USDA Natural Resources Conservation Service

Ecological site R028AY011NV
SODIC DUNE

Accessed: 04/27/2024

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.

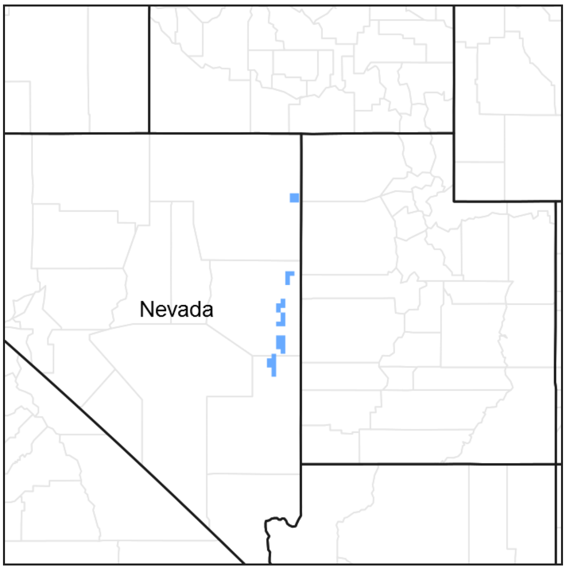

Figure 1. Mapped extent

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): 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 wind blown sand dunes typically located on the leeward side of bolson floor playas. Slopes range from 2 to 15 percent, but slope gradients of 4 to 15 percent are typical. Elevations are 5550 to 5900 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 45 to 50 degrees F. The average growing season is about 100 to 120 days.
Soils associated with this site are very deep and exhibit minimal soil development. These soils are coarse textured throughout the profile, have a very low available water capacity, and are excessively drained. Runoff is negligable to low and evaporation minimal. These soils are extremely susceptible to wind erosion.
The reference state is dominated by Indian ricegrass and fourwing saltbush. Black greasewood, spiny hopsage and alkali sacaton are other species commonly associated with this site. Production ranges from 350 to 700 pounds per acre.

Associated sites

R028AY023NV	**SODIC SANDS**

Similar sites

R028BY068NV	**DUNE 8-10 P.Z.** ARTR2 dominant shrub; SAVE4 rare to absent
R028BY021NV	**SODIC DUNE** SAVE4 dominant shrub; ATCA2 minor shrub, if present
R028AY023NV	**SODIC SANDS** SAVE4 dominant shrub; ATCA2 minor shrub; slopes mostly <4%

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Atriplex canescens* (2) *Sarcobatus vermiculatus*
Herbaceous	(1) *Achnatherum hymenoides*

Physiographic features

This site occurs on stabilized sand dunes typically located on the leeward side of bolson floor playas. Slopes range from 2 to 15 percent, but slope gradients of 4 to 15 percent are typical. Elevations are 5550 to 5900 feet.

Table 2. Representative physiographic features

Landforms	(1) Dune
Elevation	5,550–5,900 ft
Slope	2–15%
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 degrees F. The average growing season is about 100 to 130 days.

Mean annual precipitation at MONTELLO 1 SE, NEVADA (265352) is 6.95 inches.

Monthly mean precipitation is:
January 0.61; February 0.46; March 0.43;
April 0.61; May 0.91; June 0.83; July 0.56;
August 0.52; September 0.51; October 0.51;
November 0.53; December 0.48.

Table 3. Representative climatic features

Frost-free period (average)	110 days
Freeze-free period (average)	0 days
Precipitation total (average)	7 in

Influencing water features

There are no influencing water features associated with this site.

Soil features

Soils associated with this site are deep and very deep and excessively drained. These soils are fine sands over a silty clay loam horizon. Available water capacity is very low. Runoff is negligable to low and very high saturated hydraulic conductivity. They have a typic-aridic soil moisture regime and a mesic temperature regime. These soils are extremely susceptible to wind erosion. Soil series associated with this site include: Kawich.

The representative soil series is Kawich, a mixed, mesic Typic Torripsamments. Diagnostic horizons include an ochric epipedon from the surface to 18 cm. Reaction is moderately or strongly alkaline. Effervescence is violently effervescent. Lithology consists of eolian mixed rocks.

Table 4. Representative soil features

Surface texture	(1) Fine sand (2) Fine sandy loam
Family particle size	(1) Sandy
Drainage class	Excessively drained

Permeability class	Very rapid
Soil depth	60–84 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	2.3–2.4 in
Calcium carbonate equivalent (0-40in)	1–10%
Electrical conductivity (0-40in)	4–8 mmhos/cm
Sodium adsorption ratio (0-40in)	1–5
Soil reaction (1:1 water) (0-40in)	8.4–8.9
Subsurface fragment volume <=3" (Depth not specified)	0%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

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

Aeolian processes, which are presumably the dominant mechanism of soil detachment and transport on this ecological site, are largely responsible for the removal of nutrient-rich soil particles from the intercanopy areas and the deposition onto shrub patches. This sediment redistribution leads to the accumulation of nutrients under the shrub canopies, a process known as "islands of fertility" (Schlesinger et al. 1990). Thus, the landscape exhibits a mosaic of sources and sinks, with bare soil interspaces acting as sources and vegetated patches as sinks of nutrients and sediments (Puigdefabregas 2005). Hydrological processes, such as infiltration and runoff, determine the conditions favorable for the establishment and survival of different vegetation functional groups with a consequent impact on the structure and function of these systems. Sand dunes have high rates of infiltration because of the soils large pore spaces and low field capacity. These soils also have very high rates of saturated hydraulic conductivity allowing for deep percolation of moisture protected from evaporation. Moisture retention occurs below the upper 30 to 60 cm (Saltz et al 1999).

Fourwing saltbush is the most widely distributed and abundant saltbush in the southwest (Mozingo 1987). It is a native, long-lived woody shrub that grows on a variety of soils, landforms, and climatic conditions from sand dunes, sand sheets, alluvial fans and plains, hills and mountains and washes. It tolerates salinity but is not restricted to saline soils (Howard 2003). It is a polymorphic species and is evergreen or deciduous depending on climate (Ogle 2012). Fourwing saltbush has a long taproot of depths of 5 to 15 m. and many small lateral roots (Barrow 1997, Van Dersal 1938). Wallace et al. (1974) found that the roots compose 40 percent of the total mass of adult plants.

Fourwing saltbush is classified as a phreatophyte and has been documented at water tables occuring from 8 to 62 feet in New Mexico (Meinzer 1927). Atriplex species are considered medium to short-lived shrubs and possess a number of morphological and physiological traits that enable them to cope with drought. Some of these traits include: a) photosynthesis through the C4 carboxylation pathway; b) production of leaf trichomes and accumulation of salt crystals on the leaf surface to increase reflectance; c) accumulation and synthesis of inorganic and organic solutes to maintain turgor; and 4) root association with endomycorrhizae that allows absorption of soil moisture at very low water potentials (Cibils, et al. 1998, Dobrowolski 1990, Newton and Goodin 1989).

Black greasewood is also classified as a phreatophyte (Eddleman 2002), and its distribution is well correlated with the distribution of groundwater (Mozingo 1987). Meinzer (1927) discovered that the taproots of black greasewood could penetrate from 20 to 57 feet below the surface. Romo (1984) found water tables ranging from 3.5-15 m under black greasewood dominated communities in Oregon. Black greasewood stands develop best where moisture is readily available, either from surface or subsurface runoff (Brown 1965). It is commonly found on floodplains that are either subject to periodic flooding, have a high water table at least part of the year, or have a water table less than 34 feet deep (Harr and Price 1972, Blauer et al. 1976, Branson et al. 1976, Blaisdell and Holmgren 1984, Eddleman 2002). Black greasewood is usually a deep rooted shrub but has some shallow roots near the soil surface; the maximum rooting depth can be determined by the depth to a saturated zone (Harr and Price 1972). (Ganskopp (1986) reported that water tables within 9.8 to 11.8 inches of the surface had no effect on black greasewood in Oregon. However, a study, conducted in California, found that black greasewood did not survive six months of continuous flooding (Groeneveld and Crowley 1988, Groeneveld 1990).

Perennial bunchgrasses generally have somewhat shallower root systems than shrubs in these systems, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m but taper off more rapidly than shrubs. General differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems. The perennial bunchgrasses on this site include Indian ricegrass, alkali sacaton, thickspike wheatgrass, bottlebrush squirreltail, needleandthread and sand dropseed. The dominant grass within this site, is Indian ricegrass 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 these shrub – grass systems. Alkali sacaton is considered a facultative wet species in this region; therefore it is not drought tolerant. A lowering of the water table can occur with groundwater pumping and this may contribute to the loss of deep-rooted species such as black greasewood and an increase in rabbitbrush, shadscale and other species that are not groundwater dependent.
The ecological site may experience high wind erosion, especially with a decrease in vegetative cover. This can be caused by inappropriate grazing practices, drought, off-road vehicle use and/or fire. As ecological condition declines the dunes become mobile, recruitment and establishment of perennial grasses is reduced. This can cause an increase in sprouting shrubs such as rabbitbrush and horsebrush which are more adapted to disturbed sites. Annual non-native species such as Russian thistle and cheatgrass invade these sites where competition from perennial species is decreased. The ecological site has low resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Three possible stable states have been identified for this site but an annual state has been noted in other MLRAs.

Fire Ecology:
Fire is a rare disturbance in the salt-desert shrub communities likely occurring in years with above average precipitation and corresponding biomass. Historically, salt-desert shrub communities had sparse understories and bare soil in intershrub spaces, making these communities somewhat resistant to fire (Young 1983, Paysen et al. 2000). They may burn only during high fire hazard conditions; for example, years with high precipitation can result in almost continuous fine fuels, increasing fire hazard (West et al. 1994, Paysen et al. 2000).

Fourwing saltbush is the most widely distributed shrubby saltbush in North America (Meyer 2003). It is highly variable across landscapes and even within populations (McArthur et al. 1983, Petersen et al. 1987). Its ability to sprout following fire may depend on the population and fire severity. A study by Parmenter (2008) showed 58% mortality rate of fourwing saltbush following fire in New Mexico, the surviving shrubs produced sprouts shortly after fire. Fourwing saltbush readily reestablished is from seed (Howard 2003).
Black greasewood may be killed by severe fires but usually sprouts vigorously after low to moderate severity fire (Young 1983, Rickard and McShane 1984, West 1994). Bentz et al. (2008) reported that following a Nevada wildfire, black greasewood sprouts reached approximately 2.5 feet within 3 years. In a study by Rickard and

McShane (1983) black greasewood sprouted following wildfire and canopy cover was at 47 percent of preburn levels 2 years following fire. They also counted 185 shrubs before wildfire and 210 shrubs 2 years following fire. Spiny hopsage, a minor component in this community, is generally top-killed by fire (Daubenmire 1970), but often sprouts after plants are damaged by fire or mechanical injury (Shaw 1992). Spiny hopsage is reported to be least susceptible to fire during summer dormancy (Rickard and McShane 1984).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). However, season and severity of the fire will influence plant response. Plant response will also vary depending on post-fire soil moisture availability.

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.

Alkali sacaton is tolerant of, but not resistant to fire. Recovery of alkali sacaton after fire has been reported as 2 to 4 years (Bock and Bock 1978).

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). Postfire 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).

State and transition model

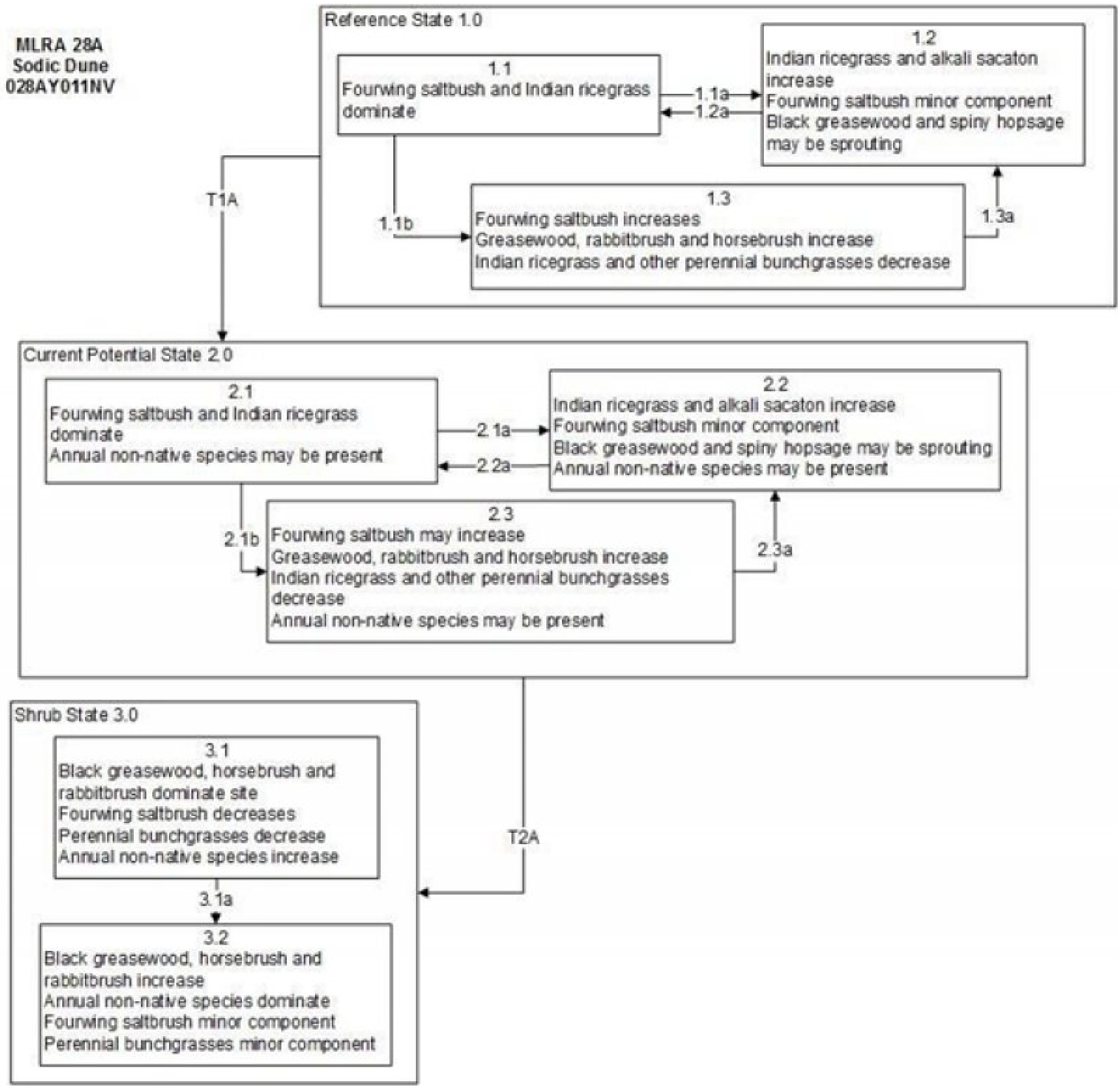

Figure 5. State and Transition Model

MLRA 28A
Sodic Dune
028AY011NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates grass/shrub mosaic
1.1b: Time and lack of disturbance such as fire. Excessive herbivory or long-term drought may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire or herbivory resulting in a mosaic pattern.

Transition T1A: Introduction of non-native species such as halogeton, bur buttercup, cheatgrass and mustards.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates grass/shrub mosaic; non-native annual species present
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub regeneration
2.3a: Low severity fire creates shrub/grass mosaic. Brush management with minimal soil disturbance(aerial herbicide application); late-fall/ winter grazing causing mechanical damage to shrubs

Transition T2A: Inappropriate grazing management favoring shrub dominance and reducing perennial bunchgrasses and/or long-term drought.

Shrub State 3.0
3.1a: Inappropriate grazing management in the presence of annual non-native species

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 three general community phases; a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community 1.1
Community Phase

Fourwing saltbush and Indian ricegrass dominate the site. Black greasewood, spiny hopsage and other shrubs are also common. Alkali sacaton, thickspike wheatgrass and bottlebrush squirreltail are also present in the understory. Forbs are present but not abundant. Potential vegetative composition is about 45% grasses, 5% forbs and 50% shrubs. Approximate ground cover (basal and crown) is 10 to 20 percent.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	175	250	350
Grass/Grasslike	157	225	315
Forb	18	25	35
Total	**350**	**500**	**700**

Community 1.2
Community Phase

This community phase is characteristic of a post-disturbance, early-seral community phase. Indian ricegrass, and other perennial bunchgrasses dominate. Fourwing saltbush may sprout after fire depending on ecotype. Black greasewood, spiny hopsage and other sprouting shrubs may increase.

Community 1.3
Community Phase

Figure 8. T.Stringham_4/24/2013, MU779_1390 Kawich soil series

Fourwing saltbush and other shrubs increase in the absence of disturbance. Excessive herbivory may cause an increase in black greasewood and other unpalatable shrubs. Fourwing saltbush and other shrubs dominate the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory.

Pathway a
Community 1.1 to 1.2

Fire will decrease or eliminate the overstory of fourwing saltbush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be low severity due to dispersed fuel loads. A fire following an unusually wet spring facilitating an increase in fine fuels may be more severe and reduce fourwing saltbush cover to trace amounts.

Pathway b
Community 1.1 to 1.3

Time and lack of disturbance such as fire allows for fourwing saltbush to increase. Chronic drought will cause a decline in perennial bunchgrasses allowing shrubs to increase. Herbivory may cause a decrease in perennial bunchgrasses and fourwing saltbush allowing other shrubs such as black greasewood and shadscale to increase.

Pathway a
Community 1.2 to 1.1

Absence of disturbance over time allows fourwing saltbush and other shrubs to recover.

Pathway a
Community 1.3 to 1.2

A low severity fire, herbivory or combinations will reduce the fourwing saltbush overstory and create a fourwing saltbush/grass mosaic.

State 2
Current Potential State

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

Community 2.1
Community Phase

Fourwing saltbush and Indian ricegrass dominate the site. Black greasewood, spiny hopsage and other shrubs are also common. Alkali sacaton, thickspike wheatgrass and bottlebrush squirreltail are also present in the understory. Forbs are present but not abundant. Non-native annual species are present.

Community 2.2
Community Phase

This community phase is characteristic of a post-disturbance, early seral community phase. Indian ricegrass and other perennial grasses dominate. Fourwing saltbush may be killed by fire depending on ecotype, therefore it may decrease in the burned community. Depending on fire severity patches of intact fourwing saltbush may remain. Sprouting shrubs such as black greasewood, spiny hopsage and rabbitbrush may dominate the aspect for a number of years following fire. Annual non-native species generally respond well after fire and may be stable to increasing within the community.

Community 2.3
Community Phase

Fourwing saltbush increases in the community and may become the dominant with lack of disturbance. Inappropriate grazing may cause a decrease in fourwing saltbush and allow other shrubs such as black greasewood, spiny hopsage and shadscale to increase.

Pathway a
Community 2.1 to 2.2

Fire would decrease or eliminate the overstory of fourwing saltbush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management facilitating an increase in fuel loads may be more severe and reduce shrub cover to trace amounts. Annual non-native species generally respond well after fire and may be stable or increasing in within the community.

Pathway b
Community 2.1 to 2.3

Time and lack of disturbance and/or chronic drought allows for fourwing saltbush to increase and dominate the site, causing a reduction in the perennial bunchgrasses. Inappropriate grazing may cause a decrease in perennial bunchgrasses and fourwing saltbush allowing other shrubs such as black greasewood and spiny hopsage to increase. However bottlebrush squirreltail and thickspike wheatgrass may increase in the understory depending on the grazing management.

Pathway a
Community 2.2 to 2.1

Time and lack of disturbance may allow for fourwing saltbush and other shrubs to establish and increase in community.

Pathway a
Community 2.3 to 2.2

Low severity fire, grazing management or combinations may decrease fourwing saltbush allowing for the perennial understory to increase. Late fall/winter grazing may cause mechanical damage to other shrubs such as black greasewood and spiny hopsage promoting the perennial bunchgrass understory.

State 3
Shrub State

This state has two community phases and is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Black greasewood, spiny hopsage and rabbitbrush dominate the overstory. Shrub cover exceeds 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. With a decrease in understory species the soils on these sites may become unstable and wind erosion may increase.

Community 3.1
Community Phase

Black greasewood dominates the overstory. Rabbitbrush and spiny hopsage may be significant components. Fourwing saltbush is still present but declining. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Annual non-native species increase. Bare ground is significant.

Community 3.2
Community Phase

Black greasewood, rabbitbrush and spiny hopsage dominate the site. Fourwing saltbush may be found in trace amounts or may be absent from the site. Annual non-native species dominate the understory. Perennial bunchgrasses make up a minor component.

Pathway a
Community 3.1 to 3.2

Heavy grazing in winter and early spring decreases fourwing saltbush and perennial bunchgrasses, and may promote other shrubs such as rabbitbrush and black greasewood.

Transition A
State 1 to 2

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

Transition A
State 2 to 3

Trigger: To Community Phase 3.1: Inappropriate cattle/horse grazing will decrease or eliminate deep rooted perennial bunchgrasses and fourwing saltbush and favor other shrub growth and establishment. Soil disturbing brush treatments will reduce fourwing saltbush and possibly increase non-native annual species and rabbitbrush. Slow variables: Long term decrease in deep-rooted perennial grass density and/or fourwing saltbush. Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter. Loss of long-lived, fourwing saltbush changes the temporal and depending on the replacement shrub, the spatial distribution of nutrient cycling.

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**			195–275	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	150–175	–
	alkali sacaton	SPAI	*Sporobolus airoides*	25–50	–
	squirreltail	ELEL5	*Elymus elymoides*	10–25	–
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	10–25	–
2	**Secondary Perennial Grasses**			10–25	
	saltgrass	DISP	*Distichlis spicata*	3–15	–
	needle and thread	HECO26	*Hesperostipa comata*	3–15	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	3–15	–
Forb					
3	**Perennial**			10–50	
	globemallow	SPHAE	*Sphaeralcea*	3–15	–
	princesplume	STANL	*Stanleya*	3–15	–
Shrub/Vine					
4	**Primary Shrubs**			210–340	
	fourwing saltbush	ATCA2	*Atriplex canescens*	150–200	–
	greasewood	SAVE4	*Sarcobatus vermiculatus*	50–100	–
	spiny hopsage	GRSP	*Grayia spinosa*	10–40	–
5	**Secondary Shrubs**			10–50	
	shadscale saltbush	ATCO	*Atriplex confertifolia*	5–15	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	5–15	–
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	5–15	–

Animal community

Livestock Interpretation:
This site is suited to livestock grazing. Grazing management considerations include timing, intensity and duration of grazing. Indian ricegrass is highly palatable to all classes of livestock in both green and cured condition. It supplies a source of green feed before most other native grasses have produced much new growth. 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 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 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.
Alkali sacaton, a sub-dominant plant on this site, has been found to be sensitive to early growing season defoliation whereas late growing season and/or dormant season use allowed recovery of depleted stands (Hickey and Springfield 1966). Thickspike wheatgrass, a minor component on this site, is a rhizomatous perennial with extensively creeping underground rootstocks. This characteristic enables the plant to withstand heavy grazing and considerable trampling. It prefers sandy soils where mature plants have been found to have average maximum root depths of about 15 inches. It is considered fair forage for all classes of livestock (Dayton 1937). It is a preferred feed for cattle, sheep, horses, and elk in spring and is considered a desirable feed for deer and antelope in spring. It is considered a desirable feed for cattle, sheep, and horses in summer, fall, and winter.

Bottlebrush squirreltail 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 untrampled conditions. Heavy trampling however was found to significantly reduce germination sites (Eckert et al. 1987). Bottlebrush squirreltail is more tolerant of grazing than Indian ricegrass but all bunchgrasses are sensitive to over utilization within the growing season. Bottlebrush squirreltail is very palatable winter forage for domestic sheep of Intermountain ranges. Domestic sheep relish the green foliage. Overall, bottlebrush squirreltail is considered moderately palatable to livestock.

Fourwing saltbush is one of the most palatable shrubs in the West. Its protein, fat, and carbohydrate levels are comparable to alfalfa. It provides nutritious forage for all classes of livestock. Palatability is rated as good for domestic sheep and domestic goats; fair for cattle; fair to good for horses in winter, poor for horses in other seasons. Fourwing saltbush is one of the most important forage shrubs in arid sites. Its importance is due to its abundance, accessibility, size, large volume of forage, evergreen habit, high palatability and nutritive value (Dayton 1937, Gordon 1975). The palatability rates from fairly good to good for cattle, and as good for sheep and goats, deer usually consume it as a winter browse (Dayton 1937). It has similar protein, fat, and carbohydrate levels as alfalfa (Medicago sativa)(Catlin 1925).

Black greasewood is an important winter browse plant for domestic sheep and cattle. It also receives light to moderate use by domestic sheep and cattle during spring and summer months. Black greasewood contains soluble sodium and potassium oxalates that may cause poisoning and death in domestic sheep and cattle if large amounts are consumed in a short time. In a study by Smith et al. (1992), utilization of new growth on greasewood shrubs by cattle was 77 percent in summer, and greasewood was found to have the highest amounts of crude protein when compared to perennial and annual grasses. Black greasewood plants have been found to contain high amounts of sodium and potassium oxalates which are toxic to livestock and caution should be taken when grazing these communities. These shrubs can be used lightly in the spring as long as there is a substantial amount of other preferable forage available (Benson et al. 2011).

Spiny hopsage is considered one of the most palatable of the salt desert shrubs, particularly during the spring. Its importance is due to its abundance, accessibility, size, large volume of forage, evergreen habit, high palatability and nutritive value (Dayton 1937, Gordon 1975). However, overall value is limited in most areas since leaves and fruits are shed by early summer (Shaw 1992). Spiny hopsage is used as forage to at least some extent by domestic sheep and goats, deer, pronghorn, and rabbits (Wasser 1982). It is somewhat tolerant of browsing, but heavy use will reduce cover. Webb and Stielstra (1979) reported mean cover of individual spiny hopsage plants decreased 29% in response to heavy domestic sheep grazing in the western Mojave Desert. The palatability rates from fairly good to good for cattle, and as good for sheep and goats, deer usually consume it as a winter browse (Dayton 1937).

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 Interpretation:

This site provides valuable habitat for several species of wildlife. Fourwing saltbush communities provide valuable habitat and year-round browse for wildlife due to its high nutritive value, large forage volume and evergreen habit (Booth 1985, Clark and Medcraft 1986). Wild and domestic ungulates, rodents, and lagomorphs readily consume all aboveground portions of the plant (Booth 1985). In a study in Wyoming, both deer (Odocoileus hemionus) and pronghorn (Antilocapra americana) consumed a large amount of fourwing saltbush, especially in winter months (Medcraft and Clark 1986). In southeastern Oregon, mule deer browsed both antelope bitterbrush and four wing saltbush. In fact, saltbush produces greater annual growth than bitterbrush, especially during periods of low precipitation; therefore it is seen as an important browse species for deer (Kindschy 1996). Fourwing saltbush also provides important habitat for mammals such as coyotes (Canis latrans) and rodents in areas where it dominates the landscape (Hafner 1977, Gese et al 1988). Additionally, the browse provides a source of water for black-tailed jackrabbits in arid environments (Hunter 1985). Birds and other small mammals will feed on the seeds and foliage. The plant acts as important cover for game-birds such as quail (Callipepla californica), and doves (Zenaida macroura), as well as passerines such as, towhees (Pipilo macualtus) and finches, that occur on arid range lands in the West (Dobbs et al. 2012, Booth 1985).

Several reptiles and amphibians are distributed throughout Nevada, where fourwing saltbush is known to grow (Bernard and Brown 1977). 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 areas saltbush species are dominant (Hamilton 2004). Studies have not determined if all species of reptiles and amphibians prefer certain species of saltbush; however, researchers agree that maintaining habitat where saltbush and reptiles and amphibians occur is important; however, there has been no research regarding the effect of saltbush on reptile and amphibian habitat and distribution (Linsdale 1938,West 1999 and ref. therein). Furthermore, fourwing saltbush provides excellent habitat for at-risk species such as the desert tortoise (Gopherus agassizii). The desert tortoise will browse fourwing saltbush and use it for cover (Durant et al. 1994).
Black greasewood is an important winter browse plant for big game animals and a food source for many other wildlife species. It also receives light to moderate use by mule deer and pronghorn during spring and summer months. Black greasewood also provides good cover for wildlife species (Benson et al. 2011). Spiny hopsage provides a palatable and nutritious food source for big game animals. Spiny hopsage is used as forage to at least some extent by domestic goats, deer, pronghorn, and rabbits.
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. In the spring, alkali sacaton is a preferred feed for elk and is considered desirable feed for deer and antelope. It is desirable feed for elk during summer, fall, and winter. Thickspike wheatgrass is also a component of black-tailed jackrabbit diets. Thickspike wheatgrass provides some cover for small mammals and birds. Bottlebrush squirreltail is a dietary component of several wildlife species. Bottlebrush squirreltail may provide forage for mule deer and pronghorn.

Hydrological functions

Runoff is negligable to low. Permeability is very rapid.

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

Fourwing saltbush is traditionally important to Native Americans. They ground the seeds for flour. The leaves, placed on coals, impart a salty flavor to corn and other roasted food. Top-growth produces a yellow dye. Young leaves and shoots were used to dye wool and other materials. The roots and flowers were ground to soothe insect bites. The leaves, seeds and stems of black greasewood are edible. Some Native American peoples traditionally ground parched seeds of spiny hopsage to make pinole flour. Indian ricegrass was traditionally eaten by some Native Americans. The Paiutes used seed as a reserve food source.

Other information

Fourwing saltbush is widely used in rangeland and riparian improvement and reclamation projects, including burned area recovery. It is probably the most widely used shrub for restoration of winter ranges and mined land reclamation. Black greasewood is useful for stabilizing soil on wind-blown areas. It successfully revegetates processed oil shale and is commonly found on eroded areas and sites too saline for most plant species. Spiny hopsage has moderate potential for erosion control and low to high potential for long-term revegetation projects. It can improve forage, control wind erosion, and increase soil stability on gentle to moderate slopes. Spiny hopsage is suitable for highway plantings on dry sites in Nevada. Alkali sacaton is one of the most commonly used species for seeding and stabilizing disturbed lands. Due to alkali sacaton's salt tolerance, is recommended for native grass seeding on subirrigated saline sites. Thickspike is a good revegetation species because it forms tight sod under dry rangeland conditions, has good seedling strength, and performs well in low fertility or eroded sites. It does not compete well with aggressive introduced grasses during the establishment period, but are very compatible with slower developing natives, bluebunch wheatgrass (Pseudoroegneria spicata), western wheatgrass (Pascopyrum smithii), and needlegrass (Achnatherum spp.) species. It's drought tolerance combined with rhizomes, fibrous root systems, and good seedling vigor make these species ideal for reclamation in areas receiving 8 to 20 inches annual precipitation. Thickspike wheatgrass can be used for hay production and will make nutritious feed, but is more suited to pasture use. Bottlebrush squirreltail is tolerant of disturbance and is a suitable species for revegetation.

Type locality

Location 1: Elko County, NV	
Township/Range/Section	T40N R70E S29
Latitude	41° 19′ 28″
Longitude	114° 4′ 12″
General legal description	SW¼SW¼, Section 29, T40N. R70E. MDBM. About 6 miles east of Montello, Tecoma (Site) area, Elko County, Nevada.

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Contributors

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Rangeland health reference sheet

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

Author(s)/participant(s)	P Novak-Echenique
Contact for lead author	State Rangeland Management Specialist
Date	10/24/2013
Approved by	
Approval date	

Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** None

2. **Presence of water flow patterns:** None

3. **Number and height of erosional pedestals or terracettes:** Pedestals are few to common with occurrence due to wind scouring. After a wildfire, the remaining vegetation may become severely pedestalled.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground up to 70%.

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

6. **Extent of wind scoured, blowouts and/or depositional areas:** Slight to moderate wind scouring. Severe blowouts and flattening of dunes may occur after a severe wildfire and the resulting loss of vegetation.

7. **Amount of litter movement (describe size and distance expected to travel):** Fine litter (foliage from grasses and annual & perennial forbs) expected to move unsheltered distance during heavy wind. Persistent litter (large woody material) expected to remain in place except during intense summer convection storms.

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 1 to 4 on the sandy soil textures found on this site.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface structure is typically single grained. Soil surface colors are very pale browns and soils are typified by an ochric epipedon. Surface textures are fine sands. Organic matter of the surface 2 to 3 inches is typically less than 1.5 percent. Organic matter content can be more or less depending on micro-topography.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., Indian ricegrass] slow runoff and increase infiltration. Shrub canopy and associated litter break raindrop impact and provide some opportunity for snow catch and accumulation on site.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Compacted layers are none.

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: tall salt-desert shrubs >

    Sub-dominant: deep-rooted, cool season, perennial bunchgrasses (i.e. Indian ricegrass) > warm season bunchgrasses > rhizomatous grasses > deep-rooted, cool season, perennial forbs.

    Other: Annual forbs

    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 30% of total woody canopy; some of the mature bunchgrasses (±20%) have dead centers.

14. **Average percent litter cover (%) and depth (in):** Between plant interspaces (± 10-15%) 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 (thru June) ± 500 lbs/ac; Favorable years ± 700 lb/ac and unfavorable years ± 350 lbs/ac.

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

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