USDA Natural Resources
Conservation Service

Ecological site F026XY060NV
Shallow Loamy Slopes 12-16 P.Z PIMO/ARTRV/ACTH7

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General information

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

MLRA notes

Major Land Resource Area (MLRA): 026X–Carson Basin and Mountains

MLRA 26 is in western Nevada and eastern California; approximately 69 percent is in Nevada, and 31 percent in California. The area is predominantly in the Great Basin Section of the Basin and Range Province of the Intermontane Plateaus. Isolated north- south trending mountain ranges are separated by aggraded desert plains. The mountains are uplifted fault-blocks with steep side slopes. The valleys are drained by three major rivers flowing east across MLRA 26; the Truckee, Carson and Walker rivers. A narrow strip along the western border of MLRA 26 is in the Sierra Nevada Section of the Cascade-Sierra Mountains Province of the Pacific Mountain System. The Sierra Nevada Mountains are primarily a large fault-block that has been uplifted with a dominant tilt to the west. The structure creates an impressive wall of mountains directly west of the area creating a rain shadow affect to MLRA 26. Parts of the eastern face; the foothills, mark the western boundary of the area. Elevations range from near 3,806 feet (1,160 meters) on the west shore of Pyramid Lake to 11,653 feet (3,552 meters) on the summit of Mount Patterson in the Sweetwater Mountains.

In MLRA 26, the valleys are composed dominantly of Quaternary alluvial deposits. Quaternary playa or alluvial flat deposits typically occupy the lowest valley bottoms in the internally drained valleys. Tertiary andesitic flows, breccias, ash flow tuffs, rhyolite tuffs or granodioritic rocks dominate the hills and mountains. Quaternary basalt flows are present in lesser amounts. Jurassic and Triassic limestone and shale, and Precambrian limestone and dolomite are also present in very limited amounts. Glacial till deposits, of limited extent are along the east flank of the Sierra Nevada Mountains; the result of alpine glaciation.

The average annual precipitation in MLRA 26 is 5 to 36 inches (125 to 915 millimeters), increasing with elevation. Most of the rainfall occurs as high-intensity, convective storms in spring and autumn. Precipitation is mostly snow in winter. Summers are dry. The average annual temperature is 37 to 54 degrees F (3 to 12 degrees C). The freeze-free period averages 115 days and ranges from 40 to 195 days, decreasing in length with elevation.

The dominant soil orders in MLRA 26 are Aridisols and Mollisols. The soils in the area typically have a mesic soil temperature regime, an aridic or xeric soil moisture regime, and mixed or smectitic mineralogy. The soils are generally well drained, clayey or loamy and are commonly skeletal. The soils depths are typically very shallow to moderately deep.

This area supports shrub-grass vegetation characterized by big sagebrush. Low sagebrush and Lahontan sagebrush are on some soils. Antelope bitterbrush, squirreltail, desert needlegrass, Thurber needlegrass, and Indian ricegrass are important associated plants. Green ephedra, Sandberg bluegrass, desert peach, and several forb species are also common. Juniper-pinyon woodland is typical on mountain slopes. Jeffrey pine, lodgepole pine, white fir, and manzanita grow on the highest mountain slopes. Shadscale is the typical plant in the drier parts of the area. Sedges, rushes, and moisture-loving grasses grow on the wettest parts of the wet flood plains and terraces. Basin wildrye, alkali sacaton, saltgrass, buffaloberry, black greasewood, and rubber rabbitbrush grow on the drier sites that have a high concentration of salts.

Wildlife species in the area are mule deer, coyote, beaver, muskrat, jackrabbit, cottontail, raptors, pheasant, chukar, blue grouse, mountain quail, and mourning dove, amongst other species. The species of fish in the area include trout and catfish. The Lahontan cutthroat trout in the Truckee River is a threatened and endangered species.

LRU notes

The Sierra Influenced Ranges LRU is characterized by wooded great basin mountains and climatic and biotic affinities to the Sierra Nevada Mountain range. The Sierra Influenced Ranges LRU receives greater precipitation than the mountain ranges of central Nevada.

Amount of precipitation varies in relation to the local strength of the Sierra Nevada rain shadow, characterized by pinyon and juniper trees. The White, Sweetwater, Pine Nut, Wassuk, and Virginia ranges of Nevada support varying amounts of Sierra Nevada flora, like ponderosa pine. Elevations range from 1610 to 2420 meters and slopes range from 5 to 49 percent, with a median value of 22 percent.
Frost free days (FFD) ranges from 92 to 163.

Ecological site concept

The Shallow Loamy Slopes 12-16 P.Z forest site occurs on mountain side slopes on all aspects except at the lower elevation range where it is restricted to northern aspects. Slopes range from 4 to 75 percent, but slopes are typically 30 to 50 percent. Elevations are from about 6000 to 8800 feet. The soils associated with this site are very shallow to moderately deep and well to somewhat excessively drained. Some soils have 35 to over 50 percent gravels, cobbles, or stones, by volume, distributed throughout the soil profile. The dominant plants are singleleaf pinyon (*Pinus monophylla*), mountain big sagebrush (*Artemisia tridentata* ssp. vaseyana), and Thurber's needlegrass (*Achnatherum thurberianum*).

Similar sites

R026XF613CA	**Rocky Upland Loam (BLM)** Similar site developed in California.

Table 1. Dominant plant species

Tree	(1) *Pinus monophylla*
Shrub	(1) *Artemisia tridentata ssp. vaseyana*
Herbaceous	(1) *Achnatherum thurberianum*

Physiographic features

The Shallow Loamy Slopes 12-16 P.Z. occurs on mountain side slopes on all aspects but is restricted to northern aspects on lower elevations. Slopes range from 4 to 75 percent, but slopes are typically 30 to 50 percent. Elevations are from about 6000 to 8800 feet.

Table 2. Representative physiographic features

Landforms	(1) Mountain slope
Runoff class	Medium to very high
Flooding frequency	None
Ponding frequency	None
Elevation	1,829–2,682 m
Slope	30–50%
Aspect	Aspect is not a significant factor

Climatic features

The climate associated with this site is semiarid, characterized by cool moist winters and warm, dry summers. Average annual precipitation is 12 to 16 inches (25 to 36 cm). Mean annual air temperature is 44 to 48 degrees F. The average growing season is about 90 to 120 days.

Nevada's climate is predominantly arid, and has large daily ranges of temperature, infrequent severe storms, heavy snowfall in the higher mountains, and significant variations with elevation. Three basic geographical factors largely influence Nevada's climate (1) continentality, (2) latitude, and (3) elevation. Continentality is the most important factor. The strong continental effect is expressed in the form of both dryness and large temperature variations. Nevada is 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 deserts 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. The terrain responds quickly to changes in solar heating.

Nevada is within the mid-latitude belt of prevailing westerly winds which occur most of the year. These winds bring frequent changes in weather during the late fall, winter, and spring months when most of the precipitation occurs. To the south of the mid-latitude westerlies, is a zone of high pressure in subtropical latitudes, with a center over the Pacific Ocean. In the summer, this high-pressure belt shifts northward over the latitudes of Nevada, blocking storms from the ocean. The resulting weather is mostly clear and dry during the summer and early fall, with scattered thundershowers. The eastern portion of the state receives significant summer thunderstorms generated from monsoonal moisture pushed up from the Gulf of California, known as the North American monsoon. The monsoon system peaks in August and by October the monsoon high over the Western U.S. begins to weaken and the precipitation retreats southward towards the tropics (NOAA 2004).

Table 3. Representative climatic features

Frost-free period (average)	105 days
Freeze-free period (average)	
Precipitation total (average)	305 mm

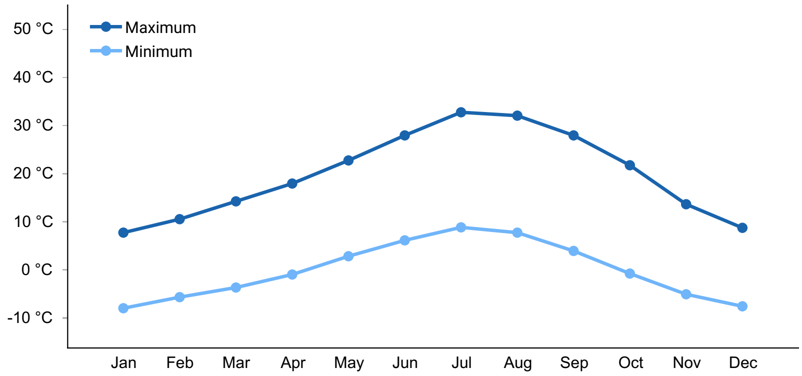


Figure 1. Monthly average minimum and maximum temperature

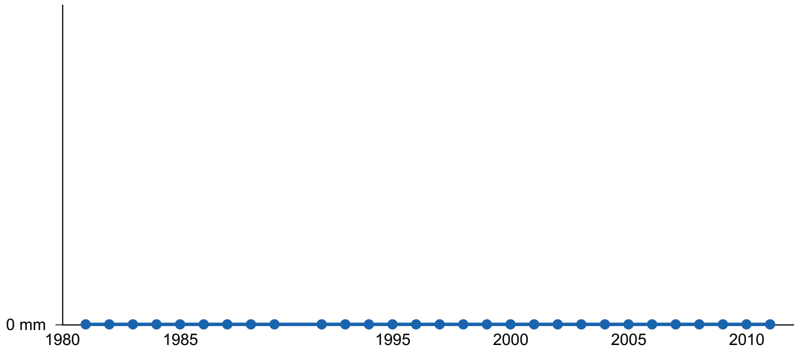


Figure 2. Annual precipitation pattern

Influencing water features

No influencing water features are associated with this site.

Soil features

The soils associated with this site are very shallow to moderately deep and well to somewhat excessively drained. Some soils have 35 to over 50 percent gravels, cobbles, or stones, by volume, distributed throughout the soil profile. Available water capacity is very low to low but trees extend their roots into fractures in the bedrock allowing them to utilize deep moisture. There might be high amounts of gravels, cobbles or stones at the soil surface which occupy plant growing space yet help to reduce evaporation and conserve soil moisture. Runoff is low to very high and the potential for sheet and rill erosion is moderate to high depending on steepness of slope and amount of rock fragments on the soil surface. The soil temperature regime is mesic and the soil moisture regime is aridic, bordering on xeric. Soil series include: Ahchew, Bombadil, Borealis, Brawley, Cagle, Duco, Haar, Itca, Nupart, Powment, Ravenswood, Squawtip, Teguro, and Wassit.

Table 4. Representative soil features

Parent material	(1) Residuum–basalt (2) Colluvium–volcanic breccia
Surface texture	(1) Stony loamy fine sand (2) Very stony, ashy sandy loam (3) Very stony loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Very slow to very rapid
Soil depth	10–89 cm
Surface fragment cover <=3"	0–50%
Surface fragment cover >3"	0–45%
Available water capacity (0-101.6cm)	0.51–9.4 cm
Calcium carbonate equivalent (0-101.6cm)	0–1%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	6.1–7.8

Subsurface fragment volume <=3" (Depth not specified)	20–65%
Subsurface fragment volume >3" (Depth not specified)	0–9%

Ecological dynamics

Description of MLRA 26 DRG 19:

Disturbance Response Group (DRG) 19 consists of six ecological sites; F026XY060NV, F026XY044NV, F026XY061NV, F026XY069NV, F026XY104NV, F026XY071NV (Stringham et al. 2021). This group receives 10 to 14 inches of precipitation each year. Elevations range from 5,000 to 9,000 while slopes range from 15 to 75 percent. The soils are typically shallow to moderately deep and well drained and the water holding capacity is low to moderate. The soils are generally skeletal with 35 to 50 percent gravels, cobbles, or stones, by volume, distributed throughout the soil profile. This group is dominated by singleleaf pinyon (*Pinus monophylla*) with mountain big sagebrush (*Artemisia tridentata* ssp. vaseyana) as the primary understory shrub. Utah juniper (*Juniperus osteosperma*) and curl-leaf mountain mahogany (*Cercocarpus ledifolius*) are minor components. Other subdominant shrubs in the group include Wyoming big sagebrush (*Artemisia tridentata* ssp. wyomingensis) and antelope bitterbrush (*Purshia tridentata*). The dominant understory grass is Thurber's needlegrass (*Achnatherum thurberianum*) or desert needlegrass (*Achnatherum speciosum*). Other grasses in the group include muttongrass (*Poa fendleriana*) and prairie junegrass (*Koeleria macrantha*). Under medium canopy cover (20-30%), understory production ranges from 200 to 450 pounds per acre in a normal year.

Ecological Dynamics and Disturbance Response:

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 invasive species. 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. 2003). 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 hectares (44.6 million 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 pre-settlement 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 per acre. In Utah, Nevada, and Oregon, trees establishing prior to 1860 accounted for only two 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). The evidence suggests that tree canopy cover of 10 to 25 percent might be more representative of these sites in pristine condition (USDA 1997). 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 two 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, USDA 1997).

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 except for 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 because 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 might germinate under favorable soil and climatic conditions (Lanner 1981). A mutualistic relationship exists between the trees that produce food and the animals that disperse the seeds, thereby ensuring perpetuation of the trees. Large crops of seeds might 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 is 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 and causes a decline in understory perennial vegetation because of increased competition for water and sunlight. Evidence suggests that phenolic compounds in juniper litter might have allelopathic effects on grass (Jameson 1970). 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). As the understory vegetation declines in vigor, the ability of native perennial plants to recover after fire is reduced (Urza et al. 2017). The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass (*Bromus tectorum*), 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 several variables: such as (a) plant species present at the time of disturbance and their individual responses to disturbance, (b) past management, (c) type and size of disturbance, (d) available seed sources in the soil or adjacent areas, and (e) site and climatic conditions throughout the successional process.

There are several insects, fungi, mosses, and mistletoe that affect singleleaf pinyon and/or juniper. The impacts of diseases and pests are moderated by factors including ecological site characteristics, drought, and tree density (Greenwood and Weisberg 2008, Miller et al.
2019).

Hepting (1971) and Miller et al. (2019) list several diseases affecting pinyon including: (1) foliage diseases, (2) a tarspot needle cast, (3) stem diseases such as blister rust and dwarf mistletoe, (4) root diseases and trunk rots, (5) red heart rot, and (6) but rot. Defoliation from native and nonnative insects is a primary driver of pinyon damage. 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. Pinyon needle scale weakens trees by killing two-year-old needles. Heavy defoliations reduce growth and sometimes cause mortality; outbreaks can affect several thousand acres at a time (Phillips 2020). The pinyon ips beetle typically kills weak and damaged trees (Phillips 2014). Dwarf mistletoe (Phorandendron spp.) a parasitic plant, affects both pinyon and juniper. While mistletoe might not kill the trees, it weakens the trees and makes them susceptible to other diseases and pests (Christopherson 2014, Phillips 2020).

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). Other diseases affecting juniper are: (a) dwarf mistletoe (Arceuthobium spp.) that might weaken trees, (b) leaf rust (Gymnosporangium sp.) on leaves and young branches, and (c) 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).

In the Great Basin, most 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. 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. 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).

The ecological sites in this DRG are dominated by deep-rooted, cool season, perennial bunchgrasses, and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs typically root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Dobrowolski et al. 1990).

Mountain big sagebrush and antelope bitterbrush are generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions. Antelope bitterbrush is dominantly found on soils which provide minimal restriction to deep root penetration such as coarse textured soil, or finer textured soil with high stone content (Driscoll 1964, Clements and Young 2002).

The perennial bunchgrasses that are co-dominant with shrubs in this group generally have shallower root systems than the shrubs. 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. Differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems.

The ecological sites in this DRG have 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 DRG.

Invasive Annual Grasses:

The species most likely to invade these sites is cheatgrass, however the sandy surface decreases the probability of cheatgrass dominance. Cheatgrass is a cool season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999).

Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983, Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead. Bradley and Mustard (2005) utilized Landsat and Advanced Very-High-Resolution Radiometer to estimate the areal extent of cheatgrass dominance in the Great Basin. Their results suggest cheatgrass dominated over 4.9 million acres in 2005. In addition, they found cheatgrass was 26 percent more likely to be found within 450 feet of areas occupied by cheatgrass in 1973, with cultivation, power lines and roads identified as primary vectors of spread (Bradley and Mustard 2006).

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass “die-off” provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but ongoing work is happening to try to predict where “die-off” occurs, to hopefully aid conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, can suppress cheatgrass growth when mature (Blank et al. 2020).

Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al.
2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution is advised in using these results, as only one year of data was reported.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 ounces per acre with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Large fires were and continue to be rare on this site due to large interspaces and low levels of fine fuels (Miller and Heyerdahl 2008). 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 (Miller at al. 2019). Surface spread was more likely to occur in more productive areas with moderately deep to deep soils, which favors the dominance of herbaceous vegetation and sagebrush (Miller and Heyerdahl 2008, Romme et al. 2009, Miller et al. 2019). The open structure of woodlands is the result of limited seedling establishment, natural thinning processes such as drought and pets, or competition from herbaceous vegetation (Miller et al. 2019). 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, Miller et al. 2019). Limited data exists that describes fire histories across woodlands in the Great Basin. Both the infilling of younger trees into old-growth stands and the expansion of trees into surrounding sagebrush communities has increased the risk of loss of pre-settlement trees through the increased 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 occurs when 60% or more of the crown is scorched (Bradley et al. 1992). Singleleaf pinyons are 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 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 might 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).

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 1997, Miller et al. 2008). As the understory vegetation declines in vigor, the ability of native perennial plants to recover after fire is reduced (Urza et al. 2017). The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass (*Bromus tectorum*), and with intensive wildfire, the potential for conversion to annual exotics is a serious threat (Tausch 1999, Miller et al. 2008).

Mountain big sagebrush is killed by fire (Neuenschwander 1980, Blaisdell et al. 1982), and does not resprout (Blaisdell 1953). Post fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and might reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush might return to pre-burn density and cover within 15-20 years following fire, but establishment after severe fires might proceed more slowly and can take up to 50 years (Bunting et al. 1987, Ziegenhagen 2003, Miller and Heyerdahl 2008, Ziegenhagen and Miller and Rose 2009). The introduction of annual weedy species, like cheatgrass (*Bromus tectorum*) might cause an increase in fire frequency and eventually lead to an annual dominated community. Conversely, without fire, big sagebrush will increase and the potential for re- establishment of pinyon and juniper also increases. Without fire or changes in management, pinyon and juniper will dominate the site and mountain big sagebrush will be severely reduced. The herbaceous understory will also be reduced; however, muttongrass and Sandberg bluegrass might be found in trace amounts. The potential for soil erosion increases as the juniper woodland matures and the understory plant community cover declines. Catastrophic wildfire in pinyon-juniper controlled sites might lead to an annual weed dominated state.

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires might allow for bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006). If cheatgrass is present, bitterbrush seedling success is much lower. The factor that most limits establishment of bitterbrush seedlings is competition for water resources with cheatgrass (Clements and Young 2002).

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 dominantly 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.

Thurber’s needlegrass is moderately resistant to wildfire (Smith and Busby 1981) but can be severely damaged and have high mortality depending on season and severity of fire. 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. 1990). 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. 1990). Post-fire regeneration usually occurs from seed, thus reestablishment 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 might preclude reestablishment (Evans and Young 1978).

Desert needlegrass might increase after burning. In a summation of 13 studies, Abella (2009) found that desert needlegrass increased in abundance (derived from cover, density, or frequency depending on the source of publication) on burned to unburned sites. Thatcher and Hart (1974) observed an increase in desert needlegrass in areas which appeared to have burned on a relict site, however they attributed this to soil type rather than species response. Muttongrass is top-killed by fire but will resprout after low to moderate severity fires. A study by Vose and White (1991) in an open saw timber site found minimal difference in overall effect of burning on muttongrass.

Sandberg bluegrass, a minor component of this group, has been found to increase following fire likely due to its low stature and productivity (Daubenmire 1975). Sandberg bluegrass might retard reestablishment of deeper-rooted bunchgrasses.

State and Transition Model Narrative for Group 19:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 disturbance response group 19.

Reference State 1.0:
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 tree 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 long-term drought, and/or insect or disease attack. Fires are typically 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 Phase 1.1:
This phase is characterized by widely dispersed old-growth singleleaf pinyon trees with an understory of mountain big sagebrush and perennial bunchgrasses. The visual aspect is dominated by singleleaf pinyon with 15 percent or greater canopy cover (USDA 1997). Utah juniper might be present. Trees have reached maximal or near maximal heights for the site and many tree crowns might be flat- or round- topped. Thurber’s needlegrass and bluegrasses are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*) and tapertip hawksbeard (*Crepis acuminata*) are minor components. Utah juniper might be present.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon overstory and the shrub component. This

allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.4:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual infilling of singleleaf pinyon.

Community Phase 1.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass, bluegrasses, and other perennial grasses dominate. Thurber's needlegrass can experience high mortality from fire and might be reduced in the community for several years. Forbs might increase post-fire but will likely return to pre-burn levels within a few years. Singleleaf pinyon seedlings up to 4 feet in height might be present. Mountain big sagebrush might be present in unburned patches. Burned tree skeletons might be present; however, these have little or no effect on the understory vegetation.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.3:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of the singleleaf pinyon component. Mountain big sagebrush reestablishes. Excessive herbivory might also reduce perennial grass understory.

Community Phase 1.3
This community phase is characterized as an immature woodland with singleleaf pinyon trees averaging over 4.5 feet in height. Pinyon canopy cover is 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 sagebrush.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.2:
Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.1:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of singleleaf pinyon. Excessive herbivory might also reduce perennial grass understory.

Community Phase 1.4 (at-risk):
This phase is dominated by singleleaf pinyon. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the mountain big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat- forming forbs might increase. Utah juniper might be present. This community is at risk of crossing a threshold. Without proper management this phase will transition to the infilled woodland state 3.0. This community phase is typically described as early Phase II woodland (Miller et al. 2008).

Community Phase Pathway 1.4a, from Phase 1.4 to 1.1:
Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 35 percent. Over time young trees mature to replace and maintain the old-growth woodland. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor.

Community Phase Pathway 1.4b, from Phase 1.4 to 1.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:
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.

T1B: Transition from Reference State 1.0 to Infilled Tree State 3.0:
Trigger: Time and a lack of disturbance allow trees to dominate site resources; might 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 canopy cover is greater than 50 percent. Little understory vegetation remains due to competition with trees for site resources.

Current Potential State 2.0:
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 tree 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 or most of the following community phases within this state.

Community Phase 2.1:
This phase is characterized by widely dispersed old-growth singleleaf pinyon trees with an understory of mountain big sagebrush and perennial bunchgrasses. The visual aspect is dominated by singleleaf pinyon with 15 percent or greater canopy cover (USDA 1997). Utah juniper might be present. Trees have reached maximal or near maximal heights for the site and many tree crowns might be flat- or round- topped. Thurber's needlegrass and bluegrasses are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot and tapertip hawksbeard are minor components. Utah juniper might be present.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.4:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual infilling of singleleaf pinyon.

Community Phase 2.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass, bluegrass, and other perennial grasses dominate. Forbs might increase post-fire but will likely return to pre-burn levels within a few years. Pinyon seedlings up to
4.5 feet in height might be present. Mountain big sagebrush might be present in unburned patches. Burned tree skeletons might be present;
however, these have little or no effect on the understory vegetation. Annual non-native species generally respond well after fire and might be stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.3:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of the singleleaf pinyon component. Mountain big sagebrush reestablishes. Excessive herbivory might also reduce perennial grass understory.

Community Phase 2.3:
This community phase is characterized by an immature woodland, with singleleaf pinyon 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. Annual non-native species are present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.2:
Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.1:

Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of singleleaf pinyon. Excessive

herbivory might also reduce the perennial grass understory.

Community Phase 2.4 (at-risk):
This phase is dominated by singleleaf pinyon and Utah juniper might be present. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the mountain big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs might increase. Annual non-native species are present primarily under tree canopies. Utah juniper might be present. This community is at risk of crossing a threshold, without proper management this phase will transition to the Infilled Tree State 3.0. This community phase is typically described as early Phase II woodland (Miller et al. 2008).

Community Phase Pathway 2.4a, from Phase 2.4 to 2.1:
Low intensity fire, insect infestation, or disease kills individual trees within the stand, reducing canopy cover to less than 35 percent. Over time young trees mature to replace and maintain the old-growth woodland. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor. Annual non-natives present in trace amounts.

Community Phase Pathway 2.4b, from Phase 2.4 to 2.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon 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 might increase in the post-fire community.

T2A: Transition from Current Potential State 2.0 to Infilled Tree State 3.0:
Trigger: Time and a lack of disturbance allow trees to dominate site resources; might also 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: Pinyon canopy cover is greater than 30 percent. Little understory vegetation remains due to competition with trees for site resources.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:
Trigger: Catastrophic crown fire facilitates the establishment of non-native, annual weeds.
Slow variables: Increase in tree crown cover, loss of perennial understory and an increase in annual non-native species.
Threshold: Cheatgrass or other non-native annuals dominate understory. Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. 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.

Infilled Tree State 3.0:
This state has two community phases characterized by the dominance of singleleaf pinyon in the overstory. This state is identifiable by greater than 50 percent cover of singleleaf pinyon and a mixed age class. Older trees are at maximal height and upper crowns might be flat-topped or rounded. Younger trees are typically cone- or pyramidal-shaped. Understory vegetation is sparse due to increasing shade and competition from trees.

Community Phase 3.1:
Singleleaf pinyon dominates the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and mountain big 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 50 percent. Utah juniper might be present. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent and soil redistribution is evident. This community phase is typically described as a Phase II woodland (Miller et al. 2008).

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of singleleaf pinyon. Infilling by younger trees continues.

Community Phase 3.2:

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

T3A Transition from Infilled Tree State 3.0 to Annual State 4.0:
Trigger: Catastrophic fire reduces the tree overstory and allows for the annual non-native species in the understory to dominate the site. Soil disturbing treatments such as slash and burn might also reduce tree canopy and allow for non-native annual species to increase.

Slow variables: Over time, cover and production 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, continuous fine fuels modify the fire regime by increasing frequency, size, and spatial variability of fires.

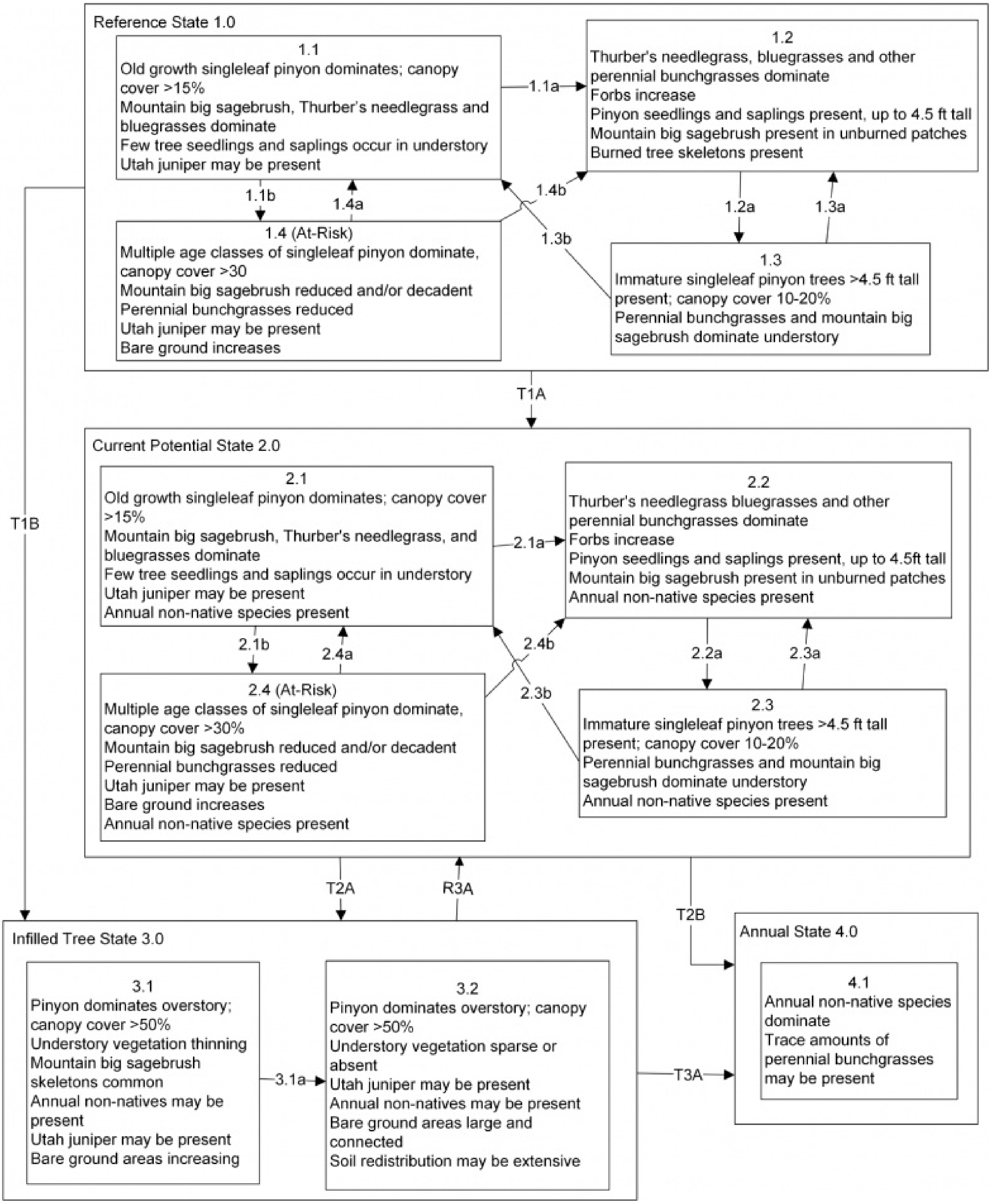
R3A Restoration from Infilled Tree State 3.0 to Current Potential State 2.0:
Manual or mechanical thinning of trees coupled with seeding. Probability of success is highest from community phase 3.1.

Annual State 4.0:
This community is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Rabbitbrush or other sprouting shrubs might dominate the overstory. Annual non-native species dominate the understory. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. This state was not seen in MLRA 26 during field work for this project, however it is possible given increased fire activity in these sites and their proximity to known annual states of sagebrush ecological sites. We refer the reader to the report for Disturbance Response Group 21 for MLRA 28A and 28B.

Community Phase 4.1:
Cheatgrass, mustards and other non-native annual species dominate the site. Trace amounts of perennial bunchgrasses might be present. Sprouting shrubs might increase. Burned tree skeletons present.

State and transition model

MLRA 26
GROUP 19
PIMO/ARTRV/ACTH7
026XY060NV



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KEY

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 drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Fire.
1.3b: Time and lack of disturbance such as fire or 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 drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.3a: Fire.
2.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing 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 drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

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

Annual State 4.0 Community Pathways
None.

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 tree 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 long-term drought, and/or insect or disease attack. Fires are typically 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 1.1
Reference Plant Community

This phase is characterized by widely dispersed old-growth singleleaf pinyon trees with an understory of mountain big sagebrush and perennial bunchgrasses. The visual aspect is dominated by singleleaf pinyon with 15 percent or greater canopy cover (USDA 1997). Utah juniper might be present. Trees have reached maximal or near maximal heights for the site and many tree crowns might be flat- or round- topped. Thurber’s needlegrass and bluegrasses are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*) and tapertip hawksbeard (*Crepis acuminata*) are minor components. Utah juniper might be present.

Forest overstory. MATURE FOREST: The visual aspect and vegetal structure are dominated by singleleaf pinyon 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. Tree canopy cover ranges from 20 to 35 percent. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic, wildfire is a natural factor influencing the development and maintenance of these mature forests. This stage of forest development is assumed to be representative of this forestland site in a pristine environment.

Forest understory. Understory vegetative composition is about 50 percent grasses, 10 percent forbs and 40 percent shrubs and young trees when the average overstory canopy is medium (20 to 35 percent). Average understory production ranges from 200 to 500 pounds per acre with a medium canopy cover. Understory production includes the total annual production of all species within 4½ feet of the ground surface.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	112	168	280
Shrub/Vine	67	101	168
Forb	22	34	56
Tree	22	34	56
Total	**223**	**337**	**560**

Community 1.2

This community phase is characterized by a post-fire shrub and herbaceous community. Thurber’s needlegrass, bluegrasses, and other perennial grasses dominate. Thurber’s needlegrass can experience high mortality from fire and might be reduced in the community for several years. Forbs might increase post-fire but will likely return to pre-burn levels within a few years. Singleleaf pinyon seedlings up to 4 feet in height might be present. Mountain big sagebrush might be present in unburned patches. Burned tree skeletons might be present; however, these have little or no effect on the understory vegetation.

Community 1.3

This community phase is characterized as an immature woodland with singleleaf pinyon trees averaging over 4.5 feet in height. Pinyon canopy cover is 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 sagebrush.

Community 1.4
(at-risk)

This phase is dominated by singleleaf pinyon. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the mountain big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat- forming forbs might increase. Utah juniper might be present. This community is at risk of crossing a threshold. Without proper management this phase will transition to the infilled woodland state 3.0. This community phase is typically described as early Phase II woodland (Miller et al. 2008).

Pathway 1.1a
Community 1.1 to 1.2

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

Pathway 1.1b
Community 1.1 to 1.4

Time without disturbance such as fire, long-term drought, or disease will allow for the gradual infilling of singleleaf pinyon.

Pathway 1.2a
Community 1.2 to 1.3

Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of the singleleaf pinyon component. Mountain big sagebrush reestablishes. Excessive herbivory might also reduce perennial grass understory.

Pathway 1.3b
Community 1.3 to 1.1

Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of singleleaf pinyon. Excessive herbivory might also reduce perennial grass understory.

Pathway 1.3a
Community 1.3 to 1.2

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

Pathway 1.4a
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 35 percent. Over time young trees mature to replace and maintain the old-growth woodland. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor.

Pathway 1.4b
Community 1.4 to 1.2

A high-severity crown fire will eliminate or reduce the singleleaf pinyon 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 tree 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 or most of the following community phases within this state.

Community 2.1

This phase is characterized by widely dispersed old-growth singleleaf pinyon trees with an understory of mountain big sagebrush and perennial bunchgrasses. The visual aspect is dominated by singleleaf pinyon with 15 percent or greater canopy cover (USDA 1997). Utah juniper might be present. Trees have reached maximal or near maximal heights for the site and many tree crowns might be flat- or round- topped. Thurber's needlegrass and bluegrasses are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot and tapertip hawksbeard are minor components. Utah juniper might be present.

Community 2.2

This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass, bluegrass, and other perennial grasses dominate. Forbs might increase post-fire but will likely return to pre-burn levels within a few years. Pinyon seedlings up to 4.5 feet in height might be present. Mountain big sagebrush might be present in unburned patches. Burned tree skeletons might be present; however, these have little or no effect on the understory vegetation. Annual non-native species generally respond well after fire and might be stable or increasing within the community.

Community 2.3

This community phase is characterized by an immature woodland, with singleleaf pinyon 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. Annual non-native species are present.

Community 2.4
(at-risk)

This phase is dominated by singleleaf pinyon and Utah juniper might be present. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the mountain big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs might increase. Annual non-native species are present primarily under tree canopies. Utah juniper might be present. This community is at risk of crossing a threshold, without proper management this phase will transition to the Infilled Tree State 3.0. This community phase is typically described as early Phase II woodland (Miller et al. 2008).

Pathway 2.1a
Community 2.1 to 2.2

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

Pathway 2.1b
Community 2.1 to 2.4

Time without disturbance such as fire, long-term drought, or disease will allow for the gradual infilling of singleleaf pinyon.

Pathway 2.2a
Community 2.2 to 2.3

Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of the singleleaf pinyon component. Mountain big sagebrush reestablishes. Excessive herbivory might also reduce perennial grass understory.

Pathway 2.3b

Community 2.3 to 2.1

Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of singleleaf pinyon. Excessive herbivory might also reduce the perennial grass understory.

Pathway 2.3a
Community 2.3 to 2.2

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

Pathway 2.4a
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 35 percent. Over time young trees mature to replace and maintain the old-growth woodland. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor. Annual non-natives present in trace amounts.

Pathway 2.4b
Community 2.4 to 2.2

A high-severity crown fire will eliminate or reduce the singleleaf pinyon 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 might increase in the post-fire community.

State 3
Infilled Tree State

This state has two community phases characterized by the dominance of singleleaf pinyon in the overstory. This state is identifiable by greater than 50 percent cover of singleleaf pinyon and a mixed age class. Older trees are at maximal height and upper crowns might be flat-topped or rounded. Younger trees are typically cone- or pyramidal-shaped. Understory vegetation is sparse due to increasing shade and competition from trees.

Community 3.1

Singleleaf pinyon dominates the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and mountain big 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 50 percent. Utah juniper might be present. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent and soil redistribution is evident. This community phase is typically described as a Phase II woodland (Miller et al. 2008).

Community 3.2

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

Pathway 3.1a
Community 3.1 to 3.2

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

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. Rabbitbrush or other sprouting shrubs might dominate the overstory. Annual non-native species dominate the understory. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. This state was not seen in MLRA 26 during field work for this project, however it is possible given increased fire activity in these sites and their proximity to known annual states of sagebrush ecological sites. We refer the reader to the report for Disturbance Response Group 21 for MLRA 28A and 28B.

Community 4.1

Cheatgrass, mustards and other non-native annual species dominate the site. Trace amounts of perennial bunchgrasses might be present. Sprouting shrubs might increase. Burned tree skeletons present.

Transition T1A
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 T1B
State 1 to 3

Trigger: Time and a lack of disturbance allow trees to dominate site resources; might 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 canopy cover is greater than 50 percent. Little understory vegetation remains due to competition with trees for site resources.

Transition T2A
State 2 to 3

Trigger: Time and a lack of disturbance allow trees to dominate site resources; might also 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: Pinyon canopy cover is greater than 30 percent. Little understory vegetation remains due to competition with trees for site resources.

Transition T2B
State 2 to 4

Trigger: Catastrophic crown fire facilitates the establishment of non-native, annual weeds. Slow variables: Increase in tree crown cover, loss of perennial understory and an increase in annual non-native species. Threshold: Cheatgrass or other non-native annuals dominate understory. Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. 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.

Restoration pathway R3A
State 3 to 2

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

Transition T3A
State 3 to 4

Trigger: Catastrophic fire reduces the tree overstory and allows for the annual non-native species in the understory to dominate the site. Soil disturbing treatments such as slash and burn might also reduce tree canopy and allow for non-native annual species to increase. Slow variables: Over time, cover and production 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, continuous fine fuels modify the fire regime by increasing frequency, size, and spatial variability of fires.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Primary Perennial Grasses**			118–272	
	Thurber's needlegrass	ACTH7	*Achnatherum thurberianum*	34–81	–
	muttongrass	POFE	*Poa fendleriana*	34–81	–
	Sandberg bluegrass	POSE	*Poa secunda*	34–81	–
	desert needlegrass	ACSP12	*Achnatherum speciosum*	17–30	–
2	**Secondary Perennial Grasses**			3–17	
	squirreltail	ELEL5	*Elymus elymoides*	3–17	–
Forb					
3	**Perennial**			10–50	
	rockcress	ARABI2	*Arabis*	3–17	–
	balsamroot	BALSA	*Balsamorhiza*	3–17	–
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	3–17	–
Shrub/Vine					
4	**Primary Shrubs**			84–151	
	mountain big sagebrush	ARTRV	*Artemisia tridentata ssp. vaseyana*	17–30	–
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	17–30	–
	mormon tea	EPVI	*Ephedra viridis*	17–30	–
	buckwheat	ERIOG	*Eriogonum*	17–30	–
	antelope bitterbrush	PUTR2	*Purshia tridentata*	17–30	–
5	**Secondary Shrubs**			10–50	
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	3–17	–
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	3–17	–
	currant	RIBES	*Ribes*	3–17	–
Tree					
6	**Evergreen**			20–47	
	singleleaf pinyon	PIMO	*Pinus monophylla*	17–30	–
	Utah juniper	JUOS	*Juniperus osteosperma*	3–17	–

Table 7. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
singleleaf pinyon	PIMO	*Pinus monophylla*	Native	–	85–100	–	–
Utah juniper	JUOS	*Juniperus osteosperma*	Native	–	0–15	–	–
curl-leaf mountain mahogany	CELE3	*Cercocarpus ledifolius*	Native	–	0–15	–	–

Animal community

Livestock/Wildlife Grazing 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 of fine fuels 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 and wildlife.

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 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) might 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.

Inappropriate grazing management during the growing season, for multiple years, will cause a decline in understory plants such as Thurber's needlegrass. Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988). Thurber's needlegrass might increase in crude protein content after grazing (Dave Ganskopp et al 2007).

Desert needlegrass is a compact bunchgrass with considerable basal leafage. The young herbage is palatable to all classes of livestock. When mature the fine basal leaves, intermingled with the coarse stems and flowering stalks, are grazed some by cattle and horses, but little by sheep (Sampson et al. 1951). Desert needlegrass is palatable to wildlife such as bighorn sheep and feral burros when young.
Desert needlegrass tolerates light grazing but overgrazing might eliminate it from an ecological site. It is best to graze it before seed develops because the seed has a sharp callus that can injure the eyes and mouths of grazing animals (Perkins and Ogle 2008).

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 might become the dominant understory with inappropriate grazing management. Field surveys indicate native, mat- forming forbs might also increase with decreased bunchgrass density.

Mountain big sagebrush is a relatively palatable shrub. Fecal samples from ungulates in Montana showed that big horn sheep, mule deer, and elk all consumed mountain big sagebrush in small amounts in winter, while cattle had no sign of sagebrush use. D. P. Sheehy and A. Winward (1981) studied preferences of mule deer and sheep in a controlled experiment: several different varieties of sagebrush (basin big sagebrush, black sagebrush, bolander silver sagebrush, foothill big sagebrush, low sagebrush, mountain big sagebrush, wyoming big sagebrush) were brought into a pen and the animals preferences were measured. Deer showed the most preference for low sagebrush, mountain and foothill sagebrush, and Bolander silver sagebrush and least preference for black sagebrush. Sheep showed highest preference for low sagebrush, medium preference for black sagebrush, and least preference for Wyoming and basin big sagebrush. In a study by Personius et al (1987), mountain big sagebrush was the most preferred taxon by mule deer.

Antelope bitterbrush is critical browse for mule deer (Odocoileus heminous), as well as domestic livestock, pronghorn (Antilocapra americana), and elk (Cervus canadensis) (M. K. Wood, Bruce A. Buchanan, & William Skeet, 1995). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison, 1953). Cattle tend to graze bitterbrush in higher areas than sheep or deer and take off newer twig growth, keeping them shorter. Palatability varies between plants and stages of growth, degree of use, and location. Columbian black-tailed deer and antelope usually graze it in the spring and summer, mule deer in the winter, and livestock in the summer. It is rather shade intolerant (Hormay, 1943). Antelope bitterbrush initiates growth in the spring and finishes by late summer. It grows large ephemeral leaves in the spring and then small overwintering leaves in the late summer. Antelope bitterbrush recovers vigorously with new growth after defoliation from grazing, and potential growth remains the same or is enhanced by browsing. Antelope bitterbrush will allocate additional resources to new growth to recover from browsing (Bilbrough and Richards 1993).

Wildlife Interpretations:
This site is used by mule deer in the summer and fall. The trees provide protection from winter storms. The pinyon jay is dependent on sites supporting pinyon pine trees. This site is also used by upland game species and various song birds, rodents, reptiles and associated predators natural to the area. Feral horses will use this site in the late spring, summer and fall.

Hydrological functions

Runoff is low to very high and the potential for sheet and rill erosion is moderate to high depending on steepness of slope and amount of rock fragments on the soil surface.

Recreational uses

The trees on this site provide a welcome break in an otherwise open landscape. Steep slopes and stony surfaces inhibit many forms of recreation. It has potential for hiking, cross-country skiing, camping, and for big game as well as upland game hunting.

Wood products

Singleleaf 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 posts and fuelwood. It probably has considerable potential in the charcoal industry and in wood fiber products.

PRODUCTIVE CAPACITY

Low quality site for tree production.
Site index ranges from approximately 35 to 50 (Howell,1940).

Productivity Class: 0.20 to 0.30
CMAI*: 2.7 to 4.6 ft3/ac/yr;
0.2 to 0.3 m3/ha/yr.
*CMAI: is the culmination of mean annual increment 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. Approximately 289,000 gross British Thermal Units (BTUs) exist per cubic foot of singleleaf pinyon wood. Firewood is commonly measured by cord, or a stacked unit equivalent to 128 cubic feet. Solid wood volume in a cord varies but assuming an average of 75 cubic feet of solid wood per cord, nearly 21 million BTUs of heat value exist in a cord of singleleaf pinyon wood.

Posts 2.1 meters (7 foot): 20 to 40 per acre in stands of medium canopy.

Christmas trees: Five trees per acre in stands of medium canopy. Ten to fifteen trees per acre in stands at sapling stage. Pinyon Nuts: Annual production varies greatly, but mature woodland stage can yield over 150 pounds per acre.
MANAGEMENT GUIDES AND INTERPRETATIONS

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

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.
2) Harvest cutting - Selectively harvest surplus trees to achieve desired spacing. Save large, healthy, full-crowned singleleaf pinyon trees for nut producers. Do not select only "high grade" trees during harvest.
3) Slash Disposal - broadcasting slash improves reestablishment of native understory herbaceous species and establishment of seeded grasses and forbs after tree harvest.
4) Spacing Guide - D+10 to D+12
b. Prescription burning program to maintain desired canopy cover and manage site reproduction.
c. Mechanical tree removal (i.e. chaining) is typically not recommended on this site due to steep slopes.
d. Pest control - Porcupines can cause extensive damage and populations should be controlled.
e. Fire hazard - Fire typically is not a problem in well-managed, mature stands.

Other products

The pitch of singleleaf pinyon was used by Native Americans as an adhesive, caulking material, and a paint binder. It might also be used medicinally and chewed like gum. Pinyon seeds are a valuable food source for humans, and a valuable commercial crop. Native Americans used big sagebrush leaves and branches for medicinal teas, and the leaves as a fumigant. Bark was woven into mats, bags and clothing. Native Americans made tea from big sagebrush leaves. They used the tea as a tonic, an antiseptic, for treating colds, diarrhea, and sore eyes and as a rinse to ward off ticks. Big sagebrush seeds were eaten raw or made into meal.

Other information

Wyoming big sagebrush is used for stabilizing slopes and gullies and for restoring degraded wildlife habitat, rangelands, mine spoils and other disturbed sites. It is particularly recommended on dry upland sites where other shrubs are difficult to establish. Antelope bitterbrush has been used extensively in land reclamation. Antelope bitterbrush enhances succession by retaining soil and depositing organic material and in some habitats and with some ecotypes, by fixing nitrogen. Green ephedra is listed as a successful shrub for restoring western rangeland communities and can be used to rehabilitate disturbed lands. It also has value for reducing soil erosion on both clay and sandy soils. Green ephedra establishes readily through direct seeding, transplants, and stem cuttings.

Table 8. 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*	35	50	3	5	–	–	–	
singleleaf pinyon	*PIMO*	35	50	3	5	–	–	–	

Inventory data references

NV-ECS-1: 3 Records
NASIS data for soil survey areas NV625, NV628, NV765, NV772NV774, and NV799.

Type locality

Location 1: Mineral County, NV	
Township/Range/Section	T9N R29E S33
UTM zone	N
UTM northing	347742
UTM easting	4273341
Latitude	38° 35′ 43″
Longitude	118° 44′ 54″
General legal description	SE¼ Approximately ¼ mile northeast of Rose Creek Reservoir, Hawthorne Army Depot, Wassuk Range, Mineral County, Nevada. This site also occurs in Carson City, Douglas, Lyon, Storey and Washoe Counties, Nevada.

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Contributors

DK/FR/GKB
Patti Novak-Echenique
Tamzen Stringham

Approval

Kendra Moseley, 4/10/2024

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	05/19/2024
Approved by	Kendra Moseley
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):**

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

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

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):**

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

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

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:**