USDA Natural Resources Conservation Service

Ecological site R028AY034NV
SHALLOW CALCAREOUS SLOPE 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.

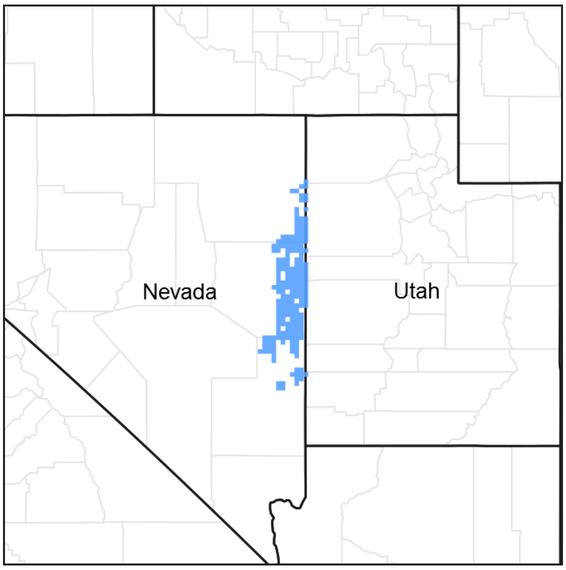

Figure 1. Mapped extent

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): 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 on summits and sideslopes of hills, mountains, and fan remnants on all aspects. At lower elevations this site is usually restricted to cooler, northerly aspects. Slopes range from 4 to 75 percent, but slopes from 15 to 50 percent are most typical. Elevations are 4400 to 8200 feet.

Average annual precipitation is 10 to 14 inches. Mean annual air temperature is 45 to 50 degrees F. The average growing season is 100 to 120 days.

The soils associated with this site are typically formed in residuum with limestone parent material. These soils normally have from 30 to over 50 percent gravel and cobbles by volume distributed throughout their profile. Some soils have a moderately fine to fine textured subsoil within 10 inches of the surface. The reaction of many soils is moderately or strongly alkaline.

The reference state is dominated by black sagebrush, Indian ricegrass and bluebunch wheatgrass. Production ranges from 200 to 600 pounds per acre.

Associated sites

R028AY027NV	**SHALLOW CALCAREOUS HILL 8-10 P.Z.**
R028AY029NV	**LIMESTONE HILL**
R028AY043NV	**SHALLOW CALCAREOUS LOAM 10-14 P.Z.**

Similar sites

R028AY036NV	**SHALLOW CLAY LOAM 12-14 P.Z.** PSSPS-ACTH7 codominant
R028AY043NV	**SHALLOW CALCAREOUS LOAM 10-14 P.Z.** More productive site
R028AY035NV	**SHALLOW CLAY LOAM 10-12 P.Z.** ACHY-ACTH7 codominant
R028AY013NV	**SHALLOW CALCAREOUS LOAM 8-10 P.Z.** ACHY-HECO26 codominant grasses
R028AY047NV	**DROUGHTY CALCAREOUS LOAM 8-10 P.Z. (burned phase)** GRSP-ARNO4 codominant
R028AY027NV	**SHALLOW CALCAREOUS HILL 8-10 P.Z.** ACHY dominant grass
R028BY008NV	**SHALLOW CALCAREOUS SLOPE 10-12 P.Z.** PLJA absent to rare and is not an increaser species
R028AY004NV	**SHALLOW CALCAREOUS SLOPE 8-10 P.Z.** ACHY-HECO26 codominant grasses

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia nova*
Herbaceous	(1) *Pseudoroegneria spicata ssp. spicata* (2) *Achnatherum hymenoides*

Physiographic features

This site occurs on summits and sideslopes of hills, mountains, and fan remnants on all aspects. At lower elevations this site is usually restricted to cooler, northerly aspects. Slopes range from 4 to 75 percent, but slopes from 15 to

50 percent are most typical. Elevations are 4400 to 8200 feet.

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Mountain (3) Fan remnant
Elevation	4,400–8,200 ft
Slope	4–75%
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 10 to 14 inches. Mean annual air temperature is 45 to 50 degrees F. The average growing season is 100 to 120 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)	110 days
Freeze-free period (average)	110 days
Precipitation total (average)	12 in

Influencing water features

There are no influencing water features associated with this site.

Soil features

The soils associated with this site are typically formed in residuum with limestone parent material. These soils normally have from 30 to over 50 percent gravel and cobbles by volume distributed throughout their profile. Some soils have a moderately fine to fine textured subsoil within 10 inches of the surface. The reaction of many soils is moderately or strongly alkaline. The available water capacity is low to very low. The soil moisture regime is typic aridic and the soil temperature regime is mesic. These soils usually have high amounts of gravels, cobbles or stones on the surface that occupy plant growing space, yet help to reduce evaporation and conserve soil moisture. Rock fragments on the surface provide a stabilizing affect on surface erosion conditions. The soil series associated with this site include: Amtoft, Borvant, Chainlink, Checkett, Eenreed, Radol, Stewval, and Tarnach.

The representative soil series is Amtoft, a Loamy-skeletal, carbonatic, mesic Lithic Xeric Haplocalcids. Diagnostic horizons include an Ochric epipedon from the surface of the soil to 18 cm, Calcic horizon from 20 to 43 cm and a Lithic contact with hard bedrock at 43 cm. Clay content in the particle control section averages 12 to 27 percent. Rock fragments range from 35 to 60 percent. Reaction is moderately or strongly alkaline. Effervescence is violent. Lithology consists of calcareous sedimentary rocks.

Table 4. Representative soil features

Parent material	(1) Residuum–limestone (2) Colluvium–andesite
Surface texture	(1) Flaggy loam (2) Very cobbly (3) Very gravelly
Family particle size	(1) Loamy
Drainage class	Well drained to somewhat excessively drained
Permeability class	Moderate to very rapid
Soil depth	9–19 in
Surface fragment cover <=3"	20–50%
Surface fragment cover >3"	0–25%
Available water capacity (0-40in)	0.4–3.8 in
Calcium carbonate equivalent (0-40in)	10–80%
Electrical conductivity (0-40in)	0–4 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	8.2–8.8
Subsurface fragment volume <=3" (Depth not specified)	35–60%
Subsurface fragment volume >3" (Depth not specified)	0–25%

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).
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 to over 3.0 m (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). However, community types with black sagebrush as the dominant shrub were found to have soil depths and thus available rooting depths of 77 to 81 cm in a study in northeast Nevada (Jensen 1990). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks especially a sagebrush defoliator, Aroga moth (Aroga websteri). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and is ongoing in Nevada since 2004 (Bentz et al. 2008). Thousands of acres of sagebrush have been impacted, with partial to complete die-off observed (Gates 1964, Hall 1965), but the research is inconclusive of the damage sustained by black sagebrush populations.

Black 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 and Indian ricegrass. Needleandthread, Sandberg bluegrass, and blue grama are other important grass species. 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 of the soil profile. General differences in root depth distributions between grasses and shrubs results 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 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 pools 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).

The range and density of singleleaf pinyon and Utah juniper have increased since the middle of the nineteenth century (Tausch 1999, Miller and Tausch 2000). Causes for expansion of trees into sagebrush ecosystems include wildfire suppression, historic livestock grazing, and climate change (Bunting 1994). Mean fire return intervals prior to European settlement in black sagebrush ecosystems are estimated to be 100 to 200 years, however frequent enough to inhibit the encroachment of singleleaf pinyon and Utah juniper into these low productive sagebrush cover types (Kitchen and McArthur 2007). Thus, trees were isolated to fire-safe areas such as rocky outcroppings and areas with low-productivity. An increase in crown density causes a decrease in understory perennial vegetation and an increase in bare ground. This allows for the invasion of non-native annual species such as cheatgrass. With annual species in the understory wildfire can become more frequent and increase in intensity. With frequent wildfires these plant communities can convert to annual species with a sprouting shrub and juvenile tree overstory.

The 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. Six possible stable states have been identified for this site.

Fire Ecology:
Fire is not a major disturbance of these community types (Winward 2001), and would be infrequent. Historic fire return intervals have been estimated at 100-200 years (Kitchen and McArthur 2007); however, fires were probably

localized and very infrequent due to the low productivity of these sites. Black sagebrush plants have no morphological adaptations for surviving fire and must reestablish from seed following fire (Wright et al. 1979). The ability of black sagebrush to establish after fire is mostly dependent on the amount of seed deposited in the seed bank the year before the fire. Seeds typically do not persist in the soil for more than one growing season (Beetle 1960). A few seeds may remain viable in soil for two years (Meyer 2008); however, even in dry storage, black sagebrush seed viability has been found to drop rapidly over time, from 81% to 1% viability after two and 10 years of storage, respectively (Stevens et al. 1981). Thus, repeated frequent fires can eliminate black sagebrush from a site, however black sagebrush in zones receiving 12 to 16 inches of annual precipitation have been found to have greater fire survival (Boltz 1994). In lower precipitation zones, spiny hopsage and/or shadscale may become the dominant shrub species following fire. Douglas' rabbitbrush and ephedra can also sprout after fire and become a dominant shrub on this site often with an understory of galleta, Sandberg bluegrass and/or cheatgrass and other weedy species.
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 (Wright 1971, Young 1983). However, season and severity of the fire will influence plant response. Plant response will vary depending on post-fire soil moisture availability.

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. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage to fire but is more susceptible in drought years (Young 1983). Plant response will vary depending on season, fire severity, fire intensity and post-fire soil moisture availability.

Indian ricegrass and needleandthread grass, have different responses to fire. Needleandthread is top-killed by fire but is likely to resprout if fire does not consume above ground stems (Akinsoji 1988, Bradley et al. 1992). In a study by Wright and Klemmedson (1965), season of burn rather than fire intensity seemed to be the crucial factor in mortality for needleandthread grass. Early spring season burning was found to kill the plants while August burning had no effect. 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.

Galleta grass, a minor component of these ecological sites, has been found to increase following fire likely due to its rhizomatous root structure and ability to resprout (Jameson 1962). Sandberg bluegrass, another minor component of these ecological sites, has also been found to increase following fire likely due to its low stature and productivity (Daubenmire 1975). Both grass species may retard reestablishment of deeper rooted bunchgrasses. Repeated frequent fire in this community will eliminate black sagebrush, significantly decrease bunchgrass density on the site and facilitate the establishment of an annual weed community with varying amounts of galleta, Sandberg bluegrass, spiny hopsage, shadscale and rabbitbrush.

Singleleaf pinyon and Utah juniper are usually killed by fire, and are most vulnerable to fire when it is under four feet tall (Bradley et al. 1992). Larger trees, because they have foliage farther from the ground and thicker bark, can survive low severity fires but mortality does occur when 60% or more of the crown is scorched (Bradley et al. 1992). With the low production of the understory vegetation, high severity fires within this plant community were not likely and rarely became crown fires (Bradley et al. 1992, Miller and Tausch 2000). Tree density on this site increases with grazing management that favors the removal of fine fuels and management focused on fire suppression. With an increase of cheatgrass in the understory, fire severity is likely to increase. Utah juniper reestablishes by seed from nearby seed source or surviving seeds. Utah juniper begins to produce seed at about 30 years old (Bradley et al. 1992). Seeds establish best through the use of a nurse plant such as sagebrush and rabbitbrush (Everett and Ward 1984, Tausch and West 1988, Bradley et al. 1992).

State and transition model

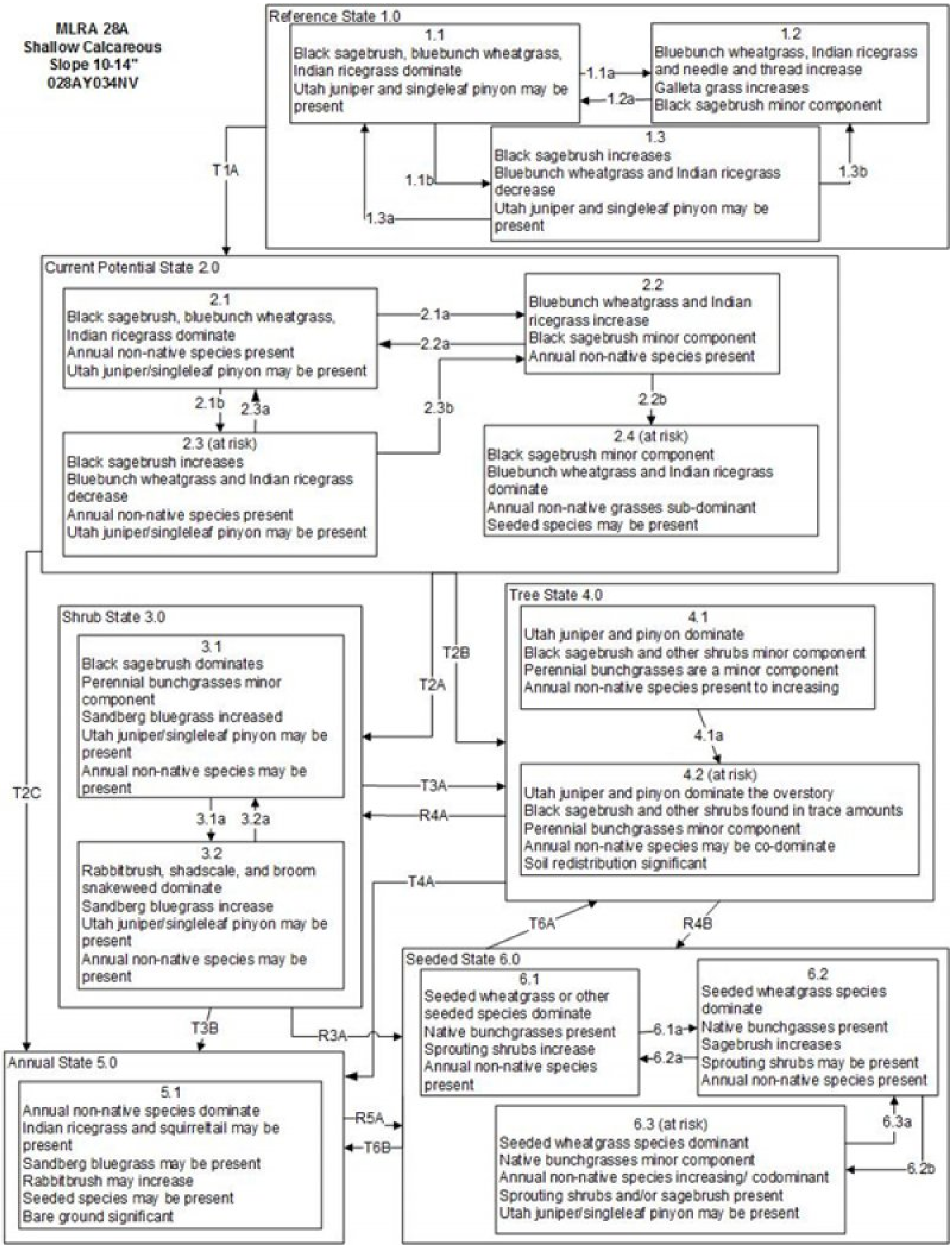

Figure 6. State and Transition Model

MLRA 28A
Shallow Calcareous Slope 10-14"
028AY034NV

Reference State 1.0
1.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs
1.1b: Time and lack of disturbance such as fire. Excessive herbivory may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub reestablishment
1.3a: Low severity fire, herbivory, Aroga moth infestation or combinations of these reduces black sagebrush
1.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs

Transition T1A: Introduction of non-native annual species

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush 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. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub reestablishment.
2.2b: Late spring moisture that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combinations. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community. Brush management with minimal soil disturbance reduces black sagebrush.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2B: Time and lack of fire allows Utah juniper and pinyon pine to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.
Transition T2C: High severity fire; failed seeding.

Shrub State 3.0
3.1a: High severity fire; brush management with minimal soil disturbance
3.2a: Time and lack of disturbance allows for black sagebrush to recover. The establishment of black sagebrush may take many years.

Transition T3A: Time and lack of fire allows Utah juniper and singleleaf pinyon pine to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.
Transition T3B: High-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (5.1)
Restoration R3A: Seeding of deep-rooted introduced bunchgrasses and other desired species; may be coupled with brush management and/or herbicide. Probability of success is higher at the upper end of the precipitation zone.

Tree State 4.0
4.1a: Time without disturbance allows maturation of the tree community

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (4.1)
Restoration R4B: Tree removal and seeding of desired species
Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (5.1)

Annual State 5.0

Restoration R5A: Seeding of deep rooted perennial bunchgrasses, probability of success is low.

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 fir and/or brush treatments with minimal soil disturbance.
6.2b: Time and lack of disturbance may be coupled with inappropriate grazing management.
6.3a: Low severity fire or brush treatment.

Transition T6B: Catastrophic fire and/or multiple fires

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. Due to the nature and extent of disturbance in this site, all three plant community phases would likely occur in a mosaic across the landscape. Utah juniper and/or singleleaf pinyon may be present on the site, but will only occur as scattered trees and will not dominate the site.

Community 1.1
Community Phase

This community is dominated by black sagebrush, bluebunch wheatgrass and Indian ricegrass. Forbs and other grasses make up smaller components. Stansbury cliffrose, Utah juniper and singleleaf pinyon are described in the site concept and may or may not be present. Potential vegetative composition is about 55% grasses, 5% forbs and 40% shrubs and trees. Approximate ground cover (basal and crown) is 10 to 15 percent.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	110	220	330
Shrub/Vine	72	144	216
Forb	10	20	30
Tree	8	16	24
Total	**200**	**400**	**600**

Community 1.2
Community Phase

This community phase is characteristic of a post-disturbance, early or mid-seral community. Bluebunch wheatgrass, needleandthread grass, Indian ricegrass, and other perennial bunchgrasses dominate. Sprouting shrubs such as Douglas' rabbitbrush, spiny hopsage, and shadscale may increase. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain.

Community 1.3
Community Phase

Sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory. Sandberg bluegrass and/or galleta may increase in the understory and become the dominant grass on the site. Scattered Utah juniper or singleleaf pinyon may be present on the site.

Pathway a
Community 1.1 to 1.2

A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring facilitating an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts.

Pathway b
Community 1.1 to 1.3

Time and lack of disturbance such as fire allows for sagebrush to increase and become decadent. Chronic drought, herbivory, or combinations of these will generally cause a reduction in perennial bunch grasses; however galleta grass may increase in the understory depending on the grazing management. Heavy spring grazing will favor an increase in sagebrush.

Pathway a
Community 1.2 to 1.1

Time and lack of disturbance will allow sagebrush to increase.

Pathway a
Community 1.3 to 1.1

A low severity fire, herbivory or combinations will reduce the sagebrush overstory and create a sagebrush/grass mosaic.

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 high intensity due to the dominance of sagebrush resulting in removal of the overstory shrub community.

State 2
Current Potential State

This state is similar to the Reference State 1.0 however with the addition of a fourth community phase. Ecological function of community phases 2.1, 2.2 and 2.3 has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance on a temporal basis as described in community phase 2.4 but will not become dominant within this State. 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 feedbacks 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. Black sagebrush, bluebunch wheatgrass and Indian ricegrass dominate the site. Forbs and other shrubs and grasses make up smaller components of the plant community.

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. Depending on fire severity patches of intact sagebrush may remain. Rabbitbrush or other sprouting shrubs may be increasing. Annual non-native species are stable or increasing within the community.

Community 2.3
Community Phase 'at risk'

Figure 9. Shallow Calcareous Slope 10-14” (028AY034NV) T. Stringham August 2013

Black sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs or from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Sandberg bluegrass may increase and become co-dominate with deep rooted bunchgrasses. Utah juniper and/or 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. This community is at risk of crossing a threshold to either State 3.0 (grazing or fire) or State 4.0 (fire).

Community 2.4
Community Phase

This community phase is characteristic of a post-disturbance, mid seral community where perennial bunchgrasses have had two plus years of recovery. Annual non-native grasses, primarily cheatgrass, are sub to co-dominate to perennial bunchgrasses. The production of annual grasses is a function of favorable climatic conditions – typically a wet spring. Sagebrush may be present in trace amounts. Rabbitbrush or other sprouting shrubs may be increasing. This community phase is at risk of transitioning to Annual State 5.0.

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.

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 black sagebrush to dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely Sandberg bluegrass and/or galleta grass may increase in the understory.

Pathway a
Community 2.2 to 2.1

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

Pathway b

Community 2.2 to 2.4

Late spring moisture that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and may create a transitory plant community phase.

Pathway a
Community 2.3 to 2.1

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 to sagebrush thus promoting the perennial bunchgrass understory. 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 the community. A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Due to low fuel loads in this State, fires will likely be small creating a mosaic pattern.

Pathway b
Community 2.3 to 2.2

Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be high intensity due to the dominance of sagebrush resulting in removal of the overstory shrub community. Annual non-native species respond well to fire and may increase post-burn. Brush treatment would reduce black sagebrush overstory and allow for perennial bunchgrasses to increase.

State 3
Shrub State

This state has two community phases; one with a decadent black sagebrush overstory, and one with a post-fire shadscale or rabbitbrush overstory, with a Sandberg bluegrass and/or galleta grass understory. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and Sandberg bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed. Bare ground and soil redistribution may be increasing.

Community 3.1
Community Phase

Figure 10. Shallow Calcareous Slope 10-14” (028AY034NV) T. Stringham August 2013

Decadent black sagebrush dominates the overstory. Rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Sandberg bluegrass and annual non-native species increase. Galleta grass may be present. Bare ground is significant and soil redistribution may be occuring. If present on the site, Utah juniper and/or singleleaf pinyon is increasing. This community phase may be at risk of transitioning to either the Tree State or Annual State.

Community 3.2
Community Phase (at risk)

Shadscale and/or rabbitbrush dominate the overstory. Broom snakeweed may be present to increasing. Annual non-native species may be increasing and bare ground is significant. This site is at risk for an increase in invasive annual weeds.

Pathway a
Community 3.1 to 3.2

Fire reduces black sagebrush to trace amounts and allows for sprouting shrubs such as rabbitbrush to dominate. Shadscale may also establish post-fire and become dominate. Inappropriate or excessive sheep grazing could also reduce cover of sagebrush and allow for shadscale or sprouting shrubs to dominate the community. Brush treatments with minimal soil disturbance would facilitate sprouting shrubs and galleta and/or Sandberg's bluegrass.

Pathway a
Community 3.2 to 3.1

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

State 4
Tree State

This state has two community phases that are characterized by a dominance of Utah juniper and/or singleleaf pinyon in the overstory. Black 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 4.1
Community Phase

Utah juniper and/or singleleaf pinyon dominates the overstory and site resources. Trees are actively growing with noticeable leader growth. Trace amounts of bunchgrasses may be found under tree canopies with trace amounts of Sandberg bluegrass and forbs in the interspaces. Sagebrush is stressed and dying. Recruitment of sagebrush cohorts is minimal. Annual non-native species are present under tree canopies. Bare ground interspaces are large and connected.

Community 4.2
Community Phase (At Risk)

Utah juniper and/or singleleaf pinyon dominates 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. Bunchgrasses may or may not be present. Sandberg bluegrass or mat forming forbs may be present in trace amounts. Bare ground interspaces are large and connected. Soil redistribution is evident.

Pathway a
Community 4.1 to 4.2

Time and lack of disturbance or management action allows for tree cover and density to further increase and trees to out-compete the herbaceous understory species for sunlight and water.

State 5
Annual State

This state has one community phase dominated by an annual grass community. In this state, a biotic threshold has been crossed and state dynamics are driven by the dominance and persistence of the annual grass community which is perpetuated by a shortened fire return interval. The herbaceous understory is dominated by annual non-native species such as cheatgrass and mustards. Resiliency has declined and further degradation from fire facilitates a cheatgrass and sprouting shrub plant community. The fire return interval has shortened due to the dominance of cheatgrass in the understory and is a driver in site dynamics.

Community 5.1
Community Phase

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

State 6
Seeded State

This state has three community phases; an introduced grass dominated phase, a shrub/grass phase and a decadent shrub phase. The state is characterized by the dominance of seeded introduced wheatgrass species in the understory. Forage kochia and other desired seeded species including black sagebrush and native and non-native forbs may be present.

Community 6.1
Community Phase

Introduced wheatgrass species and other non-native species such as forage kochia dominate the community. Native and non-native seeded forbs may be present. Sprouting shrubs such as rabbitbrush may dominate the aspect. Trace amounts of sagebrush may be present, especially if seeded. Native bunchgrasses may be present. Annual non-native species present.

Community 6.2
Community Phase

Seeded wheatgrass species dominate. Native bunchgrasses may be present. Annual non-native species present. Sagebrush may be a minor component. Sprouting shrubs present.

Community 6.3
Community Phase (at risk)

This community phase is at-risk of crossing a threshold to another state. Rabbitbrush may be a significant component. Wheatgrass vigor and density reduced. Annual non-native species have increased to the point of co-dominance with the seeded perennial bunchgrasses. Utah juniper and/or singleleaf pinyon may be present or increasing.

Pathway a
Community 6.1 to 6.2

Time and lack of disturbance may allow for sagebrush recruitment, if a seed source is available. This is an unlikely transition.

Pathway a
Community 6.2 to 6.1

Low severity fire or brush management may reduce the sagebrush overstory and allow seeded wheatgrass species to become dominant. Native bunchgrasses may be present.

Pathway b
Community 6.2 to 6.3

Time and lack of disturbance may be coupled with inappropriate grazing management and/or an unusually wet spring which increases production of annual non-native species.

Pathway a
Community 6.3 to 6.2

Low severity fire eliminates/reduces sagebrush and allows for the understory perennial grasses and sprouting shrubs to increase. Brush treatment may also cause an increase in sprouting shrubs.

Transition A
State 1 to 2

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass and mustards. Slow variables: Over time the annual non-native species 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: To Community Phase 3.1: Inappropriate cattle/horse grazing will decrease or eliminate deep rooted perennial bunchgrasses, increase Sandberg bluegrass and favor shrub growth and establishment. To Community Phase 3.2: Severe fire will remove sagebrush overstory, decrease perennial bunchgrasses and enhance Sandberg bluegrass. Soil disturbing brush treatments and/or inappropriate sheep grazing will reduce sagebrush and potentially increase sprouting shrubs and Sandberg bluegrass and/or galleta grass. Slow variables: Long term decrease in deep-rooted perennial grass density and/or black sagebrush. Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter. Loss of long-lived, black sagebrush changes the temporal and depending on the replacement shrub, the spatial distribution of nutrient cycling.

Transition B
State 2 to 4

Trigger: Time and lack of disturbance or management action allows for Utah Juniper and/or singleleaf pinyon to dominate. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources Feedbacks and ecological processes: Trees increasingly dominate use of soil water resulting in decreasing herbaceous and shrub production and decreasing organic matter inputs, contributing to reductions in soil water availability to grasses and shrubs and increased soil erodibility. 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.

Transition C
State 2 to 5

Trigger: Catastrophic fire or soil surface disturbance. Slow variables: Increased production and cover of non-native annual species. Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes energy and nutrient capture and cycling both spatially and temporally within the community. Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires.

Transition A
State 3 to 4

Trigger: Absence of disturbance over time allows for Utah juniper or singleleaf pinyon dominance. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources. Slow variables: Long-term increase in juniper and/or singleleaf pinyon density and size. Threshold: Trees overtop black sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs in number. There is minimal recruitment of new shrub cohorts. Litter builds up underneath trees while bare ground increases in interspaces; this changes nutrient cycling and levels of organic matter in the soil.

Transition B
State 3 to 5

Trigger: Severe 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.

Restoration pathway A
State 3 to 6

Seeding of deep-rooted introduced bunchgrasses and other desired species; may be coupled with brush management and/or herbicide. Probability of success is low.

Restoration pathway A
State 4 to 3

Tree removal with minimum soil disturbance such as hand felling or mastication within community phase 4.1.

Transition A
State 4 to 5

Trigger: Catastrophic fire causing a stand replacement event. Inappropriate tree removal practices with soil disturbance will also cause a transition to Annual State 5. Slow variables: Increased production and cover of non-native annual species under tree canopies. 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 impacts nutrient cycling and distribution.

Restoration pathway B
State 4 to 6

Tree removal and seeding of desired species within community phase 4.1. Tree removal practices that minimize soil disturbance are recommended. Probability of success declines with increased presence of non-native annual species.

Restoration pathway A
State 5 to 6

Seeding of deep-rooted bunchgrasses; may be coupled with brush management and/or herbicide. Probability of success extremely low.

Transition A
State 6 to 4

Trigger: Absence of disturbance over time and/or inappropriate grazing management facilitates the establishment and eventual dominance of Utah juniper or singleleaf pinyon. Slow variables: Long term increase in juniper and/or singleleaf pinyon density. Threshold: Trees out-compete understory species for water and sunlight. There is minimal recruitment of new shrub cohorts. Litter builds up underneath trees while bare ground increases in interspaces; this changes nutrient cycling and levels of organic matter in the soil. Redistribution of soil, organic matter and nutrients may occur with water and wind erosion.

Transition B

State 6 to 5

Trigger: Fire, inappropriate grazing management or treatments that disturb the soil and existing plant community (ex: failed restoration attempts). Slow variables: Increased seed 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 and impact the nutrient cycling and distribution

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Primary Perennial Grasses**			177–300	
	bluebunch wheatgrass	PSSPS	*Pseudoroegneria spicata ssp. spicata*	120–160	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	40–80	–
	blue grama	BOGR2	*Bouteloua gracilis*	1–20	–
	needle and thread	HECO26	*Hesperostipa comata*	8–20	–
	Sandberg bluegrass	POSE	*Poa secunda*	8–20	–
2	**Secondary Perennial Grasses**			8–20	
	threeawn	ARIST	*Aristida*	2–8	–
	squirreltail	ELEL5	*Elymus elymoides*	2–8	–
	James' galleta	PLJA	*Pleuraphis jamesii*	2–8	–
Forb					
3	**Perennial**			8–40	
	aster	ASTER	*Aster*	2–12	–
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	2–12	–
	lupine	LUPIN	*Lupinus*	2–12	–
Shrub/Vine					
4	**Primary Shrubs**			108–172	
	black sagebrush	ARNO4	*Artemisia nova*	100–140	–
	Stansbury cliffrose	PUST	*Purshia stansburiana*	8–32	–
5	**Secondary Shrubs**			20–60	
	fourwing saltbush	ATCA2	*Atriplex canescens*	4–12	–
	shadscale saltbush	ATCO	*Atriplex confertifolia*	4–12	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	4–12	–
	mormon tea	EPVI	*Ephedra viridis*	4–12	–
	buckwheat	ERIOG	*Eriogonum*	4–12	–
	spiny hopsage	GRSP	*Grayia spinosa*	4–12	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	4–12	–
	wild crab apple	PERA4	*Peraphyllum ramosissimum*	4–12	–
	antelope bitterbrush	PUTR2	*Purshia tridentata*	4–12	–
Tree					
6	**Evergreen**			4–16	
	Utah juniper	JUOS	*Juniperus osteosperma*	2–8	–
	singleleaf pinyon	PIMO	*Pinus monophylla*	2–8	–

Animal community

Livestock/Wildlife 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.
Black sagebrush is a significant browse species within the Intermountain region. It is especially important on low elevation winter ranges in the southern Great Basin, where extended snow free periods allow animal’s access to plants throughout most of the winter. In these areas it is heavily utilized by pronghorn (Antilocapra americana) and

mule deer. (Blaisdell et al. 1982). A review identified black sagebrush as the most important source of winter browse for pronghorn in Utah (Allen et al. 1984). In winter, it was reported by Clary and Beale (1983) that pronghorn preferred black sagebrush habitat. In winter, it was reported by Clary and Beale (1983) that pronghorn preferred black sagebrush habitat.

In a study by Behan and Welch (1985) black sagebrush accessions were preferred over six other big sagebrush accessions for winter habitat by mule deer. Black sagebrush (and other sagebrush communities) are less attractive to elk (Alces alces) and moose (Alces americanus). In southwestern Wyoming comparing winter habitat use by wild ungulates, elk and moose used Wyoming big sagebrush and black sagebrush community less than expected, while mule deer used it almost exclusively (Oedekoven et al. 1987).

Bird species use black sagebrush dominant habitat. Sage thrashers (Oreoscoptes montanus) and most passerines prefer areas with black sagebrush and other dwarf shrubs over areas with taller shrubs (Medin et al. 2000). Brewer's sparrow (Spizella breweri), sage sparrow (Amphispiza belli), and sage thrasher, also use black sagebrush communities for cover and feed (Paige and Ritter 1999). Greater Sage grouse (Centrocerus urophasianus) are known obligates in black sagebrush and other sagebrush habitats and will use black sagebrush sites as winter grounds (Connelly et al. 2000). For example: sage-grouse on the Snake River Plains of Idaho use black sagebrush-big sagebrush communities as winter range, and in Nevada, sage-grouse select wind-swept ridges with short, scattered black sagebrush plants as winter feeding areas (Clements and Young 1997). Throughout the West, greater sage grouse use mixed sagebrush habitats of big sagebrush and black sagebrush stands.

Pygmy rabbits (Brachylagus idahoensis), a threatened species of conservation concern throughout Nevada often burrow where low sagebrush mixes with mountain big sagebrush. Black sagebrush, is often a component of low sagebrush communities and is an important shrub for pygmy rabbits and other sagebrush obligate species (Oregon Conservation Strategy, 2006).

Rodents also use black sagebrush habitats. A study in northeastern Nevada showed deer mice (Peromyscus maniculatus), Great Basin pocket mice (Perognathus merriami), and Ord's kangaroo rats (Dipodomys ordii) used gray low sagebrush-black sagebrush communities on dry ridge tops in late spring and summer (McAdoo et al. 2006). Rodents on cold-desert warm-desert ecotones within the Nevada Test Site preferred cold-desert communities over transition and warm-desert communities in which black sagebrush communities were more abundant (Hansen et al. 1999). Black sagebrush communities also support predators. According to study by MacLaren et al. (1988) greater sage-grouse are the primary avian prey of golden eagles in a mixed big sagebrush-black sagebrush shrubland in southeastern Wyoming.

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 gartersnakes (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 douglassii), desert-horned lizard (Phrynosoma platyrhinos), sagebrush lizards (Sceloporus gracisosus), western fence lizards (Sceloporus occidentalis), northern side-blotched lizards (Uta uta stansburiana), western skinks (Plestiodon skiltonianus), and Great Basin whiptails (Aspidoscelis tigris 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).

Black sagebrush palatability has been rated as moderate to high depending on the ungulate and the season of use(Horton 1989, Wambolt 1996). The palatability of black sagebrush increase the potential negative impacts on remaining black sagebrush plants from grazing or browsing pressure following fire (Wambolt 1996). Pronghorn utilize black sagebrush heavily (Beale and Smith 1970). On the Desert Experiment Range, black sagebrush was found to comprise 68% of pronghorn diet even though it was only the third most common plant. Fawns were found to prefer black sagebrush utilizing it more than all other forage species combined (Beale and Smith 1970).

Domestic livestock will also utilize black sagebrush. The domestic sheep industry that emerged in the Great Basin in the early 1900s was largely based on wintering domestic sheep in black sagebrush communities (Mozingo 1987). Domestic sheep will browse black sagebrush during all seasons of the year depending on the availability of other forage species with greater amounts being consumed in fall and winter. Black sagebrush is generally less palatable

to cattle than to domestic sheep and wild ungulates (McArthur et al. 1982); however, cattle use of black sagebrush has also been shown to be greatest in fall and winter (Schultz and McAdoo 2002), with only trace amounts being consumed in summer (Van Vuren 1984).
Inappropriate grazing management during the growing season will cause a decline in understory plants such as bluebunch wheatgrass, Indian ricegrass and needleandthread. Bluebunch wheatgrass is moderately grazing tolerant however is 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). 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 deep-rooted, cool season perennial bunchgrass that is adapted primarily to coarse textured soils. 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.
Needleandthread grass, a minor component of this site, is most commonly found on warm/dry soils (Miller et al. 2013). It is not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller and Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972). With the reduction in competition from deep rooted perennial bunchgrasses, shallower rooted grasses such as Sandberg bluegrass and forbs may increase (Smoliak et al. 1972).

Reduced bunchgrass vigor or density provides an opportunity for galleta and/or Sandberg bluegrass expansion and/or cheatgrass and other invasive species such as halogeton to occupy interspaces. Increased cheatgrass cover leads to increased fire frequency and potentially an annual plant community. Galleta and/or Sandberg bluegrass increases under grazing pressure (Jameson 1962, Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors galleta or Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the type of grazing animal, and site conditions, either galleta or Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

Livestock Interpretations:
This site has limited value for livestock grazing due to steep slopes. 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. Indian ricegrass is highly palatable to all classes of livestock in both green and cured condition. It supplies a source of green feed before most other native grasses have produced much new growth. Needleandthread provides highly palatable forage, especially in the spring before fruits have developed. Needlegrasses are grazed in the fall only if the fruits are softened by rain. Sandberg 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. Blue grama is valuable forage for all classes of domestic livestock, providing excellent forage for cattle and sheep. Blue grama tends to be most productive following summer rains, but it cures well and provides forage year round. In winter, at lower elevations, black sagebrush is heavily utilized by domestic sheep. Stansbury cliffrose is an important browse species for livestock, especially in the winter.

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.

Hydrological functions

Runoff is medium to very high. Permeability is very slow to moderate. Hydrologic soil group is C and D. Rills are rare. A few rills can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt. A few water flow patterns can be expected in areas recently subjected to summer convection storms or rapid snowmelt, particularly on steeper slopes. If waterflow patterns are evident, they are typically short in length and not extensive. 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 none to rare in areas of this site that occur on stable landforms. Deep-rooted bunchgrasses (i.e., bluebunch wheatgrass & Indian ricegrass) slow runoff and increase infiltration. Although low statured, shrub canopy and associated litter break raindrop impact and provide some opportunity for snow catch 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 hiking and has potential for upland and big game hunting.

Other products

Triterpenoids extracted from Stansbury cliffrose have been shown to have inhibitory effects on HIV and Epstein-Barr virus. Native Americans used the inner bark for making clothing and ropes, and the branches for making arrows. Indian ricegrass was traditionally eaten by some Native Americans. The Paiutes used seed as a reserve food source.

Other information

Black sagebrush is an excellent species to establish on sites where management objectives include restoration or improvement of domestic sheep, pronghorn, or mule deer winter range. Stansbury cliffrose is recommended for wildlife, roadside, construction, and mine spoils plantings; and for restoring pinyon-juniper woodland, mountain brushland, basin big sagebrush grassland, black sagebrush, and black greasewood communities. It can be established on disturbed seedbeds by broadcast seeding, drill seeding, or transplanting. Fall or winter seeding is recommended. Needleandthread is useful for stabilizing eroded or degraded sites. Because of its wide adaptation, ease of establishment, and economic value, blue grama is used extensively for conservation purposes, rangeland seeding, and landscaping. Blue grama is useful for reclamation and for erosion control in arid and semiarid regions.

Type locality

Location 1: White Pine County, NV	
Township/Range/Section	T14N R69E S33
Latitude	39° 2′ 34″
Longitude	114° 14′ 0″
General legal description	About ¾ mile south of Mill Creek, Snake Range, Great Basin National Park, 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
Contact for lead author	State Rangeland Management Specialist
Date	06/22/2006
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. A few rills can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt. If formed, they will start to heal during the next growing season.

2. **Presence of water flow patterns:** A few water flow patterns can be expected in areas recently subjected to summer convection storms or rapid snowmelt, particularly on steeper slopes. If waterflow patterns are evident, they are typically short in length (<1 m), meandering and not extensive.

3. **Number and height of erosional pedestals or terracettes:** Pedestals are none to rare. Occurrence is usually limited tc areas of water flow patterns. Frost heaving of shallow rooted plants should not be considered a "normal" condition.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground ± 25%

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

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

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 typically subangular blocky. Soil surface colors are dark grayish browns and soils are typified by a mollic epipedon. Organic matter of the surface 2 to 3 inches is typically 1 to 1.5 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:** Deep-rooted bunchgrasses (i.e., bluebunch wheatgrass & Indian ricegrass) slow runoff and increase infiltration. Although low statured, shrub canopy and associated litter break raindrop impact and provide some opportunity for snow catch 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. Massive sub-surface horizons or subsoil argillic

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: Low shrubs (black sagebrush) > associated shrubs = deep-rooted, cool season, perennial forbs = shallow-rooted/rhizomatous perennial grasses = fibrous, shallow-rooted, cool season, perennial and annual forbs.

    Other: Evergreen trees, annual forbs, and succulents.

    Additional: With an extended fire return interval, the shrub and tree component will increase at the expense of the understory component. Singleleaf pinyon and Utah juniper may eventually dominate this site.

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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 30% of total woody canopy; some of the mature bunchgrasses (<20%) 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 mid-June) ± 400 lbs/ac; Favorable years are ± 600 lbs/ac and unfavorable years ± 200 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, annual mustards, and 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.
