality, latitude, and elevation. 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, as a result 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 midlatitude 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 occasional thundershowers. The eastern portion of the state receives noteworthy 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).

## Ecological site concept

This site occurs on convex mountain sidelopes. Slopes gradients of 8 to 30 percent are typical and elevations range from 6000 to 8500 feet.

The soils associated with this site are shallow to bedrock, well drained and formed in residuum and colluvium derived from limestone and dolomite. Soils are characterized by a mollic epipedon, a calcic horizon and are skeletal with greater than 35% rock fragments throughout the profile. Soil temperature regime is frigid and soil moisture regime is xeric. Available water holding capacity is very low.

The reference state is dominated by mountain big sagebrush, bluebunch wheatgrass and Indian ricegrass. Average annual production ranges from 300 to 700 pounds/acre/year. The convex landform position is an important abiotic factor associated with this site. This results in increased runoff, lower soil moisture and decreased annual production than would otherwise be expected.

## Associated sites

F028BY062NV	<b>PIMO-JUOS/ARTRV/PSSPS-ACTH7</b>
R028BY006NV	<b>SHALLOW CALCAREOUS LOAM 10-12 P.Z.</b>
R028BY008NV	<b>SHALLOW CALCAREOUS SLOPE 10-12 P.Z.</b>
R028BY030NV	<b>LOAMY 12-16 P.Z.</b>

## Similar sites

R028BY015NV	<b>LOAMY SLOPE 12-16 P.Z.</b> ACTH7 codominant grass; more productive site.
R028BY080NV	<b>SHALLOW LOAM 8-10 P.Z.</b> ARTRW dominant shrub.
R028BY033NV	<b>GRAVELLY CLAY 14+ P.Z.</b> Volcanic parent materials; more productive site; ACHY minor spp., if present.

R028BY007NV	<b>LOAMY 10-12 P.Z.</b> ACTH7-PSSP codominant grass; more productive site.
R028BY030NV	<b>LOAMY 12-16 P.Z.</b> More productive site; ACHY minor spp., if present.
R028BY070NV	<b>MOUNTAIN LOAM 16+ P.Z.</b> LEKI2 important grass; more productive site.
R028BY087NV	<b>GRAVELLY CLAY 12-14 P.Z.</b> Volcanic parent materials; ACTH7 codominant grass; more productive site.

**Table 1. Dominant plant species**

Tree	Not specified
Shrub	(1) <i>Artemisia tridentata subsp. vaseyana</i>
Herbaceous	(1) <i>Pseudoroegneria spicata</i> (2) <i>Achnatherum hymenoides</i>

## Physiographic features

This site occurs on convex portions of mountains. Slopes range from 2 to 75 percent, but slope gradients of 8 to 30 percent are most typical. Elevations range from 6000 to about 8500 feet.

**Table 2. Representative physiographic features**

Landforms	(1) Mountain (2) Mountain slope
Flooding frequency	None
Ponding frequency	None
Elevation	1,829–2,591 m
Slope	8–30%
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.

Average annual precipitation ranges from 10 to 14 inches. Mean annual air temperature is about 43 to 45 degrees F. The average growing season is about 90 to 120 days.

Mean annual precipitation across the range in which this ES occurs is 11.9 inches: Jan. 0.99; Feb. 1.05; Mar. 1.15; Apr. 1.37; May 1.3; Jun. 0.95; Jul. 0.78; Aug. 0.86; Sept. 0.80; Oct. 0.96; Nov. 0.8; Dec. 0.92.

\*The above data is averaged from the Ruth and Eureka WRCC climate stations.

**Table 3. Representative climatic features**

Frost-free period (average)	91 days
Freeze-free period (average)	120 days
Precipitation total (average)	305 mm

## Climate stations used

- (1) EUREKA [USC00262708], Eureka, NV
- (2) RUTH [USC00267175], Ely, NV

## Influencing water features

Influencing water features are not associated with this site.

## Soil features

The soils associated with this site are shallow to bedrock, well drained and formed in residuum and colluvium derived from limestone and dolomite. The soil profile is characterized by a mollic epipedon, a calcic horizon and have greater than 35% rock fragments by volume. Available water holding capacity is low and run off is very high. The soil series associated with this site include Amene, Onkeyo, and Grube.

The representative soil series is Onkeyo, a Loamy-skeletal, mixed, active, frigid Lithic Calcixerolls. Diagnostic horizons include a mollic epipedon from the soil surface to 20 cm, a calcic horizon from 20 to 38 cm, and limestone bedrock at 38 cm. Clay content in the particle size control section averages 25 to 35 percent. Rock fragments range from 50 to 80 percent, mainly cobbles. Reaction is slightly alkaline through strongly alkaline. Soils are violently effervescent throughout. Parent material consists of limestone and dolomite.

**Table 4. Representative soil features**

Parent material	(1) Residuum–limestone (2) Colluvium–dolomite
Surface texture	(1) Very gravelly silty clay loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderate to rapid
Soil depth	30–51 cm
Surface fragment cover ≤3"	45–65%
Surface fragment cover >3"	2–10%
Available water capacity (0–101.6cm)	3.3–8.64 cm
Calcium carbonate equivalent (0–101.6cm)	1–25%
Electrical conductivity (0–101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0–101.6cm)	0
Soil reaction (1:1 water) (0–101.6cm)	7.4–9
Subsurface fragment volume ≤3" (Depth not specified)	20–45%
Subsurface fragment volume >3" (Depth not specified)	5–15%

## 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 invasion. 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).

This ecological site is dominated by 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 and over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of two meters in alluvial soils in Utah (Richards and Caldwell 1987). Tap roots of antelope bitterbrush have been documented from 4.5 to 5.4 m in length (McConnell 1961). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

Mountain big sagebrush and antelope bitterbrush are 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, Indian ricegrass and bluegrasses. 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.

The Great Basin sagebrush 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 sagebrush communities by 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.

The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual state. Conversely, as fire frequency decreases, sagebrush will increase and with inappropriate grazing management the perennial bunchgrasses and forbs may be reduced.

Infilling by singleleaf pinyon and Utah juniper may also occur with an extended fire return interval. Eventually, singleleaf pinyon and Utah juniper will dominate the site and mountain big sagebrush will be severely reduced along with the herbaceous understory. Bluegrasses may remain underneath trees on north-facing slopes. The potential for soil erosion increases as the woodland matures and the understory plant community cover declines.

This ecological site has low to moderate resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Long-term disturbance response may be influenced by small differences in landscape topography. Concave areas receive run-in from adjacent landscapes and consequently retain more moisture to support the growth of deep-rooted perennial grasses (i.e. bluebunch wheatgrass, Indian ricegrass) whereas convex areas where runoff occurs are slightly less resilient and may have more shallow-rooted perennial grasses (i.e. squirreltail and bluegrasses). North slopes are also more resilient than south slopes because lower soil surface temperatures operate to keep moisture content higher on northern exposures. Six possible alternative stable states have been identified for this site.

#### Fire Ecology:

Fire is believed to be the dominant disturbance force in natural big sagebrush communities. Several authors suggest pre-settlement fire return intervals in mountain big sagebrush communities varied from 15 to 25 years (Burkhardt and Tisdale 1969, Houston 1973, and Miller et al. 2000). Kitchen and McArthur (2007) suggest a mean fire return interval of 40 to 80 years for mountain big sagebrush communities. The range from 15 to 80 years is probably more accurate and reflects the differences in elevation and precipitation where mountain big sagebrush communities occur. On a landscape scale, multiple seral stages were represented in a mosaic reflecting periodic reoccurrence of fire and other disturbances (Crawford et al 2004). Post-fire hydrologic recovery and resilience is primarily influenced by pre-fire site conditions, fire severity, and post-fire weather and land use that relate to vegetation recovery. Fire adaptation by herbaceous species is generally superior to the dominant shrubs, which are typically killed by fire. Sites with low abundances of native perennial grasses and forbs typically have reduced

resiliency following disturbance and are less resistant to invasion or increases in cheatgrass (Miller et al 2013).

Mountain big sagebrush is killed by fire (Neunswander 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 15-20 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). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). 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 for 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). 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 the invasive species cheatgrass (Clements and Young 2002).

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 along with seasonality and intensity of the fire all factor into the individual species response. 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 (Young 1983, Wright 1971). Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defosse 1995). However, season and severity of the fire will influence plant response. Plant response will vary depending on post-fire soil moisture availability.

Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below ground plant crowns. Indian ricegrass has been found to reestablish on burned sites through seed dispersed from adjacent unburned areas (Young 1983, West 1994). Thus the presence of surviving, seed producing plants is necessary for reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Catastrophic wildfire in Utah juniper and/or singleleaf pinyon controlled sites may lead to an annual weed dominated site. Depending on fire severity, rabbitbrush and snowberry may increase after fire. Rubber rabbitbrush is top-killed by fire, but can resprout after fire and can also establish from seed (Young 1983). Douglas' 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 (Noste and Bushey 1987).

## **State and transition model**

MLRA 28B  
Shallow Loam 10-14"  
028BY079NV

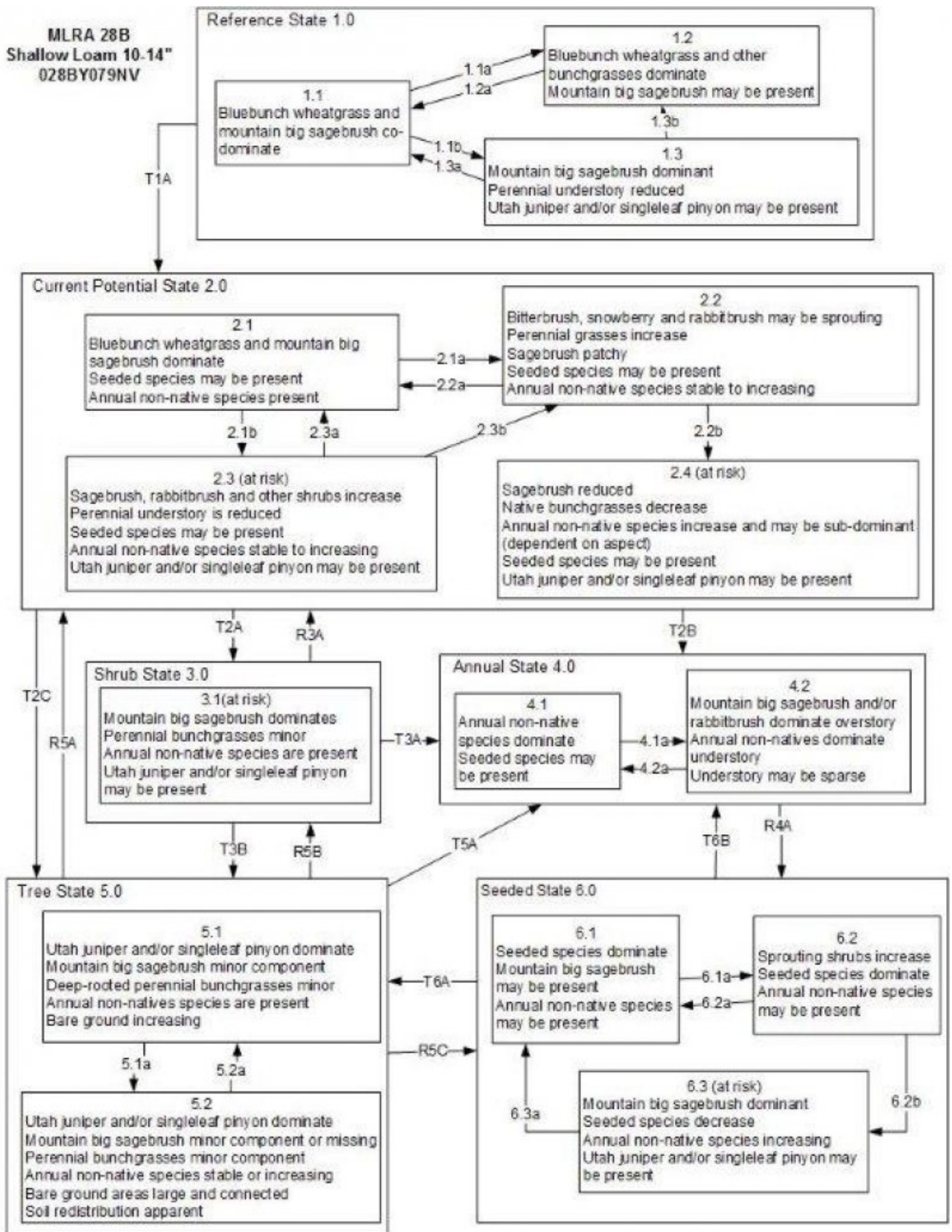


Figure 6. State and Transition Model



**MLRA 28B**  
**Shallow Loam 10-14"**  
**028BY079NV**

**Reference State 1.0 Community Phase Pathways**

- 1.1a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs.
- 1.1b: Time and lack of disturbance such as fire or long-term drought. Excessive herbivory may also decrease perennial understory.
- 1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
- 1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
- 1.3b: High severity fire or severe Aroga moth infestation significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

**Current Potential State 2.0 Community Phase Pathways**

- 2.1a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
- 2.1b: Time and lack of disturbance such as fire or long-term drought. Inappropriate grazing management may also decrease perennial understory.
- 2.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
- 2.2b: Tree/shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
- 2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
- 2.3b: High severity fire or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community.

Transition T2A: Inappropriate grazing management (3.1)

Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2)

Transition T2C: Time and lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management (5.1)

**Shrub State 3.0 Community Phase Pathways**

None.

Transition T3A: Catastrophic fire and/or soil disturbing treatments (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).

Transition T3B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance (5.1).

Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species (2.4).

**Annual State 4.0 Community Phase Pathways**

- 4.1a: Time and lack of disturbance (unlikely to occur).
- 4.2a: Fire.

Restoration R4A: Seeding of deep-rooted bunchgrasses, coupled with herbicide.

**Tree State 5.0 Community Phase Pathways**

- 5.1a: Time and lack of disturbance allows for tree maturation.
- 5.2a: Tree removal for fuels management.

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal with minimal soil disturbance and seeding of desired species (2.2).

Restoration R5B: Coming from Tree State 5.1 only: tree removal treatment or controlled burn. Controlled burn only recommended if nonnative annuals are not present.

Restoration R5C: Tree removal coupled with seeding of desired species (5.2).

**Seeded State 6.0 Community Phase Pathways**

- 6.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
- 6.2a: Low severity fire or Aroga moth infestation.
- 6.2b: Time and lack of disturbance coupled with inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
- 6.3a: Fire, Aroga moth infestation, or brush treatment with minimal soil disturbance.

Transition T6A: Time and lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management (5.1).

Transition T6B: Severe fire. This transition usually originates from 6.3.

**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 shrub-grass dominant phase, a 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 or disease attack.

## Community 1.1 Community Phase

Mountain big sagebrush and bluebunch wheatgrass dominate the site. Indian ricegrass is a sub-dominant species on this site. Basin wildrye, bluegrasses, and antelope bitterbrush are also common.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	202	336	471
Shrub/Vine	94	154	213
Forb	34	56	78
Tree	7	15	22
<b>Total</b>	<b>337</b>	<b>561</b>	<b>784</b>

## Community 1.2 Community Phase

This community phase is characteristic of a post-disturbance, early to mid-seral community phase. Bluebunch wheatgrass, Indian ricegrass and other perennial grasses dominate. Mountain big sagebrush cover and production is greatly reduced.

## Community 1.3 Community Phase

Mountain big sagebrush increases in the absence of disturbance or with grazing management that favors shrubs. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from grazing management. Utah juniper and/or singleleaf pinyon may be present.

## Pathway a Community 1.1 to 1.2

Fire would reduce or eliminate mountain big sagebrush and allow for perennial bunchgrasses to dominate the site. Fires will typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush to trace amounts. Coupled with drought conditions, a severe infestation of Aroga moth could also reduce in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. This phenomenon is more likely at the lower end of the precipitation range.

## Pathway b Community 1.1 to 1.3

Chronic drought may reduce fire frequency and increase shrub cover, time and/or inappropriate grazing management may also favor an increase in Mountain big sagebrush over deep-rooted perennial bunchgrasses. Combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses. Sandberg bluegrass may increase in density depending on the grazing management.

## **Pathway a**

### **Community 1.2 to 1.1**

Time and lack of fire allows for sagebrush to reestablish.

## **Pathway a**

### **Community 1.3 to 1.1**

A low severity fire will reduce the sagebrush overstory and create a sagebrush/grass mosaic. Coupled with drought, an aroga moth infestation may reduce sagebrush dominance and allow recovery of the perennial bunchgrass understory.

## **Pathway b**

### **Community 1.3 to 1.2**

Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be low severity, resulting in a mosaic pattern due to low fine fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

## **State 2**

### **Current Potential State**

This state is similar to the Reference State 1.0. with similar community phases plus 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. 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. Additionally, the presence of highly flammable, non-native species reduces state resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system.

## **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. Mountain big sagebrush and bluebunch wheatgrass dominate the site. Thurber's needlegrass and basin wildrye may be significant components while Sandberg bluegrass and forbs make up smaller percentages by weight of 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. Sagebrush is present in trace amounts; perennial bunchgrasses dominate the site. Mountain big sagebrush decreases, bluebunch wheatgrass, Indian ricegrass, basin wildrye, and other perennial grasses dominate. Bitterbrush, snowberry, and/or rabbitbrush may dominate the overstory aspect for a number of years following fire. Perennial forbs may be a significant component for several years following fire. Annual non-native species are stable or increasing within the community.

## **Community 2.3**

### **Community Phase (at risk)**



**Figure 9. Shallow Loam 10-14" (R028BY079NV) T. Stringham July 2013**

This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced from competition with shrubs, inappropriate grazing, or both. Rabbitbrush may be a significant component. Sandberg bluegrass may increase and become co-dominant with deep rooted bunchgrasses. Utah juniper and singleleaf pinyon may be present and without management will likely increase. Annual non-natives species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.

## **Community 2.4**

### **Community Phase (at risk)**

This community is at risk of crossing into an annual state. Native bunchgrasses dominate; however, annual non-native species such as cheatgrass may be sub-dominant in the understory. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. Seeded species may be present. Sagebrush and/or bitterbrush are a minor component. Singleleaf pinyon and/or Utah juniper may be present to increasing. This site is susceptible to further degradation from grazing, drought, and fire.

## **Pathway a**

### **Community 2.1 to 2.2**

Fire reduces the shrub overstory and allows for perennial bunchgrasses to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire. Aroga moth infestations can also cause mortality of the mountain big sagebrush overstory.

## **Pathway b**

### **Community 2.1 to 2.3**

Time and lack of disturbance allows for sagebrush to increase and become decadent. Chronic drought reduces fine fuels and leads to a reduced fire frequency, allowing big sagebrush to dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely Sandberg bluegrass may increase in the understory depending on grazing management.

## **Pathway a**

### **Community 2.2 to 2.1**

Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of big sagebrush can take many years.

## **Pathway b**

### **Community 2.2 to 2.4**

Tree/shrub removal treatment or prescribed burning in the presence of annual grass species will reduce shrub canopy may cause a shift to Phase 2.4. A subsequent year with precipitation that is favorable to nonnative annual grasses may speed up this pathway.

### **Pathway a**

#### **Community 2.3 to 2.1**

A change in grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall/winter grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in the herbaceous understory. Aroga moth infestation, release from growing season herbivory or drought or combinations of these allows for perennial bunchgrasses to increase as well. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. Annual non-native species are present and may increase in this community.

### **Pathway b**

#### **Community 2.3 to 2.2**

Fire reduces or eliminates the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires will typically be low severity resulting in a mosaic pattern due to low fine fuel loads. Following an unusually wet spring or a change in management favoring an increase in fine fuels, a fire may be more severe and reduce the shrub component to trace amounts. Annual non-native species respond well to fire and may increase post-burn.

## **State 3**

### **Shrub State**

This state has one community phase and is the product of many years of heavy grazing during time periods harmful to deep-rooted perennial bunchgrasses. With a reduction in deep-rooted perennial bunchgrass competition, bluegrasses and squirreltail will increase and become the dominant grass. Sagebrush dominates the overstory. Bitterbrush and/or rabbitbrush may be significant components. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. Bare ground is also increasing. The shrub overstory and bluegrass understory 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 (at risk)**

This site is at risk of transitioning to another state. Mountain big sagebrush, possibly decadent, dominates overstory and rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Utah juniper may be present or increasing. Annual non-native species are present to increasing. Understory may be sparse, with bare ground increasing. Utah juniper or singleleaf pinyon may be present as a result of encroachment from neighboring sites and lack of disturbance.

## **State 4**

### **Annual State**

This state has two community phases. One phase is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard. The second phase has either mountain big sagebrush and/or rabbitbrush dominating the overstory with an understory of annual non-natives.

### **Community 4.1**

#### **Community Phase**

Annual non-native plants such as tansy mustard and cheatgrass dominate this phase.

### **Community 4.2**

#### **Community Phase**

Mountain big sagebrush and/or sprouting shrubs dominate the overstory. Annual non-native plants such as tansy mustard and cheatgrass dominate the understory. Trace amounts of desirable bunchgrasses may be present. The mountain big sagebrush may be old and decadent of this transitioned from State 2.3.

### **Pathway a**

#### **Community 4.1 to 4.2**

Time and lack of fire allows for sagebrush/rabbitbrush to establish. Probability of sagebrush establishment is dependent on a near-by seed source from unburned patches of sagebrush.

### **Pathway a**

#### **Community 4.2 to 4.1**

Fire reduces or eliminates the overstory shrub component and allows for annual non-native species to dominate the phase.

## **State 5**

### **Tree State**

This state has two community phases that are characterized by the dominance of Utah juniper and singleleaf pinyon in the overstory. Mountain big sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients and soil organic matter distribution and cycling have been spatially and temporally altered.

### **Community 5.1**

#### **Community Phase**

Utah juniper and singleleaf pinyon dominate the overstory and site resources. Trees are actively growing with noticeable leader growth. The shrub and grass understory is reduced. Sagebrush is stressed and dying. Trace amounts of deep-rooted bunchgrass may be found under tree canopies with Sandberg bluegrass and forbs in the interspaces. Annual non-native species are present under tree canopies. Bare ground areas are large and connected.

### **Community 5.2**

#### **Community Phase**

Utah juniper and singleleaf pinyon dominate the site and tree leader growth is minimal; annual non-native species may be the dominant understory species and will typically be found under the tree canopies. Trace amounts of sagebrush may be present, however dead skeletons will be more numerous than living sagebrush. Deep-rooted bunchgrasses may or may not be present. Muttongrass, Sandberg bluegrass, or mat forming forbs may be present in trace amounts. Muttongrass may be more common in this phase as it is the most tolerant of shade. Bare ground areas are large and connected. Soil redistribution is excessive.

### **Pathway a**

#### **Community 5.1 to 5.2**

Time and lack of disturbance or management action allows Utah juniper and singleleaf pinyon to further mature and dominate site resources.

### **Pathway a**

#### **Community 5.2 to 5.1**

A manual thinning treatment would reduce canopy cover and allow for some of the understory to regenerate. The manual thinning of trees in this case may be for fuels treatments rather than an ecological restoration such as R5A.

## **State 6**



## **Seeded State**

This state has three community phases a grass-dominated phase; a grass-shrub phase and a shrub dominated phase. The state is characterized by the dominance of seeded species such as smooth brome and crested wheatgrass. Other seeded species include forage kochia, Wyoming big sagebrush, and native and non-native perennial forbs.

### **Community 6.1 Community Phase**

Introduced grass species and other non-native species such as forage kochia dominate the community. Native and non-native seeded forbs may be present. Trace amounts of big sagebrush may be present, especially if seeded. Annual non-native species present.

### **Community 6.2 Community Phase**

Sprouting shrubs such as rabbitbrush and seeded species co-dominate. Annual non-native species stable to increasing. Sagebrush may be a minor component.

### **Community 6.3 Community Phase (at risk)**

This community phase is at risk of crossing a threshold and transitioning to another state. Wyoming sagebrush dominates. Rabbitbrush may be a significant component. Seeded grass vigor and density are reduced. Annual non-native species stable to increasing. Utah juniper and/or singleleaf pinyon may be present. This site is susceptible to further degradation from grazing, drought, and fire.

### **Pathway a Community 6.1 to 6.2**

Inappropriate grazing management, particularly during the growing season, reduces perennial bunchgrass vigor and density and facilitates shrub establishment.

### **Pathway a Community 6.2 to 6.1**

Low severity fire, brush management, and/or Aroga moth infestation will reduce the sagebrush overstory and allow seeded species to become dominant.

### **Pathway b Community 6.2 to 6.3**

Absence of fire over time, coupled with inappropriate grazing management that promotes a reduction in perennial bunchgrasses and facilitates shrub dominance.

### **Pathway a Community 6.3 to 6.1**

Fire eliminates/reduces the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires will typically be low severity resulting in a mosaic pattern due to low fine fuel loads. A fire following an unusually wet spring or change in management favoring an increase in fine fuels, may be more severe and reduce the shrub component to trace amounts. A severe infestation of Aroga moth will also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. Annual non-native species respond well to fire and may increase post-burn.

## **Transition A**

### **State 1 to 2**

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass. Slow variables: Over time the annual non-native plants will 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: Inappropriate, long-term grazing of perennial bunchgrasses during growing season would favor shrubs and initiate transition to Community Phase 3.1. Slow variables: Long term decrease in deep-rooted perennial grass density. Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter and soil moisture.

## **Transition B**

### **State 2 to 4**

Trigger: Fire and/or multiple fires lead to plant community phase 4.1, inappropriate grazing management that favors shrubs in the presence of non-native annual species leads to community phase 4.2. Slow variables: Increased production and cover of non-native annual species. Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs truncates, spatially and temporally, nutrient capture and cycling within the community. Increased, continuous fine fuels from annual non-native plants modify the fire regime by changing intensity, size and spatial variability of fires.

## **Transition C**

### **State 2 to 5**

Trigger: Time and lack of disturbance or management action allows for Utah Juniper and singleleaf pinyon to dominate. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources. Slow variables: Over time the abundance and size of trees will increase. Threshold: Trees dominate ecological processes and number of shrub skeletons exceed number of live shrubs. Trees overtop mountain big sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

## **Restoration pathway A**

### **State 3 to 2**

Sagebrush removal by mechanical or chemical treatments such as brush beating and/or herbicide usually coupled with seeding of perennial bunchgrass species. This restoration leads to Community Phase 2.4.

### **Conservation practices**

Brush Management
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## **Transition A**

### **State 3 to 4**

Trigger: To Community Phase 4.1: Severe fire. To Community Phase 4.2: Inappropriate grazing management in the presence of annual non-native species. Slow variables: Increased production and cover of non-native annual species. Threshold: Increased continuous fine fuels modify the fire regime by changing intensity, size, and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture spatially and temporally thus impacting nutrient cycling and distribution.

## **Transition B**

### **State 3 to 5**

Trigger: Lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management that reduces perennial bunchgrasses and fine fuels. Slow variables: Over time the abundance and size of trees will increase. Threshold: Trees overtop mountain sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

## **Restoration pathway A**

### **State 4 to 6**

Seeding of deep-rooted bunchgrasses, coupled herbicide. Brush treatments may be applied if needed. Probability of success is low to medium.

#### **Conservation practices**

Range Planting

## **Restoration pathway A**

### **State 5 to 2**

Tree removal and seeding of herbaceous species may transition to State 2.0. If there are very few shrubs in the understory, the site will be restored to Phase 2.2.

#### **Conservation practices**

Range Planting

## **Restoration pathway B**

### **State 5 to 3**

This restoration is recommended for phase 5.1 only due to the lack of understory in 5.2. Removal of the pinyon and juniper overstory through tree removal practices or a controlled burn, without seeding of grass species, would move this phase into a shrub state. If nonnative annuals are present, a controlled burn is not recommended.

## **Transition A**

### **State 5 to 4**

Trigger: Catastrophic crown fire will reduce or eliminate trees to transition the site to 4.1. Inappropriate tree removal practices such as chop and burn when annual non-natives such as cheatgrass are present will also transition the site to state 4.0. Slow variable: Increased seed production and cover of annual non-native species. Threshold: Closed tree canopy with non-native annual species dominant in the understory changes the intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

## **Restoration pathway C**

### **State 5 to 6**

Tree removal and seeding of desired species. Tree removal practices that minimize soil disturbance are recommended. Probability of success declines with increased presence of non-native annual species (Community Phase 5.2).

#### **Conservation practices**

Range Planting

**Transition B**  
**State 6 to 4**

Trigger: Catastrophic fire. Slow variables: Increased production and cover of non-native annual species. Threshold: Increased continuous fine fuels modify the fire regime by changing intensity, size, and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture spatially and temporally, thus impacting nutrient cycling and distribution.

**Transition A**  
**State 6 to 5**

Trigger: Time and lack of disturbance or management action allows for Utah Juniper to dominate. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources Slow variables: Over time, the abundance and size of trees will increase. Threshold: Trees dominate ecological processes and number of shrub skeletons exceed number of live shrubs.

**Additional community tables**

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Primary Perennial Grasses</b>			280–448	
	bluebunch wheatgrass	PSSPS	<i>Pseudoroegneria spicata</i> ssp. <i>spicata</i>	168–224	–
	Indian ricegrass	ACHY	<i>Achnatherum hymenoides</i>	84–168	–
	muttongrass	POFE	<i>Poa fendleriana</i>	13–28	–
2	<b>Secondary Perennial Grasses</b>			28–56	
	squirreltail	ELEL5	<i>Elymus elymoides</i>	3–11	–
	needle and thread	HECO26	<i>Hesperostipa comata</i>	3–11	–
	basin wildrye	LECI4	<i>Leymus cinereus</i>	3–11	–
	Sandberg bluegrass	POSE	<i>Poa secunda</i>	3–11	–
<b>Forb</b>					
3	<b>Perennial</b>			28–84	
	mountain big sagebrush	ARTRV	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i>	84–140	–
	yellow rabbitbrush	CHVI8	<i>Chrysothamnus viscidiflorus</i>	3–11	–
	tapertip hawksbeard	CRAC2	<i>Crepis acuminata</i>	3–11	–
	buckwheat	ERIOG	<i>Eriogonum</i>	3–11	–
	lupine	LUPIN	<i>Lupinus</i>	3–11	–
	phlox	PHLOX	<i>Phlox</i>	3–11	–
<b>Shrub/Vine</b>					
4	<b>Primary Shrubs</b>			112–196	
	mountain big sagebrush	ARTRV	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i>	84–140	–
	antelope bitterbrush	PUTR2	<i>Purshia tridentata</i>	28–56	–
5	<b>Secondary Shrubs</b>			21–34	
	Utah serviceberry	AMUT	<i>Amelanchier utahensis</i>	3–11	–
	yellow rabbitbrush	CHVI8	<i>Chrysothamnus viscidiflorus</i>	3–11	–
	mormon tea	EPVI	<i>Ephedra viridis</i>	3–11	–
	snowberry	SYMPH	<i>Symphoricarpos</i>	3–11	–
<b>Tree</b>					
6	<b>Evergreen</b>			7–22	
	Utah juniper	JUOS	<i>Juniperus osteosperma</i>	3–11	–
	singleleaf pinyon	PIMO	<i>Pinus monophylla</i>	3–11	–

## Animal community

Livestock Interpretations:

This site is suitable for livestock grazing. Considerations for grazing management including timing, intensity and duration of grazing. Targeted grazing could be used to decrease the density of non-natives.

Bluebunch wheatgrass is considered one of the most important forage grass species on western rangelands for livestock. Although bluebunch wheatgrass can be a crucial source of forage, it is not necessarily the most highly preferred species. 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. Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971), however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck et al. 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1976). Cook and Child (1971) found significant reduction in plant cover after seven years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended. In summary, adaptive management is required to manage this bunchgrass well.

Basin wildrye is valuable forage for livestock (Ganskopp et al. 2007) and wildlife, but is intolerant of heavy or repeated grazing (Krall et al. 1971). Basin wildrye is used often as a winter feed for livestock and wildlife; not only providing roughage above the snow but also cover in the early spring months (Majerus 1992). The early growth and abundant production of basin wildrye make it a valuable source of forage for livestock. It is important forage for cattle and is readily grazed by cattle and horses in early spring and fall. Though coarse-textured during the winter, basin wildrye may be utilized more frequently by livestock and wildlife when snow has covered low shrubs and other grasses. Bluegrass is a widespread forage grass. It is one of the earliest grasses in the spring and is sought by domestic livestock and several wildlife species. Bluegrass is a palatable species, but its production is closely tied to weather conditions. It produces little forage in drought years, making it a less dependable food source than other perennial bunchgrasses. 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. Antelope bitterbrush is important browse for livestock. Domestic livestock and mule deer may compete for antelope bitterbrush in late summer, fall, and/or winter. Cattle prefer antelope bitterbrush from mid-May through June and again in September and October. 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). Antelope bitterbrush is an important shrub species to a variety of animals, such as domestic livestock, antelope, deer, and elk. Bitterbrush is critical browse for mule deer, as well as domestic livestock, antelope, and elk (Wood 1995, Clements and Young 2002). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953).

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:

Many wildlife species are dependent on the sagebrush ecosystem including the greater sage grouse, sage sparrow, pygmy rabbit and the sagebrush vole. Dobkin and Sauder (2004) identified 61 species, including 24 mammals and 37 birds, associated with the shrub-steppe habitats of the Intermountain West. Mountain big sagebrush is important to wildlife for both food and cover. Mountain big sagebrush is highly preferred and nutritious winter forage for mule deer, elk and pronghorn. Elk (*Alces alces*) and pronghorn antelope (*Antilocapra americana*) prefer mountain big sagebrush over basin and Wyoming sagebrush (Beale and Smith 1970, Wambolt 1996). A study by Brown (1977) determined that desert bighorn sheep (*Ovis canadensis nelsoni*) preferred big sagebrush over other shrub types; however, the variety was not noted. Welch and Wagstaff (1992) noted in a study near Provo, Utah, mountain big sagebrush was highly preferred winter forage of mule deer (*Odocoileus hemionus*) over other available forage. Other studies have determined, in the same study area, that mountain big sagebrush is preferred by both wintering domestic sheep as well as mule deer (Welch et al. 1986).

Furthermore, wildlife use a variety of associated understory plants and soils that occur in basin big sagebrush habitat. For example: sage grouse (*Centrocercus urophasianus*), sagebrush vole (*Lemmiscus curtatus*), Merriam's shrew (*Sorex merriami*) and Preble's shrew (*Sorex preblei*) use the grasses that occur with mountain big sagebrush for nesting, cover and forage. Mountain big sagebrush sandy soil sites provide burrowing opportunities and protection from predators for burrowing owls (*Athene cunicularia*), dark and pale kangaroo mice (*Microdipodops megacephalus* and *Microdipodops pallidus*, respectively). Mountain big sagebrush that occur on woodland and rock ecotones provides nesting and foraging habitat for the ferruginous hawk (*Buteo regalis*) (Nevada Wildlife Action Plan 2012). Basin wildrye provides winter forage for mule deer, though use is often low compared to other native

grasses. Basin wildrye provides summer forage for black-tailed jackrabbits. Because basin wildrye remains green throughout early summer, it remains available for small mammal forage for longer time than other grasses. 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. Canby's bluegrass is also an important forage species for several wildlife species.

Several reptiles and amphibians are distributed throughout the sagebrush steppe in the west in Nevada, where basin big sagebrush is known to grow (Bernard and Brown 1977). Reptile species including: eastern racers (*Coluber constrictor*), ringneck snakes (*Diadophis punctatus*), night snakes (*Hypsiglena torquata*), Sonoran mountain kingsnakes (*Lampropeltis pyromelana*), striped whipsnakes (*Masticophis taeniatus*), gopher snakes (*Pituophis catenifer*), long-nosed snakes (*Rhinocheilus lecontei*), wandering garter snakes (*Thamnophis elegans vagrans*), Great Basin rattlesnakes (*Crotalus oreganus lutosus*), Great Basin collared lizard (*Crotaphytus bicinctores*), long-nosed leopard lizard (*Gambelia wislizenii*), short-horned lizard (*Phrynosoma douglassi*), desert-horned lizard (*Phrynosoma platyrhinos*), sagebrush lizards (*Sceloporus graciosus*), western fence lizards (*Sceloporus occidentalis*), northern side-blotched lizards (*Uta uta stansburiana*), western skinks (*Plestiodon skiltonianus*), and Great Basin whiptails (*Aspidoscelis tigris*) occur in areas where sagebrush is dominant. Similarly, amphibians such as: western toads (*Anaxyrus boreas*), Woodhouse's toads (*Anaxyrus woodhousii*), northern leopard frogs (*Lithobates pipiens*), Columbia spotted frogs (*Rana luteiventris*), bullfrogs (*Lithobates catesbeianus*), and Great Basin spadefoots (*Spea intermontana*) also occur throughout the Great Basin in areas sagebrush species are dominant (Hamilton 2004). Studies have not determined if reptiles and amphibians prefer certain species of sagebrush; however, researchers agree that maintaining habitat where basin big sagebrush and reptiles and amphibians occur is important. In fact, wildlife biologists have noticed declines in reptiles where sagebrush steppe habitat has been seeded with introduced grasses (West 1999 and ref. therein).

Sagebrush communities are important for maintaining lagomorph and rodent populations. Pygmy rabbits, sagebrush obligates, use sites with big sagebrush at a higher intensity than low sagebrush sites (Heady and Laundre 2005). A study by Larrison and Johnson (1973) captured more deer mice in big sagebrush communities than in any other plant community. Although specific varieties of big sagebrush are not mentioned in these studies, thus, suggests that deer mice prefer big sagebrush plant communities where mountain big sagebrush are present, for cover over other plant communities.

It should be noted that sagebrush-grassland communities provide critical sage-grouse (*Centrocercus urophasianus*) 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.

## Hydrological functions

Permeability is moderately slow to moderately rapid. Runoff is very high. Rills are rare. A few rills can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt. Water flow patterns are rare but a few can be expected in areas subjected to summer convection storms or rapid snowmelt usually on steeper slopes. Pedestals are rare. Occurrence is usually limited to areas of water flow patterns. Frost heaving of shallow rooted plants should not be considered a "normal" condition. Gullies are rare in areas of this site that occur on stable landforms. Where this site occurs on inset fans gullies and head cuts associated with ephemeral channel entrenchment are rare to common. Gullies and head cuts should be healing or stable. Perennial herbaceous plants, especially deep-rooted bunchgrasses (i.e., bluebunch wheatgrass & Indian ricegrass), slow runoff and increase infiltration. Shrub canopy and associated litter 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 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. Indian ricegrass was traditionally eaten by some Native American peoples. The

Paiutes used the seed as a reserve food source.

## Other information

Antelope bitterbrush has been used extensively in land reclamation. Antelope bitterbrush enhances succession by retaining soil and depositing organic material and in some habitats and with some ecotypes, by fixing nitrogen. Indian ricegrass is well-suited for surface erosion control and desert revegetation although it is not highly effective in controlling sand movement.

## Type locality

Location 1: Elko County, NV	
Township/Range/Section	T26N R62E S12
Latitude	40° 8' 42"
Longitude	114° 55' 48"
General legal description	On fan piedmonts off the west side of Cherry Creek Mountains, Butte Valley area, Elko County, Nevada. This site also occurs in White Pine County, Nevada.

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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)	GK Brackley/P Novak-Echenique
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Date	07/01/2006

Approved by	P. Novak-Echenique
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

## Indicators

1. **Number and extent of rills:** Rills are none to rare. A few rills can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt. These will begin to heal during the next growing season.  

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2. **Presence of water flow patterns:** Water flow patterns are none to rare but a few (short <1m and stable) can be expected in areas subjected to summer convection storms or rapid snowmelt usually on steeper slopes.  

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3. **Number and height of erosional pedestals or terracettes:** Pedestals are rare. Occurrence is usually limited to areas of water flow patterns. Frost heaving of shallow rooted plants should not be considered a "normal" condition.  

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground 40-50% depending on amount of surface rock fragments.  

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

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6. **Extent of wind scoured, blowouts and/or depositional areas:** None  

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7. **Amount of litter movement (describe size and distance expected to travel):** Fine litter (foliage from grasses and annual & perennial forbs) expected to move 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.  

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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.  

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface structure is typically fine granular or subangular blocky. Soil surface colors are dark browns and soils are typified by a mollic epipedon. Surface textures are loams or silty clay loams. Organic matter of the surface 2 to 4 inches is typically 1.25 to 3 percent dropping off quickly below. Organic matter content can be more or less depending on micro-topography.  

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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 & Indian ricegrass), slow runoff and increase infiltration. Shrub canopy and associated litter break

raindrop impact and provide opportunity for snow catch and accumulation on site.

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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 massive structure or subsoil calcic horizons are not to be interpreted as compacted.
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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: Reference State: Deep-rooted, cool season, perennial bunchgrasses

Sub-dominant: tall shrubs (big sagebrush) > associated shrubs = deep-rooted, cool season, perennial forbs > shallow-rooted, perennial, grasses = fibrous, shallow-rooted, cool season, perennial and annual forbs

Other: evergreen trees

Additional: With an extended fire return interval, the tree and shrub component on this site may increase at the expense of the herbaceous component. With complete tree dominance on this site, the shrub and herbaceous component will significantly decline.

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Dead branches within individual shrubs common and standing dead shrub canopy material may be as much as 25% of total woody canopy; some of the mature bunchgrasses (<10%) have dead centers.
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14. **Average percent litter cover (%) and depth ( in):** Between plant interspaces (15-25%) and litter depth is <¼ inch.
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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** For normal or average growing season (through June) ±500 lbs/ac; Favorable years ±700 lbs/ac and unfavorable years ± 300 lbs/ac. Spring moisture significantly affects total production
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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, annual mustards, Russian thistle. With an extended fire return interval, singleleaf pinyon and Utah juniper can 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 growth or reproduction occurs during extreme or extended drought periods.
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