USDA Natural Resources Conservation Service

Ecological site R028BY089NV
SHALLOW CLAY LOAM 10-12 P.Z.

Accessed: 04/19/2024

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.

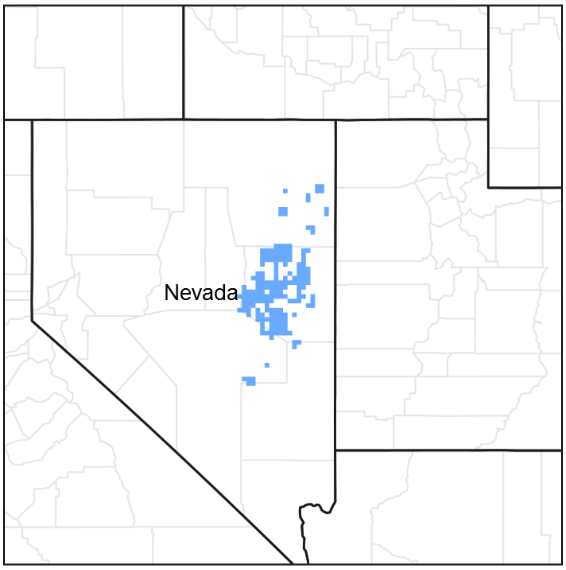

Figure 1. Mapped extent

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 fan remnants on all aspects. Slopes gradients of 4 to 30 percent are typical. Elevations are 6000 to 7000 feet.
The soils associated with this site are very shallow to an argillic horizon, well drained and formed in alluvium derived from volcanic rock. Secondary carbonates are present in the argillic horizon and increase with depth.

The reference site is dominated by black sagebrush, Indian ricegrass and Thurber's needlegrass. Average annual production ranges from 150 to 450 pounds per acre.

Associated sites

F028BY060NV	**PIMO-JUOS/ARNO4/PSSPS-ACHY**
F028BY083NV	**Cobbly Calcareous Mountain Slopes 10-12 P.Z.**
R028BY010NV	**LOAMY 8-10 P.Z.**
R028BY086NV	**GRAVELLY CLAY 10-12 P.Z.**

Similar sites

R028BY093NV	**SHALLOW CLAY LOAM 12-14 P.Z.** More productive site; PSSP-ACTH7 codominant grasses
R028BY016NV	**SHALLOW CALCAREOUS SLOPE 8-10 P.Z.** ACTH7 absent; ACHY-HECO26 codominant grasses
R028BY006NV	**SHALLOW CALCAREOUS LOAM 10-12 P.Z.** ACTH7 absent; PSSP-ACHY codominant grasses
R028BY011NV	**SHALLOW CALCAREOUS LOAM 8-10 P.Z.** More productive site; ACTH7 absent; ACHY-HECO26 codominant grasses
R028BY034NV	**MOUNTAIN RIDGE 12-14 P.Z.** PSSP-ACTH7 codominant grasses; less productive site

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia nova*
Herbaceous	(1) *Achnatherum hymenoides* (2) *Achnatherum thurberianum*

Physiographic features

This site occurs on fan remnants on all aspects. Slopes range from 2 to 50 percent, but slope gradients of 4 to 30 percent are most typical. Elevations are 5700 to 7000 feet.

Table 2. Representative physiographic features

Landforms	(1) Fan remnant
Flooding frequency	None
Ponding frequency	None
Elevation	5,700–7,000 ft
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 range from 10 to 12 inches. Mean annual air temperature is about 45 to 50 degrees F. The average growing season is about 100 to 120 days.

Mean annual precipitation across the range in which this ES occurs is 11.9 inches: Jan. 0.99; Feb. 1.05; Mar. 1.15; Apr. 1.37; May 1.3; Jun. 0.95; Jul. 0.78; Aug. 0.86; Sept. 0.80; Oct. 0.96; Nov. 0.8; Dec. 0.92.
*The above data is averaged from the Ruth and Eureka WRCC climate stations.

Table 3. Representative climatic features

Frost-free period (average)	91 days
Freeze-free period (average)	120 days
Precipitation total (average)	12 in

Climate stations used

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

Influencing water features

Influencing water features are not associated with this site.

Soil features

The soils associated with this site are shallow to a duripan, well drained and formed in alluvium derived from volcanic rocks. Soils are characterized by an ochric epipedon, argillic horizon within 10cm of the surface, and greater than 35% rock fragments distributed throughout the profile.

Identifiable secondary carbonates are found in the argillic horizon and increase with depth. Runoff is high to very high and available water holding capacity is very low. Soil series associated with this site include: Broland and Atlow.

The representative soil series is Broland, a Loamy-skeletal, mixed, superactive, mesic, shallow Haploxeralfic Argidurids. Diagnostic horizons include an ochric epipedon from the soil surface to 8 cm, argillic horizon from 8 to 41 cm, and a duripan from 48 to 102 cm. Clay content in the particle size control sections average 22 to 35 percent and rock fragments range from 35 to 50 percent. Reaction is moderately alkaline. Soils are non-effervescent to violently effervescent increasing with depth. Soils are derived from mainly volcanic rocks such as tuff. Representative occurrences of this ecological site correlated to Atlow, mapped on hills and mountains, will be field checked.

Table 4. Representative soil features

Parent material	(1) Alluvium–tuff
Surface texture	(1) Very gravelly loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderately rapid
Soil depth	40–60 in
Surface fragment cover <=3"	40–60%
Surface fragment cover >3"	5–10%
Available water capacity (0-40in)	1.2–2 in
Calcium carbonate equivalent (0-40in)	0–5%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0–5
Soil reaction (1:1 water) (0-40in)	7.9–8.4
Subsurface fragment volume <=3" (Depth not specified)	30–65%
Subsurface fragment volume >3" (Depth not specified)	0–10%

Ecological dynamics

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

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

2006).

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

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

The perennial bunchgrasses that are co-dominant with the shrubs include Indian ricegrass and Thurber needlegrass. Needleandthread and squirreltail are other important grass species. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource pools by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007).

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

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

Fire Ecology:
Fire is not a major disturbance of these community types (Winward 2001), and would be infrequent. Historic fire return intervals have been estimated at 100-200 years (Kitchen and McArthur 2007); however, fires were probably 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 Sandberg's 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, Noste and Fischer 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 seen 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. Thurber's needlegrass is moderately resistant to wildfire (Smith and Busby 1981), but can be severely damaged and have high mortality depending on season and severity of fire. Post-fire regeneration usually occurs from seed, but plants that are not completely killed by fire will continue growth during favorable conditions (Koniak 1985).

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

State and transition model

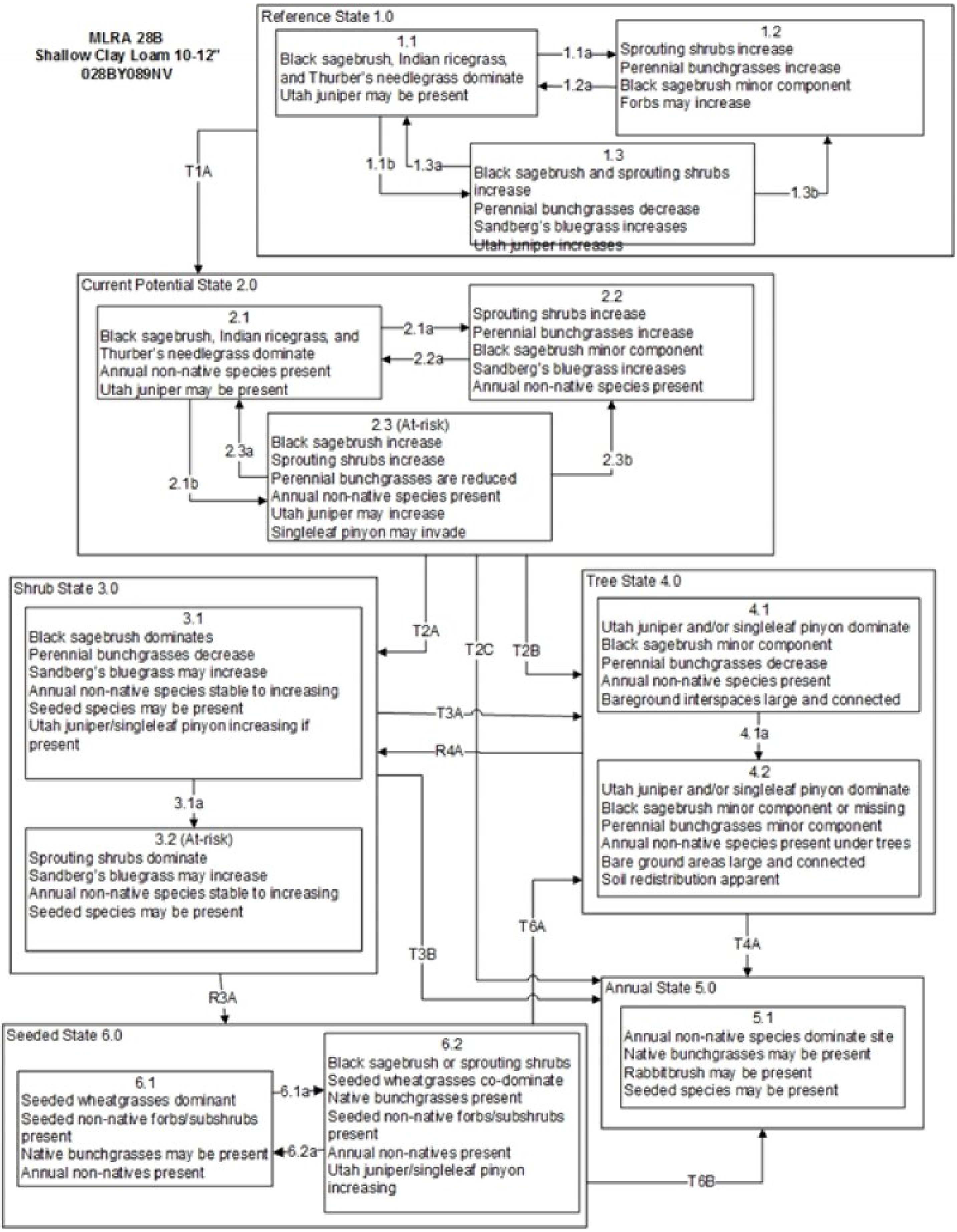

Figure 6. PNovakEchenique 3_2017

MLRA 28B
Shallow Clay Loam 10-12"
028BY089NV

Reference State 1.0 Community Pathways
1.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/ or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub reestablishment
1.3a: Low severity fire, herbivory or combinations will reduce sagebrush and create a sagebrush/grass mosaic.
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: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs: non-native annual species present
2.1b: Time and lack of disturbance such as fire; 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 and/or grazing management that favors shrub establishment.
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 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. Heavy sheep 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, and 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 plant community is dominated by black sagebrush in the overstory with Indian ricegrass, and Thurber's needlegrass dominant in the understory. Utah juniper may be present. Potential vegetative composition is about 50% grasses, 5% forbs and 45% shrubs and trees. Approximate ground cover (basal and crown) is 15 to 25 percent.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	75	150	225
Shrub/Vine	65	131	196
Forb	8	15	23
Tree	2	4	6
Total	**150**	**300**	**450**

Community 1.2
Community Phase

This community phase is characteristic of a post-disturbance, early seral community phase. Indian ricegrass and Thurber's needlegrass will increase and dominate the community. Sprouting shrubs 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.

Community 1.3
Community Phase

Black 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 or from herbivory. Scattered Utah juniper trees 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 Sandberg's bluegrass may increase in the understory depending on the timing and intensity of herbivory. Heavy spring utilization 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, 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 non-native species in trace amounts. This community is dominated by black sagebrush in the overstory with Indian ricegrass, Thurber's needlegrass and needleandthread 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 patches of intact sagebrush may remain. Rabbitbrush or other sprouting shrubs may be increasing. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community 2.3
Community Phase (At Risk)

Figure 9. T.K. Stringham_9/2013

Black sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs or from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Sandberg's bluegrass will likely increase in the understory and may be co-dominant with the deep rooted bunchgrasses. Utah juniper may be present and without management will likely increase. Annual non-native species are stable or increasing. 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 treatment) 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 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. 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 one community phase is characterized by black sagebrush or a sprouting shrub overstory. 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. 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

Rabbitbrush dominate the overstory. Annual non-native species may be increasing and bare ground is significant. This site is at risk for an increase in invasive annual weeds.

Pathway a
Community 3.1 to 3.2

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

Conservation practices

Brush Management

State 4
Tree State

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

Community 4.1
Community Phase

Utah juniper trees dominate the 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

Utah juniper trees dominate the overstory. Black sagebrush is decadent and dying with numerous skeletons present. 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 redistribution 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

This state has one community phase. 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/or halogeton 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 and 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.

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 in trace amounts. Annual non-native species present.

Community 6.2
Community Phase

Black sagebrush and seeded wheatgrass species co-dominate. Native bunchgrasses may be present in trace amounts. 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.

Pathway a
Community 6.2 to 6.1

Low severity fire or brush management with minimal soil disturbance will reduce the sagebrush overstory and may allow seeded wheatgrass species to become dominant. Native bunchgrasses may be present in trace amounts.

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

Transition B
State 2 to 4

Trigger: Absence of disturbance over time allows for Utah juniper 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 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 temporally and spatially 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/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 tree 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 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/singleleaf pinyon. Slow variables: Long term increase in Utah juniper/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 (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Primary Perennial Grasses**			111–189	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	60–90	–
	Thurber's needlegrass	ACTH7	*Achnatherum thurberianum*	45–75	–
	needle and thread	HECO26	*Hesperostipa comata*	6–24	–
2	**Secondary Perennial Grasses**			6–30	
	squirreltail	ELEL5	*Elymus elymoides*	2–9	–
Forb					
3	**Perennial**			6–24	
	spiny phlox	PHHO	*Phlox hoodii*	2–6	–
Shrub/Vine					
4	**Primary Shrub**			60–105	
	black sagebrush	ARNO4	*Artemisia nova*	60–105	–
5	**Secondary Shrubs**			13–39	
Tree					
6	**Evergreen**			2–6	
	Utah juniper	JUOS	*Juniperus osteosperma*	2–6	–

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 3rd 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).
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).
Indian ricegrass is a deep-rooted, cool season perennial bunchgrass that is adapted primarily to sandy 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 7 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.

Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988).

Needleandthread grass is most commonly found on warm/dry soils (Miller et al. 2013). It is not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller and Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972). With the reduction in competition from deep rooted perennial bunchgrasses, shallower rooted grasses such as Sandberg bluegrass and forbs may increase (Smoliak et al. 1972). Further degradation of the grass community can lead to an invasion by exotic annual species such as halogeton and cheatgrass.

Reduced bunchgrass vigor or density provides an opportunity for cheatgrass and other invasive species to occupy interspaces, leading to increased fire frequency and potentially an annual plant community. Sandberg's bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg's 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 Sandberg's bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

Halogeton is a non-competitive plant that tends to invade areas that are susceptible to repeated disturbance such as; livestock trails, roadsides, trampled areas near watering holes or corrals and rangeland areas stripped of the natural vegetation by excessive grazing or other soil disturbing activities (Young 2002). It was first introduced into the western U.S. during the 20th century with the first collection being made near Wells, Nevada in 1934. Halogeton is highly toxic to sheep and has been responsible for thousands of sheep deaths throughout the western U.S., which triggered a massive effort to eradicate the introduced species (Young 2002).

Halogeton has two distinct seed forms; black form which consists of the achene only and brown form which consists of the achene and attached sepals (Tisdale and Zappetini 1953, Robocker et al. 1969). The black form of halogeton seed germinate readily under a wide range of pH and salt concentrations within the first year. The brown form of seed was found to be 100 percent viable at the end of 2 years and 15 percent viable at the end of 10 years, proving that halogeton seed may remain viable in the soil for up to 10 years (Robocker et al. 1969). Eradication of this species is problematic therefore appropriate range management practices focused on soil and rangeland integrity may keep the plant in check.

Thurber's needlegrass species begin growth early in the year and remain green throughout a relatively long growing season. This pattern of development enables animals to use Thurber's needlegrass when many other grasses are unavailable. Cattle prefer Thurber's needlegrass in early spring before fruits have developed as it becomes less palatable when mature. Thurber's needlegrasses are grazed in the fall only if the fruits are softened by rain.

Black sagebrush are desirable forage plants and also act as good cover for wildlife (Blaisdell et al. 1982). Pronghorn do best where shrub cover is moderate to low, therefore, low sagebrush varieties may be preferred in some areas over big sagebrush varieties (Blaisdell et al. 1982). Furthermore, a review identified black sagebrush as the most important source of winter browse for pronghorn in Utah (Allen et al. 1984). In winter, it was reported by Clary and Beale (1983) that pronghorn preferred black sagebrush habitat.

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

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

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

Hydrological functions

Permeability is moderately slow. Runoff is very low to very high. Rills are none to rare. A few can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt. Water flow patterns are none to rare and can be expected in areas subjected to summer convection storms or rapid snowmelt. Pedestals are rare. Occurrence is usually limited to areas of water flow patterns. Frost heaving of shallow rooted plants should not be considered a "normal" condition. Gullies are rare. Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., bluebunch wheatgrass & Thurber needlegrass] slow runoff and increase infiltration. Shrub canopy and associated litter break raindrop impact.

Recreational uses

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

Other products

Indian ricegrass was traditionally eaten by some Native American peoples. The Paiutes used the seed as a reserve food source.

Other information

Black sagebrush is an excellent species to establish on sites where management objectives include restoration or improvement of domestic sheep, pronghorn, or mule deer winter range.
Indian ricegrass is well-suited for surface erosion control and desert revegetation although it is not highly effective in controlling sand movement. Needleandthread is useful for stabilizing eroded or degraded sites.

Type locality

Location 1: White Pine County, NV	
Township/Range/Section	T18N R65E S30
Latitude	39° 23′ 48″
Longitude	114° 42′ 9″
General legal description	About 4 miles east of McGill, Duck Creek Range, White Pine County, Nevada. This site also occurs in Elko and Eureka Counties, Nevada.

Other references

Akinsoji, A. 1988. Postfire vegetation dynamics in a sagebrush steppe in southeastern Idaho, USA. Vegetatio 78:151-155.

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. Pages 45-48 in Collaborative Management and Research in the Great Basin -- Examining the issues and developing a framework for action Gen. Tech. Rep. RMRS-GTR-204. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

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.

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.

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.

Bradley, A. F., N. V. Noste, and W. C. Fischer. 1992. Gen. Tech. Rep. INT-287: Fire ecology of forests and woodlands in Utah. . U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Britton, C. M., G. R. McPherson, and F. A. Sneva. 1990. Effects of burning and clipping on five bunchgrasses in eastern Oregon. Great Basin Naturalist 50:115-120.

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: Pgs 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.

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 andgrowth of two tussock grasses in Utah. Journal of Arid Environments 29:239-251.

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.

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.

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.

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(3):185-188.

Everett, R. L. and K. Ward. 1984. Early plant succession on pinyon-juniper controlled burns. Northwest Science 58:57-68.

Fire Effects Information System (Online; http://www.fs.fed.us/database/feis/plants/).

Ganskopp, D. 1988. Defoliation of Thurber needlegrass: herbage and root responses. Journal of Range Management 41(6):472-476.

Gates, D. H. 1964. Sagebrush infested by leaf defoliating moth. Journal of Range Management 17:209-210.

Hall, R. C. 1965. Sagebrush defoliator outbreak in Northern California. Res. Note PSW-RN-075., Berkeley, CA.

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

Hurd, R. M., and C. K. Pearse. 1944. Relative Palatability of Eight Grasses used in Range Reseeding. Agronomy Journal 36:162-165.

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.

Jones, T. A., M. H. Ralphs, and D. C. Nielson. 1994. Cattle Preference for 4 Wheatgrass Taxa. Journal of Range Management 47:119-122.

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.

Koniak, S. 1985. Succession in pinyon-juniper woodlands following wildfire in the Great Basin. The Great Basin Naturalist 45:556-566.

Martens, E., D. Palmquist, and J.A. Young. 1994. Temperature profiles for germination of cheatgrass versus native perennial bunchgrasses. 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:238-243.

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., J. C. Chambers, D. A. Pyke, F. B. Pierson, and C. J. Williams. 2013. A review of fire effects on vegetation and soils in the Great Basin Region: response and ecological site characteristics.

Miller, R. F. and R. J. Tausch. 2000. The role of fire in pinyon and juniper woodlands: a descriptive analysis. Pages 15-30 in Proceedings of the invasive species workshop: the role of fire in the control and spread of invasive species. Fire conference.

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

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

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

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.

Robocker, W. C., M. C. Williams, R. A. Evans, and P. J. Torell. 1969. Effects of Age, Burial, and Region on Germination and Viability of Halogeton Seed. Weed Science 17:63-65.

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

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

Tisdale, E. W. and G. Zappetini. 1953. Halogeton Studies on Idaho Ranges. Journal of Range Management 6:225-236.

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.

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(4):309-310.

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

Van Vuren, D. 1984. Summer diets of bison and cattle in southern Utah. Journal of Range Management 37(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.

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. 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.

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. Pgs 18-31.

Young, J. A. 2002. Halogeton Grazing Management: Historical Perspective. Journal of Range Management 55:309-311.

Contributors

RK
T. Stringham/P.Novak-Echenique
E. Hourihan

Rangeland health reference sheet

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

Author(s)/participant(s)	GK Brackley
Contact for lead author	State Rangeland Management Specialist

Date	07/01/2006
Approved by	P. Novak-Echenique
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rills are rare. A few can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt.

2. **Presence of water flow patterns:** Water flow patterns are few and can be expected in areas subjected to summer convection storms or rapid snowmelt.

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

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground ± 40%; surface rock fragments ±35%; shrub canopy to 25%; basal area for perennial herbaceous plants <5%.

5. **Number of gullies and erosion associated with gullies:** Gullies are rare.

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) is expected to move the distance of slope length during intense summer convection storms or rapid snowmelt events. Persistent litter (large woody material) will remain in place except during catastrophic 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 for most surface soil textures found on this site. Areas of this site occurring on soils that have a physical crust will probably have stability values less than 3. (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 thin to thick platy or granular. Soil surface colors are light and the soils typically have an ochric epipedon. Organic carbon of the surface 2 to 3 inches is typically 1 to 1.5 percent dropping off quickly below. Organic matter content can be more or less depending on micro-topography.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., bluebunch wheatgrass & Thurber needlegrass] slow runoff and increase infiltration. Shrub canopy and associated litter break raindrop impact.

---

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 not typical. Platy or massive sub-surface horizons, subsoil argillic, calcic horizons or hardpans shallow to the surface are not to be interpreted as compacted layers.

---

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant: Reference State: Deep-rooted, cool season, perennial bunchgrasses (bluebunch wheatgrass & Thurber needlegrass) > low shrubs (black sagebrush) (by above ground production)

    Sub-dominant: >> associated shrubs > shallow-rooted, cool season, bunchgrasses > deep-rooted, cool season, perennial forbs = fibrous, shallow-rooted, cool season, perennial and annual forbs. (by above ground production)

    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 are common and standing dead shrub canopy material may be as much as 25% of total woody canopy; some of the mature bunchgrasses (<15%) have dead centers.

---

14. **Average percent litter cover (%) and depth (in):** Within plant interspaces (± 5%) and depth of litter is ±¼ inch.

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** For normal or average growing season (through mid-June) ± 300 lbs/ac; Spring moisture significantly affects total 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:** Cheatgrass, Douglas rabbitbrush, snakeweed, halogeton, and knapweeds are invaders on this site. Where this site is adjacent to pinyon-juniper woodlands, singleleaf pinyon and Utah juniper are increasers on this site.

---

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