

Ecological site R028BY036NV CLAYPAN 14+ P.Z.

Accessed: 05/13/2025

General information

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

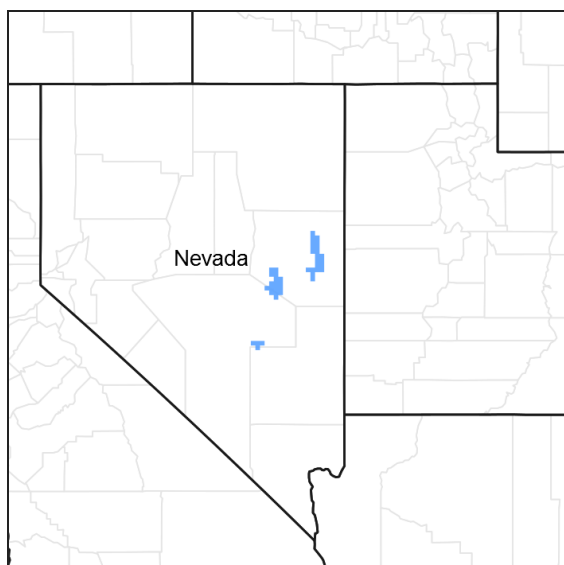


Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 028B—Central Nevada Basin and Range

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

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

The average annual precipitation ranges from 4 to 12 inches (100 to 305 millimeters) in most areas on the valley floors. Average annual precipitation in the mountains ranges from 8 to 36 inches (205 to 915 millimeters) depending on elevation. The driest period is from midsummer to midautumn. The average annual temperature is 34 to 52 degrees F (1 to 11 degrees C). The freeze-free period averages 125 days and ranges from 80 to 170 days, decreasing in length with elevation.

The dominant soil orders in this MLRA are Aridisols, Entisols, and Mollisols. The soils in the area dominantly have a mesic soil temperature regime, an aridic or xeric soil moisture regime, and mixed or carbonatic mineralogy. They generally are well drained, loamy or loamyskeletal, and shallow to very deep.

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

continentality, latitude, and elevation. The strong continental effect is expressed in the form of both dryness and large temperature variations. Nevada lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that markedly influences the climate of the State. The prevailing winds are from the west, and as the warm moist air from the Pacific Ocean ascend the western slopes of the Sierra Range, the air cools, condensation occurs and most of the moisture falls as precipitation. As the air descends the eastern slope, it is warmed by compression, and very little precipitation occurs. The effects of this mountain barrier are felt not only in the West but throughout the state, as a result the lowlands of Nevada are largely desert or steppes.

The temperature regime is also affected by the blocking of the inland-moving maritime air. Nevada sheltered from maritime winds, has a continental climate with well-developed seasons and the terrain responds quickly to changes in solar heating. Nevada lies within the midlatitude belt of prevailing westerly winds which occur most of the year. These winds bring frequent changes in weather during the late fall, winter and spring months, when most of the precipitation occurs.

To the south of the mid-latitude westerlies, lies a zone of high pressure in subtropical latitudes, with a center over the Pacific Ocean. In the summer, this high-pressure belt shifts northward over the latitudes of Nevada, blocking storms from the ocean. The resulting weather is mostly clear and dry during the summer and early fall, with occasional thundershowers. The eastern portion of the state receives noteworthy summer thunderstorms generated from monsoonal moisture pushed up from the Gulf of California, known as the North American monsoon. The monsoon system peaks in August and by October the monsoon high over the Western U.S. begins to weaken and the precipitation retreats southward towards the tropics (NOAA 2004).

Ecological site concept

This site occurs on mountains on all aspects. Slope gradients of 4 to 30 percent are typical. Elevations are 7500 to 9500 feet.

The soils associated with this site are shallow, well drained and formed in residuum/colluvium derived from volcanic rocks. The soil profile is characterized by a mollic epipedon, an argillic horizon and >35% rock fragments distributed throughout the profile.

Important abiotic factors contributing to the presence of this ecological site include depth of less than 30cm to an abrupt upper textural boundary (bedrock), high elevation, and cool soil temperatures. Plant growth is not initiated until mid or late-spring. The upper soil profile is wet, non-satiated (no free water present) during late winter and early spring following snow melt. Pedestaling of some grass plants is common during the winter due to frost heaving. The soil moisture regime is xeric bordering on aridic and the soil temperature regime is frigid.

The reference community is dominated by low sagebrush and bluebunch wheatgrass. Average annual production ranges from 350 to 700 pounds per acre.

Associated sites

R028BY029NV	LOAMY 16+ P.Z.
R028BY038NV	MOUNTAIN RIDGE 14+ P.Z.
R028BY070NV	MOUNTAIN LOAM 16+ P.Z.

Similar sites

R028BY035NV	GRAVELLY CLAYPAN 14+ P.Z. PUTR2 dominant shrub; more productive site
R028BY037NV	CLAYPAN 12-14 P.Z. PSSP-ACTH7 or ACOC3 codominant grasses
R028BY038NV	MOUNTAIN RIDGE 14+ P.Z. Less productive site

R028BY039NV	COBBLY CLAYPAN 12-14 P.Z. Less productive site
R028BY034NV	MOUNTAIN RIDGE 12-14 P.Z. PSSP-ACTH7 codominant grasses; less productive site
R028BY092NV	CALCAREOUS CLAYPAN 14-16 P.Z. Soils are calcareous; ACHNA spp. rare

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Artemisia arbuscula</i>
Herbaceous	(1) <i>Pseudoroegneria spicata</i>

Physiographic features

This site occurs on mountain sideslopes and occasionally hills on all aspects. Slopes range from 2 to 50 percent, but slope gradients of 4 to 30 percent are most typical. Elevations range from 7500 to 9500 feet.

Table 2. Representative physiographic features

Landforms	(1) Mountain (2) Mountain slope
Flooding frequency	None
Ponding frequency	None
Elevation	2,286–2,743 m
Slope	4–30%
Aspect	Aspect is not a significant factor

Climatic features

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

Average annual precipitation ranges from 14 to over 20 inches. Mean annual air temperature is about 40 to 43 degrees F. The average growing season is about 50 to 70 days. Weather stations with a long term data record are currently not available for this ecological site. Associated climate data will be updated when information becomes available.

Table 3. Representative climatic features

Frost-free period (average)	50 days
Freeze-free period (average)	70 days
Precipitation total (average)	406 mm

Influencing water features

There are no influencing water features associated with this site.

Soil features

The soils associated with this site are shallow, well drained and formed in residuum/colluvium derived from volcanic rocks. The profile is characterized by a mollic epipedon, an argillic horizon, and >35% rock fragments by volume. Soil series associated with this ecological site include: Mattier, Realmcoy, and Jonlake.

The representative soil series are Realmcoy and Mattier. Both soils are classified as Loamy-skeletal, mixed, superactive, frigid Lithic Argixerolls. Diagnostic horizons include and mollic epipedon from the soil surface to about 20 cm, and an argillic horizon that ranges from around 10 to 40cm. Clay content in the particle size control section averages 27 to 35 percent. Rock fragments range from 35 to 60 percent. Reaction is moderately acid or slightly acid. Soils are non-effervescent and derived from quartzite or welded tuff.

Table 4. Representative soil features

Parent material	(1) Colluvium–quartzite (2) Residuuum–welded tuff
Surface texture	(1) Very gravelly loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderately slow
Soil depth	36–51 cm
Surface fragment cover <=3"	30–40%
Surface fragment cover >3"	10–35%
Available water capacity (0-101.6cm)	2.54–5.08 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	7.4–7.8
Subsurface fragment volume <=3" (Depth not specified)	20–30%
Subsurface fragment volume >3" (Depth not specified)	15–30%

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).

The 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 low sagebrush as the dominant shrub were found to have soil depths and thus available rooting depths of 71 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). The perennial bunchgrasses that are co-dominant with the shrubs include bluebunch wheatgrass, muttongrass, needlegrasses and squirreltail. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m but taper off more rapidly than shrubs. Differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems.

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 with the soil profile (Bates et al. 2006). Low sagebrush is fairly drought tolerant but also tolerates wet non-satiated conditions in the late winter and early spring months following snow melt. Low sagebrush is also be susceptible to the sagebrush defoliator, Aroga moth. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), but the research is inconclusive of the damage sustained by low sagebrush populations.

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 has increased since the middle of the nineteenth century (Tausch 1999, Miller and Tausch 2000). Causes for expansion of singleleaf pinyon and Utah juniper into sagebrush ecosystems include wildfire suppression, historic livestock grazing, and climate change (Bunting 1994). Mean fire return intervals prior to European settlement in low sagebrush ecosystems were greater than 100 years, however frequent enough to inhibit the encroachment of trees into these low productive sagebrush cover types (Miller and Tausch 2000). 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.

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 return intervals have been estimated at 100 to 200 years in black sagebrush dominated sites (Kitchen and McArthur 2007) and likely is similar in the low sagebrush ecosystem; however, historically fires were probably patchy due to the low productivity of these sites. Fine fuel loads generally average 100 to 400 pounds per acre (110- 450 kg/ha) but are occasionally as high as 600 pounds per acre (680 kg/ha) in low sagebrush habitat types (Bradley et al. 1992). Low sagebrush is killed by fire and does not sprout (Young 1983). Establishment after fire is from seed, generally blown in and not from the seed bank (Bradley et al. 1992). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Recovery time of low sagebrush following fire is variable (Young 1983). After fire, if regeneration conditions are favorable, low sagebrush recovers in 2 to 5 years, however on harsh sites where cover is low to begin with and/or erosion occurs after fire, recovery may require more than 10 years (Young 1983). Slow regeneration may subsequently worsen erosion (Blaisdell et al. 1982).

Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. 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.

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

Singleleaf pinyon and Utah juniper are usually killed by fire, and are most vulnerable to fire when they are 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. 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

MLRA 28B
Claypan 14+
028BY036NV

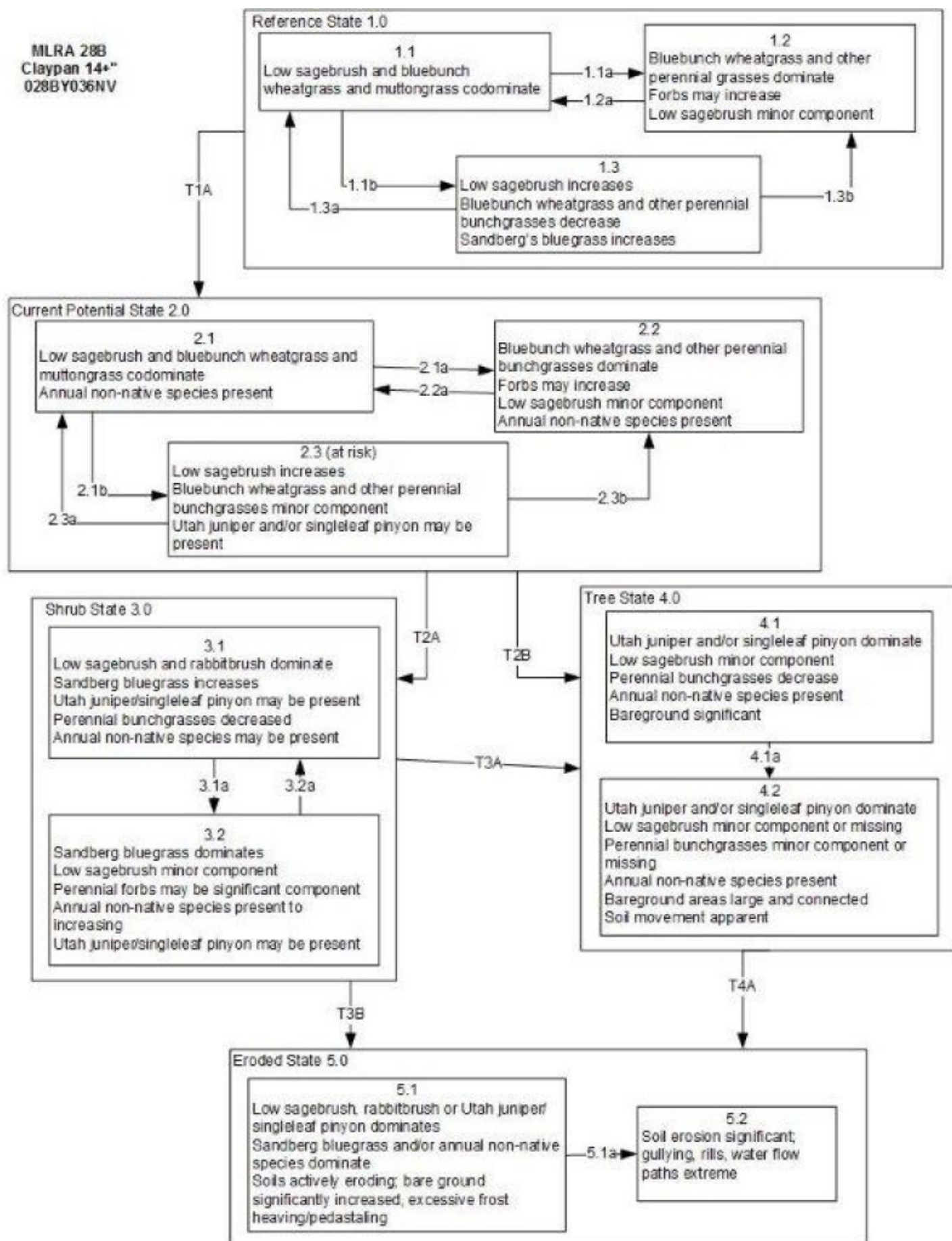


Figure 5. State and Transition Model

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 and/or herbivory
- 1.3b: High severity fire significantly reduces sagebrush.

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 and/or grazing management to reduce shrub cover
- 2.3b: High severity fire significantly reduces sagebrush. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

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).

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 (unlikely to occur)

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

Transition T3B: Inappropriate grazing management (5.1).

Tree State 4.0 Community Phase Pathways

- 4.1a: Time and lack of disturbance allows maturation of tree community.

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

Eroded State 5.0 Community Phase Pathways

- 5.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance

8/26/14 AW

-edited T3B- not fire induced by heavy grazing causing a disruption on the soil surface (see note 9/13/12 PN-13, PN-19, 7/18/13 PN-19)

Figure 6. 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 3 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 low sagebrush, lanceleaf rabbitbrush, bluebunch wheatgrass, muttongrass, pine needlegrass and Letterman's needlegrass. Forbs and other grasses make up smaller components. Utah juniper and singleleaf pinyon are described in the site concept and may or may not be present in low densities. Potential vegetative composition is about 65% grasses, 10% forbs and 25% shrubs. Approximate ground cover (basal and crown) is 20 to 30 percent.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	256	364	510
Shrub/Vine	98	140	196
Forb	39	56	78
Total	393	560	784

Community 1.2

Community Phase

This community phase is characteristic of a post-disturbance, early/mid-seral community. Bluebunch wheatgrass, needlegrasses and other perennial bunchgrasses dominate. Depending on fire severity patches of intact sagebrush may remain. Rabbitbrush and other sprouting shrubs may be present. Perennial forbs may be a significant component for a number of years following fire and may dominate in the higher elevation sites.

Community 1.3

Community Phase



Figure 8. Claypan 14+ (R028BY036NV). T. Stringham, July 2013

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.

Pathway a

Community 1.1 to 1.2

Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be low severity resulting in a mosaic pattern due to low 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 sagebrush to dominate the site.

Pathway a

Community 1.2 to 1.1

Time and lack of disturbance will allow sagebrush to establish.

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 may be high severity in this community phase due to the dominance of sagebrush resulting in removal of 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. Low sagebrush, lanceleaf rabbitbrush, bluebunch wheatgrass, muttongrass, pine needlegrass and Letterman's needlegrass dominate the site. Forbs and other shrubs and grasses make up smaller components of this site. Utah juniper and singleleaf pinyon are described in the site concept and may or may not be present in low densities.

Community 2.2

Community Phase

This community phase is characteristic of a post-disturbance, early to mid-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 or dominant in the community. Perennial forbs may be a significant component for a number of years and may dominate in the higher elevation sites. Annual non-native species are stable or increasing within the community.

Community 2.3

Community Phase (At Risk)

This community is at risk of crossing a threshold to another state. 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. Utah juniper and/or singleleaf pinyon may be present and without management will likely increase. Annual non-native 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.

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 sagebrush to dominate the site. Inappropriate grazing management reduces the perennial bunchgrass 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 low sagebrush can take many years.

Pathway a

Community 2.3 to 2.1

A change in grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall or winter grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in the herbaceous understory. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. 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. Annual non-native species are present and may increase in the community.

Pathway b

Community 2.3 to 2.2

Fire eliminates/reduces the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community. Annual non-native species respond well to fire and may increase post burn.

State 3

Shrub State

This state is characterized by low sagebrush or a sprouting shrub overstory with a Sandberg bluegrass understory. The site has crossed a biotic threshold and site processes are being controlled by shrubs. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. Bareground has increased and pedestalling of grasses may be excessive. Soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community 3.1

Community Phase

Decadent 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. Annual non-native species increase. Bare ground is significant. Utah juniper and/or singleleaf pinyon may be present.

Community 3.2

Community Phase

Annual non-native species may be present but are not dominant. Rabbitbrush may dominate overstory with trace amounts of sagebrush. Perennial forbs may be a significant component of the plant community.

Pathway a

Community 3.1 to 3.2

Fire reduces low sagebrush to trace amounts and allows for sprouting shrubs such as rabbitbrush to dominate. Excessive fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance would reduce sagebrush and facilitate sprouting shrubs.

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 the shrub component to recover. The establishment of low sagebrush can take many years.

State 4

Tree State

This state is characterized by a dominance of Utah juniper and/or singleleaf pinyon in the overstory. Low 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 bunchgrass may be found under tree canopies with trace amounts of forbs in the interspaces. Sagebrush is stressed and dying. Annual non-native species are present under tree canopies. Bare ground interspaces are large and connected.

Community 4.2

Community Phase

Utah juniper and/or singleleaf pinyon dominate overstory. Low sagebrush is decadent and dying with numerous skeletons present or sagebrush may be missing from the system. Bunchgrasses present in trace amounts and annual non-native species may dominate understory. Herbaceous species may be located primarily under the canopy or near the drip line of trees. Bare ground interspaces are large and connected. Soil movement may be apparent.

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

Eroded State

Abiotic factors including soil redistribution and erosion, soil temperature, soil crusting and sealing, and plant pedestalling are primary drivers of ecological function within this state. Soil moisture, soil nutrients and soil organic matter distribution and cycling are severely altered due to degraded soil surface conditions. Utah juniper and singleleaf pinyon or low sagebrush dominates the overstory and herbaceous species may be present in trace amounts particularly under tree or shrub canopies. Rabbitbrush may be a significant component. Regeneration of trees, shrubs or herbaceous species is not evident.

Community 5.1

Community Phase

Utah juniper and singleleaf pinyon or low sagebrush dominates the overstory and herbaceous species may be present in trace amounts particularly under tree or shrub canopies. Dead sagebrush skeletons are prominent. Pedestalled plants significant. Regeneration of trees, shrubs or herbaceous species is not evident. Annual non-native species present primarily under tree canopies.

Community 5.2

Community Phase

This phase is characterized by a significant loss of soil from this site. Erosion/soil redistribution is apparent; gullyng, rills, sheet erosion and water flow paths are extreme.

Pathway a

Community 5.1 to 5.2

Time and lack of management; excessive livestock use.

Transition A

State 1 to 2

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, mustards, and bur buttercup. 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 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 in community phase 2.3 will remove sagebrush overstory, decrease perennial bunchgrasses and enhance Sandberg bluegrass. Slow variables: Long term decrease in deep-rooted perennial grass density. Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

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. Minimal recruitment of new shrub cohorts.

Transition A
State 3 to 4

Trigger: Absence of disturbance over time allows for Utah juniper or singleleaf pinyon dominance. 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: Long-term increase in juniper and/or singleleaf pinyon density. Threshold: Trees overtop low sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs in number. There is minimal recruitment of new shrub cohorts.

Transition B
State 3 to 5

Trigger: Inappropriate grazing management causing a removal of perennial bunchgrasses and a disruption of the soil surface would increase soil erosion. Catastrophic fire followed by wind or rain events. Soil disturbing treatments such as a plowing or other mechanical shrub removal treatments. Slow variable: Bare ground interspaces large and connected; water flow paths long and continuous, understory is sparse, pedestalling of plants significant. Threshold: Soil redistribution and erosion is significant and linked to vegetation mortality evidenced by pedestalling and burying of herbaceous species and / or lack of recruitment in the interspaces.

Transition A
State 4 to 5

Trigger: Time and lack of disturbance or management allows for trees to out-compete remaining herbaceous understory; summer convection storm may initiate soil erosion event. Slow variables: Bare ground interspaces large and connected; water flow paths long and continuous; understory sparse. Threshold: Soil redistribution and erosion is significant and linked to vegetation mortality evidenced by pedestalling and burying of herbaceous species and / or lack of recruitment in the interspaces.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	Primary Perennial Grasses			207–392	
	bluebunch wheatgrass	PSSPS	<i>Pseudoroegneria spicata ssp. spicata</i>	168–280	–
	muttongrass	POFE	<i>Poa fendleriana</i>	28–56	–
	Lettermann's needlegrass	ACLE9	<i>Achnatherum lettermanii</i>	6–28	–
	pine needlegrass	ACPI2	<i>Achnatherum pinetorum</i>	6–28	–
2	Secondary Perennial Grasses			11–45	
	squirreltail	ELEL5	<i>Elymus elymoides</i>	3–11	–
	bluegrass	POA	<i>Poa</i>	3–11	–
Forb					
3	Perennial			28–84	
	aster	ASTER	<i>Aster</i>	3–11	–
	buckwheat	ERIOG	<i>Eriogonum</i>	3–11	–
	lupine	LUPIN	<i>Lupinus</i>	3–11	–
Shrub/Vine					
4	Primary Shrubs			95–168	
	little sagebrush	ARAR8	<i>Artemisia arbuscula</i>	84–140	–
	yellow rabbitbrush	CHVIL4	<i>Chrysothamnus viscidiflorus ssp. lanceolatus</i>	11–28	–
5	Secondary Shrubs			11–56	
	Utah serviceberry	AMUT	<i>Amelanchier utahensis</i>	6–17	–
	antelope bitterbrush	PUTR2	<i>Purshia tridentata</i>	6–17	–

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.

Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping rate on basal area of 5 bunchgrasses in eastern Oregon, and found grazing from August to October (after seed set) has the least impact. Heavy grazing during the growing season will reduce perennial bunchgrasses and increase sagebrush. Abusive grazing by cattle or horses will likely increase low sagebrush, rabbitbrush and some forbs. Annual non-native weedy species such as cheatgrass and mustards, and potentially medusahead, may invade.

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975, Britton et al. 1990). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949). 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.

Muttongrass is important range forage in the central Rocky Mountains, New Mexico and Arizona and is a component on this ecological site. It is a highly nutritious grass that is known for fattening sheep. Muttongrass greens up in early spring before many of the other perennial bunchgrasses, and is highly palatable to all classes of livestock as well as good forage to wildlife such as deer and elk (Dayton 1937). In a study by Currie et al. (1977) in a ponderosa pine forest deer preferred muttongrass which comprised up to 18% of their diet.

Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion and/or cheatgrass and other invasive species to occupy interspaces. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass or other weedy species. Depending on the season of use, the grazer and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

Antelope bitterbrush a minor component on this site is a critical browse species for mule deer, antelope and elk and is often utilized heavily by domestic livestock (Wood 1995). Grazing tolerance is dependent on site conditions (Garrison 1953) and the shrub can be severely hedged during the dormant season for grasses and forbs.

Domestic sheep and, to a much lesser degree, cattle consume low sagebrush, particularly during the spring, fall, and winter (Sheehy and Winward 1981). Heavy dormant season grazing by sheep will reduce sagebrush cover and increase grass production (Laycock 1967). Severe trampling damage to supersaturated soils could occur if sites are used in early spring when there is abundant snowmelt. However, trampling damage is likely to be localized in nature around areas where livestock or feral horses congregate. Trampling damage, particularly from cattle or horses, in low sagebrush habitat types is greatest when high clay content soils are wet. In drier areas with more gravelly soils, no serious trampling damage occurs, even when the soils are wet (Hironaka et al. 1983).

Wildlife Interpretations:

This ecological site provides valuable browse plants for wildlife (Clements and Young 1997, Sheehy and Winward 1981, Ngugi et al. 1992,). The ability of low sagebrush to grow on exposed sites provides important cover and feed for wintering animals. In other areas, low sagebrush may be used preferentially in winter when shorter grasses are buried by snow (Meuggler and Stewart 1980). Low sagebrush is considered valuable browse in the spring, fall and winter months for wildlife. In a study by Barnett and Crawford (1994), low sagebrush-bluebunch wheatgrass community was used during the pre-laying season of sagegrouse hens, sagebrush composed 50 to 80% of the diet by dry weight. Pronghorn antelope commonly use low sagebrush ranges throughout the summer months (Kindschy et al. 1982) and deer make heavy use of low sagebrush community types in early spring (Urness 1965).

Pygmy rabbits (*Brachylagus idahoensis*), a threatened species of conservation concern throughout Nevada often burrow where low sagebrush mixes with mountain big sagebrush. Low sagebrush is an important shrub for pygmy rabbits and other sagebrush obligate species (Oregon Conservation Strategy, 2006). In southwest Idaho, Oregon, Montana and Nevada, pygmy rabbits will burrow where the big sagebrush form islands within the low sagebrush matrix (Keinath and McGee 2004). Sage grouse (*Centrocercus urophasianus*), another threatened species of conservation concern and sagebrush obligate species, feeds almost exclusively on leaves of sagebrush. Although big sagebrush dominates the diet in most portions of the range, sage grouse inhabit low sagebrush varieties will be consumed depending on availability (Connelly et al. 2000). Other bird species, gray flycatcher (*Empidonax wrightii*), horned lark (*Eremophila alpestris*), vesper sparrow (*Poocetes gramineus*) and western meadowlark (*Sturnella neglecta*), use low sagebrush, as it provides intermediate cover (Holmes and Alman Saab and Marks. 1992). Several reptiles and amphibians are distributed throughout the sagebrush steppe in the west in Nevada, where low 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 hernandesi*), desert-horned lizard (*Phrynosoma platyrhinos*), sagebrush lizards (*Sceloporus graciosus*), western fence lizards (*Sceloporus occidentalis*), northern side-blotched lizards (*Uta stansburiana nevadaensis*), 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). Changes in plant community composition caused by fire frequency, and other threats associated with this ecological site could affect the distribution and presence of wildlife species.

Further threats to low sagebrush dominant habitats include the Aroga moth. The Aroga moth is a sagebrush defoliator that threatens to infest extensive sagebrush stands throughout Great Basin rangelands (Bentz et al. 2008). Climate is generally believed to play a key role in determining the timing of insect outbreaks on Great Basin rangelands, but the exact mechanisms are not well understood (Bentz et al. 2008). These factors make management difficult; therefore, additional knowledge is needed to identify the susceptibility of landscapes altered by climate change and humans, as well as optimal strategies for management of host plants and insects populations residing in these changed systems (Bentz et al. 2008). This information will help managers and land owners alike manage the range for optimal productivity.

Hydrological functions

Rills are none. Gravels and cobbles armor the surface. Water flow patterns are none to rare. Pedestals are none to rare. 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) slow runoff and increase infiltration. Shrub canopy and associated litter break raindrop impact and provide opportunity for snow catch and accumulation on site.

Recreational uses

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

Other products

Lanceleaf rabbitbrush can be a source of rubber and possibly valuable resins.

Other information

Low sagebrush can be successfully transplanted or seeded in restoration. Letterman's needlegrass has been used successfully in revegetating mine spoils. This species also has good potential for erosion control.

Other references

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

Barnett, J. K. and J. A. Crawford. 1994. Pre-laying nutrition of sage grouse hens in Oregon. *Journal of Range Management* 47:114-118.

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.

Beardall, L. E. and V. E. Sylvester. 1976. Spring burning of removal of sagebrush competition in Nevada. Pages 539-547 in *Proceedings- Tall Timbers fire ecology conference and fire and land management symposium*. Tall Timbers Research Station.

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

Blaisdell, J. P. and W. F. Mueggler. 1956. Sprouting of Bitterbrush (*Purshia Tridentata*) Following Burning or Top Removal. *Ecology* 37:365-370.

- Blaisdell, J. P. 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. Fire ecology of forests and woodlands in Utah. Gen. Tech. Rep. INT-287. U.S. Department of Agriculture, Forest Service, Intermountain Research Station.
- 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.
- Clark, R. G., M. B. Carlton, and F. A. Sneva. 1982. Mortality of Bitterbrush after Burning and Clipping in Eastern Oregon. *Journal of Range Management* 35:711-714.
- Clements, C. D. and J. A. Young. 2002. Restoring Antelope Bitterbrush. *Rangelands* 24:3-6.
- Comstock, J. P. and J. R. Ehleringer. 1992. Plant adaptation in the Great Basin and Colorado plateau. *Western North American Naturalist* 52:195-215.
- Conrad, C. E. and C. E. Poulton. 1966. Effect of a wildfire on Idaho fescue and bluebunch wheatgrass. *Journal of Range Management*:138-141.
- 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.
- Daubenmire, R. 1970. *Steppe vegetation of Washington*. 131 pp.
- Daubenmire, R. 1975. Plant succession on abandoned fields, and fire influences in a steppe area in southeastern Washington. *Northwest Science* 49:36-48.
- Dayton, W. 1937. *Range plant handbook*. USDA, Forest Service. Bull.
- Dobrowolski, J.P., Caldwell, M.M. and Richards, J.H. 1990. Basin hydrology and plant root systems. In: *Plant Biology of the Basin and Range*. Springer-Verlag Pub., New York, NY.
- 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/>).

- Furniss, M. M. and W. F. Barr. 1975. Insects affecting important native shrubs of the northwestern United States. US Intermountain Forest And Range Experiment Station. USDA Forest Service General Technical Report INT INT-19.
- Ganskopp, D. 1988. Defoliation of Thurber Needlegrass: Herbage and Root Responses. *Journal of Range Management* 41:472-476.
- Garrison, G. A. 1953. Effects of Clipping on Some Range Shrubs. *Journal of Range Management* 6:309-317.
- Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Bulletin Number 35. University of Idaho, Forest, Wildlife and Range Experiment Station, Moscow, ID.
- 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.
- Jensen, M.E. Interpretation of environmental gradients which influence sagebrush community distribution in northeastern Nevada. *J. of Range Management* 43(2):161-166.
- Kerns, B. K., W. G. Thies, and C. G. Niwa. 2006. Season and severity of prescribed burn in ponderosa pine forests: implications for understory native and exotic plants. *Ecoscience* 13:44-55.
- Kindschy, R. R., C. S. Undstrom, and J. D. Yoakum. 1982. Wildlife habitats in managed rangelands - the Great Basin of southeastern Oregon: pronghorns. Gen. Tech. Rep. PNW-GTR-145. Portland, OR.
- Kitchen, S. G. and E. D. McArthur. 2007. Big and black sagebrush landscapes. Pages 73-95 in *Fire ecology and mangement of the major ecosystems of southern Utah*. Gen. Teck. Rep. RMRMS-GTR-202. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
- 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* 20:206-213.
- 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.
- Mueggler, W. F. 1975. Rate and Pattern of Vigor Recovery in Idaho Fescue and Bluebunch Wheatgrass. *Journal of Range Management* 28:198-204.
- Murray, R. 1983. Response of antelope bitterbrush to burning and spraying in southeastern Idaho. Tiedemann, Arthur R.; Johnson, Kendall L., compilers. *Research and management of bitterbrush and cliffrose in western North America*. General Technical Report INT-152. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station:142-152.
- 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/>
- 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.
- Sheehy, D. P. and A. H. Winward. 1981. Relative Palatability of Seven *Artemisia* Taxa to Mule Deer and Sheep. *Journal of Range Management* 34:397-399.

- 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 119:174-184.
- Tisdale, E. W. and M. Hironaka. 1981. The sagebrush-grass region: A review of the ecological literature. University of Idaho, Forest, Wildlife and Range Experiment Station.
- Uresk, D. W., J. F. Cline, and W. H. Rickard. 1976. Impact of wildfire on three perennial grasses in south-central Washington. Journal of Range Management 29:309-310.
- Urness, P. J. 1965. Influence of range improvement practices on composition, production, and utilization of Artemisia deer winter range in central Oregon. Oregon State University.
- USDA-NRCS Plants Database (Online; <http://www.plants.usda.gov>).
- 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.
- Wood, M. K., Bruce A. Buchanan, & William Skeet. 1995. Shrub preference and utilization by big game on New Mexico reclaimed mine land. Journal of Range Management 48:431-437.
- Wright, H. A. 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
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)	Patti Novak-Echenique
Contact for lead author	State Rangeland Management Specialist
Date	12/02/2009

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. Rock fragments armor the surface.

2. **Presence of water flow patterns:** Water flow patterns are none to rare (short and stable).

3. **Number and height of erosional pedestals or terracettes:** Pedestals are none to rare. 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.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground \pm 5-20%.

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.

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. (To be field tested.)

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

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., bluebunch wheatgrass]) slow runoff and increase infiltration. Shrub canopy and associated litter 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. Subsoil argillic or massive horizons are not to be interpreted as compacted.

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 > low shrubs (low sagebrush)
>associated shrubs

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

Other:

Additional:

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 20% of total woody canopy; some of the mature bunchgrasses (<10%) have dead centers.
-

14. **Average percent litter cover (%) and depth (in):** Under canopy and between plant interspaces ($\pm 25\%$) and litter depth is $\pm \frac{1}{4}$ inch.
-

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** For normal or average growing season (thru June) ± 500 lbs/ac; Favorable years ± 700 lbs/ac and unfavorable years ± 350 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 cheatgrass, annual mustards, Russian thistle and halogeton.
-

17. **Perennial plant reproductive capability:** All functional groups should reproduce in average (or normal) and above average growing season years.
-