USDA Natural Resources Conservation Service

Ecological site R028AY018NV
COARSE GRAVELLY LOAM 5-8 P.Z.

Accessed: 05/11/2025

General information

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

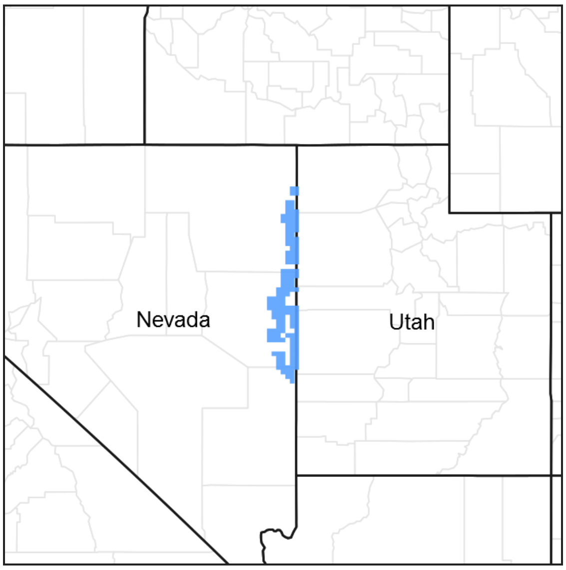

Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 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 barrier beaches, fan remnants, and alluvial flats on all exposures. Slopes range from 0 to 30 percent, but slope gradients of 2 to 15 percent are most typical. Elevations ranges from 4,200 to 6,900 feet.

The climate associated with this site is semiarid, characterized by cool, moist winters and warm, dry summers. Average annual precipitation is 5 to 8 inches. Mean annual air temperature is 47 to 52 degrees F. The average growing season is about 100 to 120 days.

The soils associated with this site have formed in alluvium from mixed rock sources. The soils are typically moderately coarse-textured in the upper soil profile. Water holding capacity is very low to low and the soils are well to somewhat excessively drained. These soils are moderately to strongly alkaline and calcareous and there are high volumes of rock fragments throughout the soil profile. Runoff is very low to high.
The reference state is dominated by Indian ricegrass and shadscale. Galleta, sand dropseed, bud sagebrush and winterfat are commonly associated plants. Production ranges from 300 to 700 pounds per acre.

Associated sites

R028AY002NV	**COARSE SILTY 5-8 P.Z.**
R028AY004NV	**SHALLOW CALCAREOUS SLOPE 8-10 P.Z.**
R028AY012NV	**LOAMY 5-8 P.Z.**
R028AY013NV	**SHALLOW CALCAREOUS LOAM 8-10 P.Z.**

Similar sites

R028AY006NV	**DROUGHTY LOAM 5-8 P.Z.** GRSP-ATCA2 codominant shrubs, ATCO minor shrub
R028AY003NV	**LOAMY SLOPE 5-8 P.Z.** Less productive site
R028AY002NV	**COARSE SILTY 5-8 P.Z.** KRLA2 dominant shrub
R028AY016NV	**GRAVELLY LOAM 5-8 P.Z.** PLJA-ACHY codominant grasses; less productive site
R028AY014NV	**GRAVELLY SANDY LOAM 5-8 P.Z.** TETRA3 & EPNE major shrubs; may be a "seral stage" of (028AY018NV) Coarse Gravelly Loam 5-8" PZ following wildfire
R028BY075NV	**COARSE GRAVELLY LOAM 6-8 P.Z.** PLJA rare to absent
R028AY012NV	**LOAMY 5-8 P.Z.** Less productive site; KRLA2 minor species

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Atriplex confertifolia*
Herbaceous	(1) *Achnatherum hymenoides*

Physiographic features

This site occurs on barrier beaches, fan remnants, and alluvial flats on all exposures. Slopes range from 0 to 30 percent, but slope gradients of 2 to 15 percent are most typical. Elevations are 4200 to 6900 feet.

Table 2. Representative physiographic features

Landforms	(1) Barrier beach (2) Fan remnant (3) Alluvial flat
Elevation	4,200–6,900 ft
Slope	0–30%
Aspect	Aspect is not a significant factor

Climatic features

Nevada’s climate is predominantly arid, with large daily ranges of temperature, infrequent severe storms, heavy snowfall in the higher mountains, and great location variations with elevation. Three basic geographical factors largely influence Nevada’s climate: continentality, latitude, and elevation. Continentality is the most important factor. The strong continental effect is expressed in the form of both dryness and large temperature variations. Nevada lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that markedly influences the climate of the State. The prevailing winds are from the west, and as the warm moist air from the Pacific Ocean ascend the western slopes of the Sierra Range, the air cools, condensation occurs and most of the moisture falls as precipitation. As the air descends the eastern slope, it is warmed by compression, and very little precipitation occurs. The effects of this mountain barrier are felt not only in the West but throughout the state, with the result that the lowlands of Nevada are largely desert or steppes. The temperature regime is also affected by the blocking of the inland-moving maritime air. Nevada sheltered from maritime winds, has a continental climate with well-developed seasons and the terrain responds quickly to changes in solar heating.
Nevada lies within the mid-latitude belt of prevailing westerly winds which occur most of the year. These winds bring frequent changes in weather during the late fall, winter and spring months, when most of the precipitation occurs. To the south of the mid-latitude westerlies, lies a zone of high pressure in subtropical latitudes, with a center over the Pacific Ocean. In the summer, this high-pressure belt shifts northward over the latitudes of Nevada, blocking storms from the ocean. The resulting weather is mostly clear and dry during the summer and early fall, with scattered thundershowers. The eastern portion of the state receives significant summer thunderstorms generated from monsoonal moisture pushed up from the Gulf of California, known as the North American monsoon. The monsoon system peaks in August and by October the monsoon high over the Western U.S. begins to weaken and the precipitation retreats southward towards the tropics (NOAA 2004).
The climate associated with this site is semiarid, characterized by cool, moist winters and warm, dry summers. Average annual precipitation is 5 to 8 inches. Mean annual air temperature is 47 to 52 degrees F. The average growing season is about 100 to 120 days.

Average annual precipitation at the Wendover climate station (429382)is 4.59 inches. Monthly mean precipitation at the Wendover climate station is as follows:
January 0.28; February 0.28; March 0.37;
April 0.48; May 0.72; June 0.51; July 0.25;
August 0.34; September 0.34; October 0.47; November 0.29; December 0.25.

Table 3. Representative climatic features

Frost-free period (average)	0 days
Freeze-free period (average)	110 days
Precipitation total (average)	5 in

Influencing water features

There are no influencing water features associated with this site.

Soil features

The soils associated with this site have formed in alluvium from mixed rock sources which are influenced by calcareous loess. The soils are typically moderately coarse-textured in the upper soil profile. Water-holding capacity is very low to low and the soils are well to somewhat excessively drained. These soils are moderately to strongly alkaline and calcareous and there are high volumes of rock fragments throughout the soil profile. Runoff is very low to high. Soil series associated with this site include: Bienfait, Izamatch, Cliffdown, Gravier, Hiko Springs, Katelana, Kawich, Luning, Piltdown, Summermute, Sycomat, and Yelbrick.

The representative soil component (NV766 MU 1510) is Izamatch, classified as a sandy-skeletal, mixed, mesic Typic Torriorthent. Diagnostic horizons include an ochric epipedon from the soil surface to 7 inches. Identifiable secondary carbonates occur from 3 to 60 inches. Clay content in the particle control section averages 0 to 8 percent. Rock fragments range from 35 to 75 percent, pre-dominantly gravel. Reaction is moderately alkaline or strongly alkaline. Effervescence is violently effervescent. Lithology consists of mixed rocks influenced by calcareous loess.

Table 4. Representative soil features

Surface texture	(1) Extremely gravelly sand (2) Very gravelly loam (3) Gravelly loam
Family particle size	(1) Loamy
Drainage class	Well drained to somewhat excessively drained
Permeability class	Slow to very rapid
Soil depth	60–84 in
Surface fragment cover <=3"	40–60%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	1.9–3.8 in
Calcium carbonate equivalent (0-40in)	12–30%
Electrical conductivity (0-40in)	2–4 mmhos/cm
Sodium adsorption ratio (0-40in)	5–30
Soil reaction (1:1 water) (0-40in)	8.6–9.6
Subsurface fragment volume <=3" (Depth not specified)	35–75%
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 has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological site is dominated by deep-rooted cool season, perennial bunchgrasses and drought tolerant shrubs with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which Fernandez and Caldwell (1975) reported as between 80 and 110 cm for shadscale and winterfat. Shadscale and winterfat both initiate root growth in early April, a few days to a week prior to aerial plant parts. Shadscale in particular exhibits active root growth for several weeks after termination of shoot growth (Fernandez and Caldwell 1975). Continued root growth, even for established plants that are not exploring new areas of the soil, facilitates water absorption particularly in low soil moisture conditions (Gardner 1960). Fernandez and Caldwell (1975) concluded that the ability of shadscale to explore the soil volume at greater depths with a more profuse system of small branching lateral roots than winterfat or sagebrush may play a role in its ability to remain photosynthetically active longer into the summer season. Although shadscale exhibits the ability to withstand drought conditions on a short-term basis, the forty year photographic record (1951-1990) from the Raft River Valley of south-central Idaho visually demonstrates the impact of multiple years of drought on shadscale communities (Sharp et al. 1990). Scale insects have also been implicated in the death of shadscale (Sharp et al. 1990) however the data on this subject remains inconclusive (Nelson et al. 1990). Interestingly, periods of above normal springtime precipitation are also linked to shadscale die-off. Nelson et al. (1990) investigated areas of severe shadscale die-off that were, for the most part, located in low areas in valley bottoms or upland depressions that apparently incurred prolonged high soil moisture during a wet period. The high soil moisture appeared to be correlated with increased pythiaceous fungi, leading to rootlet mortality and plant stress (Nelson et al. 1990). The authors suggest that depending on the degree and duration of plant stress, injury could range from a sustained disease to rapid death.

Shadscale is a densely clumped, rounded, compact native shrub. It generally attains heights of 8 to 32 inches and widths of 12 to 68 inches (Blaisdell and Holmgren 1984). Shadscale is considered an evergreen to partially deciduous shrub as a small percentage of leaves are dropped in the winter (Smith and Nobel 1986). Shadscale possesses wider ecological amplitude than most Atriplex species (Crofts and Van Epps 1975), and shows ploidy levels from diploid (2x) to decaploid (10x). The extensive polyploidy of shadscale is an important consideration when implementing revegetation projects because ploidy levels are usually associated with distinct habitats (Sanderson et al. 1990). Diploid individuals are unlikely to perform as well in areas where tetraploids are more common. Diploid individuals generally occur above Pleistocene lake levels, whereas lake floors are usually occupied by autotetraploids. Overall, tetraploids are the most widespread throughout its range (Carlson 1984). Thus, the diploid most associated with this site is a tetraploid.

Winterfat is a long-lived, drought tolerant, native shrub typically about 30 cm tall (Mozingo 1987). It has a woody base from which annual branchlets grow (Welsh et al. 1987). The most common variety is a low growing dwarf form (less than 38.1 cm), which is most often found on desert valley floors (Stevens et al. 1977). Total winter precipitation is a primary growth driver and lower than average spring precipitation can reverse the impact of plentiful winter precipitation. While summer rainfall has a limited impact, heavy August-September rain can cause a second flowering in winterfat (West and Gasto 1978).
Winterfat reproduces from seed and primarily pollinates via wind (Stevens et al. 1977). Seed production, especially in desert regions, is dependent on precipitation (West and Gasto 1978) with good seed years occurring when there is appreciable summer precipitation and little browsing (Stevens et al. 1977). Winterfat has multiple dispersal mechanisms: diaspores are shed in the fall or winter, dispersed by wind, rodent-cached, or carried on animals (Majerus 2003). Diaspores take advantage of available moisture, tolerating freezing conditions as they progress from imbibed seeds to germinants to nonwoody seedlings (Booth 1989). Under some circumstances, the degree of reproduction may be dependent on mature plant density (Freeman and Emlen 1995).
Bud sagebrush, a common shrub to this ecological site, is a native, summer-deciduous shrub. It is low growing, spinescent, aromatic shrub with a height of 4 to 10 inches and a spread of 8 to 12 inches (Chambers and Norton 1993).

The perennial bunchgrasses that are sub-dominant with the shrubs include Indian ricegrass, galleta grass, and needle and thread grass. Indian ricegrass, the dominant grass on this site, is a hardy, cool-season, densely tufted, native perennial bunchgrass that grows from 4 to 24 inches in height (Blaisdell and Holmgren 1984). These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of the shrubs in the upper 0.5m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub–grass systems.

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. Historically, shadscale dominant salt-desert shrub communities were free of exotic invaders; however, excessive grazing pressure during settlement and into the 20th century has increased the overall presence of cheatgrass, halogeton, Russian thistle and weedy mustard species (Peters and Bunting 1994). The presence of exotic annual plants within these ecosystems decreases ecosystem resilience and resistance to disturbance through competition for limited resources. Dobrowolski et al. (1990) cite multiple authors on the extent of the soil profile exploited by the competitive exotic annual cheatgrass. Specifically, the depth of rooting is dependent on the size the plant achieves and in competitive environments,

cheatgrass roots were found to penetrate only 15 cm whereas isolated plants and pure stands were found to root at least 1 m in depth with some plants rooting as deep as 1.5 to 1.7 m.
Drought and/or inappropriate grazing will initially favor shrubs but prolonged drought can cause a decrease in the winterfat, bud sagebrush and other shrubs, while bare ground increases. Squirreltail may maintain or also decline within the community. Repeated spring and early summer grazing will have an especially detrimental effect on winterfat and bud sagebrush. Cheatgrass and other non-native annual weeds increase with excessive grazing. Abusive grazing during the winter may lead to soil compaction and reduced infiltration. Prolonged abusive grazing during any season leads to abundant bare ground, desert pavement and active wind and water erosion. Repeated, frequent fire will promote cheatgrass dominance and elimination of the native plant community. These sites frequently attract recreational use, primarily by off highway vehicles (OHV). Annual non-native species increase where surface soils have been disturbed.
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. Four possible stable states have been identified for this site.

Fire Ecology:
Historically, the lack of continuous fuels to carry fires made fire rare to nonexistent in shadscale communities (Young and Tipton 1990), thus it is not surprising that shadscale and bud sagebrush are both fire intolerant (Banner 1992, West 1994). Shadscale does not readily recover from fire, except for establishment through seed (West 1994). The slow reestablishment allows for easy invasion by cheatgrass and other non-native weedy species (Sanderson et al. 1990). The increased presence of exotic annual grasses has greatly altered fire regimes in areas of the Intermountain West where shadscale is a major vegetation component. Exotic annuals increase fire frequency under wet to near-normal summer moisture conditions and repeated, frequent fire has converted large expanses of shadscale rangeland to annual non-native plant communities (Knapp 1998).

Winterfat is able to sprout from buds near the base of the plant. However, if these buds are destroyed, winterfat will not sprout. Research has shown that winterfat seedling growth is depressed in growth by at least 90% when growing in the presence of cheatgrass (Hild et al. 2007). Repeated, frequent fires will increase the likelihood of conversion to a non-native, annual plant community with trace amounts of winterfat. 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 factor into individual species' responses. For most forbs and grasses, the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). Season and severity of the fire and post-fire soil moisture availability will influence plant response, however. Bud sagebrush is fire intolerant and must reestablish from seed (Banner 1992, West 1994).

Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below ground plant crowns. Vallentine (1989) cites several studies in the sagebrush zone that classified Indian ricegrass as being slightly damaged from late summer burning. Indian ricegrass has also 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 facilitates the reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Bottlebrush squirreltail, a minor component on this site, is considered more fire tolerant than Indian ricegrass due to its small size, coarse stems, and sparse leafy material (Britton et al. 1990). Post-fire regeneration occurs from surviving root crowns and from on- and off-site seed sources. Bottlebrush squirreltail has the ability to produce large numbers of highly germinable seeds, with relatively rapid germination (Young and Evans 1977) when exposed to the correct environmental cues. Early spring growth and ability to grow at low temperatures contribute to the persistence of bottlebrush squirreltail among cheatgrass dominated ranges (Hironaka and Tisdale 1973).

Needle and thread, also a minor component on this site, is a fine leaf grass and is considered sensitive to fire (Akinsoji 1988, Bradley et al. 1992, Miller et al. 2013). In a study by Wright and Klemmedson (1965), season of burning rather than fire intensity seemed to be the crucial factor in mortality for needle-and-thread grass. Early spring season burning was seen to kill the plants while August burning had no effect. Under wildfire scenarios, needleandthread is often present in the post-burn community.

Galleta grass has been found to increase following fire likely due to its rhizomatous root structure and ability to resprout (Jameson 1962). This mat-forming grass species may retard reestablishment of deeper rooted bunchgrasses. Repeated frequent fire in this community will significantly reduce shadscale, bud sagebrush and winterfat while promoting establishment of an annual weed community with varying amounts of galleta, spiny hopsage, horsebrush, snakeweed and rabbitbrush.
Rehabilitation following fire will have limited success. Observations from one hundred and seven separate plantings within the shadscale zone in Utah and Nevada indicate a very low success rate (Bleak et al. 1965). Seed from 148 native and non-native grasses, forbs and shrubs were planted from 1937 to 1962 across ten locations. Good seedling stands were obtained with introduced wheatgrasses, but most perished during the first summer. A few plantings of crested, fairway and Siberian wheatgrass along with Russian wildrye maintained stands for ten or more years but eventually declined to a very few plants (Bleak et al. 1965). The primary cause of seeding failures appeared to be the arid climate.

State and transition model

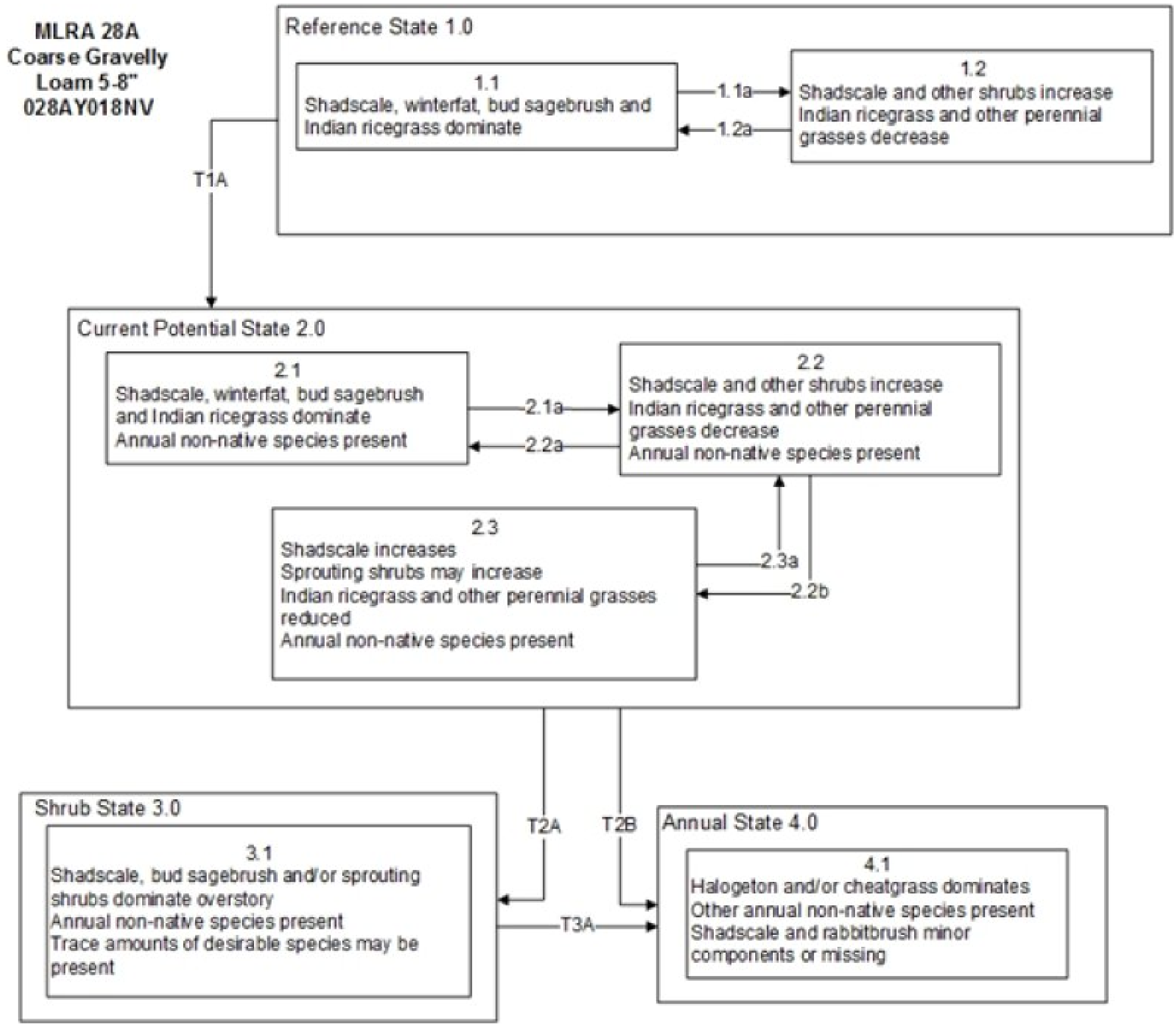

Figure 5. T. Stringham 2/2015

MLRA 28A
Coarse Gravelly Loam 5-8"
028AY018NV

Reference State 1.0 Community Phase Pathways
1.1a: Long-term drought and/or herbivory
1.2a: Release from drought and/or herbivory

Transition T1A: Introduction of non-native annual species such as halogeton.

Current Potential State 2.0 Community Phase Pathways
2.1a: Long-term drought and/or inappropriate grazing management
2.2a: Release from drought and/or appropriate grazing management that allows for an increase in bud sagebrush, winterfat and perennial grasses. Extreme growing season moisture may reduce shadscale.
2.2b: Inappropriate grazing and/or long-term drought
2.3a: Release from drought and/or inappropriate grazing management allows for an increase in bud sagebrush and perennial grasses. Extreme growing season moisture may reduce shadscale.

Transition T2A: Long-term inappropriate grazing management and/or long-term drought.

Transition T2B: Soil disturbing treatments (drill seeding, roller chopper, Lawson aerator etc.), fire, and/or unusually wet spring.

Transition T3A: Soil disturbing treatments (drill seeding, roller chopper, Lawson aerator etc.), fire, and/or unusually wet spring.

Figure 6. Legend

State 1
Reference State

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The Reference State has two general community phases: a shrub-grass dominate phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. This site is very stable, with little variation in plant community composition. Plant community changes would be reflected in production response to drought or herbivory. Wet years will increase grass production, while drought years will reduce production. Shrub production will also increase during wet years; however, above-average precipitation periods has been shown to cause shadscale death.

Community 1.1
Community Phase

This community phase is dominated by shadscale and Indian ricegrass. Galleta grass, needle and thread and sand dropseed are minor components along with winterfat and bud sagebrush. Community phase changes are primarily a function of chronic drought. Drought will favor shrubs over perennial bunchgrasses. However, long-term drought will result in an overall decline in plant community production, regardless of functional group. Extreme growing season wet periods may also reduce the shadscale component. Fire is very infrequent to non-existent. Potential vegetative composition is about 55% grasses, 5% forbs and 40% shrubs. 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	165	275	385
Shrub/Vine	120	200	280
Forb	15	25	35
Total	**300**	**500**	**700**

Community 1.2
Community Phase

Shrubs such as shadscale and bud sagebrush increase in the community. Perennial bunchgrasses decrease with drought and may become a minor component.

Pathway a
Community 1.1 to 1.2

Long-term drought, extreme wet periods and/or herbivory. Drought will favor shrubs over perennial bunchgrasses. Extreme wet periods will reduce the shadscale component.

Pathway a
Community 1.2 to 1.1

Release from drought and/or herbivory would allow the vegetation to increase and bare ground would eventually decrease. Extreme growing season wet period may reduce shadscale.

State 2
Current Potential State

This state is similar to the Reference State 1.0. with the addition of a shadscale and sprouting shrub dominated community phase. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance but will not become dominant within this State. These non-natives can be highly flammable and can promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.Management would be to maintain high diversity of desired species to promote organic matter inputs and prevent the dispersal and seed production of the non-native invasive species.

Community 2.1
Community Phase

This community 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 shadscale and Indian ricegrass. Galleta grass, bud sagebrush and winterfat are also important species on this site. Community phase changes are primarily a function of chronic drought or extreme wet periods. Fire is infrequent and patchy due to low fuel loads. Potential vegetative composition is about 55% grasses, 5% forbs and 40% shrubs.

Community 2.2
Community Phase

Figure 8. Coarse Gravelly Loam 5-8” (028AY018NV) T. Stringham May 2012

Shadscale and rabbitbrush increase while Indian ricegrass and bud sagebrush decline. Annual weeds may increase. Prolonged drought may lead to an overall decline in the plant community and increased soil erosion. Galleta grass may increase. Wet periods will decrease the shadscale component.

Community 2.3
Community Phase (At risk)

Shadscale and rabbitbrush dominate the overstory and perennial bunchgrasses, winterfat and bud sagebrush are reduced, either from competition with shrubs or from inappropriate grazing management, chronic drought or both. Galleta may increase. Annual non-native species may be stable or increasing due to a lack of completion with perennial bunchgrasses. Bare ground and wind erosion may be significant. This community is at risk of crossing a threshold to either State 3.0 (shrub) or State 4.0 (annual).

Pathway a
Community 2.1 to 2.2

Inappropriate growing season grazing favors unpalatable shrubs over bunchgrasses, winterfat and bud sagebrush. Prolonged drought will also decrease the perennial bunchgrasses in the understory.

Pathway a
Community 2.2 to 2.1

Release from drought and/or appropriate grazing management that facilitates an increase in perennial grasses, winterfat and bud sagebrush. Above-average precipitation during the growing season may reduce shadscale.

Pathway b
Community 2.2 to 2.3

Chronic drought and/or inappropriate grazing management will significantly reduce perennial grasses, winterfat and bud sagebrush in favor of shadscale and rabbitbrush.

Pathway a
Community 2.3 to 2.2

Release from drought and/or appropriate grazing management allows for bud sagebrush, winterfat and perennial grasses to increase. Above-average precipitation during the growing season may reduce shadscale.

State 3
Shrub State

This state has one community phase that is characterized by shadscale, bud sagebrush or a sprouting shrub overstory with very little to no understory. The site has crossed a biotic threshold and site processes are being controlled by shrubs. Shrub cover exceeds the site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory dominates site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed. Bareground and wind erosion has increased.

Community 3.1
Community Phase

Figure 9. Coarse Gravelly Loam 5-8" (028AY018NV) T. Stringham May 2012

Decadent shadscale and bud sagebrush dominate the overstory. Rabbitbrush and/or other sprouting shrubs may be a significant component or dominant shrub. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Annual non-native species increase. Bare ground and wind erosion is significant.

State 4
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 plant community which is perpetuated by a shortened fire return interval. The herbaceous understory is dominated by annual non-native species such as cheatgrass and halogeton. Bare ground and wind erosion may be significant. Resiliency has declined and further degradation from fire facilitates a cheatgrass and sprouting shrub plant community. The fire return interval has shortened due to the dominance of cheatgrass in the understory and is a driver in site dynamics.

Community 4.1
Community Phase

Figure 10. Coarse Gravelly Loam 5-8",T. Stringham 5/2012, NV766, MU116

Figure 11. Coarse Gravelly Loam 5-8”, T. Stringham 5/2012, NV766 MU120

Figure 12. Coarse Gravelly Loam 5-8",T. Stringham 5/2012, NV766 MU1520

Figure 13. Coarse Gravelly Loam 5-8”, T. Stringham 4/2013, NV779, MU 1354

This community is dominated by annual non-native species. Halogeton and cheatgrass most commonly invade these sites. Trace amounts of shadscale and other shrubs may be present, but are not contributing to site function. Bare ground and wind erosion may be significant, especially during low precipitation years. Wind erosion and excessive soil temperatures are driving factors in site function.

Transition A
State 1 to 2

Trigger: This transition is caused by the introduction of non-native annual plants, such as halogeton, mustards and cheatgrass. Slow variables: Over time the annual non-native species will increase within the community. Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Transition A
State 2 to 3

Trigger: Long-term inappropriate grazing management and/or long-term chronic drought will decrease or eliminate deep-rooted perennial bunchgrasses and favor shrub growth and establishment. Slow variables: Long term decrease in deep-rooted perennial grass density with a reduction in soil organic matter and corresponding soil moisture. Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

Transition B
State 2 to 4

Trigger: Fire and/or soil disturbing treatments such as drill seeding and plowing. An unusually wet spring may facilitate the increased germination and production of cheatgrass leading to its dominance within the community. Slow variables: Increased production and cover of non-native annual species. Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs truncates, spatially and temporally, nutrient capture and cycling within the community. Soil organic matter and soil moisture are reduced. Increased, continuous fine fuels from annual non-native plants modify the fire regime by changing intensity, size and spatial variability of fires.

Transition A
State 3 to 4

Trigger: Fire and/or soil disturbing treatments such as drill seeding and plowing. Slow variables: Increased production and cover of non-native annual species. Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture spatially and temporally thus impacting nutrient cycling and distribution.

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**			180–330	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	150–225	–
	needle and thread	HECO26	*Hesperostipa comata*	10–40	–
	James' galleta	PLJA	*Pleuraphis jamesii*	10–40	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	10–25	–
2	**Secondary Perennial Grasses**			10–40	
	King's eyelashgrass	BLKI	*Blepharidachne kingii*	3–15	–
	squirreltail	ELEL5	*Elymus elymoides*	3–15	–
	Sandberg bluegrass	POSE	*Poa secunda*	3–15	–
Forb					
3	**Perennial**			16–44	
	globemallow	SPHAE	*Sphaeralcea*	10–20	–
	phlox	PHLOX	*Phlox*	3–15	–
Shrub/Vine					
4	**Primary Shrubs**			135–275	
	shadscale saltbush	ATCO	*Atriplex confertifolia*	100–150	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	25–75	–
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	10–50	–
5	**Secondary Shrubs**			25–75	
	fourwing saltbush	ATCA2	*Atriplex canescens*	5–15	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	5–15	–
	Nevada jointfir	EPNE	*Ephedra nevadensis*	5–15	–
	spiny hopsage	GRSP	*Grayia spinosa*	5–15	–
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	5–15	–
	horsebrush	TETRA3	*Tetradymia*	5–15	–

Animal community

Livestock Interpretations:
This site is suitable for livestock grazing. Grazing management considerations include timing, duration and intensity of grazing.
Traditionally, shadscale plant communities provided good winter forage for the expanding sheep and cattle industry in the arid West. Indian ricegrass is the dominant grass on this site and is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). Indian ricegrass is highly palatable to all classes of livestock in both green and cured condition. It supplies a source of green forage before most other native grasses have produced much new growth. 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 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover even 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. In summary, adaptive management is required to manage this bunchgrass well.
Sand dropseed provides fair to good forage for livestock. Sand dropseed's value as livestock forage is regional and

dependent upon season. If fall rains are adequate, sand dropseed may have a period of renewed growth, producing new shoots in old sheaths. The persistent green base throughout winter makes sand dropseed an important desert winter range plant. In general, sand dropseed provides fair winter forage for domestic sheep and is most preferred by cattle of dune rangelands.

Bottlebrush squirreltail a minor component on this site, generally increases in abundance when moderately grazed or protected (Hutchings and Stewart 1953). In addition, moderate trampling by livestock in big sagebrush rangelands of central Nevada enhanced bottlebrush squirreltail seedling emergence compared to un-trampled conditions. Heavy trampling however was found to significantly reduce germination sites (Eckert et al. 1987). Squirreltail is more tolerant of grazing than Indian ricegrass but all bunchgrasses are sensitive to over utilization within the growing season.

When actively growing, galleta provides good to excellent forage for cattle and horses and fair forage for domestic sheep. Although not preferred, all classes of livestock may use galleta when it is dry. Domestic sheep show greater use in winter than summer months and typically feed upon central portions of galleta tufts, leaving coarser growth around the edges. Galleta may prove somewhat coarse to domestic sheep.

Shadscale is a valuable browse species for a wide variety of wildlife and livestock (Blaisdell and Holmgren 1984). Shadscale provides good browse for domestic sheep. Shadscale leaves and seeds are an important component of domestic sheep and cattle winter diets. The spinescent growth habit of shadscale lends to its browsing tolerance with no more than 15 to 20% utilization by sheep being reported (Blaisdell and Holmgren 1984) and significantly less utilization by cattle. Increased presence of shadscale within grazed versus ungrazed areas is generally a result of the decreased competition from more heavily browsed associates (Cibils et al. 1998). Reduced competition from more palatable species in heavily grazed areas may increase shadscale germination and establishment. Chambers and Norton (1993) found shadscale establishment higher under spring than winter browsing as well as heavy compared to light browsing. During years of below average precipitation, shadscale has been found very susceptible to grazing pressure regardless of season (Chambers and Norton 1993). Following fire, grazing exclusion for 2 or more years is beneficial for revegetation of shadscale communities as first year shadscale seedlings lack spines and are highly susceptible to browsing. Spines develop in the second year (Zielinski 1994).

Bud sagebrush is palatable and nutritious forage for domestic sheep in the winter and spring although it is known to cause mouth sores in lambs. Bud sagebrush can be poisonous or fatal to calves when eaten in quantity. Bud sagebrush can be poisonous or fatal to calves when eaten in quantity (Stubbendieck et al. 1992). Bud sagebrush is highly susceptible to effects of browsing. It decreases under browsing due to year-long palatability of its buds and is particularly susceptible to browsing in the spring when it is physiologically most active (Chambers and Norton 1993, Harper et al. 1990). Heavy browsing (>50%) may kill bud sagebrush rapidly (Wood and Brotherson 1986).

Winterfat is an important forage plant for livestock, especially during winter when forage is scarce. Abusive grazing practices have reduced or eliminated winterfat on some areas even though it is fairly resistant to browsing. Effects depend on severity and season of grazing. Winterfat, a highly nutritious winter feed shows similar results to bud sagebrush with significant declines in density with late winter or early spring grazing (Harper et al. 1990). Interestingly the same 54 year study also showed winterfat density decreasing in the ungrazed plots.

Greenmolly provides excellent forage for sheep and cattle, and is often used as a winter forage, when it is high in protein.

Needle and thread also a minor component on these sites, 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, the rhizomatous galleta grass bluegrass will likely increase (Smoliak et al. 1972).

In summary, overgrazing causes a decrease in Indian ricegrass along with winterfat and bud sagebrush, while shadscale may initially increase. Spring grazing year after year can be detrimental to bud sagebrush and the perennial bunchgrasses. Continued abusive grazing leads to increased bare ground and invasion by annual weeds (e.g., cheatgrass, halogeton, and tansy mustard). Shadscale may become dominant with an annual understory. With further deterioration, shadscale declines, bare ground increases, soil redistribution accelerates and site productivity decreases. On some soils, erosion can result in increased surface salts and development of desert pavement. Reestablishment of perennials is limited in areas of extensive desert pavement. Fire is a very infrequent and patchy event in these salt-desert shrub communities; however, where it has occurred the shrub community is greatly reduced and annual exotic weeds will increase if present. Repeated fire within a 10 to 20 year timeframe has the potential to convert this site to an annual weed dominated system. Knowledge of successful rehabilitation strategies in these droughty plant communities is limited. Cook and Child (1971) found significant reduction in plant cover even 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. Adaptive management is required to manage this bunchgrass well.
Stocking rates vary over time depending upon season of use, climate variations, site, and previous and current management goals. A safe starting stocking rate is an estimated stocking rate that is fine-tuned by the client by adaptive management through the year and from year to year.
Wildlife interpretations:
Salt-desert shrub communities provide valuable habitat for a number of species.
Shadscale is a valuable browse species, providing a source of palatable, nutritious forage for a wide variety of wildlife particularly during spring and summer before the hardening of spiny twigs. (Jameson 1952, Welch et al. 1987). It supplies browse, seed, and cover for birds, small mammals, rabbits, deer, and pronghorn antelope. Shadscale also provides feed for wild ungulates: mule deer (Odocoileus hemionus) browse shadscale, especially during winter (Bartmann 1983). Although it is not preferred, shadscale is also browsed in winter by pronghorn (Antilocapra americana) (Beal and Smith 1970). Shadscale habitats throughout northeastern Nevada are important home ranges for small mammals. The chisel-toothed kangaroo rat (Dipodomys microps) feed on shadscale foliage and use shadscale habitats during the spring, summer, and fall. Deer mice (Peromyscus maniculatus) use shadscale habitats all year (O'farrell and Clark 1986). Shadscale leaves and seeds are preferred forage for jackrabbits (Lepus californicus) (Currie and Goodwin 1966). The Great Basin kangaroo rat (Dipodomys ordii) also feeds on shadscale foliage (Kenagy 1973).
Several bird species will eat shadscale seeds and use shadscale habitats for cover and nesting sites. The horned lark (Eremophila alpestris) occurs throughout shadscale communities. Although less commonly apparent the Brewer's sparrow (Spizella breweri) and sage thrasher (Oreoscoptes montanus) also occur in shadscale habitat. Other species, observed occasionally throughout breeding season in shadscale habitat include: northern harrier (Circus cyaneus), red-tailed hawk (Buteo jamaicensis) , ferruginos hawk (Buteo regalis), golden eagle (Aquila chrysaetos), American kestrel (Falco sparverius) , prairie falcon (Falco mexicanus), mourning dove (Zenaida macroura), burrowing owl (Athene cunicularia), short-eared owl (Asio flammeus), violet-green swallow (Tachycineta thalassina), cliff swallow (Petrochelidon), barn swallow (Hirundo rustica), common raven (Corvus corax), loggerhead shrike (Lanius ludovicianus), vesper sparrow (Pooecetes gramineus), black-throated sparrow (Amphispiza bilineata), and western meadowlark (Sternella neglecta) (Medin 1990).
It should be noted the loss of shadscale and associated shrubs has a negative effect on golden eagle habitat. The golden eagle is listed as a threatened species throughout the United States. Areas of shadscale shrub-steppe provide cover and forage for black-tailed jackrabbits, which are a major food source of golden eagles. Shadscale should be maintained within 1.9 miles of golden eagle nests in order to maintain the species (Kochert et al. 1999).

Reptile and amphibian distribution is not widely studied throughout the Intermountain cold desert shrub region; however, several reptiles and amphibians are recorded to occur throughout Nevada, where shadscale, bud sagebrush, winterfat and other desert shrubs occur (Bernard and Brown 1977). In shadscale habitat specifically, western rattlesnakes (Crotalus viridis) and gopher snakes (Pituophis catenifer catenifer) were recorded in a study by Diller and Johnson (1988). Reptile species including: eastern racer (Coluber constrictor), ringneck snake (Diadophis punctatus), night snakes (Hypsiglena torquata), Sonoran mountain kingsnakes (Lampropeltis pyromelana), striped whipsnakes (Masticophis taeniatus), gopher snakes (Pituophis catenifer), long-nosed snakes (Rhinocheilus lecontei), wandering gartersnakes (Thamnophis elegans vagrans), sidewinders (Crotalus cerastes), Great Basin rattlesnakes (Crotalus oreganus lutosus), Great Basin collared lizard (Crotaphytus bicinctores), long-nosed leopard lizard (Gamelia copeii), short-horned lizard (Phrynosoma douglasii), desert-horned lizard (Phrynosoma platyrhinos), western fence lizards (Sceloporus occidentalis), northern side-blotched lizards (Uta stansburiana stansburiana), banded gecko (Coleonyx variegatus), desert iguana (Diposaurus dorsalis), chuckwalla (Sauromalus ater), zebra-tailed lizard (Callisaurus draconoides), pigmy horned-lizard (Phrynosoma douglasii), desert night lizard (Xantusia vigilis), whip-tailed lizard (Aspidoscelis tigris tigris) and western skinks (Plestiodon skiltonianus) occur in areas where sagebrush is dominant. Similarly, amphibians such as: western toads, Woodhouse's toads (Anaxyrus woodhousii), northern leopard frogs (Lithobates pipiens), Columbia spotted frogs (Rana luteiventris), bullfrogs (Lithobates catesbeianus), and Great Basin spadefoots (Spea intermontana), California toads (Anaxyrus boreas halophilus), Amargosa toads (Anaxyrus nelsoni), Sonoran toads (Anaxyrus alvarius), red-spotted toads (Bufo punctatus) and mountain toad (Bufo cavifrons), also occur throughout the Great Basin in salt desert shrub communities (Hamilton 2004). Bud sagebrush is palatable, nutritious forage for upland game birds, small game and big game in winter. Bud sagebrush is rated as "regularly, frequently, or moderately taken" by mule deer in Nevada in winter and is utilized by bighorn sheep in summer, but the importance of bud sagebrush in the diet of bighorns is not known. Bud sagebrush comprises 18 – 35% of a pronghorn's diet during the spring where it is available. Chukar will utilize the leaves and seeds of bud sagebrush.
Greenmolly is an excellent forage for deer.
Winterfat is an important forage plant for wildlife, especially during winter when forage is scarce. Winterfat seeds are

eaten by rodents. Winterfat is a staple food for black-tailed jackrabbit. Mule deer and pronghorn antelope browse winterfat. Winterfat is used for cover by rodents. It is potential nesting cover for upland game birds, especially when grasses grow up through its crown.
Indian ricegrass is eaten by pronghorn in "moderate" amounts whenever available. A number of heteromyid rodents inhabiting desert rangelands show preference for seed of Indian ricegrass. Indian ricegrass is an important component of jackrabbit diets in spring and summer. In Nevada, Indian ricegrass may even dominate jackrabbit diets during the spring through early summer months. Indian ricegrass seed provides food for many species of birds. Doves, for example, eat large amounts of shattered Indian ricegrass seed lying on the ground.
Galleta provides moderately palatable forage when actively growing and relatively unpalatable forage during dormant periods. Galleta provides poor cover for most wildlife species.
Sand dropseed provides poor forage for wildlife. Large mammals in general show little use of sand dropseed. Sand dropseed is not preferred by pronghorn, elk, and deer. Small mammals and birds utilize sand dropseed to a greater extent than large mammals.
King's desertgrass is an undesirable forage for wildlife.
Changes in plant community composition could affect the distribution and presence of wildlife species and proper management is important to maintain healthy shadscale communities.

Hydrological functions

Runoff is very low to high. Permeability is slow to very rapid. Rills are none to rare. A few short rills (<1m) can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt. These will begin to heal during the next growing season. Water flow patterns are none to rare. A few water flow patterns may be evident in areas subjected to summer convection storms. Where flow patterns are observed, they are short in length (<2m), meandering, and stable. Perennial bunchgrasses (Indian ricegrass) aid in infiltration and reduce runoff. Shrub canopy and associated litter provide some protection from raindrop impact and allow for snow capture on this site.

Recreational uses

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

Other products

Seeds of shadscale were used by Native Americans of Arizona, Utah and Nevada for bread and mush. Indian ricegrass was traditionally eaten by some Native Americans. The Paiutes used seed as a reserve food source. Sand dropseed is an edible grass used by Native Americans.

Other information

Winterfat adapts well to most site conditions, and its extensive root system stabilizes soil. However, winterfat is intolerant of flooding, excess water, and acidic soils. Needleandthread grass is useful for stabilizing eroded or degraded sites. Sand dropseed is recommended as a component of grass seed mixtures for sandy and heavy to semi-sandy soils. Good results are seen reseeding dry low lands receiving less than 9 inches (230mm) of precipitation within rangelands of Nevada.

Type locality

Location 1: Elko County, NV	
Township/Range/Section	T31N R70E S33
Latitude	40° 31′ 24″
Longitude	114° 3′ 47″
General legal description	NW¼NW¼, Section 33, T31N. R70E. MDBM. About 12 miles south of Wendover, Elko County, Nevada.

Other references

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

Banner, R. E. 1992. Vegetation Types of Utah. Rangelands 14:109-114.

Bich, B. S., J. L. Butler, and C. A. Schmidt. 1995. Effects of Differential Livestock Use on Key Plant Species and Rodent Populations within Selected Oryzopsis hymenoides/Hilaria jamesii Communities of Glen Canyon National Recreation Area. The Southwestern Naturalist 40:281-287.

Blaisdell, J. P. and R. C. Holmgren. 1984. Managing Intermountain rangelands - salt-desert shrub ranges. General Technical Report INT-163, USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

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. Western North American Naturalist 50:115-120.

Carlson, J. 1984. Atriplex cultivar development. Pages 176-182 in Proceedings - symposium on the biology of Atriplex and related chenopods Gen. Tech. Rep. INT-172. USDA, Forest Service, Intermountain Forest and Range Experiment Station, Provo, UT.

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.

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. and B. E. Norton. 1993. Effects of grazing and drought on population dynamics of salt desert species on the Desert Experimental Range, Utah. Journal of Arid Environments:261-275.

Cibils, A. F., S. M. David, and D. E. McArthur. 1998. Plant-Herbivore Interactions in Atriplex: Current State of Knowledge. General Technical Report RMRS-GTR-14, USDA: FS, Rocky Mountain Research Station, Ogden, UT.
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 24:339-343.
Crofts, K. and G. Van Epps. 1975. Use of shadscale in revegetation of arid disturbed sites. Pages 151-152 in Wildland shrubs: symposium and workshop proceedings. Brigham Young University, Provo, UT.

Dobrowolski, J. P., M. M. Caldwell, and J. H. Richards. 1990. Basin hydrology and plant root systems. Pages 243-292 Plant Biology of the Basin and Range. Springer.

Eckert, R. E., Jr., F. F. Peterson, and F. L. Emmerich. 1987. A study of factors influencing secondary succession in the sagebrush [Artemisia spp. L.] type. Pages 149-168 in Proceedings: Seed and seedbed ecology of rangeland plants. U. S. Department of Agriculture, Agricultureal Research Service, Tucson, A.Z.

Fernandez, O.A. and M.M. Caldwell. 1975. Phenology and dynamics of root growth of three cool semi-desert shrubs under field conditons. J. of Ecology 63(2):703-714.

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

Harper, K.T., F.J. Wagstaff and W.P. Clary. 1990. Shrub mortality over a 54-year period in shadscale desert, west-central Utah. Pages 119-126 in Proceedings-Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management. Gen. Tech. Rep. INT-GTR-276. USDA, Forest Service, Intermoutain Research Station, Ogden, UT.

Hironaka, M. and E. Tisdale. 1973. Growth and development of Sitanion hystrix and Poa sandbergii. Research Memorandum RM 72-24. U.S. International Biological Program, Desert Biome.

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.

Hutchings, S. S. and G. Stewart. 1953. Increasing forage yields and sheep production on intermountain winter ranges. Circular No. 925. U.S. Department of Agriculture, Washington, D.C.

Johnson, K. L. 1978. Wyoming shrublands: Proceedings, 7th Wyoming shrub ecology workshop. Page 58. University of Wyoming, Agricultural Extension Service, Rock Spring WY.

Knapp, P. A. 1998. Spatio-temporal patterns of large grassland fires in the Intermountain West, U.S.A. Global Ecology & Biogeography Letters 7:259-272.

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.

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/

Nelson, D.L., D.J. Weber and S.C. Garvin. 1990. The possible role of plant disease in the recent wildland shrub dieoff in Utah. Pages 84-90 in Proceedings-Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management. Gen. Tech. Rep. INT-GTR-276. USDA, Forest Service, Intermoutain Research Station, Ogden, UT.

Nelson, C.R., B.A. Haws and D.L. Nelson. 1990. Mealybugs and related homoptera of shadscale: Possible agents in the dieoff problem in the intermountain west. Pages 152-165 in Proceedings-Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management. Gen. Tech. Rep. INT-GTR-276. USDA, Forest Service, Intermoutain Research Station, Ogden, UT.

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

Pearson, L. C. 1965. Primary Production in Grazed and Ungrazed Desert Communities of Eastern Idaho. Ecology 46:278-285.

Peters, E. F. and S. Bunting. 1994. Fire conditions pre- and post-occurrence of annual grasses on the Snake River Plain. Pages 31-36 in Proceedings--Ecology and Management of Annual Rangelands Gen. Tech. Rep. INT-GTR-313. USDA, Forest Service, Intermountain Research Station, Boise, ID.

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

Sanderson, S. C., H. C. Stutz, and E. D. McArthur. 1990. Geographic Differentiation in Atriplex confertifolia. American Journal of Botany 77:490-498.

Smith, S. D. and P. S. Nobel. 1986. Deserts. Pages 13-62 in Photosynthesis in contrasting environments. Elsevier Science Publishers, Amsterdam, The Netherlands.

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

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

Stubbendieck, J. L. 1985. Nebraska Range and Pasture Grasses: (including Grass-like Plants). University of Nebraska, Department of Agriculture, Cooperative Extension Service, Lincoln, NE.

Stubbendieck, J. L., S. L. Hatch, and C. H. Butterfield. 1992. North American range plants. University of Nebraska Press, Lincoln, NE.

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).

Vallentine, J. F. 1989. Range development and improvements. Academic Press, Inc.
West, N. E. 1994. Effects of fire on salt-desert shrub rangelands.in Proceedings--Ecology and Management of Annual Rangelands, General Technical Report INT-313. USDA Forest Service, Intermountain Research Station, Boise, ID.

Wood, B. W. and J. D. Brotherson. 1986. Ecological adaptation and grazing response of budsage (Artemisia spinescens) Pages 75-92 in Proceedings-- symposium on the biology of Artemisia and Chrysothamnus. Gen. Tech. Rep. INT-200. U. S. Department of Agriculture, Forest Service, Intermountain Research Station, Provo, UT.

Wright, H. A. 1971. Why Squirreltail Is More Tolerant to Burning than Needle-and-Thread. Journal of Range Management 24:277-284.

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

Young, J. A. and R. A. Evans. 1977. Squirreltail Seed Germination. Journal of Range Management 30:33-36.

Young, J. A. and F. Tipton. 1990. Invasion of cheatgrass into arid environments of the Lahontan Basin. Pages 37-40 in Proceedings- Symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. Gen. Tech. Rep. INT-276. USDA, Forest Service, Intermountain Research Station, Las Vegas, NV.

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

Zielinski, M. J. 1994. Controlling erosion on lands administered by the Bureau of Land Management, Winnemucca District, Nevada. Pages 143-146 in Proceedings - ecology and management of annual rangelands Gen. Tech. Rep. INT-GTR-313. USDA, Forest Service, Intermountain Research Station, Boise ID.

Contributors

RK
T Stringham
P NovakEchenique

Rangeland health reference sheet

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

Author(s)/participant(s)	GK BRACKLEY / P NOVAK-ECHENIQUE
Contact for lead author	State Rangeland Management Specialist
Date	06/22/2006
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rills are none to rare. A few short rills (<1m) can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt. These will begin to heal during the next growing season.

2. **Presence of water flow patterns:** Water flow patterns are none to rare. A few water flow patterns may be evident in areas subjected to summer convection storms. Where flow patterns are observed, they are short in length (<2m), meandering, and stable.

3. **Number and height of erosional pedestals or terracettes:** Pedestals are none to rare with occurrence typically limited to areas within water flow patterns or after severe, extended drought with a corresponding die-off of vegetation. Terracettes are typically non-existent.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground 40-50%

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

6. **Extent of wind scoured, blowouts and/or depositional areas:** Wind-scouring is rare but may occur after several years of severe drought or wet years where shrub and grass die-off has occurred.

7. **Amount of litter movement (describe size and distance expected to travel):** Fine litter (foliage from grasses and annual & perennial forbs) expected to move distance of slope length during intense summer convection storms or rapid snowmelt events. Persistent litter (large woody material) will remain in place except during large rainfall events.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil stability values should be 2 to 6 on most soil textures found on this site.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface

soil structure is typically fine to medium platy or subangular blocky. Soil surface colors are light grays and soils are typified by an ochric epipedon. Surface textures are gravelly sandy loams. Organic matter of the surface 2 to 3 inches is less than 1 percent.

---

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Perennial bunchgrasses (Indian ricegrass) aid in infiltration and reduce runoff. Shrub canopy and associated litter provide some protection from raindrop impact and allow for snow capture on this site.

---

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Compacted layers are none. Platy or massive sub-surface horizons 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 (Indian ricegrass) = salt desert shrubs (shadscale, winterfat)

    Sub-dominant: associated shrubs > warm-season grasses > deep-rooted, perennial, forbs > fibrous, shallow-rooted, perennial forbs and annual forbs.

    Other:

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Dead branches within individual shrubs common and standing dead shrub canopy material may be as much as 25% of total woody canopy; mature bunchgrasses commonly (±15%) have dead centers.

---

14. **Average percent litter cover (%) and depth (in):** Between plant interspaces (15-25%) and depth (< ¼ in.)

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** For normal or average growing season (thru May) ± 500 lbs/ac; Favorable Years ± 700 lbs/ac and unfavorable years ± 300 lbs/ac.

---

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:** Potential invaders include halogeton, Russian thistle, annual mustards, and cheatgrass.

---

17. **Perennial plant reproductive capability:** All functional groups should reproduce in above average and average growing season years. Little growth and reproduction occurs in extreme or extended drought periods.