USDA Natural Resources Conservation Service

Ecological site R028AY088NV
GRAVELLY CLAY 12-14 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.

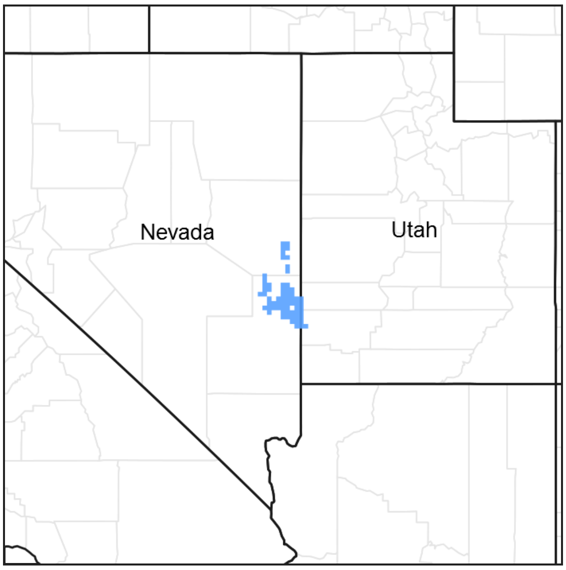

Figure 1. Mapped extent

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 sideslopes of lower mountains, fan remnants, and pediments. Slope gradients of 2 to 50 percent are typical. Elevations are 6800 to 8500 feet.

Average annual precipitation is 12 to 14 inches. Mean annual air temperature is 44 to 47 degrees F. The average growing season is about 85 to 100 days.

Soils associated with this site are typically moderately deep to very deep and well drained. The surface soil is typically dark in color and relatively high in organic matter. The soils have a mollic epipedon and an argillic horizon. Surface soils are medium to coarse textured and subsoils are medium to fine textured. The available water holding capacity is very low to low. The soil moisture regime is aridic bordering on xeric and the soil temperature regime is frigid. Some soils are modified with high volumes of rock fragments throughout the soil profile.

The reference state is dominated by bluebunch wheatgrass, mountain big sagebrush, and antelope bitterbrush. Production ranges from 450 to 900 pounds per acre.

Associated sites

R028AY059NV	**MAHOGANY SAVANNA**
R028AY094NV	**CLAYPAN 12-14 P.Z.**
R028BY030NV	**LOAMY 12-16 P.Z.**

Similar sites

R028AY095NV	**LOAMY 10-12 P.Z.** HECO26 codominant grass; ARTRW dominant shrub
R028AY022NV	**GRAVELLY CLAY 8-10 P.Z.** PSSPS minor grass, if present; ARTRW dominant shrub
R028AY050NV	**GRAVELLY CLAY 10-12 P.Z.** ARTRW and/or ARTRV dominant shrub; very similar plant community description - may be same site as 028AY088NV, or 028AY050NV should be ARTRW only; further investigation needed
R028AY066NV	**GRAVELLY LOAM 12-14 P.Z.** PURT2 dominant shrub; ARTRV important shrub but not codominant
R028AY092NV	**LOAMY 12-14 P.Z.** More productive site; ACHNA spp. codominant with PSSPS

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata ssp. vaseyana* (2) *Purshia tridentata*
Herbaceous	(1) *Pseudoroegneria spicata ssp. spicata*

Physiographic features

This site occurs on sideslopes of lower mountains, fan remnants, and pediments. Slope gradients of 2 to 50 percent are typical. Elevations are 6800 to 8500 feet.

Table 2. Representative physiographic features

Landforms	(1) Mountain (2) Fan remnant (3) Pediment

Flooding duration	Brief (2 to 7 days) to extremely brief (0.1 to 4 hours)
Flooding frequency	Very rare
Ponding frequency	None
Elevation	2,073–2,591 m
Slope	2–50%
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).

Average annual precipitation is 12 to 14 inches. Mean annual air temperature is 44 to 47 degrees F. The average growing season is about 85 to 100 days.

The Mean annual precipitation at the Great Basin Natinal Park Climate Station (263340) is 13.33 inches.

Monthly mean precipitation is:
January 1.05; February 1.18; March 1.37; April 1.21; May 1.24; June .87; July .97; August 1.18; September 1.08; October .96; December .96

Table 3. Representative climatic features

Frost-free period (average)	0 days
Freeze-free period (average)	92 days
Precipitation total (average)	330 mm

Influencing water features

There are no influencing water features associated with this site.

Soil features

Soils associated with this site are typically moderately deep to very deep and well drained. The surface soil is typically dark in color and relatively high in organic matter. The soils have a mollic epipedon and an argillic horizon.

Surface soils are medium to coarse textured and subsoils are medium to fine textured. The available water holding capacity is very low to low. The soil moisture regime is aridic bordering on xeric and the soil temperature regime is frigid. Some soils are modified with high volumes of rock fragments throughout the soil profile. There are high amounts of gravels and cobbles at the soil surface. The soil series associated with this site include: Buzztail, Heusser, Modem, Nevu, Satt, Slockey, and Starflyer.

The representative soil series is Heusser, a Clayey-skeletal, smectitic, frigid Aridic Palexerolls. Diagnostic horizons include a mollic epipedon from the soil surface to 30 cm, and an argillic horizon from 61 to 152 cm. Clay content in the particle control section averages 40 to 55 percent. Rock fragments range from 35 to 65 percent, mainly gravel. Reaction is neutral or slightly alkaline. Effervescence is none. Lithology consists of rock fragments of quartzite.

Table 4. Representative soil features

Parent material	(1) Alluvium–quartzite (2) Alluvium–welded tuff
Surface texture	(1) Extremely gravelly loam (2) Gravelly loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Very slow to moderate
Soil depth	127–213 cm
Surface fragment cover <=3"	30–35%
Surface fragment cover >3"	25–30%
Available water capacity (0-101.6cm)	1.78–10.16 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	6.6–6.8
Subsurface fragment volume <=3" (Depth not specified)	35–65%
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 invasion. 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 and over 3.0 m (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of two meters in alluvial soils in Utah (Richards and Caldwell 1987). Tap roots of antelope bitterbrush have been documented from 4.5 to 5.4 m in length (McConnell 1961). These

shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).
Mountain big sagebrush and antelope bitterbrush are 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. If cheatgrass is present, bitterbrush seedling success is much lower. The factor that most limits establishment of bitterbrush seedlings is competition for water resources with the invasive species cheatgrass (Clements and Young 2002).

The perennial bunchgrasses that are co-dominant with the shrubs include bluebunch wheatgrass, Thurber's needlegrass,
needleandthread and muttongrass. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m 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 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). Dobrowolski et al. (1990) cite multiple authors on the extent of the soil profile exploited by the competitive exotic annual cheatgrass. Specifically, the depth of rooting is dependent on the size the plant achieves and in competitive environments cheatgrass roots were found to penetrate only 15 cm whereas isolated plants and pure stands were found to root at least 1 m in depth with some plants rooting as deep as 1.5 to 1.7 m.
Utah juniper and singleleaf pinyon, with an extended period of time without disturbance may increase in density. Eventually, singleleaf pinyon and Utah juniper may dominate the site and out-compete mountain big sagebrush and antelope bitterbrush for water and sunlight, severely reducing both the shrub and herbaceous understory (Miller et al. 2000, Lett and Knapp 2005). Bluegrasses may remain underneath trees on north-facing slopes. The potential for soil erosion increases as the woodland matures and the understory plant community cover declines (Pierson et al. 2010).

These sites have moderate resilience to disturbance and resistance to invasion by non-natives. Resilience increases with elevation, aspect, increased precipitation, and increased nutrient availability. Long-term disturbance response may be influenced by small differences in landscape topography. Concave areas receive run-in from adjacent landscapes and consequently retain more moisture to support the growth of deep-rooted perennial grasses (i.e. bluebunch wheatgrass, Thurber's needlegrass) whereas convex areas where runoff occurs are slightly less resilient and may have more shallow-rooted perennial grasses (i.e. squirreltail and muttongrass). North slopes are also more resilient than south slopes because lower soil surface temperatures operate to keep moisture content higher on northern exposures. Six possible alternative stable states have been identified.

Fire Ecology:
Pre-settlement fire return intervals in mountain big sagebrush communities varied from 15 to 25 years (Burkhardt and Tisdale 1969, Houston 1973, Miller 2000). Mountain big sagebrush is killed by fire (Neuenschwander 1980, Blaisdell et al. 1982), and does not resprout (Blaisdell 1953). Post-fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush may return to pre-burn density and cover within 15-20 years following fire, but establishment after severe fires may proceed more slowly and can take up to 50 years (Bunting et al. 1987, Ziegenhagen 2003, Miller and Heyerdahl 2008, Ziegenhagen and Miller 2009).

The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual dominated community. Infilling by singleleaf pinyon and Utah juniper may also occur with an extended fire return interval. Without fire or changes in management, singleleaf pinyon and Utah juniper will dominate the site and mountain big sagebrush will be severely reduced. The herbaceous understory will also be reduced. The potential for soil erosion increases as the woodland matures and the understory plant community cover declines. Catastrophic wildfire in pinyon/juniper controlled sites may lead to an annual weed dominated site.

Depending on fire severity, rabbitbrush, snowberry, Utah serviceberry and antelope bitterbrush may increase after fire. Rubber rabbitbrush is top-killed by fire, but can resprout after fire and can also establish from seed (Young 1983). Yellow rabbitbrush is top-killed by fire, but sprouts vigorously after fire (Kuntz 1982, Akinsoji 1988). As cheatgrass increases, fire frequencies also increase to frequencies between 0.23 and 0.43 times a year; then even sprouting shrubs such as rabbitbrush will not survive (Whisenant 1990). Snowberry is also top-killed by fire, but resprouts after fire from rhizomes (Leege and Hickey 1971, Noste and Bushey 1987). Snowberry has been noted to regenerate well and exceed pre-burn biomass in the third season after a fire (Merrill et al. 1982).

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires may allow for bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006).

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).
Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage to fire but is more susceptible in drought years (Young 1983). Plant response will vary depending on season, fire severity, fire intensity and post-fire soil moisture availability.
Thurber’s needlegrass is moderately resistant to wildfire (Smith and Busby 1981), but can be severely damaged and have high mortality depending on season and severity of fire. Post-fire regeneration usually occurs from seed, but plants that are not completely killed by fire will continue growth during favorable conditions (Koniak 1985).

Needleandthread is top-killed by fire but is likely to resprout if fire does not consume above ground stems (Akinsoji 1988, Bradley et al. 1992). In a study by Wright and Klemmedson (1965), season of burn rather than fire intensity seemed to be the crucial factor in mortality for needle and thread grass. Early spring season burning was found to kill the plants while August burning had no effect.

Sandberg bluegrass, a minor component of this ecological site, has been found to increase following fire likely due to its low stature and productivity (Daubenmire 1975). Sandberg bluegrass may retard reestablishment of deeper rooted bunchgrass. Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion and/or cheatgrass and other invasive species to occupy interspaces, leading to increased fire frequency and potentially an annual plant community. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

State and transition model

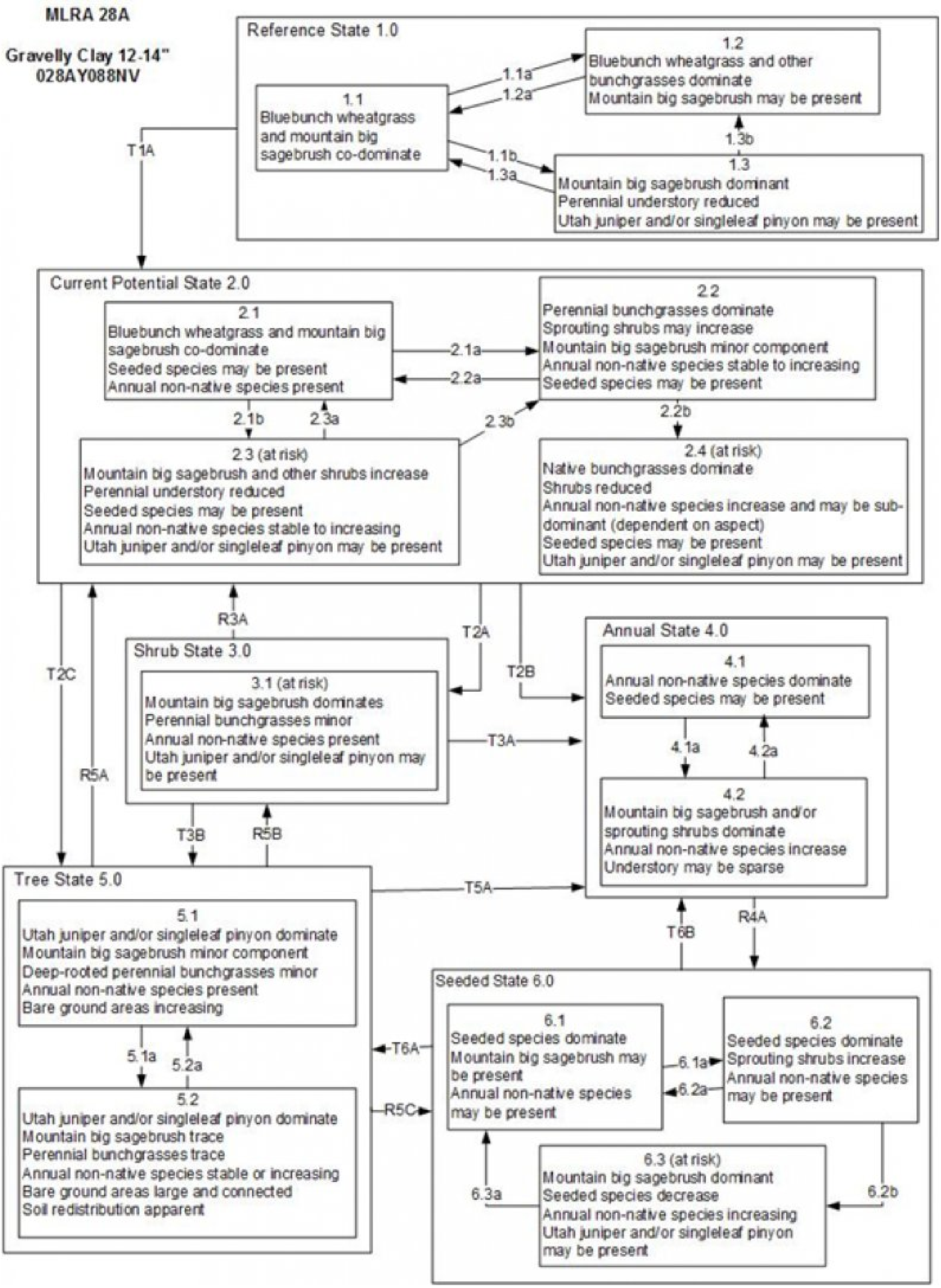

Figure 6. T. Stringham 12/7/2014

MLRA 28A
Gravelly Clay 12-14"
028AY088NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire Aroga moth infestation creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or long-term drought. Excessive herbivory may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire or severe Aroga moth infestation significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire Aroga moth infestation creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance such as fire or long-term drought. Inappropriate grazing management may also decrease perennial understory.
2.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
2.2b: Tree/shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
2.3b: High severity fire or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: Catastrophic fire or multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T2C: Time and lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management (5.1).

Shrub State 3.0 Community Phase Pathways
None.

Transition T3A: Catastrophic fire and/or soil disturbing treatments (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2)
Transition T3B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance (5.1)

Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species (2.4).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

Restoration R4A: Seeding of deep rooted perennial bunchgrasses, probability of success is medium.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for tree maturation.
5.2a: Stand thinning treatment.

Restoration R5A: Tree removal with minimal soil disturbance and seeding of desired species (2.2).
Restoration R5B: Coming from Tree State 5.1 only: tree removal treatment or controlled burn. Controlled burn only recommended if nonnative annuals are not present.
Restoration R5C: Tree removal coupled with seeding of desired species (6.2)

Transition T5A: Catastrophic fire.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
6.2a: Low severity fire or Aroga moth infestation.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire, Aroga moth infestation, or brush treatment with minimal soil disturbance.

Transition T6A: Time and lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management (5.1).
Transition T6B: Severe fire. This transition usually originates from 6.3.

Figure 7. legend

State 1
Reference State

The Reference State 1.0 is 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

This community is dominated by big sagebrush and bluebunch wheatgrass. Forbs and other grasses make up smaller components. Utah juniper and singleleaf pinyon are described in the site concept and may or may not be present.Potential vegetative composition is about 55% grasses, 10% forbs and 35% shrubs and trees.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	278	432	555
Shrub/Vine	157	243	313
Forb	50	78	101
Tree	20	31	40
Total	**505**	**784**	**1009**

Community 1.2
Community Phase

This community phase is characteristic of a post-disturbance, early-seral community. Bluebunch wheatgrass and other perennial bunchgrasses dominate. Depending on fire severity or intensity, patches of intact sagebrush may remain.

Community 1.3
Community Phase

Mountain big sagebrush increases in the absence of disturbance or with grazing management 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 grazing management. Utah juniper and/or singleleaf pinyon may be present.

Pathway a
Community 1.1 to 1.2

Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring may be more severe and reduce sagebrush cover to trace amounts. Coupled with drought conditions, a severe infestation of Aroga moth could also reduce in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. This phenomenon is more likely at the lower end of the precipitation range.

Pathway b
Community 1.1 to 1.3

Chronic drought may reduce fire frequency and increase shrub cover, time and/or inappropriate grazing management may also favor an increase in Mountain 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. Sandberg bluegrass may increase in density depending on the grazing management.

Pathway a
Community 1.2 to 1.1

Time and lack of disturbance will allow sagebrush to increase.

Pathway a
Community 1.3 to 1.1

A low severity fire will reduce the sagebrush overstory and create a sagebrush/grass mosaic. Coupled with drought, Aroga moth infestation may reduce sagebrush dominance and allow recovery of the perennial bunchgrass understory.

Pathway b
Community 1.3 to 1.2

Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be low severity, resulting in a mosaic pattern due to low fine fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts.

State 2
Current Potential State

This state is similar to the Reference State 1.0. with similar community phases plus the addition of the 2.4 at-risk community phase. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance but will not become dominant within this state. These non-natives can be highly flammable and can promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal. Additionally, the presence of highly flammable, non-native species reduces State resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system.

Community 2.1
Community Phase

This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. Sagebrush, bluebunch wheatgrass, and Indian ricegrass dominate the site. Forbs and other shrubs and grasses make up smaller components of this site.

Community 2.2
Community Phase

This community phase is characteristic of a post-disturbance, early seral community where annual non-native species are present. Sagebrush is present in trace amounts; perennial bunchgrasses dominate the site. Depending on fire severity patches of intact sagebrush may remain. Rabbitbrush may be sprouting. Perennial forbs may be a significant component for several years following fire. Annual non-native species are stable or increasing within the community.

Community 2.3
Community Phase (At Risk)

This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced from competition with shrubs, inappropriate grazing, or both. Rabbitbrush may be a significant component. Sandberg bluegrass may increase and become co-dominant with deep rooted bunchgrasses. Utah juniper and singleleaf pinyon may be present and without management will likely increase. Annual non-natives species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.

Community 2.4
Community Phase (At Risk)

This community is at risk of crossing into an annual state. Native bunchgrasses dominate; however annual non-native species such as cheatgrass may be sub-dominant in the understory. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. Seeded species may be present. Sagebrush and/or bitterbrush are a minor component. Singleleaf pinyon and/or Utah juniper may be present to increasing. This site is susceptible to further degradation from improper grazing, drought, and fire. Target grazing can be used to reduce the cheatgrass component.

Pathway a
Community 2.1 to 2.2

Fire reduces the shrub overstory and allows for perennial bunchgrasses to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire. Aroga moth infestations can also cause mortality of the mountain big sagebrush overstory.

Pathway b
Community 2.1 to 2.3

Time and lack of disturbance allows for sagebrush to increase and become decadent. Chronic drought reduces fine fuels and leads to a reduced fire frequency, allowing big sagebrush to dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely Sandberg bluegrass may increase in the understory depending on grazing management.

Pathway a
Community 2.2 to 2.1

Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of big sagebrush can take many years.

Pathway b
Community 2.2 to 2.4

Tree/shrub removal treatment or prescribed burning in the presence of annual grass species will reduce shrub canopy may cause a shift to Phase 2.4. A subsequent year with precipitation that is favorable to nonnative annual grasses may speed up this pathway.

Pathway a
Community 2.3 to 2.1

A change in grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall/winter grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in the herbaceous understory. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. Annual non-native species are present and may increase in this community.

Pathway b
Community 2.3 to 2.2

Fire reduces or eliminates the overstory of sagebrush and allows for the understory perennial grasses to increase.

Fires will typically be low severity resulting in a mosaic pattern due to low fine fuel loads. Following an unusually wet spring or a change in management favoring an increase in fine fuels, a fire may be more severe and reduce the shrub component to trace amounts. Annual non-native species respond well to fire and may increase post-burn.

State 3
Shrub State

This state has one community phase and is the product of many years of heavy grazing during time periods harmful to deep-rooted perennial bunchgrasses. With a reduction in deep-rooted perennial bunchgrass competition, bluegrasses and squirreltail will increase and become the dominant grass. Sagebrush dominates the overstory. Bitterbrush and/or rabbitbrush may be significant components. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. Bare ground is also increasing. The shrub overstory and bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community 3.1
Community Phase (At Risk)

Figure 9. Gravelly Clay 12-14" (R028AY088NV). T.Stringham, August 2013

Figure 10. Gravelly Clay 12-14" (R028AY088NV). T.Stringham, August 2013

This site is at risk of transitioning to another state. Mountain big sagebrush, possibly decadent, dominates overstory and rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Sandberg bluegrass, squirreltail, and annual non-native species increase. Understory may be sparse, with bare ground increasing. Utah juniper or singleleaf pinyon may be present as a result of encroachment from neighboring sites and lack of disturbance.

State 4
Annual State

This state has two community phases. One phase is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard. The second phase has either mountain big sagebrush and/or rabbitbrush dominating the overstory with an understory of annual non-natives.

Community 4.1
Community Phase

Annual non-native plants such as tansy mustard and cheatgrass dominate this phase.

Community 4.2
Community Phase

Rabbitbrush is typically the dominant overstory shrub. Sagebrush may be a significant component. Annual non-native plants such as tansy mustard and cheatgrass dominate the understory.

Pathway a
Community 4.1 to 4.2

Time and lack of fire allows for sagebrush/rabbitbrush to establish. Probability of sagebrush establishment is dependent on a near-by seed source from unburned patches of sagebrush.

Pathway a
Community 4.2 to 4.1

Fire reduces or eliminates the overstory shrub component and allows for annual non-native species to dominate the phase.

State 5
Tree State

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

Community 5.1
Community Phase

Utah juniper and singleleaf pinyon dominate the overstory and site resources. Trees are actively growing with noticeable leader growth. The shrub and grass understory is reduced. Sagebrush is stressed and dying. Trace amounts of deep-rooted bunchgrass may be found under tree canopies with Sandberg bluegrass and forbs in the interspaces. Annual non-native species are present under tree canopies. Bare ground areas are large and connected.

Community 5.2
Community Phase

Utah juniper and singleleaf pinyon dominate the site and tree leader growth is minimal; annual non-native species may be the dominant understory species and will typically be found under the tree canopies. Trace amounts of sagebrush may be present, however dead skeletons will be more numerous than living sagebrush. Deep-rooted bunchgrasses may or may not be present. Muttongrass, Sandberg bluegrass, or mat forming forbs may be present in trace amounts. Muttongrass may be more common in this phase as it is the most tolerant of shade. Bare ground areas are large and connected. Soil redistribution is excessive.

Pathway a
Community 5.1 to 5.2

Time and lack of disturbance or management action allows Utah juniper and singleleaf pinyon to further mature and dominate site resources.

Pathway a
Community 5.2 to 5.1

A manual thinning treatment would reduce canopy cover and allow for some of the understory to regenerate. The manual thinning of trees in this case may be for fuels treatments rather than an ecological restoration such as R5A.

State 6
Seeded State

This state has three community phases a grass-dominated phase; a grass-shrub phase and a shrub dominated phase. The state is characterized by the dominance of seeded species such as smooth brome and crested wheatgrass. Other seeded species include forage kochia, Wyoming big sagebrush, and native and non-native perennial forbs.

Community 6.1
Community Phase

Introduced grass species and other non-native species such as forage kochia dominate the community. Native and non-native seeded forbs may be present. Trace amounts of big sagebrush may be present, especially if seeded. Annual non-native species present.

Community 6.2
Community Phase

Sprouting shrubs such as rabbitbrush and seeded species co-dominate. Annual non-native species stable to increasing. Sagebrush may be a minor component.

Community 6.3
Community Phase (At Risk)

This community phase is at risk of crossing a threshold and transitioning to another state. Wyoming sagebrush dominates. Rabbitbrush may be a significant component. Seeded grass vigor and density are reduced. Annual non-native species stable to increasing. Utah juniper and/or singleleaf pinyon may be present. This site is susceptible to further degradation from grazing, drought, and fire.

Pathway a
Community 6.1 to 6.2

Inappropriate grazing management, particularly during the growing season, reduces perennial bunchgrass vigor and density and facilitates shrub establishment.

Pathway a
Community 6.2 to 6.1

Low severity fire, brush management, and/or Aroga moth infestation will reduce the sagebrush overstory and allow seeded species to become dominant.

Pathway b
Community 6.2 to 6.3

Absence of fire over time, coupled with inappropriate grazing management that promotes a reduction in perennial bunchgrasses and facilitates shrub dominance.

Pathway a
Community 6.3 to 6.1

Fire eliminates/reduces the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires will typically be low severity resulting in a mosaic pattern due to low fine fuel loads. A fire following an unusually wet spring or change in management favoring an increase in fine fuels, may be more severe and reduce the shrub component to trace amounts. A severe infestation of Aroga moth will also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. Annual non-native species respond well to fire and may increase post-burn.

Transition A
State 1 to 2

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, mustards, and bur buttercup. 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: Repeated heavy growing season grazing will decrease or eliminate deep rooted perennial bunchgrasses, increase Sandberg bluegrass and favor shrub growth and establishment. Slow variables: Long term decrease in deep-rooted perennial grass density. Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

Transition B
State 2 to 4

Trigger: Fire and/or multiple fires lead to plant community phase 4.1, inappropriate grazing management that favors shrubs in the presence of non-native annual species leads to community phase 4.2. Slow variables: Increased production and cover of non-native annual species. Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs truncates, spatially and temporally, nutrient capture and cycling within the community. Increased, continuous fine fuels from annual non-native plants modify the fire regime by changing intensity, size and spatial variability of fires.

Transition C
State 2 to 5

Trigger: Time and lack of disturbance or management action allows for Utah Juniper and singleleaf pinyon to dominate. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources Slow variables: Over time the abundance and size of trees will increase. Threshold: Trees dominate ecological processes and number of shrub skeletons exceed number of live shrubs.

Restoration pathway A
State 3 to 2

Brush management such as mowing, coupled with seeding of deep-rooted native bunchgrasses will reduce the shrub overstory and release the perennial understory species. Presence of annual nonnative species increases the risk of transitioning to an annual state if this treatment fails.

Transition A
State 3 to 4

Trigger: To Community Phase 4.1: Severe fire. To Community Phase 4.2: Inappropriate grazing management in the presence of annual non-native species. Slow variables: Increased production and cover of non-native annual species. Threshold: Increased continuous fine fuels modify the fire regime by changing intensity, size, and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture spatially and temporally thus impacting nutrient cycling and distribution.

Transition B
State 3 to 5

Trigger: Time and a lack of disturbance or management action allows for Utah Juniper and singleleaf pinyon to dominate site. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources. Slow variables: Over time the abundance and size of trees will increase. Threshold: Trees overtop mountain sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

Restoration pathway A
State 4 to 6

Seeding of deep-rooted bunchgrasses, coupled with brush management and/or herbicide. Probability of success is extremely low.

Restoration pathway A
State 5 to 2

Tree removal and seeding of desired species. Tree removal practices that minimize soil disturbance are recommended. Probability of success declines with increased presence of non-native annual species (Community Phase 5.2).

Restoration pathway 5
State 5 to 2

Tree removal and seeding of desired species. Tree removal practices that minimize soil disturbance are recommended. Probability of success declines with increased presence of non-native annual species (Community Phase 5.2).

Restoration pathway B
State 5 to 3

This restoration is recommended for phase 5.1 only due to the lack of understory in 5.2. Removal of the pinyon and juniper overstory through tree removal practices or a controlled burn, without seeding of grass species, would move this phase into a shrub state. If nonnative annuals are present, a controlled burn is not recommended.

Transition A
State 5 to 4

Trigger: Catastrophic fire causing a stand replacement event will transition to Annual State 4.0. Inappropriate tree removal practices with soil disturbance will cause a transition to the Annual State 4.0. Slow variables: Increased production and cover of non-native annual species under tree canopies. Threshold: Closed tree canopy with non-native annual species dominant in the understory changes the intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact nutrient cycling and distribution.

Transition A
State 6 to 5

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**			282–502	
	bluebunch wheatgrass	PSSPS	*Pseudoroegneria spicata ssp. spicata*	235–314	–
	Thurber's needlegrass	ACTH7	*Achnatherum thurberianum*	16–63	–
	needle and thread	HECO26	*Hesperostipa comata*	16–63	–
	muttongrass	POFE	*Poa fendleriana*	16–63	–
2	**Secondary Perennial Grasses**			39–78	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	4–24	–
	blue grama	BOGR2	*Bouteloua gracilis*	4–24	–
	squirreltail	ELEL5	*Elymus elymoides*	4–24	–
	Sandberg bluegrass	POSE	*Poa secunda*	4–24	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	4–24	–
Forb					
3	**Perennial**			39–118	
	aster	ASTER	*Aster*	4–24	–
	buckwheat	ERIOG	*Eriogonum*	4–24	–
	lupine	LUPIN	*Lupinus*	4–24	–
	phlox	PHLOX	*Phlox*	4–24	–
Shrub/Vine					
4	**Primary Shrub**			157–314	
	mountain big sagebrush	ARTRV	*Artemisia tridentata ssp. vaseyana*	118–196	–
	antelope bitterbrush	PUTR2	*Purshia tridentata*	39–118	–
5	**Secondary Shrubs**			39–118	
	Utah serviceberry	AMUT	*Amelanchier utahensis*	8–24	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	8–24	–
	snowberry	SYMPH	*Symphoricarpos*	8–24	–
Tree					
6	**Evergreen**			9–31	
	Utah juniper	JUOS	*Juniperus osteosperma*	4–16	–
	singleleaf pinyon	PIMO	*Pinus monophylla*	4–16	–

Animal community

Livestock Interpretations:
This site is suitable for livestock grazing. Considerations for grazing management including timing, intensity and duration of grazing. Targeted grazing could be used to decrease the density of non-natives.
Bluebunch wheatgrass is considered one of the most important forage grass species on western rangelands for livestock. Although bluebunch wheatgrass can be a crucial source of forage, it is not necessarily the most highly preferred species. Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990). Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler

(1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.
Thurber's needlegrass species begin growth early in the year and remain green throughout a relatively long growing season. This pattern of development enables animals to use Thurber's needlegrass when many other grasses are unavailable. Cattle prefer Thurber's needlegrass in early spring before fruits have developed as it becomes less palatable when mature. Thurber's needlegrasses are grazed in the fall only if the fruits are softened by rain. Thurber's needlegrass is an important forage source for livestock in the arid regions of the West (Ganskopp 1988). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988). Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk et al. 1976).
Muttongrass is excellent forage for domestic livestock especially in the early spring. Muttongrass begins growth in late winter and early spring, which makes it available before many other forage plants. Mountain big sagebrush is eaten by domestic livestock but has long been considered to be of low palatability, and a competitor to more desirable species.
Needleandthread grass is most commonly found on warm/dry soils (Miller et al. 2013). It is not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller and Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972).
Needleandthread provides highly palatable forage, especially in the spring before fruits have developed.
Needlegrasses are grazed in the fall only if the fruits are softened by rain
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). Yet, Cook and Child (1971) found significant reduction in plant cover even after 7 years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended.
Antelope bitterbrush is important browse for livestock. Domestic livestock and mule deer may compete for antelope bitterbrush in late summer, fall, and/or winter. Cattle prefer antelope bitterbrush from mid-May through June and again in September and October.
Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion and/or cheatgrass and other invasive species to occupy interspaces, leading to increased fire frequency and potentially an annual plant community. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Depending on the season of use, the grazer and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.
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:
Mountain big sagebrush is to wildlife for both food and cover. Mountain big sagebrush is highly preferred and nutritious winter forage for mule deer, elk and pronghorn. Elk (Alces alces) and pronghorn antelope (Antilocapra americana) prefer mountain big sagebrush over basin and Wyoming sagebrush (Beale and Smith 1970, Wambolt 1996). A study by Brown (1977) determined that desert bighorn sheep (Ovis canadensis nelisoni) preferred big sagebrush over other shrub types; however, the variety was not noted. Welch and Wagstaff (1992) noted in a study near Provo, Utah, mountain big sagebrush was highly preferred winter forage of mule deer (Odocoileus hemionus) over other available forage. Other studies have determined, in the same study area, that mountain big sagebrush is preferred by both wintering domestic sheep as well as mule deer (Welch et al. 1986).
Furthermore, wildlife use a variety of associated understory plants and soils that occur in big sagebrush habitat. For example: sage grouse (Centrocercus urophasianus), sagebrush vole (Lemmiscus curtatus), Merriam's shrew (Sorex merriami) and Preble's shrew (Sorex preblei) use the grasses that occur with mountain big sagebrush for nesting,

cover and forage. Mountain big sagebrush sandy soil sites provide burrowing opportunities and protection from predators for burrowing owls (Athene cunicularia), dark and pale kangaroo mice (Microdipodops megacephalus and Microdipodops pallidus, respectively). Mountain big sagebrush that occur on woodland and rock ecotones provides nesting and foraging habitat for the ferruginous hawk (Buteo regalis) (Nevada Wildlife Action Plan 2012).
Several reptiles and amphibians are distributed throughout the sagebrush steppe in the west in Nevada, where basin 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 basin 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).
Sagebrush communities are important for maintaining lagomorph and rodent populations. Pygmy rabbits, sagebrush obligates, use sites with big sagebrush at a higher intensity than low sagebrush sites (Heady and Laundre 2005). A study by Larrison and Johnson (1973) captured more deer mice in big sagebrush communities than in any other plant community. Although specific varieties of big sagebrush are not mentioned in these studies, thus, suggests that deer mice prefer big sagebrush plant communities where mountain big sagebrush are present, for cover over other plant communities.
It should be noted that sagebrush-grassland communities provide critical sage-grouse (Centrocercus urophaianus) breeding and nesting habitats. Meadows surrounded by sagebrush may be used as feeding and strutting grounds. 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.
Pronghorn antelope, mule deer, elk, and bighorn sheep utilize antelope bitterbrush extensively. Mule deer use of antelope bitterbrush peaks in September, when antelope bitterbrush may compose 91 percent of the diet. Winter use is greatest during periods of deep snow. Antelope bitterbrush seed is a large part of the diets of rodents, especially deer mice and kangaroo rats.
Thurber's needlegrass is palatable to wildlife and is grazed during the spring.
Needleandthread is moderately important spring forage for mule deer, but use declines considerably as more preferred forages become available.
Bluebunch wheatgrass is considered one of the most important forage grass species on western rangelands for wildlife. Bluebunch wheatgrass does not generally provide sufficient cover for ungulates, however, mule deer are frequently found in bluebunch-dominated grasslands.
Indian ricegrass is eaten by pronghorn in "moderate" amounts whenever available. In Nevada it is consumed by desert bighorns, and is a highly valued fall elk food. Indian ricegrass is eaten by mule deer in spring.
Deer and elk make heavy use of muttongrass, especially in early spring when other green forage is scarce. Depending upon availability of other nutritious forage, deer may use mutton grass in all seasons. Muttongrass cures well and is an important fall and winter deer food in some areas.

Hydrological functions

Permeability is very slow to moderate. Runoff is high to very high.

Recreational uses

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

Other products

Native americans used big sagebrush leaves and branches for medicinal teas, and the leaves as a fumigant. Bark was woven into mats, bags and clothing.

Other information

Antelope bitterbrush has been used extensively in land reclamation. Antelope bitterbrush enhances succession by retaining soil and depositing organic material and in some habitats and with some ecotypes, by fixing nitrogen. Needleandthread grass is useful for stabilizing eroded or degraded sites.

Type locality

Location 1: Lincoln County, NV	
Township/Range/Section	T9N R64E S10
Latitude	38° 35′ 48″
Longitude	114° 49′ 51″
General legal description	SE¼ Cottonwood Canyon area, Cave Valley, Lincoln County, Nevada

Location 2: White Pine County, NV	
Township/Range/Section	T14N R68E S31
Latitude	39° 2′ 3″
Longitude	114° 23′ 0″
General legal description	About 4 miles southeast of USHwy 50, Willard Creek area, west side of Snake Range, White Pine County, Nevada

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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	03/20/2015
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rills are none to rare. A few may occur on steeper slopes in areas subjected to summer convection storms or rapid snowmelt.

2. **Presence of water flow patterns:** Water flow patterns are none to rare but can be expected in areas subjected to summer convection storms or rapid snowmelt. They are short (<1 m) and not connected. They will begin to heal during the next growing season.

3. **Number and height of erosional pedestals or terracettes:** Pedestals are none to rare with occurrence typically limitec to area within water flow patterns. Frost heaving of shallow rooted plants should not be considered as normal condition.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground 15 to 20% depending on surface rock fragments.

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

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

7. **Amount of litter movement (describe size and distance expected to travel):** Fine litter (foliage from grasses and annual & perennial forbs) expected to move distance of slope length(<5m) 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 3 to 6 on most soil textures found on this site.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface structure is typically subangular blocky. Soil surface colors are grayish browns and soils are typified by a mollic epipedon. Surface textures are loams, sandy loams and ashy sandy loams. 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., bluebunch wheatgrass and Thurber's needlegrass]) slow runoff and increase infiltration. Shrub canopy and associated litter break raindrop impact and provide opportunity for snow catch and accumulation on site. Coarse textured surface soils allow medium to rapid infiltration.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Compacted layers are none. Platy or massive sub-surface horizons, subsoil argillic horizons or hardpans shallow to the surface are not to be interpreted as compacted.

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: Mountain big sagebrush >> associated shrubs > deep-rooted, cool season, perennial forbs = fibrous, shallow-rooted, cool season, annual and perennial forbs > shallow-rooted, cool season, perennial bunchgrasses

    Other: evergreen trees, warm season rhizamotous grasses

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Dead branches within individual shrubs common and standing dead shrub canopy material may be as much as 25% of total woody canopy; some of the mature bunchgrasses (<20%) have dead centers.

14. **Average percent litter cover (%) and depth (in):** Between plant interspaces (30-40%) 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, ± 700 lbs/ac; Spring moisture significantly affects total production. Favorable years ~900 lbs/ac and unfavorable years ~450 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, Russian thistle and annual mustards. Singleleaf pinyon and Utah juniper may increase and eventually dominate this site.

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