USDA Natural Resources
Conservation Service

Ecological site R028AY005NV
SANDY 8-10 P.Z.

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General information

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

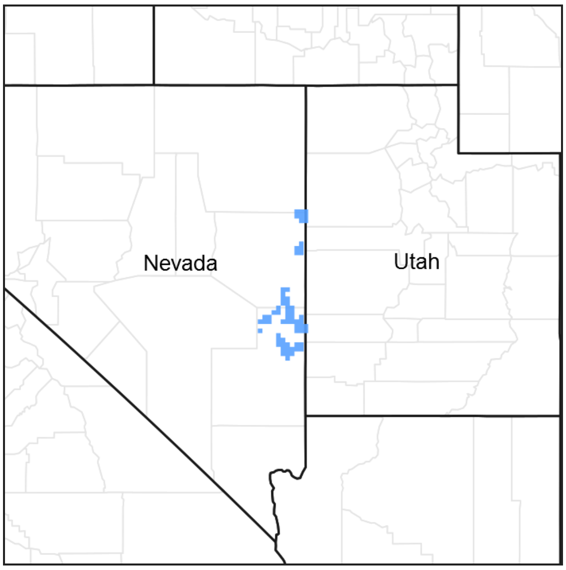

Figure 1. Mapped extent

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

MLRA notes

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

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

Ecological site concept

This site occurs on inset fans, fan remnants and longshore bars. Slopes range from 2 to 15 percent, but slope gradients of 2 to 8 percent are most typical. Elevations are 5700 to 7200 feet.
The climate associated with this site is semiarid, characterized by cool, moist winters and warm, dry summers. Average annual precipitation is 8 to 12 inches. Mean annual air temperature is 44 to 50 degrees F. The average growing season is about 90 to 140 days.
Soils associated with this site are moderately deep to very deep alluvial sands derived from alluvium parent material. Soil surface textures are gravelly and very sandy loams. Water intake rates are rapid, available water holding capacity is very low to moderate, runoff is very low to high, and soils are well to somewhat excessively drained.
The reference state is dominated by Wyoming big sagebrush, fourwing saltbush, Indian ricegrass and needleandthread. Sand dropseed, galleta, globemallow and winterfat are commonly associated plants. Production ranges from 400 to 1000 pounds per acre.

Associated sites

R028AY013NV	**SHALLOW CALCAREOUS LOAM 8-10 P.Z.**
R028AY018NV	**COARSE GRAVELLY LOAM 5-8 P.Z.**
R028AY019NV	**SANDY 5-8 P.Z.**

Similar sites

R028AY010NV	**COARSE GRAVELLY LOAM 10-12 P.Z.** PSSPS important grass; ATCA2 minor shrub, if present
R028AY019NV	**SANDY 5-8 P.Z.** ATCA2-KRLA2 codominant shrubs; ARTR2 absent
R028AY015NV	**LOAMY 8-10 P.Z.** ATCA2 minor shrub, if present
R028AY022NV	**GRAVELLY CLAY 8-10 P.Z.** ACTH7 dominant grass; ATCA2 minor shrub, if present
R028AY028NV	**DROUGHTY LOAM 8-10 P.Z.** ARTRW-GRSP codominant shrubs
R028BY005NV	**SANDY 8-10 P.Z.** PLJA & SPCR rare to absent

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata ssp. wyomingensis* (2) *Atriplex canescens*
Herbaceous	(1) *Achnatherum hymenoides* (2) *Hesperostipa comata*

Physiographic features

This site occurs on barrier bars, alluvial fans, fan remnants, spits, and longshore bars. Slopes range from 2 to 15 percent, but slope gradients of 2 to 8 percent are most typical. Elevations are 5700 to 7200 feet.

Table 2. Representative physiographic features

Landforms	(1) Barrier beach (2) Longshore bar (relict) (3) Fan remnant

Flooding duration	Extremely brief (0.1 to 4 hours)
Flooding frequency	Very rare
Ponding frequency	None
Elevation	1,737–2,195 m
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 8 to 12 inches. Mean annual air temperature is 44 to 50 degrees F. The average growing season is about 90 to 140 days.

Mean annual precipitaion at the LUND, NEVADA climate station (264745) is 10.04 inches.

January 0.78; February 0.85; March 1; April 0.98:
May 0.95; June 0.82; July 0.69; August 0.87;
September 0.77; October 0.92; November 0.69;
December 0.73.

Table 3. Representative climatic features

Frost-free period (average)	0 days
Freeze-free period (average)	115 days
Precipitation total (average)	254 mm

Influencing water features

There are no influencing water features associated with this site.

Soil features

Soils associated with this site are moderately deep to very deep alluvial sands derived from alluvium parent material. Soil surface textures are gravelly and very sandy loams. Water intake rates are rapid, available water holding capacity is very low to moderate, runoff is very low to high, and soils are well to somewhat excessively drained. Soil series associated with this site include: Medburn, Poobaa, Ragnel, Springbar, and Toopits.

The representative soil series is Poobaa, a Coarse-loamy, mixed, superactive, mesic Xeric Calciargids. Diagnostic horizons include an ochric epipedon from the soil surface to 5 inches, an argillic horizon from 5 to 25 inches, a calcic horizon from 16 to 25 inches. Clay content in the particle control section averages 13 to 18 percent. Rock fragments range from 10 to 25 percent gravel, dominantly 2 to 5 mm in diameter. Reaction is slightly to moderately alkaline. Effervescence is neutral to strongly effervescent. Lithology consists of andesite.

Table 4. Representative soil features

Parent material	(1) Residuum–andesite
Surface texture	(1) Loamy coarse sand
Family particle size	(1) Sandy
Drainage class	Well drained
Permeability class	Moderate to rapid
Soil depth	64–183 cm
Surface fragment cover <=3"	10–25%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	5.59–16 cm
Calcium carbonate equivalent (0-101.6cm)	0–20%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	7.2–8.2
Subsurface fragment volume <=3" (Depth not specified)	10–25%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).
This ecological site is dominated by deep-rooted cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Dobrowolski et al. 1990)
In the Great Basin, the majority of annual precipitation is received during the winter and early spring. This continental semiarid climate regime favors growth and development of deep-rooted shrubs and herbaceous cool season plants using the C3 photosynthetic pathway (Comstock and Ehleringer 1992).

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

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

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks especially a sagebrush defoliator, Aroga moth (Aroga websteri). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and is ongoing in Nevada since 2004 (Bentz, et al 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

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 that are sub-dominant with the shrubs include Indian ricegrass and needle and thread. 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.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation, both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The 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. The invasion of sagebrush communities by cheatgrass has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007). The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency. Conversely, as fire frequency decreases, sagebrush will increase and with inappropriate grazing management the perennial bunchgrasses and forbs may be reduced.

The ecological site may experience high wind erosion, especially with a decrease in vegetative cover. This can be caused by inappropriate grazing practices, drought, Aroga moth infestation, off-road vehicle use and/or fire. As ecological condition declines the dunes become mobile, and recruitment and establishment of sagebrush and 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 invade these sites where competition from perennial species is decreased.

This ecological site has low resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Three alternative states have been identified for this ecological site but an annual state has been noted in other MLRA's and may be possible within this site.

Fire Ecology:

Fire return intervals for Wyoming big sagebrush communities are estimated from 50 to 100+ years. Fire severity in big sagebrush communities is described as "variable" depending on weather, fuels, and topography. However, fire in Wyoming big sagebrush communities are typically stand replacing (Sapsis and Kauffman 1991). Wyoming big sagebrush is killed by fire. Because of the time needed to produce seed, they are eliminated by frequent fires (Bunting et al. 1987). Wyoming big sagebrush reinvades a site primarily by off-site seed or seed from plants that survive in unburned patches. Approximately 90% of big sagebrush seed is dispersed within 30 feet (9 m) of the parent shrub (Goodrich et al. 1985) with maximum seed dispersal at approximately 108 feet (33 m) from the parent shrub (Shumar and Anderson 1986). Therefore regeneration of big sagebrush after stand replacing fires is difficult and dependent upon proximity of residual mature plants and favorable moisture conditions (Johnson and Payne 1968, Humphrey 1984). Reestablishment after fire may require 50-120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013), therefore altering restoration potential of big sagebrush communities (Evans and Young 1978). Sites with low abundances of native perennial grasses and forbs typically have reduced resiliency following disturbance and are less resistant to invasion or increases in cheatgrass (Miller et al 2013).

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).
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.
Needle and thread 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 burn rather than fire intensity seemed to be the crucial factor in mortality for needle-and-thread grass. Early spring burning was found to kill the plants while August burning had no effect. Thus, under wildfire scenarios needle-and-thread is often present in the post-burn community.
Spiny hopsage is generally top-killed by fire (Daubenmire 1970), but often sprouts after plants are damaged by fire or mechanical injury (Shaw 1992). Fires in spiny hopsage sites generally occur in late summer when plants are dormant, and sprouting generally does not occur until the following spring (Daubenmire 1970). Spiny hopsage is reported to be least susceptible to fire during summer dormancy (Rickard and McShane 1984). Plants often survive fires that kill adjacent sagebrush (Blauer et al. 1976).
Depending on fire severity, rabbitbrush may increase after fire. Rabbitbrush is top-killed by fire, but can sprout after fire and can also establish from seed (Young 1983).
Invasion of cheatgrass, mustards and other annual weeds decreases site resilience, increases the risk of stand replacing fire and decreases the potential for sagebrush and Indian ricegrass reestablishment. Soil movement associated with fire and other activities such as OHV use or brush treatment has been observed. Spiny hopsage, a minor component in the reference community, has increased on burned areas due to the ability to resprout. Repeated fire within a 10 to 20 year timeframe has the potential to convert this site to an annual weed dominated system which was observed in MLRA 24 but not in MLRA 28A or 28B. See (024XY001NV).

State and transition model

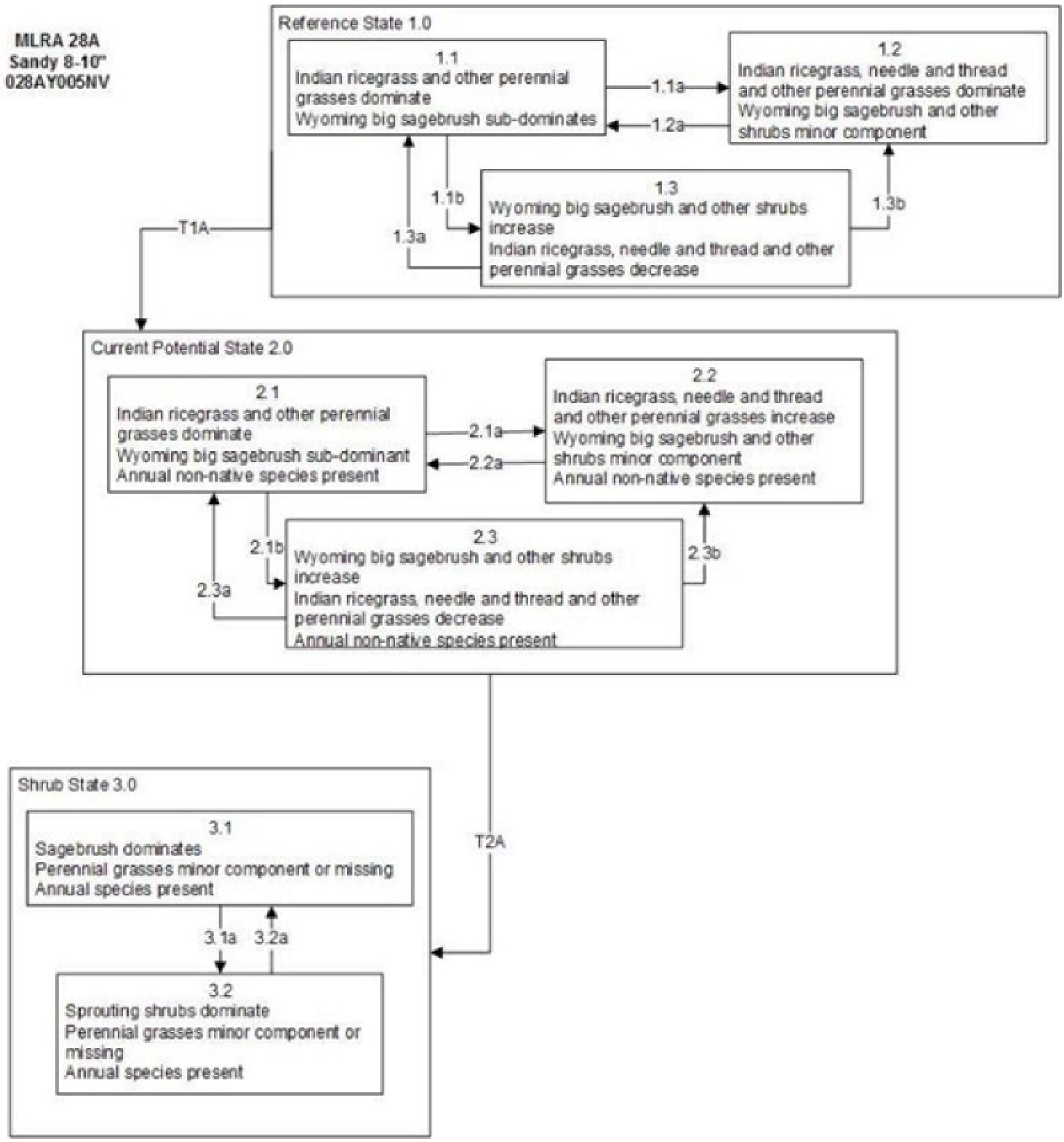

Figure 5. State and Transition Model

MLRA 28A
Sandy 8-10"
028AY005NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance allows for sagebrush regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass, mustards and Russian thistle.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic; non-native annual species present
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing and/or drought will reduce perennial bunchgrasses.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management (aerial herbicide application), late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community

Transition T2A: Inappropriate grazing management favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2)

Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition)

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

Wyoming big sagebrush, fourwing saltbush, winterfat, Indian ricegrass and needle and thread dominate the site. Spiny hopsage and other salt-desert shrubs are also common. Thickspike wheatgrass and other perennial grasses are also present in the understory. Forbs are present but not abundant. Potential vegetative composition is about 60 percent grasses, 5 percent forbs and 35 percent shrubs. Ground cover (basal and canopy) is 10 to 25 percent.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	269	471	673
Shrub/Vine	157	275	392
Forb	22	39	56
Total	**448**	**785**	**1121**

Community 1.2
Community Phase

This community phase is characteristic of a post-disturbance, early seral community phase. Indian ricegrass, thickspike wheatgrass, needle and thread grass, and other perennial grasses dominate. Wyoming big sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches. Forbs may increase post-fire but will likely return to pre-burn levels within a few years.

Community 1.3
Community Phase

Wyoming big sagebrush increases in the absence of disturbance or with herbivory that favors shrubs. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from herbivory.

Pathway a
Community 1.1 to 1.2

Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to dispersed fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

Pathway b
Community 1.1 to 1.3

Chronic drought, time and/or herbivory favor an increase in Wyoming big sagebrush over deep-rooted perennial bunchgrasses. Combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses. Thickspike wheatgrass may increase in density depending on herbivory impacts.

Pathway a
Community 1.2 to 1.1

Absence of disturbance over time allows for the shrubs, perennial grasses and forbs to recover.

Pathway a
Community 1.3 to 1.1

A low severity fire and/or a moderate Aroga moth infestation may reduce sagebrush overstory and allow perennial bunchgrasses to increase.

Pathway b
Community 1.3 to 1.2

Severe fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

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. 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

Wyoming big sagebrush, fourwing saltbush, needle and thread and Indian ricegrass dominate the site. Sand dropseed, galleta, globemallow and winterfat are commonly associated plants. Forbs make up smaller percentages by weight of the understory. Non-native annual species, such as cheatgrass and annual mustards are present in minor amounts (<5%). Potential vegetative composition is about 60% grasses, 5% forbs and 35% shrubs. Approximate ground cover (basal and crown) is 10 to 25 percent.

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. Wyoming big sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Annual non-native species generally respond well after fire and may be stable or increasing within the community. Rabbitbrush and other sprouting shrubs (spiny hopsage, fourwing saltbush) may dominate the aspect for a number of years following fire.

Community 2.3
Community Phase

Wyoming and basin big sagebrush increase and the perennial understory is reduced. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from grazing management. Other shrubs such as spiny hopsage and rabbitbrush may also increase in the overstory. Annual non-natives are present.

Pathway a
Community 2.1 to 2.2

Fire would decrease or eliminate the overstory of sagebrush 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 may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Pathway b
Community 2.1 to 2.3

Time, chronic drought, grazing management that favors shrubs or combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses. However thickspike wheatgrass may increase in the understory depending on the grazing management. Heavy spring grazing will favor an increase in sagebrush. Annual non-native species may be stable or increasing within the understory.

Pathway a
Community 2.2 to 2.1

Absence of disturbance over time allows for the shrubs, grasses and forbs to recover.

Pathway a
Community 2.3 to 2.1

Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush can also reduce sagebrush overstory and allow an increase in perennial bunchgrasses or thickspike wheatgrass.

Pathway b
Community 2.3 to 2.2

High severity fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

State 3
Shrub State

This state consists of two community phases one which is dominated by Wyoming big sagebrush and one that is dominated by sprouting shrubs such as rabbitbrush. This site has crossed a biotic threshold and site processes are being controlled by shrubs. Bare ground has increased and soil erosion has accelerated.

Community 3.1
Community Phase

Perennial bunchgrasses, like Indian ricegrass and needle and thread are reduced and the site is dominated by Wyoming big sagebrush. Thickspike wheatgrass may be present. Bare ground has increased. Annual non-native species are present.

Community 3.2
Community Phase

Sprouting shrubs such as rabbitbrush or spiny hopsage may dominate aspect following disturbance for a number of years. Wind erosion may be significant and lead to soil redistribution, significantly reducing safe sites for sagebrush reestablishment. Trace amounts of sagebrush may be present. Annual non-native species are present.

Pathway a
Community 3.1 to 3.2

Fire, Aroga moth, late-fall/winter grazing or brush management would decrease or eliminate the overstory of sagebrush. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to forbs and sprouting shrubs.

Conservation practices

Brush Management

Pathway a
Community 3.2 to 3.1

Time and lack of disturbance allows for regeneration of sagebrush. This may take many years.

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 plants will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Transition A
State 2 to 3

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during the growing season, and/or long term drought would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2. Slow variables: Long term decrease in deep-rooted perennial grass density. Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Primary Perennial Grasses**			306–573	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	157–235	–
	needle and thread	HECO26	*Hesperostipa comata*	118–196	–
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	16–63	–
	James' galleta	PLJA	*Pleuraphis jamesii*	8–39	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	8–39	–
2	**Secondary Perennial Grasses**			8–63	
	threeawn	ARIST	*Aristida*	4–24	–
	blue grama	BOGR2	*Bouteloua gracilis*	4–24	–
Forb					
3	**Perennial**			8–63	
	globemallow	SPHAE	*Sphaeralcea*	4–24	–
Shrub/Vine					
4	**Primary Shrubs**			157–353	
	fourwing saltbush	ATCA2	*Atriplex canescens*	39–118	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	39–78	–
5	**Secondary Shrubs**			16–78	
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	8–16	–
	spiny hopsage	GRSP	*Grayia spinosa*	8–16	–
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	8–16	–
	greasewood	SAVE4	*Sarcobatus vermiculatus*	8–16	–

Animal community

Livestock Interpretations:
This site is suited to livestock grazing. Grazing management considerations include timing, intensity, frequency, and duration of grazing. Indian ricegrass is a deep-rooted, cool season perennial bunchgrass that is adapted primarily to sandy soils. Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new

growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971) however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck 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 in the desert ranges of Utah. 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.

Thickspike wheatgrass is palatable to all classes of livestock and wildlife. 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. Thickspike wheatgrass's extensive rhizome system allows established stands to withstand heavy grazing and trampling. 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 (USDA 1937).

Needle and thread provides highly palatable forage, especially in the spring before fruits have developed. 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).

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.

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.

Livestock browse Wyoming big sagebrush, but may use it only lightly when palatable herbaceous species are available. 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.

Inappropriate grazing leads to an increase in sagebrush and a decline in understory plants like Indian ricegrass and needle and thread grass. Invasion of annual weedy forbs and cheatgrass could occur with further grazing degradation, leading to an increase in bare ground. A combination of overgrazing and prolonged drought leads to soil erosion, increased bare ground and a loss in plant production. Without management, cheatgrass and annual forbs are likely to invade and dominate the site, especially after fire.

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:

Wyoming big sagebrush is the preferred sub-species of sagebrush among wild ungulates. Pronghorn (Antilocapra americana), elk (Alces alces), mule deer (Odocoileus hemionus) and bighorn sheep (Ovis canadensis nelsoni) will browse Wyoming big sagebrush in winter months. (Bray et al. 1991). Studies have found Wyoming big sagebrush to be an important browse in pronghorn diets, especially in winter. Wyoming big sagebrush, and other big sagebrush varieties comprised approximately 75% to 90% of Pronghorn antelope diet in the winter months across western ranges. The shrub is a staple for the pronghorn throughout the year; however, it is not browsed as heavily in the summer months when preferred browse are available (Beale and Smith 1970, Ngugi et al. 1992). Mule deer and elk will also browse sagebrush intensively in winter. In fact, studies have noted dead sagebrush stands associated with elk browsing (Wambolt 1996). Further, mule deer and elk will browse Wyoming big sagebrush over basin big and black sagebrush, according to a ten year study in Montana (Wambolt 1996).

Shrubs are important to bighorn sheep diet, as these plants are higher in protein when grasses senesce in the winter months (Wagner and Peek 2006). A study by Brown (1977) determined that big sagebrush was preferred over other shrub types; however, the variety of the big sagebrush was not noted.

Sagebrush communities are important for maintaining lagomorph and rodent populations. Pygmy rabbits (Brachylagus idahoensis), sagebrush obligates, use sites with big sagebrush at a higher intensity than lower

sagebrush sites (Heady and Laundre 2005). A study by Larrison and Johnson (1973) captured more deer mice (Perymscus maniculatus) in big sagebrush communities than in any other plant community. Thus, suggesting that deer mice prefer these plant communities for cover over other plant communities.
Native birds also prefer Wyoming big sagebrush habitats. A study by Welch (1991) found sage grouse (Centrocercus urophasianus) feed on Wyoming big sagebrush over basin big sagebrush. However, sagebrush habitat should be managed for sage grouse as they prefer to use medium-height sagebrush communities for habitat (Gregg et al. 1994). Birds such as Brewer's sparrows (Spizella breweri), are considered dependent on sagebrush communities for cover and will nest in Wyoming big sagebrush. Thus, when Wyoming big sagebrush communities are converted to agriculture fields, Brewer's sparrow populations can decline due to loss of habitat (Knick et al. 2003). Big sagebrush are used as nesting structures, protection from predators and as thermal cover by sage grouse, the loggerhead shrike (Lanius ludovicianus), the sage sparrow (Artemisiospiza nevadensis) and the sage thrasher (Oreoscoptes montanus) (Nevada Wildlife Action Plan 2012). Sagebrush-grassland communities provide critical sage-grouse breeding and nesting habitats. Sagebrush is a crucial component of their diet year-round, and sage-grouse select sagebrush almost exclusively for cover. Sage-grouse prefer mountain big sagebrush and Wyoming big sagebrush communities to basin big sagebrush communities.
Several reptiles and amphibians are distributed throughout the sagebrush steppe in the west in Nevada, where Wyoming big sagebrush is known to grow (Bernard and Brown 1977). Reptile species including: eastern racers (Coluber constrictor), ringneck snakes (Diadophis punctatus), night snakes (Hypsiglena torquata), Sonoran mountain kingsnakes (Lampropeltis pyromelana), striped whipsnakes (Masticophis taeniatus), gopher snakes (Pituophis catenifer), long-nosed snakes (Rhinoceheilus lecontei), wandering garter snakes (Thamnophis elegans vagrans), Great Basin rattlesnakes (Crotalus oreganus lutosus), Great Basin collared lizard (Crotaphytus bicinctores), long-nosed leopard lizard (Gambelia wislizenii), short-horned lizard (Phrynosoma douglassi), desert-horned lizard (Phrynosoma platyrhinos), sagebrush lizards (Sceloporus graciosus), western fence lizards (Sceloporus occidentalis), northern side-blotched lizards (Uta uta stansburiana), western skinks (Plestiodon skiltonianus), and Great Basin whiptails (Aspidoscelis tigris) occur in areas where sagebrush is dominant. Similarly, amphibians such as: western toads (Anaxyrus boreas), Woodhouse's toads (Anaxyrus woodhousii), northern leopard frogs (Lithobates pipiens), Columbia spotted frogs (Rana luteiventris), bullfrogs (Lithobates catesbeianus), and Great Basin spadefoots (Spea intermontana) also occur throughout the Great Basin in areas sagebrush species are dominant (Hamilton 2004). Studies have not determined if reptiles and amphibians prefer certain species of sagebrush; however, researchers agree that maintaining habitat where Wyoming big sagebrush and reptiles and amphibians occur is important. In fact, wildlife biologists have noticed declines in reptiles where sagebrush steppe habitat has been seeded with introduced grasses (West 1999 and ref. therein).
Fourwing saltbush provides valuable habitat and year-round browse for wildlife. Fourwing saltbush also provides browse and shelter for small mammals. Additionally, the browse provides a source of water for black-tailed jackrabbits in arid environments. Granivorous birds consume the fruits. Wild ungulates, rodent and lagomorphs readily consume all aboveground portions of the plant. Palatability is rated good for deer, elk, pronghorn and bighorn sheep.
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. 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, it 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. 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. Thickspike wheatgrass is also a component of black-tailed jackrabbit diets. Thickspike wheatgrass provides some cover for small mammals and birds.
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.
Galleta provides moderately palatable forage when actively growing and relatively unpalatable forage during dormant periods. Galleta provides poor cover for most wildlife species.
Changes in plant community composition caused by fire frequency associated with this ecological site could affect the distribution and presence of wildlife species.

Hydrological functions

Runoff is very low to very high. Permeability is slow. Rills are non-existent. Water flow patterns are none to rare and limited to steeper slopes in areas subjected to summer convection storms or rapid snowmelt. Water flow patterns, if present, are short in length (<1 m) and not connected. Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., Indian ricegrass & needleandthread] slow runoff and increase infiltration. Shrub canopy and associated litter break raindrop impact and provide opportunity for snow catch and accumulation on site.

Recreational uses

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

Other products

Native Americans made tea from big sagebrush leaves. They used the tea as a tonic, an antiseptic, for treating colds, diarrhea, and sore eyes and as a rinse to ward off ticks. Big sagebrush seeds were eaten raw or made into meal. 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. 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

Wyoming big sagebrush is used for stabilizing slopes and gullies and for restoring degraded wildlife habitat, rangelands, mine spoils and other disturbed sites. It is particularly recommended on dry upland sites where other shrubs are difficult to establish. 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. 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. 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. 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	
General legal description	This site also occurs in White Pine county, Nevada

Other references

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

Baker, W. L. 2006. Fire and restoration of sagebrush ecosystems. Wildlife Society Bulletin 34:177-185.

Baker, W. L. 2011. Pre-euro-american and recent fire in sagebrush ecosystems. Pages 185-201 in S. T. Knick and J. W. Connelly, editors. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. University of California Press, Berkeley, California.

Balch, J. K., B. A. Bradley, C. M. D'Antonio, and J. Gómez-Dans. 2013. Introduced annual grass increases regional fire activity across the arid western USA (1980–2009). Global Change Biology 19:173-183.

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. 1953. Ecological effects of planned burning of sagebrush-grass range on the upper Snake River Plains. US Dept. of Agriculture.

Blauer, A. C., A. P. Plummer, E. D. McArthur, R. Stevens, and B. C. Giunta. 1976. Characteristics and hybridization of important Intermountain shrubs. II. Chenopod family. USDA For Serv Res Pap INT-177 US Department of Agriculture Intermountain Forest and Range Experiment Station:42.

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.

Bunting, S. C., B. M. Kilgore, and C. L. Bushey. 1987. Guidelines for prescribed burning sagebrush-grass rangelands in the northern Great Basin. US Department of Agriculture, Forest Service, Intermountain Research Station Ogden, UT, USA.

Chambers, J., B. Bradley, C. Brown, C. D'Antonio, M. Germino, J. Grace, S. Hardegree, R. Miller, and D. Pyke. 2013. Resilience to Stress and Disturbance, and Resistance to Bromus tectorum L. Invasion in Cold Desert Shrublands of Western North America. Ecosystems:1-16.

Chambers, J. C., B. A. Roundy, R. R. Blank, S. E. Meyer, and A. Whittaker. 2007. What makes great basin sagebrush ecosystems invasible by Bromus tectorum? Ecological Monographs 77:117-145.

Cook, C. W. 1962. An Evaluation of Some Common Factors Affecting Utilization of Desert Range Species. Journal of Range Management 15:333-338.

Cook, C. W. and R. D. Child. 1971. Recovery of Desert Plants in Various States of Vigor. Journal of Range Management 24:339-343.

Daubenmire, R. 1970. Steppe vegetation of Washington. Technical Bulletin 62. Washington State University, College of Agriculture, Washington Agriculture Experiment Station, Pullman, WA.

Evans, R. A. and J. A. Young. 1978. Effectiveness of Rehabilitation Practices following Wildfire in a Degraded Big Sagebrush-Downy Brome Community. Journal of Range Management 31:185-188.

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

Furniss, M. M. and W. F. Barr. 1975. Insects affecting important native shrubs of the northwestern United States. US Intermountain Forest And Range Experiment Station. USDA Forest Service General Technical Report INT INT-19.
Goodrich, S., E. D. McArthur, and A. H. Winward. 1985. A new combination and a new variety in Artemisia tridentata. The Great Basin Naturalist 45:99-104.

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.

Humphrey, L. D. 1984. Patterns and mechanisms of plant succession after fire on Artemisia-grass sites in southeastern Idaho. Vegetatio 57:91-101.

Johnson, J. R. and G. F. Payne. 1968. Sagebrush reinvasion as affected by some environmental influences. Journal of Range Management 21:209-213.

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/.

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

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

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

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

Rickard, W. and M. McShane. 1984. Demise of spiny hopsage shrubs following summer wildfire: An authentic record. Northwest Science 58:282-285.

Sapsis, D. B. and J. B. Kauffman. 1991. Fuel consumption and fire behavior associated with prescribed fires in sagebrush ecosystems. Northwest Science 65:173-179.

Shaw, N. L. 1992. Germination and seedling establishment of spiny hopsage (Grayia spinosa [Hook.] Moq.).

Shumar, M. L. and J. E. Anderson. 1986. Water relations of two subspecies of big sagebrush on sand dunes in southeastern Idaho. Northwest Science 60:179-185.

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.

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.

Wasser, C. H. and J. W. Shoemaker. 1982. Ecology and culture of selected species useful in revegetating disturbed lands in the West. FWS/OBS-82/56. Fish and Wildlife Service, US Department of the Interior.
Webb, R. and S. Stielstra. 1979. Sheep grazing effects on Mojave Desert vegetation and soils. Environmental Management 3:517-529.

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.

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 A. W. Bailey. 1982. Fire ecology: United States and southern Canada. Wiley & Sons.

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

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

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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:** Rills are typically non-existent on this site.

2. **Presence of water flow patterns:** Water flow patterns are none to rare and limited to steeper slopes in areas subjected to summer convection storms or rapid snowmelt. Water flow patterns, if present, are short in length (<1 m) and not connected.

3. **Number and height of erosional pedestals or terracettes:** Pedestals are typically none to rare. After a severe wildfire remaining plants may become pedestalled due to soil redistribution.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground 50-60%

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

6. **Extent of wind scoured, blowouts and/or depositional areas:** Wind scouring is typically minimal on this site. Wind scouring and blowouts may occur immediately after a severe wildfire that has removed all 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 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 5 on most soil textures found on this site. (This will be field tested.)

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface structure is typically thin to thick platy. Soil surface colors are pale browns or grays and soils are typified by an ochric epipedon. Organic matter of the surface 2 to 3 inches is typically 1 to 1.5 percent dropping off quickly below. Organic matter content can be more or less depending on micro-topography.

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

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Compacted layers are none. Platy or massive sub-surface structure and argillic or calcic 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 >>

    Sub-dominant: Wyoming big sagebrush >> associated shrubs > cool season, shallow-rooted bunchgrasses and/or rhizomatous grasses > deep-rooted, cool season, perennial forbs > fibrous, shallow-rooted, cool season, perennial forbs and annual forbs.

    Other: Warm season grasses

    Additional: With an extended fire return interval, the shrub component will increase at the expense of the herbaceous component.

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; some of the mature bunchgrasses (<20%) have dead centers.

14. **Average percent litter cover (%) and depth (in):** Between plant interspaces 20-30% 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 June) ± 700 lbs/ac; Favorable years± 1000 lbs/ac and unfavorable years ± 400 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. Cheatgrass is most likely to invade after wildfire.

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