Ecological site F028BY060NV
PIMO-JUOS/ARNO4/PSSPS-ACHY

Accessed: 05/20/2024

General information

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

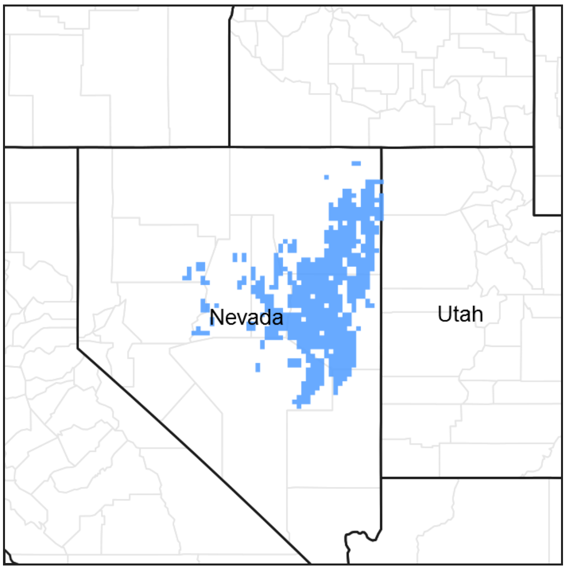

Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 028B–Central Nevada Basin and Range

MLRA 28B occurs entirely in Nevada and comprises about 23,555 square miles (61,035 square kilometers). More than nine-tenths of this MLRA is federally owned. This area is in the Great Basin Section of the Basin and Range Province of the Intermontane Plateaus. It is an area of nearly level, aggraded desert basins and valleys between a series of mountain ranges trending north to south. The basins are bordered by long, gently sloping to strongly sloping alluvial fans. The mountains are uplifted fault blocks with steep sideslopes. Many of the valleys are closed basins containing sinks or playas. Elevation ranges from 4,900 to 6,550 feet (1,495 to 1,995 meters) in the valleys and basins and from 6,550 to 11,900 feet (1,995 to 3,630 meters) in the mountains.
The mountains in the southern half are dominated by andesite and basalt rocks that were formed in the Miocene and Oligocene. Paleozoic and older carbonate rocks are prominent in the mountains to the north. Scattered outcrops of older Tertiary intrusives and very young tuffaceous sediments are throughout this area. The valleys consist mostly of alluvial fill, but lake deposits are at the lowest elevations in the closed basins. The alluvial valley fill consists of cobbles, gravel, and coarse sand near the mountains in the apex of the alluvial fans. Sands, silts, and clays are on the distal ends of the fans.
The average annual precipitation ranges from 4 to 12 inches (100 to 305 millimeters) in most areas on the valley floors. Average annual precipitation in the mountains ranges from 8 to 36 inches (205 to 915 millimeters) depending on elevation. The driest period is from midsummer to midautumn. The average annual temperature is 34 to 52 degrees F (1 to 11 degrees C). The freeze-free period averages 125 days and ranges from 80 to 170 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 soil temperature regime, an aridic or xeric soil moisture regime, and mixed or carbonatic mineralogy. They generally are well drained, loamy or loamyskeletal, and shallow to very deep.
Nevada's climate is predominantly arid, with large daily ranges of temperature, infrequent severe storms and heavy snowfall in the higher mountains. Three basic geographical factors largely influence Nevada's climate: continentality, latitude, and elevation. 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, as a result 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 midlatitude 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 occasional thundershowers. The eastern portion of the state receives noteworthy 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).

Ecological site concept

This forestland site occurs on mountain on all exposures. Slopes typically range from 15 to 50 percent. Elevations are 5500 to 9000 feet.

The soils are shallow, well drained and formed in residuum & colluvium derived from limestone. Soils are characterized by an ochric epipedon and a calcic horizon. Soil temperature regime is mesic and soil moisture regime is aridic bordering on xeric.

The reference state is dominated by singleleaf pinyon and Utah juniper. Black sagebrush is the principal understory shrub. Bluebunch wheatgrass, bluegrass and Indian ricegrass are the most prevalent understory grasses. An overstory canopy of 10 to 25 percent is assumed to be representative of tree dominance in a pristine environment. Overstory tree canopy composition is about 50 to 70 percent Utah juniper and about 30 to 50 percent singleleaf pinyon. Understory production ranges from 250 to 500 pounds per acre.

The current ecological site concept that exists for this site requires 10 percent of the total overstory to be made up of mature trees 150 years old, or older. Starting in 2008, an extensive review of pinyon and juniper ecological site concepts has compared soil characteristics, abiotic factors and vegetative cover and structure information. It has been discovered that it is very difficult to find areas currently mapped as pinyon- juniper forest that actually meet the current site concept requirements. Future soil survey work will further investigate site relationships, which may result in the adjustment of current site concepts.

Similar sites

F028BY083NV	**Cobbly Calcareous Mountain Slopes 10-12 P.Z.** Lower site index. Pinyon is a minor component in the overstory.

Table 1. Dominant plant species

Tree	(1) *Pinus monophylla* (2) *Juniperus osteosperma*
Shrub	(1) *Artemisia nova*

Herbaceous	(1) *Pseudoroegneria spicata* (2) *Achnatherum hymenoides*

Physiographic features

This forest site occurs on hills, and mountain sideslopes, summits and crests on all exposures. Slopes range from 2 to over 75 percent, but are typically 15 to 50 percent. Elevations are 5500 to 9000 feet.

Table 2. Representative physiographic features

Landforms	(1) Mountain (2) Hill
Elevation	1,676–2,743 m
Slope	15–75%
Aspect	Aspect is not a significant factor

Climatic features

This site’s climate is semi-arid. In general it is characterized by cold, moist winters and warm, dry summers.

Average annual precipitation ranges from 10 to 14 inches. Mean annual air temperature is about 44 to 47 degrees F. The average growing season is 85 to 100 days.
Mean annual precipitation across the range in which this ES occurs is 11.9 inches: Jan. 0.99; Feb. 1.05; Mar. 1.15; Apr. 1.37; May 1.3; Jun. 0.95; Jul. 0.78; Aug. 0.86; Sept. 0.80; Oct. 0.96; Nov. 0.8; Dec. 0.92.
*The above data is averaged from the Ruth and Eureka WRCC climate stations.

Table 3. Representative climatic features

Frost-free period (average)	90 days
Freeze-free period (average)	120 days
Precipitation total (average)	330 mm

Climate stations used

- (1) EUREKA [USC00262708], Eureka, NV
- (2) RUTH [USC00267175], Ely, NV

Influencing water features

Influencing water features are not associated with this site.

Soil features

The soils associated with this site are shallow, well drained and formed in residuum/colluvium from limestone parent material. Depth to bedrock is 50cm or less. Soils are characterized by a ochric epipedon and a calcic horizon. The soil profile is skeletal with greater than 35% rock fragments by volume. Available water holding capacity is very low to low. The soil moisture regime is aridic bordering on xeric and the soil temperature regime is mesic.

These soils normally have high amounts of gravels, stones, or cobbles on the surface that occupy plant growing space. Rock fragments on the surface provide a stabilizing effect on surface erosion conditions. Runoff is high to very high. Soil series correlated to this site include: Pookaloo, Hyzen, Hopeka, Kzin, Urmafot, Upatad, Overland, Biken and Hymas.

The representative soil series is Pookaloo, a Loamy-skeletal, carbonatic, mesic Lithic Xeric Haplocalcids.

Diagnostic horizons include an ochric epipedon from the soil surface to 18cm, a calcic horizon from 10-48cm and lithic contact at 48cm. Clay content in the particle size control section averages 10 to 18 percent. Rock fragments range from 35 to 50 percent, mainly gravel. Reaction is slightly alkaline or moderately alkaline. Soils are violently effervescent throughout and are derived from limestone, dolomite and calcareous siltstone.

Table 4. Representative soil features

Parent material	(1) Residuum–dolomite (2) Colluvium–limestone
Surface texture	(1) Very gravelly loam (2) Very gravelly loamy fine sand (3) Extremely cobbly loam
Family particle size	(1) Loamy
Drainage class	Well drained to somewhat excessively drained
Permeability class	Slow to moderately rapid
Soil depth	25–76 cm
Surface fragment cover <=3"	15–60%
Surface fragment cover >3"	2–8%
Available water capacity (0-101.6cm)	0.76–11.43 cm
Calcium carbonate equivalent (0-101.6cm)	20–70%
Electrical conductivity (0-101.6cm)	0–8 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–5
Soil reaction (1:1 water) (0-101.6cm)	7.9–9
Subsurface fragment volume <=3" (Depth not specified)	35–50%
Subsurface fragment volume >3" (Depth not specified)	0–10%

Ecological dynamics

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Pinyon and juniper dominated plant communities in the cold desert of the Intermountain West occupy over 18 million ha (44,600,000 acres) (Miller and Tausch 2001). In the mid to late 1900’s the number of pinyon and juniper trees establishing per decade began to increase compared to the previous several hundred years. The substantial increase in conifer establishment is attributed to a number of factors the most important being (1) cessation of the aboriginal burning (Tausch 1999), (2) change in climate with rising temperatures (Heyerdahl et al. 2006), (3) the reduced frequency of fire likely driven by the introduction of domestic livestock, (4) a decrease in wildfire frequency along with improved wildfire suppression efforts and (5) potentially increased CO_2 levels favoring woody plant establishment (Tausch 1999, Bunting 1994). Miller et al. (2008) found presettlement tree densities averaged 2 to 11 per acre in six woodlands studied across the Intermountain West. Current stand densities range from 80 to 358 trees/ac. In Utah, Nevada, and Oregon, trees establishing prior to 1860 accounted for only 2 percent or less of the total population of pinyon and juniper (Miller et al. 2008). The research strongly suggests that for over 200 years prior to settlement, woodlands in the Great Basin were relatively low density with limited rates of establishment

(Miller et al. 2008, Miller and Tausch 2001). This evidence strongly suggests that tree canopy cover of 10 to 20 % may be more representative of these sites in pristine condition. Increases in pinyon and juniper densities post-settlement were the result of both infill in mixed age tree communities and expansion into shrub-steppe communities. Pre-settlement trees accounted for less than 2 percent of the stands sampled in Nevada, Oregon and Utah (Miller et al. 2008, Miller and Tausch 2001, Miller et al. 1999). However, the proportion of old-growth can vary depending on disturbance regimes, soils and climate. Some ecological sites are capable of supporting persistent woodlands, likely due to specific soils and climate resulting in infrequent stand replacement disturbance regimes. In the Great Basin, old-growth trees have been found to typically grow on rocky shallow or sandy soils that support little understory vegetation to carry a fire (Holmes et al. 1986, Miller and Rose 1995, West et al. 1998).
Singleleaf pinyon and Utah juniper are long-lived tree species with wide ecological amplitudes (Tausch et al 1981, Weisberg and Dongwook 2012, West et al 1998). Maximum ages of pinyon and juniper exceed 1000 years and stands with maximum age classes are only found on steep rocky slopes with no evidence of fire (West et al 1975). Singleleaf pinyon is slow-growing and very intolerant to shade with the exception of young plants, usually first year seedlings (Tueller and Clark 1975). Singleleaf pinyon seedling establishment is episodic. Population age structure is affected by drought, which reduces seedling and sapling recruitment more than other age classes. The ecotones between singleleaf pinyon woodlands and adjacent shrublands and grasslands provide favorable microhabitats for singleleaf pinyon seedling establishment since they are active zones for seed dispersal, nurse plants are available, and singleleaf pinyon seedlings are only affected by competition from grass and other herbaceous vegetation for a couple of years.
The pinyon jay (Gymnorhinus cyanocephalus) and other members of the seed caching corvids play an important role in pinyon pine regeneration. These birds cache the seeds in the soil for future use. Those seeds that escape harvesting by the birds and rodents have the opportunity to germinate under favorable soil and climatic conditions (Lanner 1981). Singleleaf pinyon seedling establishment is episodic. Population age structure is affected by drought, which reduces seedling and sapling recruitment more than other age classes. A mutualistic relationship exists between the trees that produce food and the animals that disperse the seeds, thereby insuring perpetuation of the trees. Large crops of seeds may stimulate reproduction in birds, especially the pinyon jay (Ligon 1974).
Pinyon and juniper growth is dependent mostly upon soil moisture stored from winter precipitation, mainly snow. Much of the summer precipitation is ineffective, being lost in runoff after summer convection storms or by evaporation and interception (Tueller and Clark 1975). Pinyon and juniper are highly resistant to drought which are common in the Great Basin. Tap roots of pinyon and juniper have a relatively rapid rate of root elongation and are thus able to persist until precipitation conditions are more favorable (Emerson 1932).
Infilling by younger trees increases canopy cover causing a decrease in understory perennial vegetation and an increase in bare ground. As pinyon and juniper trees increase in density so has their litter. Phenolic compounds of juniper scales can have an inhibitory effect on grass growth (Jameson 1970). Furthermore, infilling shifts stand level biomass from ground fuels to canopy fuels which has the potential to significantly impact fire behavior. The more tree dominated pinyon and juniper woodlands become, the less likely they are to burn under moderate conditions, resulting in infrequent high intensity fires (Gruell 1999, Miller et al. 2008). Additionally, as the understory vegetation declines in vigor and density with increased canopy the seed and propagules of the understory plant community also decrease significantly. The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass and with intensive wildfire the potential for conversion to annual exotics is a serious threat (Tausch 1999, Miller et al. 2008).
Specific successional pathways after disturbance in pinyon-juniper stands are dependent on a number of variables such as plant species present at the time of disturbance and their individual responses to disturbance, past management, type and size of disturbance, available seed sources in the soil or adjacent areas, and site and climatic conditions throughout the successional process.

Utah juniper can be killed by a fungus called Juniper Pocket Rot (Pyrofomes demidoffi), also known as white truck rot (Eddleman et al. 1994 and Durham 2014). Pocket rot enters the tree through any wound or opening that exposes the heartwood. In an advanced stage, this fungus can cause high mortality (Durham 2014). Dwarf mistletoe (Phorandendron spp.) a parasitic plant, may also affect Utah juniper and without treatment or pruning, may kill the tree 10-15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: witches'-broom (Gymnosporangium sp.) that may girdle and kill branches; leaf rust (Gymnosporangium sp.) on leaves and young branches; and juniper blight (Phomopsis sp.). Flat-head borers (Chrysobothris sp.) attack the wood; long-horned beetles (Methia juniper, Styloxus bicolor) girdle limbs and twigs; and round-head borers (Callidium spp.) attack twigs and limbs (Tueller and Clark 1975).
Phillips (1909) recognized that the pinyons are more resistant to disease than most of the conifers with which it associates. Hepting (1971) lists several diseases affecting pinyon including: foliage diseases, a tarspot needle cast, stem diseases such as blister rust and dwarf mistletoe, root diseases and trunk rots, red heart rot, and but rot. The

pinyon ips beetle (Ips confuses) and pinyon needle scale (Matsucoccus acalyptus) are both native insects to Nevada that attack pinyon pines throughout their range. The pinyon needle scale weakens trees by killing needles older than 1 year. Sometimes small trees are killed by repeated feeding and large trees are weakened to the point that they are attacked by the pinyon ips beetle. The beetle typically kills weak and damaged trees (Phillips 2014). During periods of chronic drought the impact of these two insects on singleleaf pinyon can be substantial.
Black sagebrush is generally long-lived; therefore it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.
The perennial bunchgrasses that are co-dominant with the shrubs include Indian ricegrass, bluebunch wheatgrass, Thurber's needlegrass and Sandberg's bluegrass. 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 of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.
This site has low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Four possible alternative stable states have been identified for this site.

Fire Ecology:
Lightning-ignited fires were common but typically did not affect more than a few individual trees. Replacement fires were uncommon to rare (100-600 years) and occurred primarily during extreme fire behavior conditions. Spreading, low-intensity surface fires had a very limited role in molding stand structure and dynamics. Surface spread was more likely to occur in higher-density woodlands growing on more productive sites (Romme et al 2007). Pre-settlement fire return intervals in the Great Basin National Park, Nevada were found to have a mean range between 50 to 100 years with north-facing slopes burning every 15 to 20 years and rocky landscapes with sparse understory very infrequently (Gruell 1999). Woodland dynamics are largely attributed to long-term climatic shifts (temperature, amounts and distribution of precipitation) and the extent and return intervals of fire (Miller and Tausch 2001). Limited data exists that describes fire histories across woodlands in the Great Basin. The infilling of younger trees into the old-growth stands and the expansion of trees into the surrounding sagebrush steppe ecological sites has increased the risk of loss of pre-settlement trees due to increased fire severity and size resulting from the increase in the abundance and landscape level continuity of fuels (Miller et al. 2008).

Utah juniper is usually killed by fire, and is most vulnerable to fire when it is under four feet tall (Bradley et al. 1992). Larger trees, because they have foliage farther from the ground and thicker bark, can survive low severity fires but mortality does occur when 60% or more of the crown is scorched (Bradley et al. 1992). Singleleaf pinyon is also most vulnerable to fire when less than four feet tall, however mature trees do not self-prune their dead branches allowing for accumulated fuel in the crowns. This characteristic and the relative flammability of the foliage make individual mature trees susceptible to fire (Bradley et al. 1992). With the low production of the understory vegetation and low density of trees per acre, high severity fires within this plant community were not likely and rarely became crown fires (Bradley et al. 1992, Miller and Tausch 2001).

Singleleaf pinyon and Utah juniper reestablish by seed from nearby seed sources or surviving seeds. Junipers have a long-lived seed bank due to delayed germination by impermeable seed coats, immature or dormant embryos and germination inhibitors (Chambers et al. 1999). Singleleaf pinyon trees have relatively short-lived seeds with little innate dormancy that form only temporary seed banks with most seeds germinating the spring following dispersal (Meewig and Bassett 1983). Density of pinyon seeds in the seed bank is dependent upon the current year's cone crop. Singleleaf pinyon are known to have favorable cone production every two to three years thus the potential for a large temporary seed bank is high during mast years and likely low during non-mast years (Chambers et al. 1999). The role of nurse plant requirements between the two tree species is important to post-fire establishment. Chambers et al. (1999) found that singleleaf pinyon seedlings rarely establish in interspaces or open environments. In contrast, Utah juniper seedlings were found capable of establishing in interspace microhabitats as frequently as under sagebrush. Therefore, fire that removes both trees and understory shrubs in pinyon-juniper woodlands may have a relatively greater effect on the establishment of pinyon than juniper.

Initial response of native understory species following fire correlates closely with percent crown cover. In general, research indicates that understory response to disturbance is most productive when crown cover is at or below 20% while beyond 30% there is a rapid decline in understory species and soil seed reserves (Huber et al. 1999). The reference state understory vegetation of black sagebrush, bluebunch wheatgrass and Indian ricegrass further supports the evidence of a presettlement community with an open overstory and infrequent ground fire.

Black sagebrush plants have no morphological adaptations for surviving fire and must reestablish from seed following fire (Wright et al. 1979). Fire return intervals in black sagebrush ecosystems have been estimated at 100-200 years (Kitchen and McArthur 2007); however, fires were probably patchy and very infrequent due to the low productivity of these sites. The ability of black sagebrush to establish after fire is mostly dependent on the amount of seed deposited in the seed bank the year before the fire. Seeds typically do not persist in the soil for more than 1 growing season (Beetle 1960). A few seeds may remain viable in soil for 2 years (Meyer 2008); however, even in dry storage, black sagebrush seed viability has been found to drop rapidly over time, from 81% to 1% viability after 2 and 10 years of storage, respectively (Stevens et al. 1981). Thus, repeated frequent fires can eliminate black sagebrush from a site, however black sagebrush in zones receiving 12 to 16 inches of annual precipitation have been found to have greater fire survival (Boltz 1994). In lower precipitation zones rabbitbrush may become the dominant shrub species following fire, often with an understory of Sandberg bluegrass and/or cheatgrass and other weedy species.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). However, season and severity of the fire will influence plant response. Plant response will vary depending on post-fire soil moisture availability. 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.
Indian ricegrass, a prominent grass on this site, is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below ground plant crowns. Vallentine (1989) cites several studies in the sagebrush zone that classified Indian ricegrass as being slightly damaged from late summer burning. Indian ricegrass has also been found to reestablish on burned sites through seed dispersed from adjacent unburned areas (Young 1983, West 1994). Thus the presence of surviving, seed producing plants facilitates the reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.
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.
Curlleaf mountain mahogany may depend on fire to reduce conifer competition and produce favorable soil conditions for seedling establishment. Individual curlleaf mountainmahogany are severely damaged by fire. Because many dead branches persist in the crown and leaves are slightly resinous, curlleaf mountainmahogany is probably very flammable. Curlleaf mountainmahogany is a weak sprouter after a fire. Fire effects on Stansbury cliffrose are variable. Fire may kill or severely damage plants. Late-season fire also increases the risk of mortality. Stansbury cliffrose is a weak sprouter that is generally killed by severe fire.

State and transition model

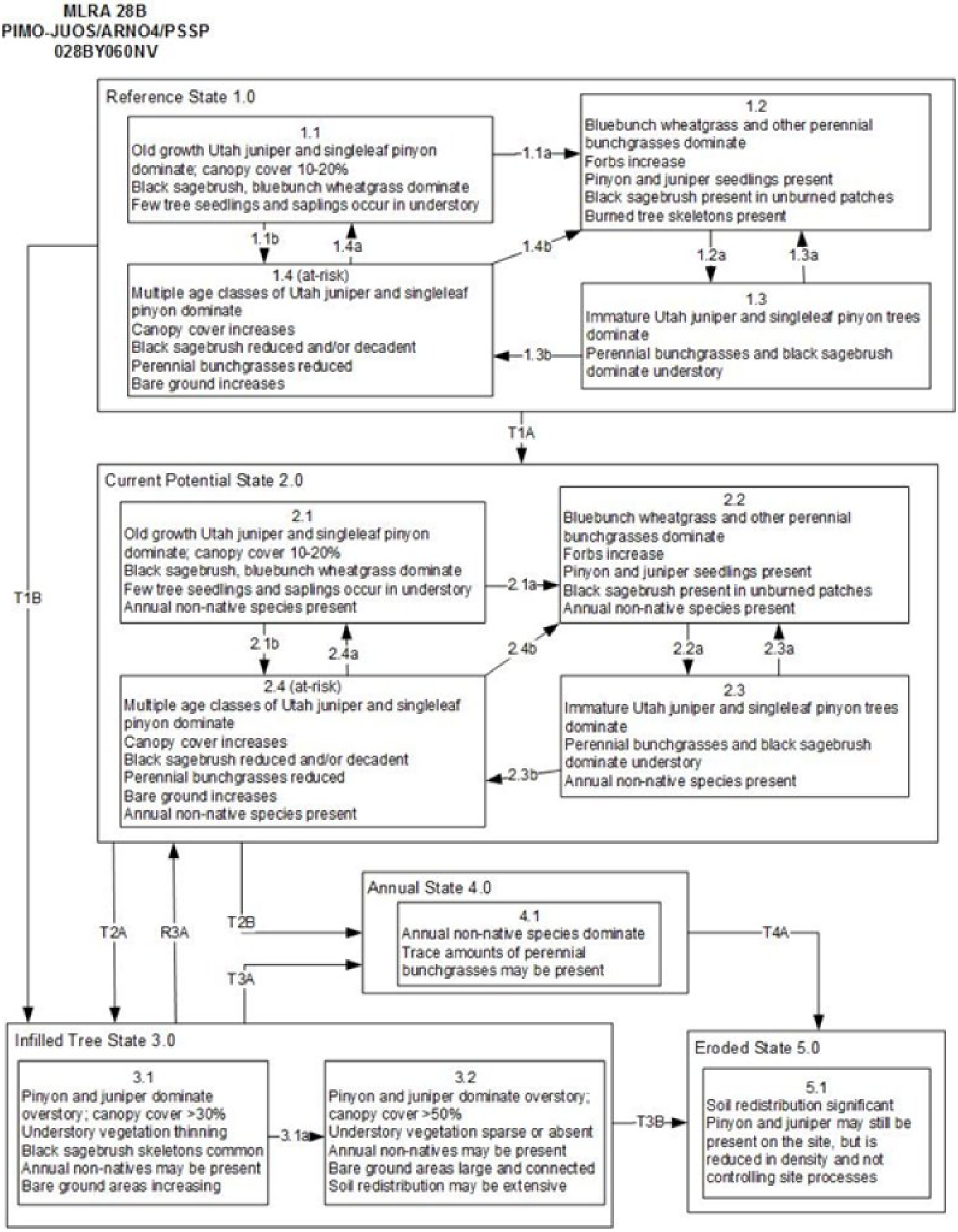

Figure 6. PNovakEchenique 3_2017

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Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or long-term drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or long-term drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Fire.
1.3b: Time and lack of disturbance such as fire or long-term drought. Excessive herbivory may also reduce perennial grass understory.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: 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.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or long-term drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or long-term drought. Excessive herbivory may also reduce perennial grass understory.
2.3a: Fire.
2.3b: Time and lack of disturbance such as fire or long-term drought. Excessive herbivory may also reduce perennial grass understory..
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: 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.
Transition T2B: Catastrophic fire.

Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or long-term drought allows younger trees to infill.

Transition T3A: Catastrophic fire.
Transition T3B: Loss of understory vegetation destabilizes soil surface. Inappropriate grazing management may further reduce the perennial grass understory.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

Transition T4A: Catastrophic fire or multiple fires.

Eroded State 5.0 Community Pathways
None.

Figure 7. Legend

State 1
Reference State

The Reference State 1.0 is representative of the natural range of variability under pristine conditions. This Reference State has four general community phases: an old-growth woodland phase, a shrub-herbaceous phase, an immature woodland phase, and an infilled tree 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. Management should focus on maintaining high species diversity of desired species to promote site resiliency.

Community 1.1
Community Phase

This phase is characterized by widely dispersed old-growth pinyon and juniper trees with a black sagebrush perennial bunchgrass understory. The visual aspect is dominated by singleleaf pinyon and Utah juniper which make up 10 to 20 percent of the overstory canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Bluebunch wheatgrass and Indian ricegrass are the most prevalent grasses in the understory. Black sagebrush is the primary understory shrub. Forbs such as goldenweed, buckwheat, and phlox are minor components. Overall, the understory is sparse with production ranging between 250 to 500 pounds per acre. Fires within this community are infrequent and likely small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Forest overstory. The visual aspect and vegetal structure are dominated by old growth singleleaf pinyon and Utah juniper that have reached or are near maximal heights for the site. Dominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns of pinyon and juniper are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges from 10 to 20 percent.

Forest understory. Understory vegetative composition is about 35 percent grasses, 15 percent forbs and 50 percent shrubs and young trees when the average overstory canopy is medium (10 to 20 percent). Average understory production ranges from 250 to 500 pounds per acre with a medium canopy cover. Understory production includes the total annual production of all species within 5m of the ground surface. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic wildfire is a natural factor influencing the understory of mature pinyon and juniper woodlands. Few seedlings and/or saplings of pinyon and juniper occur in the understory.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	106	128	213
Grass/Grasslike	99	118	196
Forb	41	50	84
Tree	34	40	67
Total	**280**	**336**	**560**

Community 1.2
Community Phase

This community phase is characterized by a post-fire shrub and herbaceous community. Bluebunch wheatgrass and other perennial grasses dominate. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Black sagebrush may be present in unburned patches. It will take 10 years or more for the recovery of black sagebrush and adequate moisture conditions plus a nearby seed source are critical. Pinyon and juniper seedlings up to 20 inches in height may be present. Burned tree skeletons may be present; however these have little or no effect on the understory vegetation.

Forest understory. Various amounts of tree seedlings (less than 20 inches in height) may be present up to the point where they are obviously a major component of the vegetal structure. Herbaceous vegetation and sprouting shrubs dominate the site. Understory production ranges from 600 to 1000 pounds per acre.

Community 1.3
Community Phase

This community phase is characterized by an immature woodland, with pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation consists of smaller tree seedling and saplings, as well as perennial bunchgrasses and shrubs.

Forest overstory. IMMATURE WOODLAND: The visual aspect and vegetal structure are dominated by singleleaf pinyon and Utah juniper greater than 5m in height. The upper crown of dominant and codominant singleleaf pinyon and Utah juniper are cone or pyramidal shaped. Seedlings and saplings are present in the understory.

Community 1.4
Community Phase (At Risk)

This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 20 percent. The density and vigor of the black sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs may increase. This community is at risk of crossing a threshold; without proper management this phase will transition to the infilled tree state 3.0.

Forest overstory. The visual aspect and vegetal structure are dominated by singleleaf pinyon and Utah juniper that have reached or are near maximal heights for the site. Dominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns of pinyon and juniper are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover exceeds 20 percent. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Few seedlings and/or saplings of pinyon and juniper occur in the understory.

Forest understory. Understory is reduced and decreasing. Black sagebrush, perennial grass and other understory vegetation is severely affected by overstory, through completion from light, nutrients and water resources.

Pathway a
Community 1.1 to 1.2

A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site. This community phase pathway would be rare, but can occur if conditions are right.

Pathway b
Community 1.1 to 1.4

Time without disturbance such as fire, drought, or disease will allow for the gradual infilling of singleleaf pinyon and Utah juniper.

Pathway a
Community 1.2 to 1.3

Time without disturbance such as fire, drought, or disease will allow for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Black sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Pathway a
Community 1.3 to 1.2

Time without disturbance such as fire, drought, or disease will allow for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

Pathway b
Community 1.3 to 1.4

Fire reduces or eliminates tree canopy, allowing perennial grasses and sprouting shrubs to dominate the site.

Pathway a
Community 1.4 to 1.1

Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 20%. Over time young trees mature to replace and maintain the old-growth woodland. The black sagebrush and perennial bunchgrass community increases in density and vigor. Infrequent, yet periodic wildfire is a natural factor influencing the understory of mature pinyon and juniper woodlands.

Pathway b
Community 1.4 to 1.2

A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site.

State 2
Current Potential State

This state is similar to the Reference State 1.0, with four general community phases: an old-growth woodland phase, a shrub-herbaceous phase, an immature tree phase, and an infilled woodland phase. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of non-native species. These non-natives, particularly cheatgrass, can be highly flammable and promote fire where historically fire had been infrequent. 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. 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. Fires within this community with the small amount of non-native annual species present are likely still small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community 2.1
Community Phase

Figure 9. T.Stringham June 2013, NV780 MU 108 Lithic Haplocalcids

This phase is characterized by a widely dispersed old-growth pinyon and juniper trees with a black sagebrush perennial bunchgrass understory. The visual aspect is dominated by singleleaf pinyon and Utah juniper which make up 10 to 25 percent of the overstory canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Bluebunch wheatgrass and Indian ricegrass are the most prevalent grasses in the understory. Black sagebrush is the primary understory shrub. Forbs such as goldenweed, phlox, and lupine are minor components. Overall, the understory is sparse with production ranging between 250 to 500 pounds per acre. Annual non-native species are present in trace amounts.

Forest overstory. The visual aspect and vegetal structure are dominated by singleleaf pinyon and Utah juniper that have reached or are near maximal heights for the site. Dominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns of pinyon and juniper are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges from 10 to 20 percent. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic wildfire is a natural factor influencing the understory of mature pinyon and juniper forestlands. Few seedlings and/or saplings of pinyon and juniper occur in the understory.

Forest understory. Understory vegetative composition is about 35 percent grasses, 15 percent forbs and 50 percent shrubs and young trees when the average overstory canopy is medium (10 to 25 percent). Average understory production ranges from 250 to 500 pounds per acre with a medium canopy cover. Understory production includes the total annual production of all species within 5m feet of the ground surface. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Few seedlings and/or saplings of pinyon and juniper occur in the understory. Non-native species are present.

Community 2.2
Community Phase

This community phase is characterized by a post-fire shrub and herbaceous community. Bluebunch wheatgrass and other perennial grasses dominate. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 20 inches in height may be present. Black sagebrush may be present in unburned patches. Burned tree skeletons may be present; however these have little or no effect on the understory vegetation. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Forest understory. Herbaceous vegetation and woody shrubs dominate the site. Production ranges from 600 to 1000 pounds per acre.

Community 2.3
Community Phase

This community phase is characterized by an immature woodland, with pinyon and juniper trees averaging over 5m in height. Tree canopy cover is between 5 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation consists of smaller tree seedling and saplings, as well as perennial bunchgrasses and shrubs. Annual non-native species are present.

Community 2.4
Community Phase (At Risk)

This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 20 percent. The density and vigor of the black sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs may increase. Annual non-native species are present primarily under tree canopies. This community is at risk of crossing a threshold, without proper management this phase will transition to the infilled tree state 3.0.

Forest overstory. The visual aspect and vegetal structure are dominated by singleleaf pinyon and Utah juniper that have reached or are near maximal heights for the site. Dominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns of pinyon and juniper are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges exceeds 20 percent.

Forest understory. Understory is reduced and decreasing. Black sagebrush, perennial grass and other understory vegetation is severely affected by overstory, through completion from light, nutrients and water resources.

Pathway a
Community 2.1 to 2.2

A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the herbaceous vegetation to dominate the site.

Pathway b
Community 2.1 to 2.4

Time without disturbance such as fire, drought, or disease will allow for the gradual infilling of singleleaf pinyon and

Utah juniper.

Pathway a
Community 2.2 to 2.3

Time without disturbance such as fire, drought, or disease will allow for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Black sagebrush reestablishes slowly, adequate moisture conditions and near-by seed source are critical for restablishment. Excessive herbivory may also reduce perennial grass understory.

Pathway a
Community 2.3 to 2.2

Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Pathway b
Community 2.3 to 2.4

Time without disturbance such as fire, drought, or disease will allow for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

Pathway a
Community 2.4 to 2.1

Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 20 percent. Over time young trees mature to replace and maintain the old-growth woodland. The black sagebrush and perennial bunchgrass community increases in density and vigor. Annual non-natives present in trace amounts.

Pathway b
Community 2.4 to 2.2

A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site. Annual non-native grasses typically respond positively to fire and may increase in the post-fire community.

State 3
Infilled Tree State

This state has two community phases. The community phases are dominated by Utah juniper and singleleaf pinyon. Community phase 1 has a canopy cover of trees greater than 25 percent with understory species still present. Community phase 2 has a canopy cover of 30 to 50 percent cover of Utah juniper and singleleaf pinyon. Trees are at maximal height and upper crowns may be flat-topped or rounded. Understory vegetation is sparse due to increasing shade and competition from trees. Management would include thinning of trees and possible seeding of understory species.

Community 3.1
Community Phase

Singleleaf pinyon and Utah juniper dominate the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and black sagebrush skeletons are as common as live shrubs due to tree competition for soil water, overstory shading, and duff accumulation. Tree canopy cover is greater than 25 percent. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent. This community phase is typically described as a Phase II woodland (Miller et al. 2008). Tree recruitment is still active.

Forest overstory. In the absence of wildfire or other naturally occurring disturbances, the tree canopy on this site can become very dense. This stage is dominated by Utah juniper and singleleaf pinyon that have reached maximal heights for the site. Tree canopy cover is at a maximum for the site and is commonly greater than 25 percent.

Forest understory. Shrub and grasses canopy cover is reduced. Understory production ranges from 75 to 250 pounds per acre.

Community 3.2
Community Phase

Figure 10. T.Stringham April 2013, NV 766, MU1630, Aridic Calcixerolls

Singleleaf pinyon and Utah juniper dominate the aspect. Tree canopy cover exceeds 30 percent and may be as high as 50 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present exist in the dripline or under the canopy of trees. Black sagebrush skeletons are common or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg's bluegrass may dominate interspaces. Annual non-native species are present and are typically found under the trees. Bare ground areas are large and interconnected. Soil redistribution may be extensive. This community phase is typically described as a Phase III woodland (Miller et al. 2008). Tree recruitment is limited. Trees are the dominant vegetation and are controlling ecological processes on the site.

Forest overstory. In the absence of wildfire or other naturally occurring disturbances, the tree canopy on this site can become very dense. This stage is dominated by Utah juniper and singleleaf pinyon that have reached maximal heights for the site. Tree canopy cover is at a maximum for the site and is commonly greater than 50 percent.

Forest understory. Understory vegetation is sparse to absent. Understory production is less than 150 pounds per acre.

Pathway a
Community 3.1 to 3.2

Time without disturbance such as fire, drought, or disease will allow for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

State 4
Annual State

This State has one community phase and is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard. Rabbitbrush may dominate the overstory.

Community 4.1
Community Phase

Cheatgrass, mustards and other non-native annual species dominate the site. Sandberg's bluegrass and other perennial bunchgrasses may be present in trace amounts. Tree skeletons may dominate aspect for a number of years. Rabbitbrush may be present.

State 5
Eroded State

This State has one community phase dominated by trees. Abiotic factors including soil redistribution and erosion, soil temperature, soil crusting and sealing are primary drivers of ecological condition within this state. Soil moisture, soil nutrients and soil organic matter distribution and cycling are severely altered due to degraded soil surface conditions. Utah juniper and singleleaf pinyon dominate the overstory and herbaceous species may be present in trace amount particularly under tree canopies. Regeneration of trees or herbaceous species is not evident.

Community 5.1
Community Phase

Soil erosion is driving site dynamics. Singleleaf pinyon and Utah juniper and other species may still be present on the site, but are reduced in density and not controlling site processes. Recruitment of trees or herbaceous species is limited. Site function is controlled by soil erosion, wind and extreme soil temperature.

Forest overstory. Dominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns of pinyon and juniper are typically irregularly or smoothly flat-topped or rounder. Little to no recruitment of trees.

Forest understory. Understory is sparse and production is less than 150 pounds per acre.

Transition A
State 1 to 2

Trigger: Introduction of non-native annual species. 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 B
State 1 to 3

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate herbivory that favors shrub and tree dominance. Slow variables: Over time the abundance and size of trees will increase. Threshold: Pinyon and juniper canopy cover is greater than 30 percent. Little understory vegetation remains due to competition with trees for site resources.

Transition A
State 2 to 3

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance. Slow variables: Over time the abundance and size of trees will increase. Threshold: Singleleaf pinyon and Utah juniper canopy cover is greater than 30%. Little understory vegetation remains due to competition with trees for site resources.

Transition B
State 2 to 4

Catastrophic wildfire

Restoration pathway A
State 3 to 2

Manual or mechanical thinning of trees coupled with seeding. Probability of success is highest from community phase 3.1.

Transition A
State 3 to 4

Trigger: Canopy fire reduces the pinyon and juniper overstory and facilitates the annual non-native species in the understory to dominate the site. Slow variables: Over time, cover, production and seed bank of annual non-native species increases. Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes temporal and spatial nutrient capture and cycling within the community. Increased canopy cover of trees allows severe stand-replacing fire. The increased seed bank of non-native, annual species responds positively to post-fire conditions facilitating the transition to an Annual State.

Transition B
State 3 to 5

Trigger: Time allows for an increase in tree canopy cover and greatly reduces cover of all understory species. Bare ground greatly increases, allowing for soil movement. Slow variables: Increasing water and wind erosion coupled with lack of cover changes site soil properties: temperature, infiltration rates, and levels of organic matter no longer support reference vegetation. Threshold: Soil redistribution and erosion is significant and linked to vegetation mortality evidenced by pedestalling and burying of herbaceous species and / or lack of recruitment in the interspaces.

Transition A
State 4 to 5

Trigger: Catastrophic fire or multiple fires. Slow variables: Bare ground interspaces become large and connected; water flow paths long and continuous; understory sparse. Threshold: Soil redistribution and erosion is significant and linked to vegetation mortality evidenced by pedestalling and burying of herbaceous species and / or lack of recruitment in the interspaces.

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				101–202	
	bluebunch wheatgrass	PSSPS	*Pseudoroegneria spicata ssp. spicata*	34–81	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	17–30	–
	squirreltail	ELEL5	*Elymus elymoides*	17–30	–
	bluegrass	POA	*Poa*	17–30	–
2	**Secondary Perennial Grasses**			2–3	
	basin wildrye	LECI4	*Leymus cinereus*	2–3	–
Forb					
3	**Perennial**			41–84	
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–17	–
	arrowleaf balsamroot	BASA3	*Balsamorhiza sagittata*	3–17	–
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	3–17	–
	California yerba santa	ERCA6	*Eriodictyon californicum*	0–11	–
	matted buckwheat	ERCA8	*Eriogonum caespitosum*	0–11	–
	lousewort	PEDIC	*Pedicularis*	0–6	–
	beardtongue	PENST	*Penstemon*	0–6	–
	spiny phlox	PHHO	*Phlox hoodii*	0–6	–
	rockcress	ARABI	*Arabidopsis*	0–6	–
Shrub/Vine					
4	**Primary Shrubs**			50–112	
	black sagebrush	ARNO4	*Artemisia nova*	34–81	–
	Stansbury cliffrose	PUST	*Purshia stansburiana*	17–30	–
	curl-leaf mountain mahogany	CELE3	*Cercocarpus ledifolius*	17–28	–
5	**Secondary Shrubs**			6–22	
	antelope bitterbrush	PUTR2	*Purshia tridentata*	3–17	–
	desert snowberry	SYLO	*Symphoricarpos longiflorus*	0–6	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–6	–
	serviceberry	AMELA	*Amelanchier*	2–3	–
Tree					
7	**Evergreen**			7–34	
	Utah juniper	JUOS	*Juniperus osteosperma*	3–17	–
	singleleaf pinyon	PIMO	*Pinus monophylla*	3–17	–

Animal community

Livestock Interpretations:
The history of livestock grazing in the pinyon-juniper ecosystem goes back to more than 200 years, depending on the particular locality within the ecosystem (Hurst 1975). Historically, pinyon-juniper woodlands were much more open and supported a diverse understory that provided forage for both livestock and wildlife. Historic livestock overuse and increased stand densities have reduced the carrying capacity of these pinyon-juniper stands and many current stands only provide shade and shelter for livestock.

Black sagebrush palatability has been rated as moderate to high depending on the ungulate and the season of use (Horton 1989, Wambolt 1996). The palatability of black sagebrush increase the potential negative impacts on remaining black sagebrush plants from grazing or browsing pressure following fire (Wambolt 1996). Pronghorn utilize black sagebrush heavily (Beale and Smith 1970). On the Desert Experiment Range, black sagebrush was found to comprise 68% of pronghorn diet even though it was only the 3rd most common plant. Fawns were found to prefer black sagebrush utilizing it more than all other forage species combined (Beale and Smith 1970). Domestic livestock will also utilize black sagebrush. The domestic sheep industry that emerged in the Great Basin in the early 1900s was largely based on wintering domestic sheep in black sagebrush communities (Mozingo 1987). Domestic sheep will browse black sagebrush during all seasons of the year depending on the availability of other forage species with greater amounts being consumed in fall and winter. Black sagebrush is generally less palatable to cattle than to domestic sheep and wild ungulates (McArthur et al. 1982); however, cattle use of black sagebrush has also been shown to be greatest in fall and winter (Schultz and McAdoo 2002), with only trace amounts being consumed in summer (Van Vuren 1984).

Inappropriate grazing management during the growing season will cause a decline in understory plants such as bluebunch wheatgrass, Indian rice ricegrass and Thurber’s needlegrass. 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, Britton et al. 1990). 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). 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.

Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971) however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover after seven 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. Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass, mat forming forbs and/or cheatgrass and other invasive species to occupy interspaces. 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. Field surveys indicate native, mat-forming forbs may also increase with decreased bunchgrass density.

Wildlife Interpretations:
Pinyon-juniper woodlands provide a diversity of habitat for wildlife. Although the foliage of pinyon and juniper varies in palatability among fauna, the pinyon nuts and juniper berries are preferred by many species. The understory species provide fruits and browse for large ungulates, small mammals, birds and beaver (Wildlife Action Plan Team 2012).
Ungulates will use pinyon and juniper trees for cover and graze the foliage. The understory species also provide critical browse for deer. The trees provide important cover for mule deer (Odocoileus heminous), elk (Cervus canadensis) wild horses, mountain lion (Puma concolor), bobcat (Lynx rufus) and pronghorn (Antilocapra americana) (Gottfried and Severson 1994, Coates and Schemnitz 1994, Logan and Irwin 1985, Evans 1988). Mule deer is considered the dominant big game species in the pinyon-juniper woodland and depend heavily on these woodlands for cover, shelter, and emergency forage during severe winters (Frischknecht 1975). Mule deer will eat singleleaf pinyon and juniper foliage, using the foliage moderately in winter, spring, and summer (Kufeld et al. 1973). Deep snows in higher elevation forest zones force mule deer and elk down into pinyon-juniper habitats during winter. This change in habitat allows mule deer and elk to browse the dwarf trees and shrubs (Gottfried and Severson 1994).

The diet of pronghorn antelope varies considerably; however, singleleaf pinyon was shown to comprise 1 to 2 percent of winter diet of pronghorn antelope that occur in pinyon-juniper habitat. Desert bighorn sheep (Ovis nelson) may utilize pinyon-juniper habitat, but only where the terrain is rocky and steep (Gottfried et al. 2000). Gray foxes, bobcats (Lynx rufus), coyotes (Canis latrans), weasels (Mustela frenata), skunks (Mephitis spp.), badgers (Taxidea taxus), and ringtail cats (Bassariscus astutus) search for prey in pinyon-juniper habitat woodlands (Short and McCulloch 1977).
Juniper "berries" or berry-cones are eaten by black-tailed jackrabbits, Lepus californicus, and coyotes (Gese et al. 1988, Kitchen et al. 2000). A study by Kitchen et al (1999) conducted in juniper-pinion habitat found vegetation in coyote scats was mainly grass seeds or juniper berries. Jackrabbits are a major dispenser of juniper seeds (Schupp et al. 1999). The pinyon mouse (Peromyscus truei) is a pinyon-juniper obligate and uses the woodlands for cover and food (Hoffmeister 1981). Other small mammals include the porcupine (Hystricomorph hystricidae), desert cottontail (Sylvilagus audubonii), Nuttall's cottontail (S. nuttallii), deer mouse (Peromyscus maniculatus), Great Basin pocket mouse (Perognathus parvus), chisel-toothed kangaroo rat (Dipodomys microps) and desert woodrat (Neotoma lepida) (Turkowski and Watkins 1976).
Many bird species are associated with the pinyon-juniper habitat; some are permanent residents, some summer residents, and some winter residents, depending upon location. For birds and bats, the woodland provides structure for nesting and roosting, and locations for foraging. Singleleaf pinyon provides a number of cavities and the stringy, fibrous bark provides quality nesting material as well as the food provided by the tree's seeds and berries (Short and McCulloch 1977). Many bird species depend on juniper berry-cones and pine nuts for fall and winter food (Balda and Masters 1980). Several bird species are obligates including (gray flycatcher (Epidonax wrightii) scrub jay (Aphelocoma californica), plain titmouse (Parus inornatus ridgwayi), and gray vireo (Vireo vicinior) and several species are semi-obligates including black-chinned hummingbird (Archilochus alexandri), ash-throated flycatcher (Myiarchus cinerascens), pinion jay (Gymnorhinus cyanocephalus), American bushtit (Psaltriparus minimus), Bewick's wren (Thryomanes bewickii), Northern mockingbird (Mimus polyglottos), blue-gray gnatcatcher (Polioptila caerulea), black-throated gray warbler (Dendroica nigrescens), house finch (Haemorhous mexicanus), spotted towhee (Pipilo maculatus), lark sparrow (Chondestes grammacus) and black-chinned sparrow (Zonotrichia atricapilla) (Balda and Masters 1980). Ferruginous hawk (Buteo regalis), a conservation priority species due to recent population declines in Nevada, nest in older trees of sufficient size and structure to support their large nest platforms. (Holechek 1981).
Diurnal reptiles include the sagebrush swift (Sceloporus graciosus), the blue-bellied lizard (Sceloporus elongates) the western collard lizard, the Great Basin rattlesnake, the Great Basin gopher snake (Pituophis catenifer) and horned lizard, also occur in Utah juniper habitat (Frischknecht 1975). However, the distribution of most of herpetofauna present in pinyon-juniper woodlands is poorly understood and more research and management are needed.

Hydrological functions

Permeability is very slow to moderately rapid. Runoff is low to very high. Hydrologic soil groups include B, C, and D. Hydrologic processes are influenced by species composition, structural development and density patterns of the tree overstories and the nature of precipitation events occurring. Interception of precipitation is related to the composition, distribution, and density of trees in the overstory and intensity, duration, and type of precipitation. Infiltration rates are typically greater beneath tree overstories than on sites supporting herbaceous plants because the trees reduce the raindrop impact. The litter accumulation beneath the trees also slows overland flows. Evapotranspiration is generally the largest route of water outflow from the site.

Recreational uses

The trees on this site provide a welcome break in an otherwise open landscape. Steep slopes inhibit many forms of recreation. It has potential for hiking, cross-country skiing, camping and deer and upland game hunting. Off-road vehicles can destroy the fragile soil-vegetation complex causing severe erosion problems.

Wood products

Pinyon wood is rather soft, brittle, heavy with pitch, and yellowish brown in color. Singleleaf pinyon has played an important role as a source of fuelwood and mine props. It has been a source of wood for charcoal used in ore smelting. It still has a promising potential for charcoal production.

Utah juniper wood is very durable. Its primary uses have been for fence posts and fuelwood. It probably has considerable potential in the charcoal industry and in wood fiber products.

PRODUCTIVE CAPACITY

This site has a low to moderate site quality for tree production. Site index ranges from about 30 to 50 (Howell, 1946).

Productivity Class: 0.2 to 0.3
CMAI*: 2.2 to 4.6 cu ft/ac/yr;
0.16 to 0.32 cu m/hr/yr.

*CMAI: is the culmination of mean annual increment or highest average growth rate of the stand in the units specified.

Fuelwood Production: 3 to 6 cords per acre for stands averaging 5 inches in diameter at 1 foot height. There are about 289,000 gross British Thermal Units (BTUs) heat content per cubic foot of pinyon pine wood and about 274,000 gross BTUs heat content per cubic foot of juniper. Firewood is commonly measured by cord, or a stacked unit equivalent to 128 cubic feet. Solid wood volume in a cord varies, but usually ranges from 65 to 90 cubic feet. Assuming an average of 75 cubic feet of solid wood per cord, there are about 21 million BTUs of heat value in a cord of mixed Utah juniper and singleleaf pinyon wood.

Posts (7 foot): (7 foot): 15 to 30 per acre in stands of medium canopy.

Christmas trees: 15 trees per acre per year in stands of medium canopy. 30 trees per acre in stands of sapling stage.

Pinyon nuts: Production varies year to year, but mature woodland stage can yield 150 to 300 pounds per acre in favorable years.

MANAGEMENT GUIDES AND INTERPRETATIONS

1. LIMITATIONS AND CONSIDERATIONS
a. Potential for sheet and rill erosion is moderate to severe depending on slope.
b. Moderate to severe equipment limitations on steeper slopes and on sites having extreme surface stoniness.
c. Proper spacing is the key to a well managed, multiple use and multi-product pinyon-juniper woodland.

2. ESSENTIAL REQUIREMENTS
a. Adequately protect from uncontrolled burning.
b. Protect soils from accelerated erosion.
c. Apply proper grazing management.

3. SILVICULTURAL PRACTICES
a. Harvest cut selectively or in small patches size dependent upon site conditions) to enhance forage production.
1) Thinning and improvement cutting - Removal of poorly formed, diseased and low vigor trees for fuelwood. D+9 is the optimum spacing. As the spacing approaches D+4, thinning should be done to maintain the vigor of the stand. Thinning and improvement cutting would be of particular importance during the immature woodland stage. Proper spacing improves the health and development of the trees, and the overall health of the stand.
2) Harvest cutting - Selectively harvest surplus trees to achieve desired spacing. Rotation time for cutting should be geared to the desired products and extent of the previous harvest. Save large, healthy, full-crowned trees for a seed source and cover for wildlife and livestock. Save 4 to 5 foot tall singleleaf pinyons for Christmas trees. Do not select only "high grade" trees during harvest.
3) Spacing Guide: D+9.
b. Prescription burning program to maintain desired canopy cover and manage site reproduction.
c. Mechanical tree removal (i.e., chaining) on suitable sites to enhance forage production and manage site reproduction.
d. Pest control - Porcupines and insects can cause extensive damage and populations should be controlled.
e. Fire hazard - In dense stands, potential for crown fire during dry seasons is high.

Other products

Singleleaf pinyon is also used for Christmas trees and as a source of nuts for wildlife and human food. These trees have provided American Indians with food for centuries. Pinyon-juniper ecosystems have had subsistence, cultural, spiritual, economic, aesthetic and medicinal value to Native American peoples for centuries, and singleleaf pinyon has provided food, fuel, medicine and shelter to Native Americans for thousands of years. The pitch of singleleaf pinyon was used as adhesive, caulking material, and a paint binder. It may also be used medicinally and chewed like gum. Pinyon seeds are a valuable food source for humans, and a valuable commercial crop. The berries of Utah Juniper have been used by Indians for food. Indian ricegrass was traditionally eaten by some Native Americans. The Paiutes used seed as a reserve food source.

Other information

Black sagebrush is an excellent species to establish on sites where management objectives include restoration or improvement of domestic sheep, pronghorn, or mule deer winter range.

Table 7. Representative site productivity

Common Name	Symbol	Site Index Low	Site Index High	CMAI Low	CMAI High	Age Of CMAI	Site Index Curve Code	Site Index Curve Basis	Citation
singleleaf pinyon	*PIMO*	30	50	2	5	–	–	–	

Type locality

Location 1: White Pine County, NV	
Township/Range/Section	T20N R59E S4
Latitude	39° 37′ 46″
Longitude	115° 20′ 14″
General legal description	NE¼, Approximately 2½ miles southeast of McBride Sheep Well in Long Valley, White Pine County, Nevada. This site also occurs in Elko and Eureka Counties, 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)	
Contact for lead author	
Date	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

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

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5. **Number of gullies and erosion associated with gullies:**

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6. **Extent of wind scoured, blowouts and/or depositional areas:**

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7. **Amount of litter movement (describe size and distance expected to travel):**

---

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

---

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

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

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

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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:

    Sub-dominant:

    Other:

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

---

14. **Average percent litter cover (%) and depth (in):**

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-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:**

17. **Perennial plant reproductive capability:**