

Ecological site R028AY047NV DROUGHTY CALCAREOUS LOAM 8-10 P.Z. (burned phase)

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General information

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

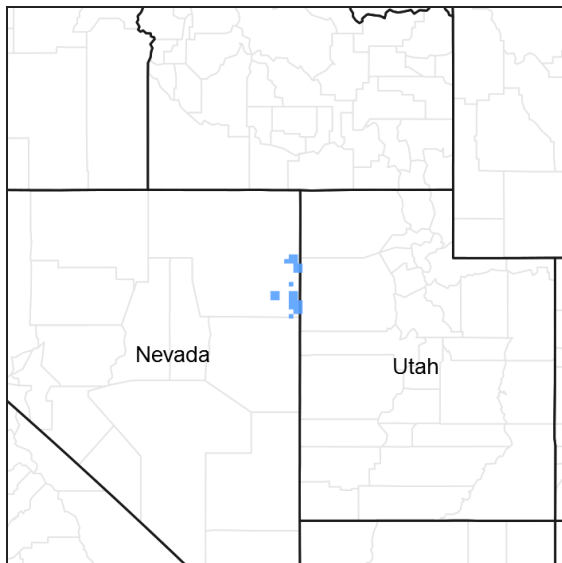


Figure 1. Mapped extent

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

MLRA notes

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

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

Ecological site concept

This site occurs on fan piedmonts and on hill footslopes. Slopes range from 4 to 30 percent, but slope gradients of 4 to 15 percent are typical. Elevations are 5300 to 6500 feet.

The climate associated with this site is semiarid, characterized by cool, moist winters and warm, dry summers. Average annual precipitation is 8 to 10 inches. Mean annual air temperature is 45 to 50 degrees F. The average growing season is about 100 to 120 days.

The soils of this site are generally moderately deep to deep and well drained. They are moderately coarse with surface textures being gravelly to very gravelly. They have medium runoff and have moderate to moderately rapid permeability. Available water holding capacity is low to moderate.

The reference state is dominated by spiny hopsage, black sagebrush, Indian ricegrass and needleandthread.

Production ranges from 200 to 600 pounds per acre.

Associated sites

R024XY015NV	DEEP SODIC FAN
R028AY004NV	SHALLOW CALCAREOUS SLOPE 8-10 P.Z.
R028AY013NV	SHALLOW CALCAREOUS LOAM 8-10 P.Z.

Similar sites

R028AY013NV	SHALLOW CALCAREOUS LOAM 8-10 P.Z. Shallow Calcareous Loam 8-10" PZ. ARNO4 dominant shrub; GRSP minor shrub.
R028AY035NV	SHALLOW CLAY LOAM 10-12 P.Z. Shallow Clay Loam 10-12" PZ. ACHY-ACTH7 codominant; more productive site.
R028AY004NV	SHALLOW CALCAREOUS SLOPE 8-10 P.Z. Shallow Calcareous Slope 8-10" PZ. ARNO4 dominant shrub; GRSP minor shrub.
R028AY027NV	SHALLOW CALCAREOUS HILL 8-10 P.Z. Shallow Calcareous Hill 8-10" PZ. JUOS dominates visual aspect.
R028AY034NV	SHALLOW CALCAREOUS SLOPE 10-14 P.Z. Shallow Calcareous Slope 10-14" PZ. PSSPS dominant grass.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Grayia spinosa</i> (2) <i>Artemisia nova</i>
Herbaceous	(1) <i>Achnatherum hymenoides</i> (2) <i>Hesperostipa comata</i>

Physiographic features

This site occurs on fan piedmonts and on hill footslopes. Slopes range from 4 to 30 percent, but slope gradients of 4 to 15 percent are typical. Elevations are 5300 to 6500 feet.

Table 2. Representative physiographic features

Landforms	(1) Fan piedmont (2) Hill
Elevation	1,615–1,981 m
Slope	4–30%

Climatic features

Nevada's climate is predominantly arid, with large daily ranges of temperature, infrequent severe storms, heavy snowfall in the higher mountains, and great location variations with elevation. Three basic geographical factors largely influence Nevada's climate: continentality, latitude, and elevation. Continentality is the most important factor. The strong continental effect is expressed in the form of both dryness and large temperature variations. Nevada lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that markedly influences the climate of the State. The prevailing winds are from the west, and as the warm moist air from the Pacific Ocean ascend the western slopes of the Sierra Range, the air cools, condensation occurs and most of the moisture falls as precipitation. As the air descends the eastern slope, it is warmed by compression, and very little precipitation occurs. The effects of this mountain barrier are felt not only in the West but throughout the state, with the result that the lowlands of Nevada are largely desert or steppes. The temperature regime is also affected by the blocking of the inland-moving maritime air. Nevada sheltered from maritime winds, has a continental climate with well-developed seasons and the terrain responds quickly to changes in solar heating.

Nevada lies within the mid-latitude belt of prevailing westerly winds which occur most of the year. These winds bring frequent changes in weather during the late fall, winter and spring months, when most of the precipitation occurs. To the south of the mid-latitude westerlies, lies a zone of high pressure in subtropical latitudes, with a center over the Pacific Ocean. In the summer, this high-pressure belt shifts northward over the latitudes of Nevada, blocking storms from the ocean. The resulting weather is mostly clear and dry during the summer and early fall, with scattered thundershowers. The eastern portion of the state receives significant summer thunderstorms generated from monsoonal moisture pushed up from the Gulf of California, known as the North American monsoon. The monsoon system peaks in August and by October the monsoon high over the Western U.S. begins to weaken and the precipitation retreats southward towards the tropics (NOAA 2004).

The climate associated with this site is semiarid, characterized by cool, moist winters and warm, dry summers. Average annual precipitation is 8 to 10 inches. Mean annual air temperature is 45 to 50 degrees F. The average growing season is about 100 to 120 days.

Mean annual precipitation at OASIS, NEVADA (265722) Climate station is 8.58 inches.

Monthly mean precipitation is:

January 0.65; February 0.58; March 0.69;
April 0.96; May 1.23; June 0.94; July 0.46;
August 0.62; September 0.47; October 0.76;
November 0.63; December 0.59.

Table 3. Representative climatic features

Frost-free period (average)	110 days
Freeze-free period (average)	110 days
Precipitation total (average)	229 mm

Influencing water features

There are no influencing water features associated with this site.

Soil features

The soils of this site are generally very deep and well drained. They are moderately coarse with surface textures being gravelly to very gravelly. They have medium runoff and have moderate to moderately rapid permeability. Available water holding capacity is low to moderate.

The representative soil series is Armespan, a Loamy-skeletal, mixed, superactive, mesic Durinodic Xeric Haplocalcids. Diagnostic horizons include an Ochric epipedon from the soil surface to 18 cm, Calcic horizon from 23 to 79 cm and a Duric feature from 48 to 79 cm. Clay content in the particle control section averages 10 to 18 percent. Rock fragments range from 35 to 60 percent, mainly gravel of mixed lithologies. Reaction is moderately or strongly alkaline. Effervescence is strongly or violently effervescent throughout. Lithology consists of mixed rocks.

Table 4. Representative soil features

Surface texture	(1) Very gravelly sandy loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderately rapid
Soil depth	183–213 cm
Surface fragment cover <=3"	35–40%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	5.08–10.16 cm
Calcium carbonate equivalent (0-101.6cm)	10–35%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	8.3–9
Subsurface fragment volume <=3" (Depth not specified)	35–60%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

This ecological site is dominated by deep-rooted cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). However, community types with black sagebrush as the dominant shrub were found to have soil depths and thus available rooting depths of 77 to 81 cm in a study in northeast Nevada (Jensen 1990). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

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

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

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

The perennial bunchgrasses that are co-dominant with the shrubs include Indian ricegrass, needleandthread, Sandberg bluegrass, galleta 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 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 Utah juniper has increased since the middle of the nineteenth century (Tausch 1999, Miller and Tausch 2000). Causes for expansion of 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 black sagebrush ecosystems were greater than 100 years, however frequent enough to inhibit the encroachment of Utah juniper into these low productive sagebrush cover types (Kitchen and McArthur 2007). Thus, trees were isolated to fire-safe areas such as rocky outcroppings and areas with low-productivity. An increase in crown density causes a decrease in understory perennial vegetation and an increase in bare ground. This allows for the invasion of non-native annual species such as cheatgrass. With annual species in the understory wildfire can become more frequent and increase in intensity. With frequent wildfires these plant communities can convert to annual species with a sprouting shrub and juvenile tree overstory.

The ecological site has low to moderate resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Six possible stable states have been identified for this site.

Fire Ecology:

Fire is not a major disturbance of these community types (Winward 2001), and would be infrequent. Historic fire return intervals have been estimated at 100 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 1 growing season (Beetle 1960). A few seeds may remain viable in soil for 2 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, spiny hopsage and/or shadscale may become the dominant shrub species following fire. Douglas' rabbitbrush and ephedra can also sprout after fire and become a dominant shrub on this site often with an understory of galleta, Sandberg bluegrass and/or cheatgrass and other weedy species.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. The two dominant grasses on this site, Indian ricegrass and needleandthread grass, have different responses to fire. Needleandthread is top-killed by fire but is likely to resprout if fire does not consume above ground stems (Akinsoji 1988, Bradley et al. 1992). In a study by Wright and Klemmedson (1965), season of burn rather than fire intensity seemed to be the crucial factor in mortality for needleandthread grass. Early spring season burning was found to kill the plants while August burning had no effect. Indian ricegrass is fairly fire tolerant

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

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

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). 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). Utah juniper woodlands reach mature stage between 85 to 150 years after fire (Barney and Frischknecht 1974, Tausch and West 1988).

State and transition model

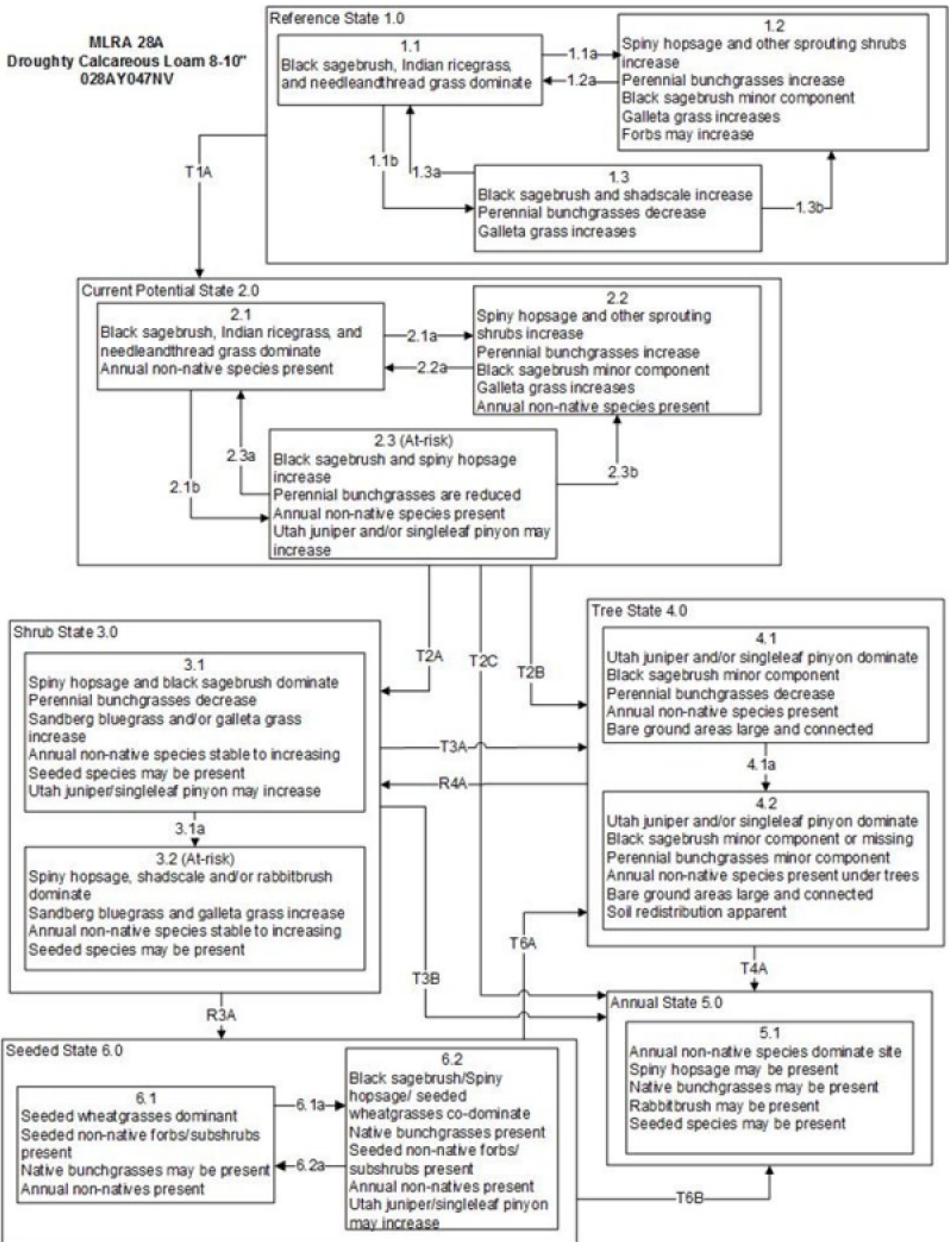


Figure 6. State and Transition Model

MLRA 28A
Droughty Calcareous Loam 8-10"
028AY047NV

Reference State 1.0 Community Pathways

- 1.1a: Low severity fire resulting in a mosaic pattern.
- 1.1b: Time and lack of disturbance such as fire, long-term drought, herbivory, or combinations of these.
- 1.2a: Time and lack of disturbance such as fire, long-term drought, herbivory, or combinations of these.
- 1.3a: Low severity fire or herbivory resulting in a mosaic pattern.
- 1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native plants.

Current Potential State 2.0 Community Pathways:

- 2.1a: Fire or brush treatments (i.e. mowing) with minimal soil disturbance.
- 2.1b: Time and lack of disturbance such as fire; long-term drought, inappropriate grazing management, or combinations of these would allow the sagebrush overstory to increase and dominate the site.
- 2.2a: Time and lack of disturbance such as fire, long-term drought, inappropriate grazing management, or combinations of these.
- 2.3a: Low severity fire, late fall/winter grazing or brush treatment with minimal soil disturbance creates sagebrush/ grass mosaic.
- 2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community

Transition T2A: Inappropriate cattle/horse grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or inappropriate sheep grazing management will lead to phase 3.2.

Transition T2B: Time and lack of disturbance allows for maturation of the tree community.

Transition T2C: Catastrophic fire or soil disturbing brush treatments.

Shrub State 3.0 Community Pathways

- 3.1a: Fire and/or sheep grazing. Brush treatments (i.e. mowing) with minimal soil disturbance.

Transition T3A: Time and lack of disturbance allows for maturation of the tree community. Inappropriate grazing will expedite this transition.

Transition T3B: Fire and/or soil disturbing treatments.

Restoration Pathway R3A: Drill or aerial seeding of native and non-native wheatgrasses, forbs, and other species.

Tree State 4.0 Community Pathways

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

Transition T4A: Catastrophic fire that significantly reduces or eliminates tree and any remaining shrub overstory. Inappropriate tree removal practices may also contribute to this transition.

Restoration Pathway R4A: Removal of trees and seeding of desired species.

Seeded State 6.0 Community Pathways

- 6.1a: Inappropriate grazing management during the growing season facilitates shrub establishment and dominance.
- 6.2a: Fire or brush treatments with minimal soil disturbance.

Transition T6A: Time without disturbance allows trees to establish and dominate the site; may be coupled with grazing management that favors reduced perennial grass density and increased tree establishment.

Transition T6B: High severity fire and/or inappropriate grazing management. Soil disturbing brush treatments may also lead to the annual state.

Figure 7. Legend

State 1

Reference State

The Reference State 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 shrub dominant phase and a grass dominate phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack. Due to the nature and extent of disturbance in this site, all three plant community phases would likely occur in a mosaic across the landscape. Utah juniper may be present on the site, but will only occur as scattered trees and will not dominate the site.

Community 1.1 Community Phase

This community is dominated by spiny hopsage and black sagebrush in the overstory with Indian ricegrass and needle, thread grass, Sandberg's bluegrass and galleta grass are dominant in the understory. Utah juniper may be present. Potential vegetative composition is about 40% grasses, 5% forbs and 55% shrubs. Approximate ground cover (basal and crown) is 25 to 35 percent.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	123	247	370
Grass/Grasslike	90	179	269
Forb	11	22	34
Total	224	448	673

Community 1.2 Community Phase

This community phase is characteristic of a post-disturbance, early seral community phase. Indian ricegrass and needleandthread and other perennial bunchgrasses dominate. Sprouting shrubs such as Douglas' rabbitbrush, spiny hopsage, and shadscale may increase. Black sagebrush could still be present in unburned patches. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Galleta will generally increase following fire, but may decrease in below-average years of precipitation. Sandberg's bluegrass may also increase.

Community 1.3 Community Phase

Black sagebrush increases in the absence of disturbance. Spiny hopsage and black sagebrush, dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or herbivory. Sandberg's bluegrass and/or galleta may increase in the understory and become the dominant grass on the site. Scattered Utah juniper may be present on the site.

Pathway a Community 1.1 to 1.2

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

Pathway b Community 1.1 to 1.3

Absence of disturbance over time, significant herbivory, chronic drought or combinations of these would allow the sagebrush overstory to increase and dominate the site. This will generally cause a reduction in perennial bunch grasses; however galleta grass may increase in the understory depending on the grazing management. Heavy spring grazing will favor an increase in sagebrush.

Pathway a Community 1.2 to 1.1

Time and lack of disturbance will allow sagebrush to establish.

Pathway a

Community 1.3 to 1.1

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

Pathway b

Community 1.3 to 1.2

Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be high intensity due to the dominance of sagebrush resulting in removal of the overstory shrub community.

State 2

Current Potential State

This state is similar to the Reference State 1.0 and has three similar community phases. Ecological function has not changed in this state, but the resiliency of the state has been reduced by the presence of invasive weeds. These non-native species can be highly flammable, and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate and adaptations for seed dispersal.

Community 2.1

Community Phase

This community phase is compositionally similar to the Reference State Community Phase 1.1 with the presence of non-native species in trace amounts. This community is dominated by spiny hopsage and black sagebrush in the overstory with Indian ricegrass, needleandthread grass, Sandberg's bluegrass, and galleta dominant in the understory. Utah juniper may be present.

Community 2.2

Community Phase

This community phase is characteristic of a post-disturbance, early seral community where annual non-native species are present. 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 or other sprouting shrubs may be increasing. Annual non-native species are stable or increasing within the community. Galleta will generally increase following fire, but may decrease in below-average years of precipitation. Annual non-native species generally respond well after fire and may be 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. Galleta and/or Sandberg bluegrass may increase and become co-dominant with deep rooted bunchgrasses. Utah juniper 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).

Pathway a

Community 2.1 to 2.2

A low severity fire (or brush management) would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring 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.

Conservation practices

Brush Management

Pathway b Community 2.1 to 2.3

Absence of disturbance over time, chronic drought, inappropriate grazing management or combinations of these would allow the sagebrush overstory to increase and dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely galleta grass and/or Sandberg bluegrass may increase in the understory.

Pathway a Community 2.2 to 2.1

Absence of disturbance over time 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 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 promoting the perennial bunchgrass understory. An infestation of Aroga moth will reduce some sagebrush overstory and allow perennial grasses to increase in the community. 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.

Conservation practices

Brush Management

Pathway b Community 2.3 to 2.2

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

State 3 Shrub State

This state has two community phases, one that is characterized by a black sagebrush overstory and the other with a shadscale or rabbitbrush overstory with a Sandberg bluegrass or galleta grass 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

Black sagebrush dominates overstory while Sandberg bluegrass or galleta grass dominates the understory. Deep-rooted perennial bunchgrasses have significantly declined. Annual non-native species may be present. Bare ground and soil redistribution may be increasing. If present on the site, Utah juniper is increasing. The community phase may be at risk of transitioning into a Tree State or Annual State

Community 3.2

Community Phase

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

Pathway a

Community 3.1 to 3.2

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

Conservation practices

Brush Management

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, which are characterized by a dominance of Utah juniper in the overstory. Singleleaf pinyon may play a significant role in the higher elevation ranges within this site. Black sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients and soil organic matter distribution and cycling have been spatially and temporally altered.

Community 4.1

Community Phase

Juniper trees dominate overstory, sagebrush is decadent and dying, deep rooted perennial bunchgrasses are decreasing. Recruitment of sagebrush cohorts is minimal. Annual non-natives may be present or increasing. Bare ground in interspaces are large and connected.

Community 4.2

Community Phase

Juniper trees dominate overstory. Black 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

Annual State

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, halogeton, and mustards. Resiliency has declined and further degradation from fire facilitates a cheatgrass and sprouting shrub plant community. 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

Cheatgrass, mustards, halogeton and other annuals dominate the site. Halogeton more readily invades this site. Sprouting shrubs may be present. Erosion may be significant.

State 6

Seeded State

This state has two community phases, a grass-dominated phase and a shrub dominated phase. The grass phase is characterized by the dominance of seeded introduced wheatgrass species. Forage kochia and other desired seeded species including black sagebrush and native and non-native forbs may be present. The shrub phase is dominated by black sagebrush which has reestablished on the site.

Community 6.1

Community Phase

Introduced wheatgrass species and other non-native species such as forage kochia dominate the community. Native and non-native seeded forbs may be present. Trace amounts of black sagebrush may be present. Native bunchgrasses may be present. Annual non-native species present.

Community 6.2

Community Phase

Black sagebrush and seeded wheatgrass species co-dominate. Native bunchgrasses may be present. Annual non-native species stable to increasing.

Pathway a

Community 6.1 to 6.2

Inappropriate grazing management particularly during the growing season reduces perennial bunchgrass vigor and density and facilitates shrub establishment if a seed source is available.

Pathway a

Community 6.2 to 6.1

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

Conservation practices

Brush Management

Transition A

State 1 to 2

Trigger: Introduction of non-native annual plants. Slow variables: Over time the annual non-native plants will increase within the community. Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Transition A

State 2 to 3

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

Transition B

State 2 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 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. Redistribution of soil, organic matter and nutrients may occur with water and wind erosion.

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. 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 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: Fire or treatments that disturb the soil and existing plant community (ex: failed restoration attempts). Slow variables: Increased seed production and cover of annual non-native species. Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

Restoration pathway A

State 3 to 6

Seeding of deep-rooted introduced bunchgrasses and other desired species; may be coupled with brush

management and/or herbicide. Probability of success is low.

Conservation practices

Range Planting

Restoration pathway A

State 4 to 3

Removal of trees and range seeding in community phase 4.1. If restoration efforts fail, this site could transition to Annual State 5.0

Conservation practices

Brush Management

Range Planting

Transition A

State 4 to 5

Trigger: Catastrophic fire causing a stand replacement event. Inappropriate tree removal practices with soil disturbance will also cause a transition to Annual State 5. Slow variables: Increased production and cover of non-native annual species under tree canopies. Threshold: Closed tree canopy with non-native annual species dominant in the understory changes the intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impacts nutrient cycling and distribution.

Transition A

State 6 to 4

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

Transition B

State 6 to 5

Trigger: Fire, inappropriate grazing management or treatments that disturb the soil and existing plant community (ex: failed restoration attempts). Slow variables: Increased seed production and cover of annual non-native species. Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	Primary Perennial Grasses			108–202	
	Indian ricegrass	ACHY	<i>Achnatherum hymenoides</i>	67–112	–
	needle and thread	HECO26	<i>Hesperostipa comata</i>	22–45	–
	James' galleta	PLJA	<i>Pleuraphis jamesii</i>	9–22	–
	Sandberg bluegrass	POSE	<i>Poa secunda</i>	9–22	–
2	Secondary Perennial Grasses			22–45	
	threeawn	ARIST	<i>Aristida</i>	2–13	–
	squirreltail	ELEL5	<i>Elymus elymoides</i>	2–13	–
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	2–13	–
Forb					
3	Primary Perennial Forbs			9–22	
	globemallow	SPHAE	<i>Sphaeralcea</i>	9–22	–
4	Secondary Perennial Forbs			9–36	
	buckwheat	ERIOG	<i>Eriogonum</i>	2–13	–
	phlox	PHLOX	<i>Phlox</i>	2–13	–
Shrub/Vine					
5	Primary Perennial Shrubs			157–247	
	spiny hopsage	GRSP	<i>Grayia spinosa</i>	90–135	–
	black sagebrush	ARNO4	<i>Artemisia nova</i>	67–112	–
6	Secondary Perennial Shrubs			9–67	
	shadscale saltbush	ATCO	<i>Atriplex confertifolia</i>	4–13	–
	yellow rabbitbrush	CHVI8	<i>Chrysothamnus viscidiflorus</i>	4–13	–
	Nevada jointfir	EPNE	<i>Ephedra nevadensis</i>	4–13	–
	broom snakeweed	GUSA2	<i>Gutierrezia sarothrae</i>	4–13	–
	horsebrush	TETRA3	<i>Tetradymia</i>	4–13	–

Animal community

Livestock/Wildlife Grazing Interpretations:

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

Black sagebrush 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 increases the potential negative impacts on remaining black sagebrush plants from grazing or browsing pressure following fire (Wambolt 1996). Pronghorn utilize black sagebrush heavily (Beale and Smith 1970). On the Desert Experiment Range, black sagebrush was found to comprise 68% of pronghorn diet even though it was only the third most common plant. Fawns were found to prefer black sagebrush utilizing it more than all other forage species combined (Beale and Smith 1970). Domestic livestock will also utilize black sagebrush. The domestic sheep industry that emerged in the Great Basin in the early 1900s was largely based on wintering domestic sheep in black sagebrush communities (Mozingo 1987). Domestic sheep will browse black sagebrush during all seasons of the year depending on the availability of other forage species, with greater amounts being consumed in fall and winter. Black sagebrush is generally less palatable to cattle than to domestic sheep and wild ungulates (McArthur et al. 1979); 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). Dormant season use of black sagebrush can reduce sagebrush density and increase the density of bunchgrasses such as Indian ricegrass.

Inappropriate grazing management during the growing season will cause a decline in understory plants such as

needleandthread and Indian ricegrass. Growing season grazing by cattle may initially cause a decrease in the bunchgrass component and give a competitive advantage to shrub species including black sagebrush (Eckert et al. 1972).

Specifically, needleandthread grass is most commonly found on warm/dry soils (Miller et al. 2013) and is not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller and Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972). With the reduction in competition from deep rooted perennial bunchgrasses, the rhizomatous galleta grass and short-statured Sandberg bluegrass will likely increase (Jameson 1962, Smoliak et al. 1972)

Indian ricegrass is a deep-rooted, cool season perennial bunchgrass that is adapted primarily to coarse textured soils. Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971), however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck et al. 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1976). Cook and Child (1971) found significant reduction in plant cover after seven years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended. In summary, adaptive management is required to manage this bunchgrass well.

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

Hydrological functions

Runoff is medium.

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

Some Native American peoples traditionally ground parched seeds of spiny hopsage to make pinole flour. Indian ricegrass was traditionally eaten by some Native Americans. The Paiutes used seed as a reserve food source.

Other information

Spiny hopsage has moderate potential for erosion control and low to high potential for long-term revegetation projects. It can improve forage, control wind erosion, and increase soil stability on gentle to moderate slopes. Spiny hopsage is suitable for highway plantings on dry sites in Nevada. 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. Needleandthread grass is useful for stabilizing eroded or degraded sites.

Other references

- Akinsoji, A. 1988. Postfire vegetation dynamics in a sagebrush steppe in southeastern Idaho, USA. *Vegetatio* 78:151-155.
- 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 (2006): 670-697.
- Beale, D.M. and A.D. Smith. 1970. Forage use, water consumption, and productivity of pronghorn antelope in western Utah. *Journal of Wildlife Management* 34(3):570-582.
- Beetle, A.A. 1960. A study of sagebrush: The section *Tridentatae* of *Artemisia*. Bulletin 368. Laramie, WY: University of Wyoming, Agricultural Experiment Station. 83 p.
- Bentz, B., D. Alston, and T. Evans. 2008. Great Basin Insect Outbreaks. In: Chambers, Jeanne C.; Devoe, Nora; Evenden, Angela, eds. Collaborative management and research in the Great Basin - examining the issues and developing a framework for action. Gen. Tech. Rep. RMRS-GTR-204. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 45-48.
- Bich, B.S., J.L. Butler, and C.A. Schmidt. 1995. Effects of differential livestock use of key plant species and rodent populations within selected *Oryzopsis hymenoides*/*Hilaria jamesii* communities in Glen Canyon National Recreation Area. *The Southwestern Naturalist* 40(3):281-287.
- Booth, D. T., C. G. Howard, and C. E. Mowry. 2006. 'Nezpar' Indian ricegrass: description, justification for release, and recommendations for use. *Rangelands Archives* 2:53-54.
- Boltz, M. 1994. Factors influencing postfire sagebrush regeneration in south-central Idaho. In: Monsen, S.B. and S.G. Kitchen (compilers). *Proceedings--ecology and management of annual rangelands; 1992 May 18-22; Boise, ID*. Gen. Tech. Rep. INT-GTR-313. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: Pp. 281-290.
- Bradley, A., Noste, N. and Fischer, W. 1992. Fire ecology of forests and woodlands in Utah. USDA Forest Service, Intermountain Research Station, General Technical Report INT-287, 92 pp.
- 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.
- Caudle, D., J. DiBenedetto, M. Karl, H. Sanchez, and C. Talbot. 2013. Interagency ecological site handbook for rangelands. Available at: <http://jornada.nmsu.edu/sites/jornada.nmsu.edu/files/InteragencyEcolSiteHandbook.pdf>. Accessed 4 October 2013.
- Comstock, J and J. Ehleringer. 1992. Plant adaptation in the Great Basin and Colorado plateau. *Western North American Naturalist* 52(3):195-215.
- Cook, C. W. 1962. An Evaluation of Some Common Factors Affecting Utilization of Desert Range Species. *Journal of Range Management* 15:333-338.
- Cook, C.W. and R.D. Child. 1971. Recovery of desert plants in various states of vigor. *Journal of Range Management* 24(5):339-343.
- Daubenmire, R.F. 1970. Steppe vegetation of Washington. Technical Bulletin 62. Pullman, WA: Washington State University, College of Agriculture, Washington Agricultural Experiment Station. 131 p.
- Daubenmire, R.F. 1975. Plant succession on abandoned fields, and fire influences, in a steppe area in southeastern Washington. *Northwest Science* 49(1):36-48.
- 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., A.D. Bruner and G.J. Klomp. 1972. Response of understory species following herbicidal control of

low sagebrush. *Journal of Range Management* 25:280-285.

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(2):156-159.

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/>).

Horton, H. 1989. Interagency forage and conservation planting guide for Utah. Extension Circular 433. Logan, UT: Utah State University, Cooperative Extension Service. 67 p.

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.

Jameson, Donald A. 1962. Effects of burning on a galleta-black grama range invaded by juniper. *Ecology*. 43(4): 760-763.

Jensen, M. E. 1990. Interpretation of Environmental Gradients Which Influence Sagebrush Community Distribution in Northeastern Nevada. *Journal of Range Management* 43:161-167.

Kitchen, S.G. and E.D. McArthur. 2007. Big and black sagebrush landscapes. In: Hood, S.M. and M. Miller (Eds.). *Fire ecology and management of the major ecosystems of southern Utah*. Gen. Tech. Rep. RMRS-GTR-202. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 73-95.

McArthur, E.D., A.C. Blauer, A.P. Plummer, and R. Stevens. 1979. Characteristics and hybridization of important Intermountain shrubs. III. Sunflower family. Res. Pap. INT-220. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 82 p.

Meyer, S.E. 2008. *Artemisia L.--sagebrush*. In: Bonner, F.T. and R.P. Karrfalt (Eds.). *The woody plant seed manual*. Agriculture Handbook 727. Washington, DC: U.S. Department of Agriculture, Forest Service: 274-280.

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.

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.

Mozingo, H.N. 1987. *Shrubs of the Great Basin: A natural history*. Reno, NV: University of Nevada Press. 342 p.

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

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

Pearson, L. 1964. Effect of harvest date on recovery of range grasses and shrubs. *Agronomy Journal* 56:80-82.

Pearson, L.C. 1976. Primary production in grazed and ungrazed desert communities of eastern Idaho. *Ecology* 46(3):278-285.

Quinones, F.A. 1981. Indian ricegrass evaluation and breeding. Bulletin 681. Las Cruces, NM: New Mexico State University, Agricultural Experiment Station. 19 p.

Schultz, B. and K. McAdoo. 2002. Common sagebrush in Nevada. Special Publication SP-02-02. Reno, NV. University of Nevada, Cooperative Extension. 9 p.

- 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.
- Stevens, R., K.R. Jorgensen, and J.N. Davis. 1981. Viability of seed from thirty-two shrub and forb species through fifteen years of warehouse storage. *The Great Basin Naturalist* 41(3):274-277.
- 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.
- Stubbendieck, J., J.T. Nichols, and K.K. Roberts. 1985. Nebraska range and pasture grasses (including grass-like plants). E.C. 85-170. Lincoln, NE: University of Nebraska, Department of Agriculture, Cooperative Extension Service. 75 p.
- Tausch, R. J. and N. E. West. 1988. Differential establishment of pinyon and juniper following fire. *American Midland Naturalist*:174-184.
- 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.
- Tisdale, E.W. and M. Hironaka. 1981. The sagebrush-grass region: a review of the ecological literature. Bull. 33. Moscow, ID: University of Idaho, Forest, Wildlife and Range Experiment Station. 31 p.
- 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.
- 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(3): 260-261.
- Wambolt, C.L. 1996. Mule deer and elk foraging preference for 4 sagebrush taxa. *Journal of Range Management* 49(6):499-503.
- West, N.E. 1994. Effects of fire on salt-desert shrub rangelands. In: *Ecology and Management of Annual Rangelands*. Gen. Tech. Rep. INT-313. Boise, ID: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 416 p.
- Winward, A.H. 2001. Sagebrush taxonomy and ecology workshop--October 5-6, 1999. In: *Vegetation, wildlife and fish ecology and rare species management--Wasatch-Cache National Forest*. Logan, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region, Uinta- Wasatch-Cache National Forest.
- Wright, H.A., L.F. Neuenschwander, and C.M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: A state-of-the-art review. Gen. Tech. Rep. INT-58. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 48 p.
- 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.
- Wright, H. A. 1985. Effects of fire on grasses and forbs in sagebrush-grass communities. Pages 12-21 in *Rangeland Fire Effects; A Symposium*: Boise, ID, USDI-BLM.
- Young, R.P. 1983. Fire as a vegetation management tool in rangelands of the Intermountain region. In: Monsen, S.B. and N. Shaw (Eds). *Managing Intermountain rangelands—improvement of range and wildlife habitats: Proceedings of symposia; 1981 September 15-17; Twin Falls, ID; 1982 June 22-24; Elko, NV*. Gen. Tech. Rep. INT-157. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Pp. 18-31.

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Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

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

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

-
9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**
-
10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**
-
11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**
-
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:
- Sub-dominant:
- Other:
- Additional:
-
13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**
-
14. **Average percent litter cover (%) and depth (in):**
-
15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**
-
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:**
-
17. **Perennial plant reproductive capability:**
-