

Ecological site R028BY059NV SHALLOW CALCAREOUS HILL 8-12 P.Z.

Accessed: 05/12/2025

General information

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

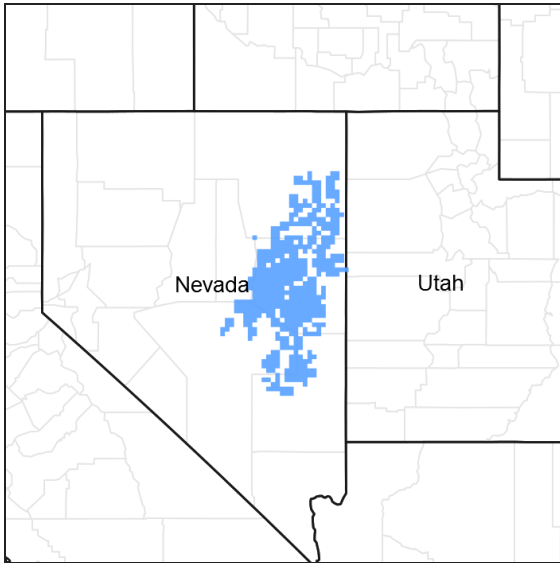


Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 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

The site typically occurs on hills and mountains. Slopes gradients >30 percent are typical. Elevations range from 5500 to 7500 feet.

The soils associated with this site are shallow, well drained, and characterized by an ochric epipedon. They formed in residuum and colluvium derived from limestone. The presence of this site is driven by droughty soil conditions resulting from low available water holding capacity and carbonatic parent material.

The reference state is dominated by black sagebrush and Indian ricegrass, with scattered Utah juniper. Bedrock outcrops associated with this site provide favorable sites for the establishment and persistence of trees. Tree canopy cover is less than 10 percent and is considered to be part plant community under reference conditions. Understory production ranges from 125 to 400 pounds per acre.

Following a comprehensive review of ecological site concepts and soil map unit components in 2016, it was determined that there is currently no way to separate or compete the site characteristics of this ecological site with those of Shallow Calcareous Slope 8-10"PZ (028BY016NV). It is very possible that these two sites are one site and expressing different community phases, however this won't be confirmed without further field investigations. Any user of this ecological site should understand this possibility when making land management decisions.

Associated sites

F028BY060NV	PIMO-JUOS/ARNO4/PSSPS-ACHY
F028BY083NV	Cobbly Calcareous Mountain Slopes 10-12 P.Z.
R028BY006NV	SHALLOW CALCAREOUS LOAM 10-12 P.Z.
R028BY008NV	SHALLOW CALCAREOUS SLOPE 10-12 P.Z.
R028BY011NV	SHALLOW CALCAREOUS LOAM 8-10 P.Z.
R028BY016NV	SHALLOW CALCAREOUS SLOPE 8-10 P.Z.

Similar sites

R028BY011NV	SHALLOW CALCAREOUS LOAM 8-10 P.Z. gentler slopes; more productive site; JUOS minor spp., if present
R028BY008NV	SHALLOW CALCAREOUS SLOPE 10-12 P.Z. PSSPS dominant grass, ACHY codominant; JUOS minor spp., if present; PECA12 absent; more productive site
R028BY016NV	SHALLOW CALCAREOUS SLOPE 8-10 P.Z. JUOS minor spp., if present; HECO26 codominant; PECA12 absent
R028BY090NV	SHALLOW CALCAREOUS HILL 14+ P.Z. PSSP dominant grass and ACHY codominant; PIMO codominant with JUOS

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Artemisia nova</i>
Herbaceous	(1) <i>Achnatherum hymenoides</i>

Physiographic features

This site occurs on all exposures of hills and mountains, although south aspects are most typical. Slopes range from 8 to 75 percent, but slope gradients >30% percent are typical. Elevations typically range from 5500 to 7500 feet, but may occur between 5000 and 8000 feet in some areas.

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Mountain
Flooding frequency	None
Ponding frequency	None
Elevation	1,676–2,286 m
Slope	30–75%
Aspect	SE, S, SW

Climatic features

The climate associated with this site is semiarid, characterized by cool, moist winters and warm, dry summers.

Average annual precipitation ranges from 8 to 12 inches. Mean annual air temperature is about 44 to 47 degrees F. The average growing season is about 90 to 120 days.

Mean annual precipitation across the range in which this ES occurs is 9.01".

Monthly mean precipitation: January 0.69; February 0.65; March 0.87; April 0.88; May 1.14; June 0.73; July 0.65; August 0.77; September 0.66; October 0.79; November 0.62; December 0.60.

*The above data is averaged from the Diamond Valley- Eureka and McGill WRCC climate stations.

Table 3. Representative climatic features

Frost-free period (average)	90 days
Freeze-free period (average)	120 days
Precipitation total (average)	229 mm

Climate stations used

- (1) DIAMOND VALLEY - EUREKA 14NNW [USC00262296], Eureka, NV

- (2) MCGILL [USC00264950], Ely, NV

Influencing water features

Influencing water features are not associated with this site.

Soil features

The soils associated with this site are shallow, well drained and formed in residuum/colluvium derived from limestone and dolomite. The surface is often very cobbly, stony, or gravelly. Available water holding capacity is very low, runoff is high. Soil temperature regime is mesic and the soil moisture regime is aridic bordering on xeric. Soil series associated with this site include: Izar, Puett, Palnor, Biken and Zimbo.

The representative soil series is Zimbo, a Loamy-skeletal, carbonatic, mesic Lithic Xeric Torriorthents. Diagnostic horizons and features recognized in this soil include an ochric epipedon from the soil surface to 18cm, identifiable secondary carbonates from 13 to 30cm, and fractured limestone bedrock at 30cm. Clay content in the particle size control section averages 10 to 18 percent. Rock fragments range from 35 to 50 percent, consisting mainly of gravel. Reaction is moderately alkaline or strongly alkaline and soils are strongly to violently effervescent, increasing with depth.

Table 4. Representative soil features

Parent material	(1) Residuum–limestone (2) Colluvium–dolomite
Surface texture	(1) Extremely gravelly loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderately rapid
Soil depth	10–36 cm
Surface fragment cover <=3"	35–75%
Surface fragment cover >3"	0–15%
Available water capacity (0-101.6cm)	1.27–3.05 cm
Calcium carbonate equivalent (0-101.6cm)	50–70%
Electrical conductivity (0-101.6cm)	1 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–5
Soil reaction (1:1 water) (0-101.6cm)	8.4–8.6
Subsurface fragment volume <=3" (Depth not specified)	35–50%
Subsurface fragment volume >3" (Depth not specified)	5–10%

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 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. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992). In the Great Basin, the majority of annual precipitation is received during the winter and early spring. This continental semiarid climate regime favors growth and development of deep-rooted shrubs and herbaceous cool season plants using the C3 photosynthetic pathway (Comstock and Ehleringer 1992). Winter precipitation and slow melting of snow results in deeper percolation of moisture into the soil profile. Herbaceous plants, that are more shallow-rooted than shrubs, grow earlier in the growing season and thrive on spring rains, while the deeper rooted shrubs lag in phenological development because they draw from deeply infiltrating moisture from snowmelt the previous winter. 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 dominant perennial bunchgrass is Indian ricegrass. Scribner's needlegrass, bluebunch wheatgrass, Sandberg bluegrass and squirreltail are other important grass species. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high 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 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 trees 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.

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. Five possible alternative

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 to 200 years (Kitchen and McArthur 2007); however, fires were probably patchy 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 2 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 rabbitbrush may become the dominant shrub species following fire, often with an understory of Sandberg bluegrass and/or cheatgrass and other weedy species.

Utah juniper is usually killed by fire, and is 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). With an increase of cheatgrass in the understory, fire severity is likely to increase. Singleleaf pinyon and Utah juniper reestablish 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).

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).

State and transition model

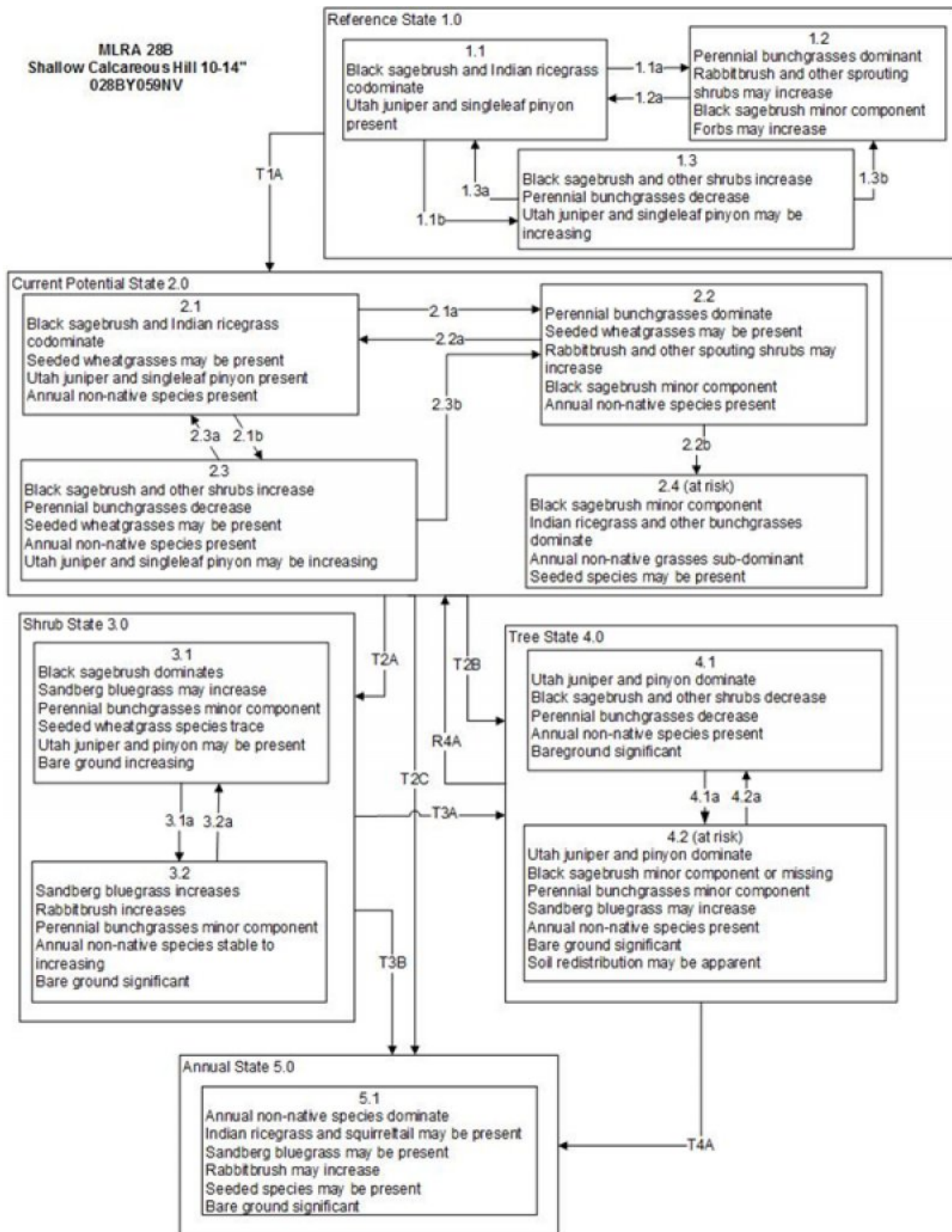


Figure 6. State and Transition Model

Reference State 1.0 Community Phase Pathways

- 1.1a: Low severity fire creates grass/sagebrush 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 would also reduce perennial understory.
- 1.2a: Time and lack of disturbance allows for shrub regeneration.
- 1.3a: Low severity fire resulting in a mosaic pattern, fall/winter herbivory may cause mechanical damage to shrubs and reduce shrub density.
- 1.3b: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.

Current Potential State 2.0 Community Phase Pathways

- 2.1a: Low severity fire creates grass/sagebrush 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 fire or long-term drought. Inappropriate grazing management may also reduce perennial understory.
- 2.2a: Time and lack of disturbance allows for shrub regeneration.
- 2.3a: Low severity fire resulting in a mosaic pattern. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
- 2.3b: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.

Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).

Transition T2B: Time and lack of disturbance allows for maturation of trees, may be coupled with inappropriate grazing management (4.1).

Transition T2C: High severity fire, failed seeding

Shrub State 3.0 Community Phase Pathways

- 3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
- 3.2a: Time and lack of disturbance.

Transition T3A: Time and lack of disturbance allows for tree maturation; may be coupled with inappropriate grazing management (4.1).

Transition T3B: Catastrophic fire and/or soil disturbing treatments (5.1).

Tree State 4.0 Community Phase Pathways

- 4.1a: Time and lack of disturbance allows maturation of tree community.
- 4.2a: Tree management with minimal soil disturbance such as mastication will reduce tree cover.

Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (5.1)

Restoration R4A: Tree removal with minimal soil disturbance and seeding of desired species.

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

This community is dominated by black sagebrush and Indian ricegrass. Forbs and other perennial grasses make up smaller components. Utah juniper is described in the site concept and may or may not be present. Potential vegetative composition is approximately 30% grasses, 10% forbs and 60% shrubs and trees. Approximate ground cover (basal and canopy) is 10 to 25 percent.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	68	169	221
Grass/Grasslike	43	84	135
Tree	16	33	48
Forb	13	28	45
Total	140	314	449

Community 1.2 Community Phase

This community phase is characteristic of a post-disturbance, early-seral community. Indian ricegrass, bottlebrush squirreltail and other perennial bunchgrasses dominate. Sprouting shrubs such as Douglas rabbitbrush, green ephedra and shadscale may increase. Depending on fire severity, 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 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 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 fuel loads. A fire following an unusually wet spring 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 cause a decline in perennial bunchgrasses and fine fuels leading to a reduced fire frequency and allowing black sagebrush to dominate the site.

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 severity due to the dominance of sagebrush in this community phase, resulting in removal of the overstory shrub community.

State 2

Current Potential State

This state is similar to the Reference State 1.0 with three similar community phases. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance 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, Indian ricegrass, Sandberg's bluegrass and bottlebrush squirreltail dominate the site. Forbs and other shrubs and perennial grasses make up smaller components of this site.

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 or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Rabbitbrush may be sprouting. Annual non-native species are stable or increasing within the community.

Community 2.3

Community Phase

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-dominant 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 (At Risk)

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 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 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 in this community phase 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 that is characterized by a decadent black sagebrush overstory and the other with a shadscale or rabbitbrush overstory with a Sandberg bluegrass understory. The site has crossed a biotic threshold and site processes are being controlled by shrubs. Bare ground has increased and pedestalling of grasses may be excessive.

Community 3.1 **Community Phase**



Figure 9. TStringham_9/2013



Figure 10. TStringham_9/2013

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. Bare ground is significant and soil redistribution may be occurring. 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



Figure 11. TStringham_9/2012

Shadscale and/or rabbitbrush dominate the overstory. 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

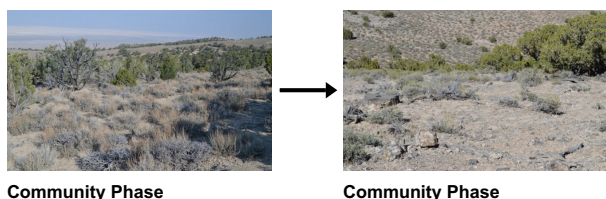
Community 3.1 to 3.2



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 Sandberg 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. 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 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.

Pathway a

Community 4.2 to 4.1

Tree thinning with minimal soil disturbance such as mastication to reduce tree cover and seeding of desired species.

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 fire. 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



Figure 12. TStringham_5/2012

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

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. 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 4 to 2

Tree removal with minimum soil disturbance such as hand felling or mastication within community phase 4.1. This is usually combined with seeding of desired species.

Conservation practices

Brush Management
Range Planting

Transition A

State 4 to 5

Trigger: Catastrophic fire causing a stand replacement event will transition Annual State 5.0. 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 impact nutrient cycling and distribution.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	Primary Perennial Grass			65–129	
	Indian ricegrass	ACHY	<i>Achnatherum hymenoides</i>	43–71	–
	Scribner needlegrass	ACSC11	<i>Achnatherum scribneri</i>	6–15	–
	squirreltail	ELEL5	<i>Elymus elymoides</i>	6–15	–
	Sandberg bluegrass	POSE	<i>Poa secunda</i>	6–15	–
2	Secondary Perennial Grass			6–15	
	needle and thread	HECO26	<i>Hesperostipa comata</i>	1–9	–
	bluebunch wheatgrass	PSSP6	<i>Pseudoroegneria spicata</i>	1–9	–
Forb					
3	Perennial			15–28	
	milkvetch	ASTRA	<i>Astragalus</i>	1–6	–
	buckwheat	ERIOG	<i>Eriogonum</i>	1–6	–
	gilia	GILIA	<i>Gilia</i>	1–6	–
	mat rockspirea	PECA12	<i>Petrophytum caespitosum</i>	1–6	–
	phlox	PHLOX	<i>Phlox</i>	1–6	–
	goldenweed	PYRRO	<i>Pyrrocoma</i>	1–6	–
Shrub/Vine					
4	Primary Shrubs			84–99	
	black sagebrush	ARNO4	<i>Artemisia nova</i>	84–99	–
5	Secondary Shrubs			15–43	
	shadscale saltbush	ATCO	<i>Atriplex confertifolia</i>	1–9	–
	yellow rabbitbrush	CHVI8	<i>Chrysothamnus viscidiflorus</i>	1–9	–
	Nevada jointfir	EPNE	<i>Ephedra nevadensis</i>	1–9	–
	spiny hopsage	GRSP	<i>Grayia spinosa</i>	1–9	–
	winterfat	KRLA2	<i>Krascheninnikovia lanata</i>	1–9	–
	bud sagebrush	PIDE4	<i>Picrothamnus desertorum</i>	1–9	–
	Stansbury cliffrose	PUST	<i>Purshia stansburiana</i>	1–9	–
Tree					
6	Evergreen			16–48	
	Utah juniper	JUOS	<i>Juniperus osteosperma</i>	15–43	–
	singleleaf pinyon	PIMO	<i>Pinus monophylla</i>	1–3	–

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.

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. In winter, at lower elevations,

black sagebrush is heavily utilized by domestic sheep.

Scribner's needlegrass is palatable to livestock and is grazed during the spring. 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). Domestic livestock will 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. Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). 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).

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:

Black sagebrush is a desirable forage plant and also provides cover for some types of wildlife (Blaisdell et al. 1982). In Nevada, black sagebrush communities are used by mule deer (*Odocoileus hemionus*) and pronghorn (*Antilocapra americana*) (Blaisdell et al. 1982). Pronghorn (*Antilocapra americana*) do best where shrub cover is moderate to low, therefore, black sagebrush may be preferred in some areas over big sagebrush varieties (Blaisdell et al. 1982). It is especially important on low elevation winter ranges in the southern Great Basin, where extended snow free periods allow animals access to plants throughout most of the winter. In these areas it is heavily utilized by pronghorn and mule deer. Furthermore, a review identified black sagebrush as the most important source of winter browse for pronghorn in Utah (Allen et al. 1984). 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).

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 (*Centrocercus 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). In fact, 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 California, Oregon, Nevada, Idaho, Montana, Wyoming and Utah (endangered in Washington) 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 graciosus*), 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 where 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).

Bluebunch wheatgrass is considered one of the most important forage grass species on western rangelands for wildlife. Bluebunch wheatgrass does not generally provide sufficient cover for ungulates, however, mule deer were frequently found in bluebunch-dominated grasslands.

Thurber's needlegrass is palatable to wildlife and is grazed during the spring.

Bluegrass is desirable to wildlife species in the spring and early summer.

Scribner's needlegrass is palatable to wildlife and is grazed during the spring.

Indian ricegrass is eaten by pronghorn in "moderate" amounts whenever available. A number of heteromyid rodents inhabiting desert rangelands show preference for seed of Indian ricegrass. Indian ricegrass is an important component of jackrabbit diets in spring and summer. Indian ricegrass seed provides food for many species of birds. Doves, for example, eat large amounts of shattered Indian ricegrass seed lying on the ground.

Bottlebrush squirreltail is a dietary component of domestic livestock and wildlife species. Bottlebrush squirreltail may provide forage for mule deer and pronghorn.

Hydrological functions

Permeability is moderate to moderately rapid. Runoff is high to very high. Rills are none to rare. Rock fragments armor the soil surface. Water flow patterns are none to rare. Pedestals are rare to few. Occurrence is usually limited to areas of water flow patterns. Frost heaving of shallow rooted plants should not be considered an indicator of soil erosion. Gullies are none. Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., Indian ricegrass]) slow runoff and increase infiltration. Trees and understory shrubs break raindrop impact and provide opportunity for snow catch and accumulation on site.

Recreational uses

Aesthetic value is derived from the diverse floral and faunal composition 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

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. Bottlebrush squirreltail is tolerant of disturbance and is a suitable species for revegetation.

Type locality

Location 1: White Pine County, NV	
Township/Range/Section	T21N R56E S27
Latitude	39° 39' 47"
Longitude	115° 39' 8"
General legal description	About 3 miles southeast of Buck Station in Newark Valley, on southwest slopes of the Buck Mountains, White Pine County, Nevada. This site is also located in Elko and Eureka Counties, Nevada.

Other references

- Akinsoji, A. 1988. Postfire vegetation dynamics in a sagebrush steppe in southeastern Idaho, USA. *Vegetatio* 78:151-155.
- Anderson, E. W. and R. J. Scherzinger. 1975. Improving quality of winter forage for elk by cattle grazing. *Journal of Range Management*:120-125.
- Barney, M. A. and N. C. Frischknecht. 1974. Vegetation Changes following Fire in the Pinyon-Juniper Type of West-Central Utah. *Journal of Range Management* 27:91-96.
- Bates, J. D., T. Svejcar, R. F. Miller, and R. A. Angell. 2006. The effects of precipitation timing on sagebrush steppe vegetation. *Journal of Arid Environments* 64:670-697.
- Beale, D. M. and A. D. Smith. 1970. Forage Use, Water Consumption, and Productivity of Pronghorn Antelope in Western Utah. *The Journal of Wildlife Management* 34:570-582.
- Bentz, B., D. Alston, and T. Evans. 2008. Great Basin Insect Outbreaks. Pages 45-48 in Collaborative Management and Research in the Great Basin -- Examining the issues and developing a framework for action Gen. Tech. Rep. RMRS-GTR-204. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
- Blaisdell, J. P. and J. F. Pechanec. 1949. Effects of Herbage Removal at Various Dates on Vigor of Bluebunch Wheatgrass and Arrowleaf Balsamroot. *Ecology* 30:298-305.
- Bradley, A. F., N. V. Noste, and W. C. Fischer. 1992. Gen. Tech. Rep. INT-287: Fire ecology of forests and woodlands in Utah. . U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.
- Britton, C. M., G. R. McPherson, and F. A. Sneva. 1990. Effects of burning and clipping on five bunchgrasses in eastern Oregon. *Great Basin Naturalist* 50:115-120.
- Bunting, S. 1994. Effects of Fire on Juniper woodland ecosystems in the great basin.in *Proceedings--Ecology and Management of Annual Rangelands*. USDA: FS Intermountain Research Station.
- Busso, C. A. and J. H. Richards. 1995. Drought and clipping effects on tiller demography and growth of two tussock grasses in Utah. *Journal of Arid Environments* 29:239-251.
- Caudle, D., J. Dibenedetto , M. Karl , H. Sanchez , and C. Talbot. 2013. Interagency ecological site handbook for rangelands.
- Chambers, J., B. Bradley, C. Brown, C. D'Antonio, M. Germino, J. Grace, S. Hardegree, R. Miller, and D. Pyke. 2013. Resilience to Stress and Disturbance, and Resistance to *Bromus tectorum* L. Invasion in Cold Desert Shrublands of Western North America. *Ecosystems*:1-16.
- Chambers, J. C., B. A. Roundy, R. R. Blank, S. E. Meyer, and A. Whittaker. 2007. What makes great basin sagebrush ecosystems invasible by *Bromus tectorum*? *Ecological Monographs* 77:117-145.

- Comstock, J. P. and J. R. Ehleringer. 1992. Plant adaptation in the Great Basin and Colorado plateau. *Western North American Naturalist* 52:195-215.
- Conrad, C. E. and C. E. Poulton. 1966. Effect of a wildfire on Idaho fescue and bluebunch wheatgrass. *Journal of Range Management*:138-141.
- Currie, P. O., D. W. Reichert, J. C. Malechek, and O. C. Wallmo. 1977. Forage Selection Comparisons for Mule Deer and Cattle under Managed Ponderosa Pine. *Journal of Range Management* 30:352-356.
- Dayton, W. 1937. Range plant handbook. USDA, Forest Service. Bull.
- Eckert, R. E., Jr. and J. S. Spencer. 1987. Growth and reproduction of grasses heavily grazed under rest-rotation management. *Journal of Range Management* 40:156-159.
- Evans, R. A. and J. A. Young. 1978. Effectiveness of Rehabilitation Practices following Wildfire in a Degraded Big Sagebrush-Downy Brome Community. *Journal of Range Management* 31:185-188.
- Everett, R. L. and K. Ward. 1984. Early plant succession on pinyon-juniper controlled burns. *Northwest Science* 58:57-68.
- Fire Effects Information System (Online; <http://www.fs.fed.us/database/feis/plants/>).
- Ganskopp, D. 1988. Defoliation of Thurber Needlegrass: Herbage and Root Responses. *Journal of Range Management* 41:472-476.
- Gates, D. H. 1964. Sagebrush infested by leaf defoliating moth. *Journal of Range Management* 17:209-210.
- Hall, R. C. 1965. Sagebrush defoliator outbreak in Northern California. Res. Note PSW-RN-075., Berkeley, CA.
- Horton, H. 1989. Interagency forage and conservation planting guide for Utah. Extension circular 433. Utah State University, Utah Cooperative Extension Service, Logan UT.
- Houghton, J.G., C.M. Sakamoto, and R.O. Gifford. 1975. Nevada's Weather and Climate, Special Publication 2. Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno, NV.
- Kitchen, S. G. and E. D. McArthur. 2007. Big and black sagebrush landscapes. *Fire Ecology and Management of the Major Ecosystems of Southern Utah*. General Technical Report RMRS-GTR-202, Fort Collins, CO. US Department of Agriculture, Forest Service, Rocky Mountain Research Station. :73-94.
- Koniak, S. 1985. Succession in pinyon-juniper woodlands following wildfire in the Great Basin. *The Great Basin Naturalist* 45:556-566.
- Laycock, W. A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. *Journal of Range Management*:206-213.
- McArthur, E. D., A. Blaner, A. P. Plummer, and R. Stevens. 1982. Characteristics and hybridization of important Intermountain shrubs: 3. Sunflower family. En Ref. in *Forest. Abstr* 43:2176.
- Miller, R. F., J. C. Chambers, D. A. Pyke, F. B. Pierson, and C. J. Williams. 2013. A review of fire effects on vegetation and soils in the Great Basin Region: response and ecological site characteristics.
- Miller, R.F., R.J. Tausch, E.D. McArthur, D.D. Johnson, S.C. Sanderson 2008. Age structure and expansion of pinon-juniper woodlands: a regional perspective in the Intermountain West. Res.Pap.RMRS-RP-69. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.
- Miller, R. F. and R. J. Tausch. 2000. The role of fire in pinyon and juniper woodlands: a descriptive analysis. Pages 15-30 in *Proceedings of the invasive species workshop: the role of fire in the control and spread of invasive species*.

Fire conference.

Mozingo, H. N. 1987. Shrubs of the Great Basin: A natural history. Pages 67-72 in H. N. Mozingo, editor. Shrubs of the Great Basin. University of Nevada Press, Reno NV.

Mueggler, W. F. 1975. Rate and Pattern of Vigor Recovery in Idaho Fescue and Bluebunch Wheatgrass. *Journal of Range Management* 28:198-204.

National Oceanic and Atmospheric Administration. 2004. The North American Monsoon. Reports to the Nation. National Weather Service, Climate Prediction Center. Available online: <http://www.weather.gov/>

Norton, J.B., T.A. Monaco, J.M. Norton, D.A. Johnson, and T. A. Jones 2004. Soil morphology and organic matter dynamics under cheatgrass and sagebrush-steppe plant communities. *Jo. of Arid Environments*: 57, 445-466.

Noy-Meir, I. 1973. Desert Ecosystems: Environment and Producers. *Annual Review of Ecology and Systematics* 4:25-51.

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

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

Schultz, B. W. and J. K. McAdoo. 2002. Common Sagebrush in Nevada. Special Publication SP-02-02. University of Nevada, Cooperative Extension, Reno, NV.

Smoliak, S., J. F. Dormaar, and A. Johnston. 1972. Long-Term Grazing Effects on *Stipa-Bouteloua* Prairie Soils. *Journal of Range Management* 25:246-250.

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

Tausch, R. J. 1999. Historic pinyon and juniper woodland development. *Proceedings: ecology and management of pinyon-juniper communities within the Interior West*. Ogden, UT, USA: US Department of Agriculture, Forest Service, Rocky Mountain Research Station, RMRS-P-9:12-19.

Tausch, R. J. and N. E. West. 1988. Differential establishment of pinyon and juniper following fire. *American Midland Naturalist*:174-184.

Tueller, P. T. and W. H. Blackburn. 1974. Condition and Trend of the Big Sagebrush/Needleandthread Habitat Type in Nevada. *Journal of Range Management* 27:36-40.

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

USDA-NRCS Plants Database (Online; <http://www.plants.usda.gov>).

Van Vuren, D. 1984. Summer Diets of Bison and Cattle in Southern Utah. *Journal of Range Management* 37:260-261.

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

Wambolt, C. L. 1996. Mule Deer and Elk Foraging Preference for 4 Sagebrush Taxa. *Journal of Range Management* 49:499-503.

Wright, H. A. 1971. Why Squirreltail Is More Tolerant to Burning than Needle-and-Thread. *Journal of Range*

Wright, H. A. and J. O. Klemmedson. 1965. Effect of Fire on Bunchgrasses of the Sagebrush-Grass Region in Southern Idaho. Ecology 46:680-688.

Young, R. P. 1983. Fire as a vegetation management tool in rangelands of the intermountain region. Pages 18-31 in Managing intermountain rangelands - improvement of range and wildlife habitats. USDA, Forest Service.

Contributors

HA/MD/RK

T. Stringham/P.Novak-Echenique

E. Hourihan

Rangeland health reference sheet

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

Author(s)/participant(s)	P. Novak-Echenique
Contact for lead author	State Rangeland Management Specialist
Date	09/24/2009
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 may occur on steeper slopes after summer convection storms or rapid snowmelt.

- 2. Presence of water flow patterns:** Water flow patterns are none to rare. Occurrence is limited to steeper slopes after summer convection storms or rapid snowmelt. They are typically short (<1m) and meandering. They are interrupted by plants and exposed rock.

- 3. Number and height of erosional pedestals or terracettes:** Pedestals are rare to few. Occurrence is usually limited to areas of water flow patterns. Frost heaving of shallow rooted plants should not be considered an indicator of soil erosion. Terracettes are none to rare and are limited to steeper slopes.

- 4. Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground \pm 10-25% depending on amount of surface rock fragments.

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

-
6. **Extent of wind scoured, blowouts and/or depositional areas:** None.
-
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. Mat of accumulating needle litter under mature trees is very stable and shows no obvious movement.
-
8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil stability values should be 4 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 thin platy or subangular blocky. Soil surface colors are brownish grays and soils are typified by an ochric epipedon. Organic carbon 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:** Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., Indian ricegrass]) slow runoff and increase infiltration. Trees and understory shrubs break raindrop impact and provide opportunity for snow catch and accumulation on site.
-
11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Compacted layers are none. Subangular blocky sub-surface horizons should not to be interpreted as compacted layers.
-
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: Low shrubs (black sagebrush) = deep-rooted, cool season, perennial bunchgrasses (Indian ricegrass)
- Sub-dominant: evergreen trees > associated shrubs > deep-rooted, cool season, perennial forbs = shallow-rooted, cool season, perennial grasses = fibrous, shallow-rooted, cool season, perennial forbs = annual forbs
- Other:
- Additional: With an extended fire return interval, the shrub and tree component will increase at the expense of the herbaceous component. Singleleaf pinyon and Utah juniper may eventually dominate this site.
-
13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Overstory trees have little mortality. Dead branches within understory shrubs are common and standing dead shrub canopy material may be as much as 35% of total shrub canopy; mature bunchgrasses (<25%) may have dead centers.

-
14. **Average percent litter cover (%) and depth (in):** Litter within tree canopy interspaces (\pm 10-20%) and litter depth is \pm ¼inch. Needle litter forms a mat 2 to 4inches thick under the drip line of mature trees. Large, persistent, litter from trees (limbs, etc.) variable to 5%.
-
15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** For understory vegetation to 4½ feet and normal or average growing season (through May) = \pm 250 lbs/ac. Favorable years \pm 400 lbs/ac and unfavorable years \pm 125 lbs/ac.
-
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 Russian thistle, annual mustards, and cheatgrass. Singleleaf pinyon and Utah juniper may increase and eventually dominate this site.
-
17. **Perennial plant reproductive capability:** All functional groups should reproduce in average (or normal) and above average growing season years. Reduced reproduction and growth occur during extended drought periods.
-