Ecological site R024XY020NV
DROUGHTY LOAM 8-10 P.Z.

Accessed: 05/11/2025

General information

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

MLRA notes

Major Land Resource Area (MLRA): 024X–Humboldt Basin and Range Area

Major land resource area (MLRA) 24, the Humboldt Area, covers an area of approximately 8,115,200 acres (12,680 sq. mi.). It is found in the Great Basin Section of the Basin and Range Province of the Intermontane Plateaus. Elevations range from 3,950 to 5,900 feet (1,205 to 1,800 meters) in most of the area, some mountain peaks are more than 8,850 feet (2,700 meters).
A series of widely spaced north-south trending mountain ranges are separated by broad valleys filled with lacustrine sediment and alluvium washed in from adjacent mountain ranges. Most valleys are drained by tributaries to the Humboldt River. However, playas occur in lower elevation valleys with closed drainage systems. Isolated ranges are dissected, uplifted fault-block mountains. Geology is comprised of Mesozoic and Paleozoic volcanic rock and marine and continental sediments. Occasional young andesite and basalt flows (6 to 17 million years old) occur at the margins of the mountains. Dominant soil orders include Aridisols, Entisols, Inceptisols and Mollisols. Soils of the area are generally characterized by a mesic soil temperature regime, an aridic soil moisture regime and mixed geology. They are generally well drained, loamy and very deep.
Approximately 75 percent of MLRA 24 is federally owned, the remainder is primarily used for farming, ranching and mining. Irrigated land makes up about 3 percent of the area; the majority of irrigation water is from surface water sources, such as the Humboldt River and Rye Patch Reservoir. Annual precipitation ranges from 6 to 12 inches (15 to 30 cm) for most of the area, but can be as much as 40 inches (101 cm) in the mountain ranges. The majority of annual precipitation occurs as snow in the winter. Rainfall occurs as high-intensity, convective thunderstorms in the spring and fall.

Classification relationships

National Vegetation Classification (USNVC): 3 Semi-Desert, 3.B Cool Semi-Desert Scrub and Grassland, 3.B.1 Cool Semi-Desert Scrub and Grassland, D040 Western North American Cool Semi-Desert Scrub and Grassland, M169 Great Basin and Intermountain Tall Sagebrush Shrubland and Steppe, G303 Intermountain Dry Tall Sagebrush Shrubland Group, CEGL001052 *Artemisia tridentata* ssp. wyomingensis/ *Achnatherum thurberianum* Shrubland.

Ecological site concept

This ecological site is found on fan remnants, fan piedmonts and inset fans on all exposures. The soils associated with this ecological site are deep, well drained, and formed in alluvium derived from mixed parent material. The soil profile is characterized by an ochric epipedon and high amounts of sand and gravel below 40cm. Soil temperature regime is mesic and the soil moisture regime is aridic bordering on xeric. Important abiotic factors contributing to the presence of this site include limited available soil moisture due to texture and precipitation zone. Plant available water is influenced by soil texture, presence and abundance of rock fragments, soil depth, aspect, elevation and landscape position.
Vegetative cover is less than 25% and is dominated by deep-rooted, cool season perennial bunchgrasses and drought tolerant shrubs. Dominant species include Thurber’s needlegrass, Indian ricegrass, Wyoming big sagebrush, and spiny hopsage. This ecological site is of moderate extent throughout MLRA 24.

This site has many of the same species found on the extensively mapped Loamy 8-10” P.Z. (024XY005NV). However, a primary distinguishing factor between Droughty Loam 8-10” P.Z. and Loamy 8-10” P.Z. is that the Droughty Loam site does not have the potential to support bluebunch wheatgrass (Pseudoroegneria spicata), due to elevation, landscape position, aspect, soil texture, soil moisture or a combination.

Associated sites

R024XY002NV	**LOAMY 5-8 P.Z.** Less productive site, found at lower elevations on low hills, piedmont slopes, and alluvial plains. Shadscale is the dominant shrub. Wyoming big sagebrush and Thurber’s needlgrass are not associated with the plant community.
R024XY005NV	**LOAMY 8-10 P.Z.** More productive site found on similar landforms. Soils are characterized by an argillic horizon. Bluebunch wheatgrass is an important grass and shadscale and budsage are not associated with the plant community.

Similar sites

R024XY045NV	**ERODED SLOPE 6-10 P.Z.** Less productive site, found on steep sideslopes of erosional fan remnants and pediments. Indian ricegrass dominant grass. Spiny hopsage and shadscale are found in small percentages.
R024XY017NV	**SANDY 8-10 P.Z.** More productive site, found on sand sheets and lower piedmont slopes. Needleandthread grass important associated species.
R024XY058NV	**SANDY LOAM 8-10 P.Z.** More productive site, found on north facing convex mountain sideslopes. Needleandthread and Indian ricegrass are co-dominant grasses. Basin big sagebrush occurs in association with Wyoming big sagebrush.
R024XY047NV	**SHALLOW LOAM 8-10 P.Z.** Less productive site, found on south slopes of hills and low mountains on soils shallow to bedrock. Bluebunch wheatgrass is found in small percentages.
R024XY005NV	**LOAMY 8-10 P.Z.** Bluebunch wheatgrass is an important associated grass. Shadscale and budsage are not associated with the plant community. Spiny hopsage is a minor component, if present. Soils associated with 024XY005NV are characterized by an argillic horizon.
R024XY026NV	**STONY SLOPE 8-10 P.Z.** Less productive site, found on low mountains and upp piedmont slopes. ARTRW-ATCO codominant; may be this site following recent burn or a less productive expression of this site.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata* (2) *Grayia spinosa*
Herbaceous	(1) *Achnatherum thurberianum* (2) *Achnatherum hymenoides*

Physiographic features

This ecological site occurs on fan piedmonts, fan remnants, and inset fans. Slopes range from 2 to 50 percent, but slope gradients of 4 to 15 percent are most typical. This site typically occurs between 4000 to 6000 feet, but can be found between 3900 and 6500 feet in some locations.

Table 2. Representative physiographic features

Landforms	(1) Fan remnant (2) Inset fan (3) Alluvial fan
Flooding duration	Very brief (4 to 48 hours)
Flooding frequency	None to rare
Ponding frequency	None
Elevation	4,000–6,000 ft
Slope	4–15%
Aspect	Aspect is not a significant factor

Climatic features

The climate associated with this site is semiarid, characterized by cold, moist winters and warm, somewhat dry summers. Over 70% of the precipitation occurs from November through May. Average annual precipitation is 6.5 to 8.5 inches. Mean annual temperatures are 45 to 53 degrees F. The average growing season is about 80 to 130 days.
At the Beowawe climate station (#260795) mean annual precipitation is 7.53 inches, for the period of record 1893-2013, and the mean annual air temperature is 48.3 degrees F. Mean precipitation by month (inches): Jan 0.78, Feb 0.62, Mar 0.64, Apr 0.77, May 1.02, Jun 0.71, Jul 0.29, Aug 0.33, Sep 0.38, Oct 0.55, Nov 0.70, Dec 0.75.
At the Kings River Valley climate station (#264236) mean annual precipitation is 8.42 inches, for the period of record 1956-2013, and the mean annual air temperature is 48.7 degrees F. Mean precipitation by month (inches): Jan 1.05, Feb 0.83, Mar 0.68, Apr 0.71, May 0.92, Jun 0.72, Jul 0.24, Aug 0.28, Sep 0.4, Oct 0.51, Nov 0.9, Dec 1.19.

Table 3. Representative climatic features

Frost-free period (average)	105 days
Freeze-free period (average)	125 days
Precipitation total (average)	8 in

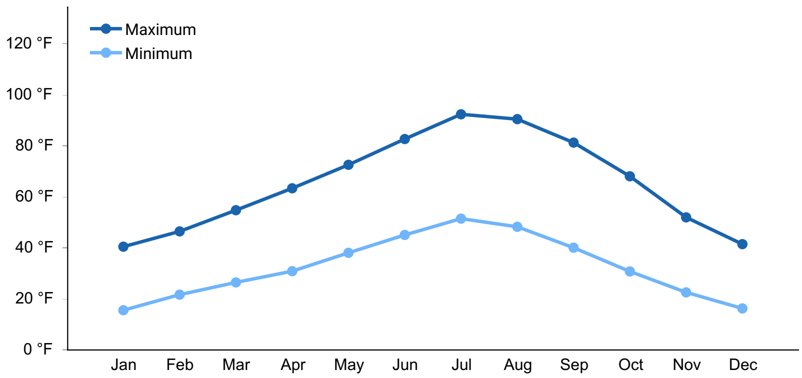


Figure 1. Monthly average minimum and maximum temperature

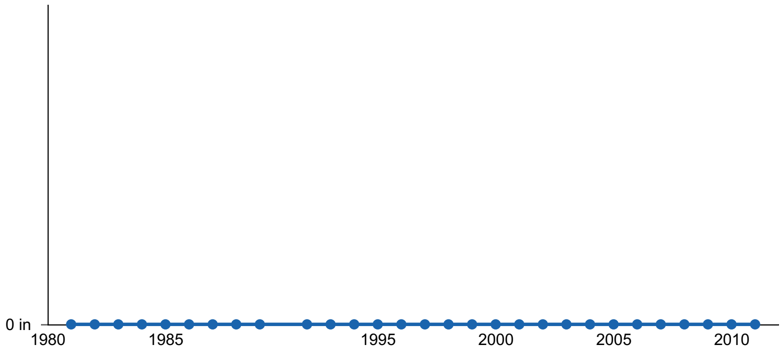


Figure 2. Annual precipitation pattern

Influencing water features

Influencing water features are not associated with this site.

Soil features

Soils associated with this site are very deep, well drained, and formed in alluvium derived from mixed parent material. These soils are characterized by an ochric epipedon, minimal soil development, and accumulation of secondary carbonates in the lower profile.
The soil moisture regime is aridic bordering on xeric and soil temperature regime is mesic.
The representative soil series for this ecological site is McConnel; a sandy-skeletal, mixed, mesic Xeric Haplocambids. McConnel is characterized by a layer of sand and gravel from 40cm to greater than 150cm. The particle size control section has greater than 35% rock fragments by volume and less than 8% clay content.
Additional soil series correlated to this site include: Orovada, Bliss, Enko, Connel, Macnot, Flue, Mcwatt, Panlee, Frewa, rebel, Clurde and Doowak.
Occurrences of this ecological site correlated to shallow soils including Dewar, Souge, Adelaide, Tumtum, Midraw, Gwena, Shabliss, Genaw, Boger, Bojo, Brock, Burrita and Sedsked will be field checked for recorrelation to a Shallow loam site concept (024XY035NV or 024XY047NV).
Deep soils characterized by an agrillic horizon including Gorzell, Chime, and Snapp will be field checked for recorrelation to Loamy 8-10PZ (024XY005NV).
Occurrences of this ecological site correlated to Blackhawk will be field checked for correlation to a more appropriate soil or site.
Occurrences of this site correlated to Davey will be field checked for recorrelation to Sandy 8-10PZ (024XY017NV).
Typically, where this ecological site occurs on deep to very deep soil series, with loamy texture throughout (such as Orovada, Rebel, and Enko series) it is found below 5200 feet in elevation. Below about 5200 feet, reduced annual precipitation and lack of available soil moisture outweighs any favorable soil characteristics, such as depth and texture. In these cases texture, structure, and hardness at 20 to 30 inches of depth responds as a root limiting layer, much like a duripan. Soil horizons composed of fine soil particles (fine and very fine sands) have very small pore spaces resulting in greater pore space tortuosity and slower water flow through the horizon, which may limit root growth.

Table 4. Representative soil features

Surface texture	(1) Fine sandy loam (2) Loamy fine sand (3) Loamy very fine sand
Family particle size	(1) Loamy
Drainage class	Well drained to excessively drained
Permeability class	Moderately slow to moderately rapid
Soil depth	30–73 in
Surface fragment cover <=3"	0–10%
Surface fragment cover >3"	0–10%

Available water capacity (0-40in)	1.9–3.6 in
Calcium carbonate equivalent (0-40in)	0–3%
Electrical conductivity (0-40in)	0–3 mmhos/cm
Sodium adsorption ratio (0-40in)	0–5
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	5–60%
Subsurface fragment volume >3" (Depth not specified)	5–15%

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 influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al 2013).

The plant communities of this site are dynamic in response to changing weather patterns and disturbance regimes. 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 reference community phase is characterized by co-dominance of big sagebrush (*Artemisia tridentata*) and Thurber's needlegrass (*Achnatherum thurberianum*) and Indian ricegrass (*Achnatherum hymenoides*).

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). Winter precipitation and slow melting of snow results in deeper percolation of moisture into the soil profile. 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 (Comstock and Ehleringer 1992). Herbaceous plants, more shallow-rooted than shrubs, grow earlier in the growing season and thrive on spring rains, while the deeper rooted shrubs lag in phenological development because they draw from deeply infiltrating moisture from snowmelt the previous winter. The perennial bunchgrasses generally have somewhat shallower root 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 results in resource partitioning in these shrub/grass systems. Periodic drought regularly influences sagebrush ecosystems. 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).

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). This site inherently has low resistance to invasion by non-natives, and low resilience following invasion by non-natives. In Great Basin ecosystems, inherent resilience typically increases with elevation due to higher levels of water, nutrients and annual biomass production. Wyoming sagebrush ecosystems are the most vulnerable to cheatgrass (*Bromus tectorum*) invasion due to the combination of low resilience to disturbances such as fire and low resistance to cheatgrass invasion (Chambers et al. 2012). Management activities should be prioritized based on the relative resilience and resistance of a specific ecological site. The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual state. Conversely, as fire frequency decreases, sagebrush will increase and with inappropriate grazing management the perennial bunchgrasses and forbs may be reduced.

Slight variations in soil surface texture can result in variability in plant community. Thurber's needlegrass will increase on gravelly soils, whereas Indian ricegrass will increase with sandy soil surfaces. The amount of sagebrush in the plant community is dependent upon disturbances such as fire, Aroga moth infestations and grazing. Sandberg bluegrass more easily dominates sites where surface soils are gravelly loams than those where surface soils are silt loams.

Spiny hopsage, an important shrub species in this ecological site, is drought-deciduous and has a combination of shallow and deep roots that maximizes water extraction from the soil profile. These characteristics help spiny hopsage tolerate the droughtiness of this site by using available soil moisture during the first part of the growing season, prior to leaf drop and drought dormancy (Sperry and Hacke 2002). Dormancy in spiny hopsage is one of the longest in desert shrubs, it remains dormant throughout the hot, dry summer months and summer rains will not cause initiation of new growth (Tirmenstein 1999).

Sagebrush species 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 sagebrush seedlings is dependent on adequate moisture conditions. Young plants are susceptible to less than desirable conditions for several years following germination. Density and age of sagebrush and other woody perennials in the plant community is dependent upon fire frequency, which would be highly infrequent under historic conditions.

Disturbance Ecology:
The primary disturbances effecting this ecological site are fire and drought. Prior to Euro-American settlement, Wyoming big sagebrush communities historically had low fuel loads, and patchy fires, which burned in a mosaic pattern. Fires were common at 10-70 year return intervals depending on the year and the climate (Young et al. 1979, West and Hassan 1985, Bunting et al. 1987). Davies et al. (2007) suggest fire return intervals in Wyoming big sagebrush communities were around 50-100 years. More recently, Baker (2011) estimates fire rotation to be 200-350 years in Wyoming big sagebrush communities.

Fire is the principal means of renewal for decadent stands of Wyoming big sagebrush. Depending on site conditions prior to wildfire perennial grasses and forbs will dominate initially. Wyoming big sagebrush is killed by fire and establishes from a seedbank and from seed produced by remnant plants that escaped fire. Prolific seed production from nearby unburned plants coupled with high germination and survival rates is required to ensure establishment following fire. The VAM, upon which Wyoming big sagebrush depends for healthy growth are usually harmed by fire and may take several years to recover. Typically, fewer VAM are killed by low-intensity wildfire than by more severe fire intensities (Howard 1999). Recovery time for Wyoming big sagebrush may require 50 to 120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities. Post-fire hydrologic recovery and resilience is primarily influenced by pre-fire site conditions, fire severity, and post-fire weather and land use that relate to vegetation recovery. 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 related to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Young 1983, Wright 1971).
Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Britton et al. 1990a). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influenced the response and mortality of Thurber's needlegrass, smaller bunch sizes were less likely to be damaged by fire (Wright and Klemmedson 1965). Thurber's needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Koniak 1985, Britton et al. 1990a). Reestablishment on burned sites has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Evans and Young 1978).
Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below-ground root 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.
Squirreltail is considered more fire tolerant than Indian ricegrass due to its small size, coarse stems, broad leaves and generally sparse leafy material (Wright 1971, Britton et al. 1990). Postfire regeneration occurs from surviving root crowns and from on-and off-site seed sources. Bottlebrush squirreltail has the ability to produce large numbers of highly germinable seeds, with relatively rapid germination (Young and Evans 1977) when exposed to the correct environmental cues. Early spring growth and ability to grow at low temperatures contribute to the persistence of bottle brush squirreltail among cheatgrass dominated ranges (Hironaka and Tisdale 1972).
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). 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. Repeated frequent fire in this community will eliminate big sagebrush and severely decrease or eliminate the deep rooted perennial bunchgrasses from the site and facilitate the establishment of an annual weed community with varying amounts of Sandberg bluegrass and rabbitbrush.
Wildfire in sites with cheatgrass present could transition to cheatgrass dominated communities. Without management cheatgrass and annual forbs are likely to invade and dominate the site, especially after fire.
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 have been 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).
Individual plants are partially or entirely killed through defoliation under low to moderate moth population densities. Under high population densities, entire stands involving thousands of acres can be eliminated (Furniss and Barr 1975). Adult moths lay eggs in the late summer/early fall on small cracks in the bark or on the leaves of sagebrush plants. After approximately two weeks larvae hatch and mine into the leaves and remain there through the winter. The following spring larvae resume work mining the leaves. Leaves are cut off the plant and used to build cocoons. In later part of June or July larvae go in to the pupil stage and adult moths emerge in approximately two weeks (Gates 1964). The aroga moth is a native insect and therefore has native predators. It is impacted by 20 or more species of parasites. The moth and the larvae are also preyed upon by two species of beetles (Furniss and Barr 1975).
Wyoming big sagebrush may also be impacted by other native insects including, desert shrub longhorned rootborers (Crossidius spp.), leaf beetles (Trirhabda pilosa), fruit flies (Eutreta spp.), harvester ants (Pogonomyrmex occidentalis and P. owyheei), bagworm moths (Apterona crenulella), and buck moths and day moths (Hemileuca hera hera and H. nuttalli nuttalli) (Furniss and Barr 1975). Effects of native insects on sagebrush populations can range from partial defoliation to individual plant mortality to complete stand failure.

Abiotic features:

The primary factor driving the presence of this ecological site is the overall lack of soil moisture. Actual precipitation for this ecological site ranges from 7-9" and comes predominantly as snow in the winter. Plant communities receive almost no measurable precipitation during the growing season. This site is found at elevations, landscape positions or aspects that result in droughty soil conditions and may be associated with Loamy 5-8" ecological site. Plant available water is influenced by soil texture, presence and abundance of rock fragments, soil depth, aspect, elevation and landscape position. Soils in aridic bordering on xeric moisture regime experience little to no leaching, and soluble salts will accumulate if there is a source.
Overall productivity of soils supporting this ecological site is limited by subsurface horizons. High volumes of coarse fragments can affect the total available water holding capacity. Coarse textured soils have larger pores, experience faster infiltration rates and are subject to free drainage, reducing the amount of water stored in the soil profile. Amount of water available in the soil profile is inversely related to the percent of coarse fragments in the soil (Brakensiek and Rawls 1994). In deep and very deep soils associated with this site the texture, structure, and hardness at 20 to 30 inches of depth responds as a root limiting layer, much like a duripan. When a soil horizon lacks structure, and is massive, the horizon lacks pore space between peds which can limit water flow and root growth. Soil consistence that is moderately hard through very hard may result in a horizon with slower root growth and reduced water flow. When these soil characteristics combine together (fine texture, massive structure and moderately hard through hard) in sub-horizons of deep soils water flow and root growth may be restricted. While these characteristics may not meet duripan criteria, the soil is capable of supporting the Droughty Loam ecological site concept.

Wyoming big sagebrush is the most drought-tolerant of the three major big sagebrush subspecies. The root system is deep and well-developed with many laterals and one or more taproots. The majority of the roots are in the upper foot of soil with tap roots extending up to 6 feet in depth. The combination of deep and shallow roots provides excellent soil stabilization. The roots are also inoculated with the vesicular-arbuscular mycorrhizae (VAM) Glomus microcarpus and Gigaspora spp., which help to mitigate nutrient and moisture limitations. Mycorrhizas ('fungus-roots') are the result of a symbiotic relationship between specialized soil organisms and plants roots. Beneficial changes in the water relations of plants inoculated with VAM include altered rates of water uptake, hydraulic conductivity, leaf and stem water potentials, stomatal resistance and transpiration rates (Stahl et al. 2008).

Vegetative cover of perennial plants on this ecological site is generally sparse, even under reference conditions. However, soil space not occupied by living plants is usually covered in biological soil crusts. In Wyoming big sagebrush communities of southeastern Idaho, biological soil crust were found to occupy between 40-60% of the soil surface in an undisturbed setting (Memmott et al. 1998, Kaltenecker et al. 1999). Biological soil crusts are formed by living organisms, cyanobacteria, green algae, lichens, mosses, microfungi, etc., and their by-products, creating a crust of soil particles bound together by organic materials. In rangelands they have several important functions including; helping to retain soil moisture, reducing wind and water erosion, fixing atmospheric nitrogen and contributing to soil organic matter (USDI-BLM 2001). Soil crusts are also good indicators of physical disturbance. Disturbances such as off-road vehicles and trampling by humans and livestock destroy the physical structure of soil crusts. Once destroyed the pieces of crust are blown or washed away, reducing soil stability and fertility (Belnap 2003). Extent of impact is determined by severity, frequency, size and timing of disturbance. Recovery of biological crust may take decades to hundreds of years. Therefore, it is important to prevent degradation.

Inappropriate management, grazing, recreation, etc., and reoccurring disturbances, natural or anthropogenic, will result in a loss of desirable native species and increased cover of disturbance tolerant shrubs and non-natives. Loss of structural and functional groups affects ecosystem functioning and can result in soil loss. Additional discussion regarding how functional groups and disturbance impact the hydrologic functions of this ecological site can be found in the Ecological Site Interpretations under Hydrology Functions.

It is well know that sagebrush species naturally hybridize (McArthur et al., 1988, Richardson et al., 2012 and others). Natural hybridization has been important in the differentiation and success of sagebrush as a landscape dominant (McArthur et al. 1988). The sagebrush found on this site is most likely a hybrid. It frequently displays intermediate morphological characteristics between basin big sagebrush (*A. tridentata* spp. tridentata) and Wyoming big sagebrush (*A. tridentata* spp. wyomingesis) including mature plant height, growth form, and leaf shape (B. Perryman, personal communication, May 19, 2014).
Following this discussion of hybridization you will find references to Wyoming big sagebrush throughout the document. At this time, research is lacking regarding the ecological potential of all possible hybridized sagebrush species/subspecies. The suspected hybrid dominating this ecological site is found in the same elevation zone and precipitation zone and on the same landscape position and soils as Wyoming big sagebrush, therefore making it

appropriate to existing literature about Wyoming big sagebrush to describe ecological dynamics of the site. Updates and revisions will be made as more information is available.

State and transition model

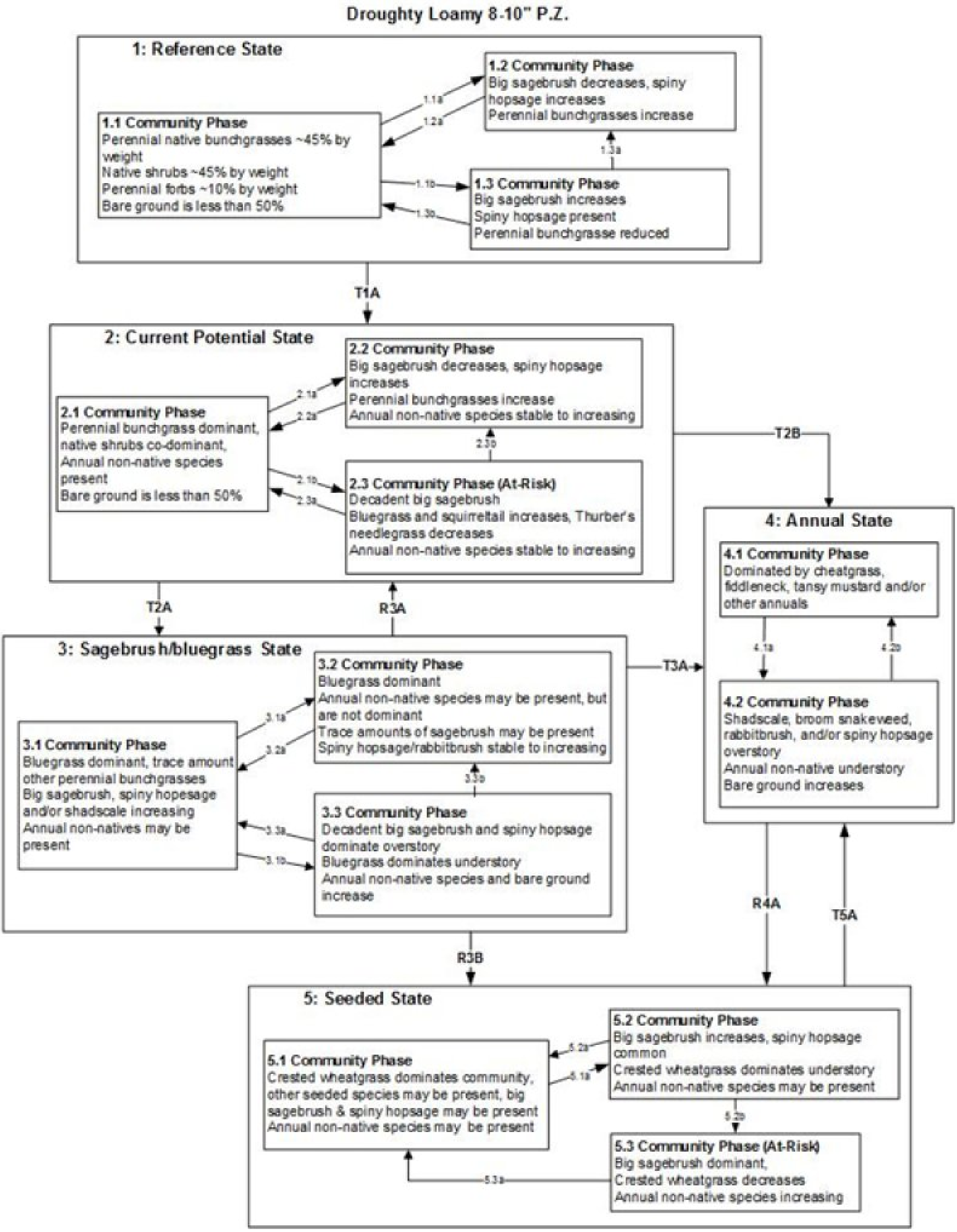


Figure 4. R024XY020NV Droughty Loam 8-10" PZ

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
Reference Community

Wyoming big sagebrush and Thurber's needlegrass dominate the site. Indian ricegrass, Sandberg bluegrass and squirreltail are also common. Forbs are present but not abundant.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	140	225	315
Shrub/Vine	135	225	315
Forb	25	50	70
Total	**300**	**500**	**700**

Community 1.2
Community Phase

This community phase is characteristic of a post-disturbance, early seral community phase. Thurber's needlegrass and other perennial grasses dominate. Following fire sprouting shrubs, like spiny hopsage and rabbitbrush, respond favorably. Depending on fire severity or intensity of Aroga moth infestation, patches of intact sagebrush may remain.

Community 1.3
Community Phase

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

Pathway 1.1a
Community 1.1 to 1.2

Fire decreases or eliminates sagebrush overstory and allows perennial bunchgrasses to dominate. 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 would also cause a decrease in sagebrush canopy, giving a competitive advantage to the perennial grasses and forbs.

Pathway 1.1b
Community 1.1 to 1.3

Time and lack of disturbance such as fire allows for sagebrush to increase and become decadent. Long-term drought, herbivory, or combinations of these would cause a decline in perennial bunchgrasses and fine fuels and lead to a reduced fire frequency allowing big sagebrush to dominate the site.

Pathway 1.2a
Community 1.2 to 1.1

Absence of disturbance over time would allow for sagebrush to increase.

Pathway 1.3a
Community 1.3 to 1.1

A low severity fire reduces sagebrush overstory and creates a mosaic with sagebrush and perennial bunchgrasses co-dominant. An Aroga moth infestation could also reduce sagebrush cover releasing perennial grass understory.

Pathway 1.3b
Community 1.3 to 1.2

Fire removes sagebrush overstory and allows perennial bunchgrasses to dominate. Typical fires would be low severity, but fires may be more severe following an unusually wet spring favoring an increase in fine fuels 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.

State 2
Current Potential State

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

Community 2.1
Community Phase

Wyoming big sagebrush and Thurber's needlegrass dominate the site. Spiny hopsage, Indian ricegrass and squirreltail may be significant components while Sandberg bluegrass and forbs make up smaller percentages by weight of the understory. Non-native annual species are present.

Community 2.2
Community Phase

Figure 6. Community Phase 2.2; post wildfire

This community phase is characteristic of a post-disturbance, early seral community phase. Thurber's needlegrass and other perennial grasses dominate. Wyoming big sagebrush is present in trace amounts. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Spiny hopsage and rabbitbrush are stable to increasing. 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.

Community 2.3
Community Phase (At-Risk)

Figure 7. Droughty Loam 8-10 P.Z. Community Phase 2.3

This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs, inappropriate grazing management, drought or a combination. Rabbitbrush and spiny hopsage may be a significant component. Sandberg bluegrass may increase and become co-dominate with deep rooted bunchgrasses. 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.

Pathway 2.1a
Community 2.1 to 2.2

Fire reduces the shrub overstory and allows perennial bunchgrasses to dominate. 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. A severe infestation of Aroga moth could also cause a large decrease in sagebrush, giving a competitive advantage to the perennial grasses and forbs. Annual non-native species are likely to increase after fire.

Pathway 2.1b
Community 2.1 to 2.3

Time and lack of disturbance such as fire allows for sagebrush to increase and become decadent. Chronic drought, herbivory and competition from shrubs reduces fine fuels and leads to a reduced fire frequency allowing Wyoming big sagebrush to dominate. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely Sandberg bluegrass may increase in the understory depending on grazing management. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle and/or horses are the dominant grazers, cheatgrass often increases.

Pathway 2.2a
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 Wyoming big sagebrush can take many years.

Pathway 2.3a
Community 2.3 to 2.1

A change in grazing management that decreases shrubs would 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. An infestation of Aroga moth or a low severity fire would reduce some sagebrush overstory and allow perennial grasses to increase in the community. Brush treatments with minimal soil disturbance would also decrease sagebrush and release the perennial understory. Annual non-native species are present and may increase in the community.

Pathway 2.3b
Community 2.3 to 2.2

Community Phase (At-Risk)

Community Phase

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.

State 3
Shrub State

This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Sandberg bluegrass may increase with a reduction in deep rooted perennial bunchgrass competition and may become the dominate grass or the herbaceous understory may be completely eliminated. Sagebrush dominates the overstory and spiny hopsage and/or rabbitbrush may be a significant component. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory dominates site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed. Bare ground may be significant with soil redistribution occurring between interspace and canopy locations.

Community 3.1
Community Phase

Figure 8. Community Phase 3.1; Wyoming sagebrush/bluegrass community with non-natives

Figure 9. Community phase 3.1: bluegrass dominated, shadscale increasing, non-natives present (11/12/13; E. Hourihan; SSA NV612; MU WH)

Wyoming big sagebrush dominates overstory and spiny hopsage and/or rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Sandberg bluegrass may dominate the understory. Annual non-native species are present and may be co-dominant. Bare ground is significant. Utah juniper may be present.

Table 6. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	30-50%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	15-50%

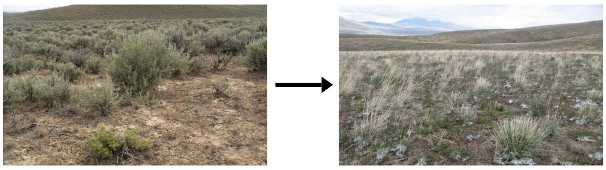
Community 3.2
Community Phase

Figure 10. Community phase 3.2; droughty loam post wildfire, bluegrass

dominated

Bluegrass dominates the site; annual non-native species may be present but are not dominant. Trace amounts of sagebrush may be present. Sprouting shrubs such as spiny hopsage or rabbitbrush may be dominant.

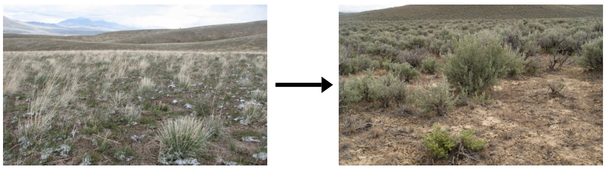
Pathway 3.1a
Community 3.1 to 3.2



Community Phase   Community Phase

Fire, heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, will greatly reduce the overstory shrubs to trace amounts and allow for Sandberg bluegrass to dominate the site.

Pathway 3.2a
Community 3.2 to 3.1



Community Phase   Community Phase

Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The re-establishment of Wyoming big sagebrush can take many years. With the dominance of bluegrass this pathway is unlikely to occur.

State 4
Annual State

This community is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Sprouting shrubs such as rabbitbrush, shadscale, broom snakeweed and spiny hopsage may dominate the overstory.

Community 4.1
Community Phase

Figure 11. Community phase 4.1; dominated by cheatgrass

Annual non-native plants such as cheatgrass or tansy mustard dominate the site. Rabbitbrush may or may not be present.

Community 4.2
Community Phase

Sprouting shrubs such as spiny hopsage and Rabbitbrush along with broom snakeweed dominate overstory. Wyoming big sagebrush may be a minor component. Annual non-native species dominate understory. Trace amounts of desirable bunchgrasses may be present. Bare ground is significant.

Pathway 4.1a
Community 4.1 to 4.2

Time and lack of fire allows for the sagebrush to establish. Probability of sagebrush establishment is extremely low.

Pathway 4.2a
Community 4.2 to 4.1

Fire removes sagebrush and allows for annual non-native species to dominate the site.

State 5
Seeded State

This state is characterized by the dominance of seeded introduced wheatgrass species. Forage kochia and other desired seeded species including Wyoming big sagebrush and native and non-native forbs may be present. Soil nutrients and soil organic matter distribution and cycling are primarily driven by deep rooted bunchgrasses.

Community 5.1
Community Phase

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

Community 5.2
Community Phase

Big sagebrush and seeded wheatgrass species co-dominate. Spiny hopsage and other disturbance tolerance shrubs common. Annual non-native species stable to increasing.

Community 5.3
Community Phase (At-Risk)

This community phase is at-risk of crossing a threshold to another state. Big sagebrush dominates. Rabbitbrush and spiny hopsage may be a significant component. Wheatgrass and other perennial grass vigor and density reduced. Annual non-native species stable to increasing.

Pathway 5.1a
Community 5.1 to 5.2

Inappropriate grazing management particularly during the growing season reduces perennial bunchgrass vigor and density and facilitates shrub establishment. Absence of shrub removing disturbances over time coupled with inappropriate grazing management facilitates shrub dominance.

Pathway 5.2a
Community 5.2 to 5.1

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

Pathway 5.2b
Community 5.2 to 5.3

Natural regeneration over time, inappropriate grazing management and drought promotes a reduction in perennial bunchgrasses and facilitates shrub dominance.

Pathway 5.3a
Community 5.3 to 5.1

Fire eliminates/decreases the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires would 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 would 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 would also decrease sagebrush and release the perennial understory. Annual non-native species respond well to fire and may increase post-burn.

Transition T1A
State 1 to 2

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass, mustards, bur buttercup and halogeton. 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 T2A
State 2 to 3

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during the growing season would favor sagebrush. 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.

Transition T2B
State 2 to 4

Trigger: To Community Phase 4.1: Severe fire and/or soil disturbing treatments. To Community Phase 4.2: Inappropriate grazing management that favors shrubs in the presence of non-native species. 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.

Restoration pathway R3A
State 3 to 2

Brush management with minimal soil disturbance, coupled with seeding of deep rooted perennial native bunchgrasses. Probability of success very low.

Transition T3A
State 3 to 4

Trigger: To Community Phase 4.1: Severe fire and/or soil disturbing treatments. 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.

Restoration pathway R3B
State 3 to 5

Brush management with minimal soil disturbance, coupled with seeding of desired species, usually wheatgrasses (5.1 or 5.2). Restoration attempts causing soil disturbance will likely initiate a transition to an annual state. Probability of success very low.

Restoration pathway R4A
State 4 to 5

Seeding of deep-rooted introduced bunchgrasses and other desired species; may be coupled with brush management and/or herbicide. Probability of success is extremely low.

Transition T5A
State 5 to 4

Trigger: Catastrophic wildfire. Catastrophic wildfire is characterized as a wildfire long, hot and/or frequent enough to remove all vegetation, kill below ground biomass, damage biological crust and volatilize organic matter. Slow variables: Increased reproduction and cover of non-native invasive species. Threshold: Changes in plant community composition, loss of seeded perennial bunchgrasses and severe reduction or loss of native shrubs and increased cover of non-native annuals, changes infiltration and runoff dynamics. Energy capture is truncated do to the nature of annual species. Continuous bed of fine fuel provided by non-native annuals results in a modified fire regime (changes in frequency, intensity, size, and spatial variability of fires).

Transition T5A
State 5 to 4

Trigger: Fire Slow variables: Increased production and cover of non-native annual species Threshold: Cheatgrass or other non-native annuals dominate understory

Additional community tables

Table 7. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Primary Perennial Grasses**			100–300	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	75–125	–
	Thurber's needlegrass	ACTH7	*Achnatherum thurberianum*	25–75	–
	squirreltail	ELEL5	*Elymus elymoides*	10–25	–
	Sandberg bluegrass	POSE	*Poa secunda*	10–25	–
2	**Secondary Perennial Grasses**			10–25	
	Webber needlegrass	ACWE3	*Achnatherum webberi*	3–10	–
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	3–10	–
	needle and thread	HECO26	*Hesperostipa comata*	3–10	–
3	**Annual Grasses**			0–5	
	sixweeks fescue	VUOC	*Vulpia octoflora*	0–2	–
Forb					
4	**Primary Perennial Forbs**			5–15	
	spiny hopsage	GRSP	*Grayia spinosa*	23–90	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	8–23	–
	shadscale saltbush	ATCO	*Atriplex confertifolia*	5–23	–
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	5–15	–
5	**Secondary Perennial Forbs**			10–40	
	milkvetch	ASTRA	*Astragalus*	1–10	–
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	1–10	–
	buckwheat	ERIOG	*Eriogonum*	3–10	–
	desertparsley	LOMAT	*Lomatium*	3–10	–
	lupine	LUPIN	*Lupinus*	1–10	–
	spiny phlox	PHHO	*Phlox hoodii*	1–10	–
	phlox	PHLOX	*Phlox*	1–10	–
	deathcamas	ZIGAD	*Zigadenus*	1–10	–
6	**Annual Forbs**			1–5	
	woollystar	ERIAS	*Eriastrum*	0–2	–
	spreading groundsmoke	GADI2	*Gayophytum diffusum*	0–2	–
	ipomopsis	IPOMO2	*Ipomopsis*	0–2	–
Shrub/Vine					
7	**Primary Shrubs**			135–315	
	big sagebrush	ARTR2	*Artemisia tridentata*	125–175	–
	spiny hopsage	GRSP	*Grayia spinosa*	25–100	–
	shadscale saltbush	ATCO	*Atriplex confertifolia*	5–25	–
8	**Secondary Shrubs**			25–50	
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	5–15	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	5–15	–
	horsebrush	TETRA3	*Tetradymia*	5–15	–

Animal community

Livestock Interpretations:
This site has value for livestock grazing. Grazing management should be keyed to dominant grasses and palatable shrub production. Livestock browse Wyoming big sagebrush, but may use it only lightly when palatable herbaceous species are available. Spiny hopsage provides a palatable and nutritious food source for livestock, particularly during late winter through spring. Domestic sheep browse the succulent new growth of spiny hopsage in late winter and early spring. Budsage is palatable and nutritious forage for domestic sheep in the winter and spring although it is known to cause mouth sores in lambs. Budsage can be poisonous or fatal to calves when eaten in quantity. Budsage, while desired by cattle in spring, is poisonous to cattle when consumed alone. Shadscale is a valuable browse species, providing a source of palatable, nutritious forage for a wide variety of livestock. Shadscale provides good browse for domestic sheep. Shadscale leaves and seeds are an important component of domestic sheep and cattle winter diets.
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. It is grazed in the fall only if the fruits are softened by rain. Thurber's needlegrass is sensitive to defoliation, especially during the boot stage (Ganskopp 1988). Indian ricegrass is a valuable forage species for livestock and wildlife, and is relatively tolerant of grazing. However, this species is heavily utilized in winter because it cures well. 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). Heavy grazing will reduce seed production and may reduce density and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck et al. 1985). Bottlebrush squirreltail is considered moderately palatable to livestock and provides valuable winter forage. Sandberg bluegrass is a palatable species, but its production is closely tied to weather conditions. It produces little forage in drought years, making it a less dependable food source than other perennial bunchgrasses.
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.
Inappropriate grazing management leads to an increase in sagebrush, spiny hopsage and other unpalatable shrubs and a decline in understory plants like Thurber's needlegrass and Indian ricegrass. Squirreltail will increase temporarily with further degradation. Invasion of annual non-native invasive forbs and cheatgrass could occur with further grazing degradation, leading to a decline in squirreltail and an increase in bare ground.

Wildlife Interpretations:
A large suite of wildlife species, including many bird, small and large mammals, and reptile species, depend on or at least partially utilize this ecological site. Large mammals common to this ecological site include mule deer (Odocoileus hemionus) and pronghorn antelope (Antilocarpa americana). Desert bighorn sheep (Ovis canadensis sierra) and Rocky Mountain elk (Cervus elaphus nelsonii) may occasionally use this ecological site; especially when in search of green forage in the late-winter and early-spring months. Big sagebrush is preferred browse for wild ungulates. Pronghorn usually browse Wyoming big sagebrush heavily. Spiny hopsage provides a palatable and nutritious food source for big game, particularly during late winter through spring. Bud sagebrush is browsed by mule deer in Nevada in winter and is utilized by bighorn sheep in summer, but the importance of bud sagebrush in the diet of bighorns is not known. Bud sagebrush comprises 18 – 35% of a pronghorn's diet during the spring, where it is available. Bud sagebrush is highly susceptible to effects of browsing. It decreases under browsing, due to year-long palatability of its buds, and is particularly susceptible to browsing in the spring when it is physiologically most active. Shadscale is a valuable browse species, providing a source of palatable, nutritious forage for a wide variety of wildlife particularly, during spring and summer before the hardening of spiny twigs. It supplies browse, seed, and cover for deer and pronghorn antelope. Thurber's needlegrass is valuable forage for wildlife. Indian ricegrass is eaten by pronghorn in moderate amounts whenever available. In Nevada Indian ricegrass is consumed by desert bighorns. Bottlebrush squirreltail is a dietary component of several wildlife species; including mule deer and pronghorn. Sandberg bluegrass is utilized by wildlife including mule deer, pronghorn, various small mammals, nongame birds and upland game birds. However, it matures early and remains choice for a shorter time than other bunchgrasses.
Sagebrush-grassland communities provide critical sage-grouse (Centrocercus urophasianus) breeding and nesting habitats. Sagebrush is a crucial component of their diet year-round, and sage-grouse select sagebrush almost exclusively for cover. Widespread natural hybridization of big sagebrush species, such as is suspected on this site, has important implications for wildlife management especially sage-grouse. Sage-grouse select Wyoming big

sagebrush communities for wintering and nesting habitat. The growth form of Wyoming big sagebrush provides suitable nesting and other habitat requirements of sage-grouse (Goodrich 2005). Favorable morphological characteristics for sage-grouse habitat include plant heights ranging from 16-36inches (40-90cm) and a dense spreading crown, with the lower part of the crown in proximity to the ground, but not so close that it obstructs sage-grouse nesting (Goodrich 2005). Stands of big sagebrush with a less spreading and more upright branching pattern, when compared to pure Wyoming big sagebrush, will not be preferred for nesting habitat. Big sagebrush is generally palatable to sage-grouse, though its palatability is highly variable (Rosentreter 2005). Sage-grouse prefer mountain big sagebrush and Wyoming big sagebrush communities to basin big sagebrush communities. In addition to sage-grouse; California quail (Callipepla californica), chukar (Alectoris chukar), mourning dove (Zenaida macroura), Brewers sparrow (Spizella breweri), gray flycatcher (Empidonax wrightii), lark sparrow (Chondestes grammacus), sage sparrow (Amphispiza belli), sage thrasher (Oreoscoptes montanus), and Vesper's sparrow (Pooecetes gramineus) utilize this ecological site. 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. Chukar utilize the leaves and seeds of budsage.
This sagebrush-grassland ecological site also provides habitat for small mammals such as: black-tailed (Lepus californicus) and white-tailed jackrabbit (L. townsendii), mountain cottontail (Sylvilagus nuttallii), pygmy rabbit (Brachylagus idahoensis), dark kangaroo mouse (Microdipodops megacephalus), Great Basin ground squirrel (Sermophilus mollis), Great Basin pocket mouse (Perognathus parvus), little pocket mouse (P. longimembris), Merriam's shrew (Sorex merriami), Northern grasshopper mouse (Onychomys leucogaster), Ord's kangaroo rat (Dipodomys ordii), sagebrush vole (Lemmiscus curtatus), Western jumping mouse (Zapus princeps), and Wyoming ground squirrel (Urocitellus elegans). A number of heteromyid rodents inhabiting desert rangelands show preference for seed of Indian ricegrass. In Nevada, Indian ricegrass may dominate jackrabbit diets during the spring through the early summer months. Spiny hopsage is a major food source for black-tailed jackrabbits. The seedlings of spiny hopsage are eaten by a variety of small mammals; including rabbits and mice. Shadscale supplies browse, seed, and cover for small mammals; including rabbits, mice and squirrels. This ecological site may also provide a significant insect foraging resource for bats.
A variety of predatory bird, mammal, and reptile species utilize this ecological site. Common mammalian predators to this site are the American badger (Taxidea taxus), bobcat (Lynx rufus), coyote (Canis latrans), kit fox (Vulpes macrotis), cougar or mountain lion (Puma concolor), short-tailed weasel (Mustela ermine) and long-tailed weasel (M. frenata). All of which utilize wildlife species in the area as sources of prey. Predatory reptiles utilizing habitat in this ecological site to catch prey are common sagebrush lizard (Sceloporus graciosus), Great Basin spadefoot (Spea intermontana), Great Basin collared lizard (Crotaphytus bicinctores), long-nosed leopard lizard (Gambelia wislizenii), Western skink (Plestiodon skiltonianus), Great Basin whiptail (Aspidoscelis tigris tigris), Great Basin gopher snake (Pituophis catenifer deserticola), Great Basin rattle snake (Crotalus oreganus lutosus). Avian predators present in the site are the American kestrel (Falco sparverius), common raven (Corvus corax), golden eagle (Aquila chrysaetos), loggerhead shrike (Lanius ludovicianus), Western burrowing owl (Athene cunicularia), Ferruginous Hawk (Buteo regalis), Swainson's hawk (B. swainsoni), and Prairie falcon (Falco mexicanus).
Changes in the soil, the plant community, precipitation, and fire regime of this ecological site could affect the distribution and presence of wildlife species in this ecological site.

Hydrological functions

The accumulation and decomposition of litter under sagebrush shrub canopies and the breakdown of aging roots contributes to organic matter and nutrient cycling in the sagebrush system. Soil organic matter is important to soil function, because it binds soil particles together into stable aggregates, improving porosity, infiltration and root penetration, and reducing runoff and erosion (USDA-NRCS 2001). Soil aggregate stability is the ability of the aggregates to resist degradation. Soils with stable aggregates at the surface are more resistant to wind and water erosion than other soils. Where organic matter inputs are reduced, unstable aggregates disperse during rainstorms resulting in soil loss and possible formation of a hard physical crust when the soil dries (USDA-NRCS 2001). Mature properly functioning sagebrush communities have higher infiltration rates, less runoff, and lower sediment production than their degraded counterparts.
Rills are none to rare. A few can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt. Water flow patterns are none to rare but can be expected on steeper slopes in areas subjected to summer convection storms or rapid snowmelt. Pedestals are none to rare. Frost heaving of shallow rooted plants should not be considered a "normal" condition. Gullies are none to rare in areas of this site that occur on stable landforms. Perennial herbaceous plants (especially deep-rooted bunchgrasses [i.e., Thurbers needlegrass and Indian ricegrass] 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 bird and big game hunting.

Other products

Traditional uses:
This site supports many plant species traditionally used and in some instances still utilized by Northern Paiute American Indians. Traditional plants that can be found in association with this ecological site include: sagebrush, balsamroot, Indian ricegrass, basin wildrye, saltbush, and rabbitbrush. These plants and others are addressed in various publications including Couture et al. (1986). Native Americans made tea from big sagebrush leaves. They used the tea as a tonic, an antiseptic, for treating colds, diarrhea, sore eyes and as a rinse to ward off ticks. Big sagebrush seeds were eaten raw or made into meal. Some American peoples traditionally ground parched seeds of spiny hopsage to make pinole flour. The Northern Paiutes used Indian ricegrass seed as a reserve food source. This ecological site was part of the aboriginal home territory of American Indians currently residing on the Burns Indian Reservation, Oregon. In Nevada, Indian groups residing on the Summit Lake Indian Reservation, the Fort McDermitt Indian Reservation, the Winnemucca Indian Colony and Te-Moak groups residing on the Battle Mountain Indian Colony consider this their aboriginal territory. The eastern edge of the site represents an ethnographic boundary between Northern Paiute and Shoshonean American Indians and some Shoshonean groups may also consider their home territory.

Other information

Restoration:
Plant establishment in the Great Basin is highly dependent upon precipitation and available moisture; which is highly variable among years. Seed mixes need to include sagebrush in areas where habitats lack adjacent seed sources. Seed mixes that include sagebrush tend to be more successful when plantings occur in November and December. Minimizing soil disturbing practices, applying seed immediately before a period of high-precipitation, or using high-moisture microsites may improve success. Determination of seeding success is best delayed until the end of the second growing season. Seeding failures should be reseeded before complete seedbed preparation is required. Many rangeland seedings are only marginally successful, and can be improved by means of natural or secondary seeding and plant establishment if given extra time and protection (USDA 1993). Vesicular-arbuscular mycorrhizae (VAM) have been found to be vitally important during the early stages of sagebrush seedling establishment. Wyoming big sagebrush seedlings exhibit greater drought resistance when inoculated with VAM. Seedlings inoculated with VAM are able to withstand lower soil water potentials without dying, than seedlings not inoculated with VAM (Stahl et al. 1998). Improved ability to extract soil nutrients and increased drought tolerance in Wyoming big sagebrush seedlings may have important consequences for restoring degraded sagebrush habitat.

Other types of projects:
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. Spiny hopsage has moderate potential for erosion control and low to high potential for long-term revegetation projects. It can improve forage, control wind erosion, and increase soil stability on gentle to moderate slopes. Spiny hopsage is suitable for highway plantings on dry sites in Nevada. Bottlebrush squirreltail is tolerant of disturbance and is a suitable species for revegetation.

Type locality

Location 1: Eureka County, NV	
Township/Range/Section	T32N R49E S15
Latitude	40° 38′ 46″
Longitude	116° 25′ 55″

General legal description	Eureka County, Nevada; about 4.5 miles northeast of Beowawe, Nevada; 2,400 feet north and 2,000 feet west of the apparent southeast corner of sec. 15, T.32N., R.49E.
Location 2: Humboldt County, NV	
Township/Range/Section	T43N R37E S3
General legal description	In the Quinn River Valley northwest of Orovada. SSA NV777, MU330 and MU331.

Other references

Baughman, O.W. and S.E. Meyer. 2013. Is Pyrenophora semeniperda the cause of downy brome (*Bromus tectorum*) die-offs? Invasive Plant Science and Management. 6:105-111.

Brakensiek, D.L. and W.J. Rawls. 1994. Soil containing rock fragments: effects on infiltration. Catena. 23:99-110.

Belnap, J. 2003. The world at your feet: desert biological soil crusts. Frontiers in Ecology and the Environment. 1: 181-189.

Bunting, S.C., B.M. Kilgore, and C.L. Bushey. 1987. Guidelines for prescribed burning sagebrush-grass rangelands in the northern Great Basin. Gen. Tech. Rep. INT-231. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 33 p.

Chambers, J. B. Roundy, R. Blank, S. Meyer and A. Whittaker. 2007. What makes Great Basin sagebrush ecosystems invasible by *Bromus tectorum*? Ecological Monographs. 77(1): 117-145.

Chambers, J., R. Miller and J. Grace. 2012. The importance of resilience and resistance to the restoration of sagebrush rangelands. SageSTEP News 18:4-6.

Couture, M.D., M.F. Ricks and L. Housley. 1986. Foraging behavior of a contemporary northern Great Basin population. J. of California and Great Basin Anthropology. 8.2:150-160.

Davies, K., J. Bates and R. Miller. 2007. Environmental and vegetation relationships of the *Artemisia tridentata* spp. wyomingensis alliance. J. of Arid Environments. 70: 478-797.

Duda, J.J., D.C. Freemand, J. M. Emlen, J. Belnap, S.G. Kitchen, J.C. Zak, E. Sobek, M. Tracy, and J. Montante. 2003. Difference in native soil ecology associated with invasion of the exotic annual chenopod, Halogeton glomeratus. Biol Fertil Soils 38:72-77.

Furniss, M.M. and W.F. Barr. 1975. Insects affecting important native shrubs of the northwest United States. USDA FS General Technical Report INT-19: Pgs 30-32.

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

Gates, D.H. 1964. Sagebrush infested by leaf defoliation moth. J. of Range Mgt 17: 209-310.

Goodrich, S. 2005. Classification and capabilities of woody sagebrush communities of Western North America with emphasis on sage-grouse habiat. USDA Forest Service Proceedings RMRS-P-38:17-37.

Holling, C.S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics. 4:1-23.

Howard, J. L. 1999. *Artemisia tridentata* subsp. wyomingensis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/

Howard, J. L. 1997. Poa secunda. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer).

Available: http://www.fs.fed.us/database/feis/ [2014, January 27].

Kaltenecker, J.H., M.C. Wicklow-Howard, and R. Rosentreter. 1999. Biological soil crust in three sagebrush communities recovering from a century of livestock trampling. In: Proceedings: shrubland ecotones; 1998 Aug 12-14; Ephraim, UT. Proc. RMRS-P-11.

Koniak, S. 1985. Succession in pinyon-juniper woodlands following wildfire in the Great Basin. The Great Basin Naturalist 45 (3:556-566).

McArthur, E.D., B.L. Welch and S.C. Sanderson. 1988. Natural and Artificial Hybridization between Big Sagebrush (*Artemisia tridentata*) Subspecies. J. of Heredity 79:268-276.

Meyer, S.E. 2008. Artemisia L. USDA FS Agriculture Handbook 727- Woody Plant Seed Manual. p 274-280.

Meyer, S.E., S.L. Carlson, S.C. Garvin. 1998. Seed germination regulation and field seed bank carryover in shadscale (Atrilplex confertifolia: Chenopodiaceae). J. of Arid Environments. 38:255-267.

Memmott, K.L., V.J. Anderson, and S.B. Monsen. 1998. Seasonal grazing impact on crytogamic crust in a cold desert ecosystem. J of Range Management. 51(5):547-550.

Miller, R. F., J.C. Chambers, D.A. Pyke, F.B. Peirson and C.J. Williams. 2013. A review of fire effects on vegetation and soils in the Great Basin region: response and ecological site characteristics. RMRS-GTR-308.

Monaco, T.A., D.A. Johnson, J.M. Norton, T.A. Jones, K.J. Connors, J.B. Norton and M.B. Redinbaugh. 2003. Contrasting responses of intermountain west grasses to soil nitrogen. Journal of Range Management 56:289-290.

Norton, J.B., T.A. Monaco, J.M. Norton, D.M. Johnson, T.A. Jones. 2004. Cheatgrass invasion alters soil morphology and organic matter dynamics in big sagebrush-steppe rangelands. USDA Forest Service Proceedings RMRS-P-31:57-63.

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

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

Richardson, B.A., J.T. Page, P. Bajgain, S.C. Sanderson and J.A. Udall. 2012. Deep sequencing of amplicons reveals widespread intraspecific hybridization and multiple origins of polyploidy in big sagebrush (*Artemisia tridentata*; Asteraceae). American J of Botany 99(12):1926-1975.

Rosentreter, R. 2005. Sagebrush identification, ecology, and palatability relative to sage-grouse. USDA Forest Service Proceedings RMRS-P-38:3-16.

Simonin, Kevin A. 2001. Elymus elymoides. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2014, March 14].

Smith, M.A. and F. Busby. 1981. Prescribed burning: effective control of sagebrush in Wyoming. RJ-165. Laramie, WY: University of Wyoming, Agricultural Experiment Station. 12 p.

Sperry J.S. and U.G. Hacke. 2002. Desert shrub water relations with respect to soil characteristics and plant functional type. Functional Ecology. 16:367-378.
Stahl, P.D., G.E. Schuman, S. M. Frost and S.E. Williams. 1998. Arbuscular mycorrhizae and water stress tolerance of Wyoming big sagebrush seedlings. Soil Sci. Am. J. 62:1309-1313.

Stringham, T.K. and E. Freese. 2011. Final Report for Agreement No. 68-9327-9-09 USDA Ecological Site Description, MLRA 24. University of Nevada, Reno.

Stubbendieck, J., J.T. Nichols, and K.K. Roberts. 1985. Nebraska range and pasture grasses (including grass-like plants). E.C. 85-170. Lincoln, NE: University of Nebraska, Department of Agriculture, Cooperative Extension Service. 75 p.

Tirmenstein, D. A. 1999. Grayia spinosa. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2013, January 30].

USDA-NRCS. 2001. Soil quality Technical Note No. 3. Soil quality information sheets for rangelands.

USDA-NRCS. 2012. WEB Soil Survey. Available online at: http://soils.usda.gov

USDA-SCS. 1993. Determining success of forage production seedings. TN- Plant Materials No. 32. Reno NV.

USDI-BLM. 2001. Biological soil crusts: ecology and management. Technical Reference 1730-2.

West, N.E. 1994. Effects of fire on salt-desert shrub rangelands. In: Monsen, S.B. and S.G. Kitchen (compilers). Proceedings--ecology and management of annual rangelands; 1992 May 18-22; Boise, ID. Gen. Tech. Rep. INT-GTR-313. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: Pgs 71-74.

West, N.E. and M.A. Hassan. 1985. Recovery of sagebrush-grass vegetation following wildfire. Journal of Range Management 38(2):131-134.

Winward, A.H. 1991. A renewed commitment to management of sagebrush grasslands. P. 2-7 In: Management of the sagebrush steppe. Agricultural Experimental Station Special Report 880. Oregon State University, Corvallis, OR.

Young, J.A., R.E. Eckert, Jr., R.A. Evans. 1979. Historical perspectives regarding the sagebrush ecosystem. In: The sagebrush ecosystem: a symposium: Proceedings; 1978 April; Logan, UT. Logan, UT: Utah State University, College of Natural Resources: 1-13.

Zlatnik, E. 1999. Agropyron cristatum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/

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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	02/05/2010
Approved by	PNovak-Echenique

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 can be expected on steeper slopes in areas subjected to summer convection storms or rapid spring snowmelt.

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2. **Presence of water flow patterns:** Water flow patterns are none to rare but can be expected on steeper slopes in areas subjected to summer convection storms or rapid snowmelt. Generally up to 20 ft apart and short (<10 ft. long) with numerous obstructions that alter the flow path. Flow pattern length and numbers may double after wildfires, high levels of natural herbivory, extended drought, or combinations of these disturbances if summer convection storms occur.

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3. **Number and height of erosional pedestals or terracettes:** Pedestals are none to rare and usually occur in water flow paths. Wind pedestals are rare and would only occur after wildfires, after high levels of herbivory, extended drought, or combinations of these disturbances. Frost heaving of shallow rooted plants should not be considered a "normal" condition.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground 20-50% depending on amount of rock fragments. Lower slopes are expected to have less bare ground than steeper slopes. Bare ground would expect to increase to 80% or more the first year following wildfire. Multi-year droughts can also increase bare ground.

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

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Wind erosion is minimal. Moderate wind erosion can occur after major disturbances such as wildfires, high levels of natural herbivory, extended drought or combinations of these disturbances. After rain events, exposed soil surfaces form a physical crust that tends to reduce wind erosion.

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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.

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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. Areas of this site occurring on soils that have a physical crust will probably have stability values less than 3. (To be field tested.)

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface structure is typically fine granular. Soil surface colors are light and soils are typified by an ochric epipedon. Organic matter of the surface 2 to 3 inches is typically less than 1 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., Thurber""s needlegrass and Indian ricegrass] slow runoff and increase infiltration. Shrub canopy (especially sagebrush) and associated litter break raindrop impact and provide opportunity for snow catch and accumulation on site. Loss of sagebrush after a severe wildfire reduces snow accumulation in the winter, reducing the depth of soil water recharge negatively affecting recovery and growth and reproduction of deep-rooted perennial forbs and grasses.

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, subangular blocky, prismatic, or massive sub-surface horizons or subsoil argillic 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 Plant Community: Deep-rooted, cool season, perennial bunchgrasses > tall shrubs (Wyoming big sagebrush)

    Sub-dominant: Associated shrubs > shallow-rooted, cool season, perennial bunchgrasses > deep-rooted, cool season, perennial forbs = fibrous, shallow-rooted, cool season, perennial and annual forbs.

    Other: Microbiotic crusts

    Additional: After wildfires, the functional/structural dominance changes to the herbaceous components with a slow 10-20 year recovery of the non-resprouting shrubs (big sagebrush). Resprouting shrubs (spiny hopsage, horsebrush, rabbitbrush) tend to increase until sagebrush reestablishes. High levels of natural herbivory, extended drought or combinations of these factors can increase shrub functional/structural groups at the expense of the herbaceous groups and biological crusts.

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Most of the perennial plants are long-lived. 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 (to 20%) have dead centers. Extended drought would cause a relatively high mortality of short-lived species such as bottlebrush squirreltail and Sandberg bluegrass.

14. **Average percent litter cover (%) and depth (in):** Within plant interspaces (± 20%) and depth of litter is <½ inch. After wildfires, high levels of natural herbivory, extended drought, or combinations of these disturbances, litter cover and depth decreases to none. Depending on climate and vegetative recovery, litter will increase to pre-fire levels in one to five growing seasons.

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** For normal or average growing season (end of June) ± 500 lbs/ac; Favorable years ± 700 lbs/ac and unfavorable years ± 300 lbs/ac. Spring moisture significantly affects total production.

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

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17. **Perennial plant reproductive capability:** All functional groups should reproduce in average (or normal) and above average growing season years. Only limitations to reproductive capability are weather related, natural disease or herbivory, insect infestations, or combinations of all of the disturbances.
