USDA Natural Resources Conservation Service

Ecological site F026XY062NV
Shallow Sandy Loam Slope 10-14 P.Z

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General information

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

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.

Classification relationships

PIMO-JUOS WSG:0R0502

Ecological site concept

The Shallow Sandy Loam Slope 10-14 P.Z is on summits and side slopes of lower elevation mountains on all aspects. Slopes range from 4 to 75 percent but are typically 15 to 50 percent. Elevations are 4800 to about 7800 feet. Soils are typically shallow to very shallow and well drained to somewhat excessively drained. The dominant plants are singleleaf pinyon (*Pinus monophylla*), Utah juniper (Juniperus osteospermum), Wyoming big sagebrush (*Artemisia tridentata* ssp. wyomingensis), and Thurber's needlegrass (*Achnatherum thurberianum*).

Associated sites

F026XY044NV	**Shallow Sandy Slope 10-12 P.Z.**
F026XY061NV	**Very Shallow Steep Sandy Slopes 12-14 P.Z.**
F026XY069NV	**Shallow Clayey Summit 11-14 P.Z. PIMO/ARTRV/POA-KOMA**
R026XY005NV	**LOAMY 12-14 P.Z.**

Similar sites

F026XY044NV	**Shallow Sandy Slope 10-12 P.Z.** mountain big sagebrush (ARTRV) dominant shrub
F026XY069NV	**Shallow Clayey Summit 11-14 P.Z. PIMO/ARTRV/POA-KOMA** mountain big sagebrush (ARTRV) dominant shrub
F026XY061NV	**Very Shallow Steep Sandy Slopes 12-14 P.Z.** Lower site index

Table 1. Dominant plant species

Tree	(1) *Pinus monophylla* (2) *Juniperus osteosperma*
Shrub	(1) *Artemisia tridentata ssp. wyomingensis*
Herbaceous	(1) *Achnatherum thurberianum*

Physiographic features

The Shallow Sandy Loam Slope 10-14 P.Z is on summits and side slopes of lower elevation mountains on all aspects. Slopes range from 4 to 75 percent but are typically 15 to 50 percent. Elevations are 4800 to near 7800 feet.

Table 2. Representative physiographic features

Landforms	(1) Mountain slope
Runoff class	Medium to very high
Elevation	4,800–7,800 ft
Slope	15–50%
Aspect	Aspect is not a significant factor

Climatic features

The climate associated with this site is arid, characterized by cool, moist winters and warm, dry summers. Average annual precipitation is 10 to near 14 inches (25 to 30 cm). Mean annual air temperature is 45 to 52 degrees F. The average frost-free period is 80 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)	100 days
Freeze-free period (average)	
Precipitation total (average)	11 in

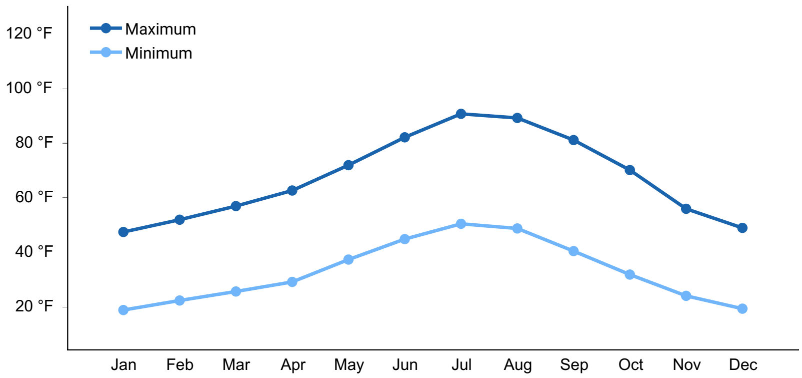


Figure 1. Monthly average minimum and maximum temperature

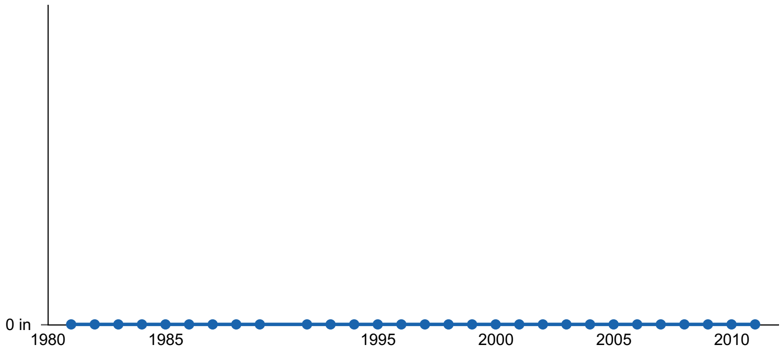


Figure 2. Annual precipitation pattern

Influencing water features

No influencing water features are associated with this site.

Soil features

Soils are typically shallow to very shallow and are well drained to somewhat excessively drained. They are formed in residuum and colluvium from granitic and volcanic rocks. The soils have 35 to over 50 percent gravels, cobbles, or stones by volume distributed throughout their profile. Available water capacity is very low but trees and shrubs can extend their roots into fissures within the underlying material allowing them to utilize deep moisture. Runoff is medium to very high and potential for sheet and rill erosion is moderate to severe depending on slope. Coarse fragments on the soil surface provide a stabilizing effect on surface erosion condition. The soil series associated with this site include: Berit, Bouncer, Brier, Hyloc, Koontz, Kram, Minneha, and Wile.

Table 4. Representative soil features

Parent material	(1) Residuum–granite (2) Residuum–basalt
Surface texture	(1) Very cobbly sandy loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Very slow to moderately rapid
Soil depth	8–20 in
Surface fragment cover <=3"	12–42%
Surface fragment cover >3"	5–31%
Available water capacity (0-40in)	1.6–2.5 in

Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	6.1–7.8
Subsurface fragment volume <=3" (Depth not specified)	6–44%
Subsurface fragment volume >3" (Depth not specified)	3–7%

Ecological dynamics

Disturbance Response Group (DRG) 18 consists of four ecological sites; F026XY062NV, F026XY064NV, F026XY092NV, and F026XY093NV (Stringham et al. 2021). The group falls in the 8 to 14 inch precipitation zone. Elevations range from 4,500 to 8,000 feet and these sites are found on slopes ranging from 2 to 75 percent. The soils in this group are typically shallow to very shallow and available water holding capacity is low. These soils usually have high amounts of rock fragments at the soil surface which help to reduce evaporation and provide a stabilizing effect on erosion conditions. This group is dominated by singleleaf pinyon (*Pinus monophylla*) or Utah juniper (*Juniperus osteosperma*) or both with Wyoming big sagebrush (*Artemisia tridentata* ssp. wyomingensis) or low sagebrush (*Artemisia arbuscula*) as the primary understory shrub. Other shrubs in the group include antelope bitterbrush (*Purshia tridentata*), Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), green ephedra (*Ephedra viridis*), and currant (Ribes spp.). The dominant understory grass of the group is Thurber's needlegrass (*Achnatherum thurberianum*). Other understory grasses include muttongrass (*Poa fendleriana*), Sandberg bluegrass (*Poa secunda*), and Indian ricegrass (*Achnatherum hymenoides*). Understory production ranges from 75 to 400 pounds per acre with a medium canopy cover (11 to 30 percent, dependent on ecological site).

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 invasives. Key characteristics include: (1) climate (precipitation, temperature), (2) topography (aspect, slope, elevation, and landform), (3) hydrology (infiltration, runoff), (4) soils (depth, texture, structure, organic matter), (5) plant communities (functional groups, productivity), and (6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include: (a) site productivity, (b) species composition and structure, and (c) 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 (44,600,000 acres) (Miller and Tausch 2001). In the mid to late 1900's, the number of pinyon and juniper trees establishing per decade began to increase compared to the previous several hundred years. The substantial increase in conifer establishment is attributed to a number of factors the most important being: (1) cessation of the aboriginal burning (Tausch 1999), (2) change in climate with rising temperatures (Heyerdahl et al. 2006), (3) the reduced frequency of fire likely driven by the introduction of domestic livestock, (4) a decrease in wildfire frequency along with improved wildfire suppression efforts and (5) potentially increased CO_2 levels favoring woody plant establishment (Tausch 1999, Bunting 1994). Miller et al. (2008) found 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/ac. The research strongly suggests that for over 200 years prior to settlement, woodlands in the Great Basin were relatively low density with limited rates of establishment (Miller et al. 2008, Miller and Tausch 2001). This evidence strongly suggests that tree canopy cover of 10 to 20 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 2 percent of the stands sampled in Nevada, Oregon, and Utah (Miller et al. 2008, Miller and Tausch 2001, Miller et al. 1999). However, the proportion of old-growth can vary depending on: (a) disturbance regimes, (b) soils and (c) climate. Some ecological sites can support 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). 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: (1) they are active zones for seed dispersal, (2) nurse plants are available, and (3) 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. The 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 are common in the Great Basin. Tap roots of pinyon and juniper have a relatively rapid rate of root elongation and thus are 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.

Insects and diseases of western juniper are not well understood or studied (Eddleman et al. 1994). Utah juniper can be killed by a fungus called Juniper Pocket Rot (Pyrofomes demidoffi), also known as white trunk rot (Eddleman et al. 1994 and Durham 2014). Pocket rot enters the tree through any wound or opening that exposes the heartwood. In an advanced stage, this fungus can cause high mortality (Durham 2014). Dwarf mistletoe (Phorandendron spp.) a parasitic plant, might also affect Utah juniper and without treatment or pruning, might kill the tree 10-15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: (1) dwarf mistletoe (Arceuthobium spp.) that might weaken trees; (2) leaf rust (Gymnosporangium sp.) on leaves and young branches; and (3) juniper blight (Phomopsis sp.). Flat-head borers (Chrysobothris sp.) attack the wood; long-horned beetles (Methia juniper, Styloxus bicolor) girdle limbs and twigs; and round-head borers (Callidium spp.) attack twigs and limbs (Tueller and Clark 1975).

Phillips (1909) recognized that the pinyons are more resistant to disease than most of the conifers with which it associates. Hepting (1971) lists several diseases affecting pinyon including: (a) foliage diseases, (b) a tarspot needle cast, (c) stem diseases such as blister rust and dwarf mistletoe, (d) root diseases and trunk rots, (e) red heart rot, and (f) but rot. The pinyon ips beetle (Ips confuses) and pinyon needle scale (Matsucoccus acalyptus) are both native insects to Nevada that attack pinyon pines throughout their range. The pinyon needle scale weakens trees by killing needles older than 1 year. Sometimes small trees are killed by repeated feeding and large trees are weakened to the point that they are attacked by the pinyon ips beetle. The beetle typically kills weak and damaged trees (Phillips 2014). During periods of chronic drought, the impact of these two insects on singleleaf pinyon can be substantial.

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

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 usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 meters. (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).

Wyoming big sagebrush, the most drought tolerant of the big sagebrush species, is generally long-lived and 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 depended on adequate moisture conditions.

Low sagebrush, which is dominant on three sites in this group, is fairly drought tolerant but also tolerates perched water tables during some portion of the growing season. Low sagebrush is also susceptible to the sagebrush defoliator, Aroga moth (Aroga websteri). While Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), research is inconclusive of the damage sustained by low sagebrush populations.

Thurber’s needlegrass has somewhat shallower root system than Wyoming big sagebrush and low sagebrush, but root densities are often as high as or higher than those of shrubs in the upper 0.5 meters. Thurber’s needlegrass root densities however taper off more rapidly than shrubs. Differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub and 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.

Annual Invasive 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) suggest 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 100percent control of ventenata and medusahead and greater than 95percent 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). Results were less conclusive in a similar study in the Bodie Hills, however it was apparent that old (300+ yr) pinyon primarily survived in protected, low-fuel areas. 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 60percent 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 20percent while beyond 30percent there is a rapid decline in understory species and soil seed reserves (Huber et al. 1999). The reference community understory vegetation of Wyoming big sagebrush and Thurber's needlegrass further supports the evidence of a pre-settlement community with an open overstory and infrequent ground fire.

Wyoming big sagebrush communities historically had low fuel loads. Patchy fires that burned in a mosaic pattern were common at 10-to-70-year return intervals (Young et al. 1978, West and Hassan 1985, Bunting et al. 1987), however newer research suggests longer return intervals. Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50-100 years. More recently, Baker (2011) estimates fire rotation to be 200 to 350 years in Wyoming big sagebrush communities. Wyoming big sagebrush is killed by fire and only regenerates from seed. Recovery time for Wyoming big sagebrush might require 50 to 120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

Low sagebrush is killed by fire and does not sprout (Young 1983). Establishment after fire is from seed, generally blown in and not from the seed bank (Bradley et al. 1992). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Recovery time of low sagebrush following fire is variable (Young 1983). After fire, if regeneration conditions are favorable, low sagebrush recovers in 2 to 5 years, however on harsh sites where cover is low to begin with and/or erosion occurs after fire, recovery might require more than 10 years (Young 1983). Slow regeneration might subsequently worsen erosion (Blaisdell et al. 1982).

Antelope bitterbrush, the second most abundant shrub on sites in this group, is moderately fire tolerant (McConnell & 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 the invasive species 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.

Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk, Cline, & Rickard, 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Carlton M. Britton, Guy R. McPherson, & Forrest A. Sneva, 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). Fall prescribed burns did not significantly affect cover of Thurber's needlegrass over the course of two years, indicating that fall fire is not detrimental to this plant (Davies and Bates, 2008).
Thurber's needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Britton et al. 1990, Koniak 1985). Reestablishment on burned sites has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and might preclude reestablishment (Evans and Young, 1978). Thurbers needlegrass was shown to decrease in density following a spring fire, but it produced more reproductive culms the year after a fall fire (Ellsworth and Kauffman 2010). Thurber's needlegrass is tolerant to barley yellow dwarf virus and shows no adverse symptoms when infected (Ingwell and Bosque-Perez, 2015).

Muttongrass, a minor component in this group, is top killed by fire but will sprout 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 mutton grass.

Livestock/ Wildlife Grazing Interpretations:

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

Generally, Wyoming sagebrush is the least palatable of the big sagebrush taxa (Bray et al. 1991, Sheehy and Winward 1981), however, it might receive light or moderate use depending upon the amount of understory herbaceous cover (Tweit and Houston 1980). Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush to be intermediately palatable to mule deer when compared to mountain big sagebrush (most palatable) and black sagebrush (least palatable).

Domestic sheep and, to a much lesser degree, cattle, consume low sagebrush particularly during the spring, fall, and winter (Sheehy and Winward 1981). Heavy dormant season grazing by sheep will reduce sagebrush cover and increase grass production (Laycock 1967).
Severe trampling damage to supersaturated soils could occur if sites are used in early spring when snowmelt is abundant. Trampling damage, particularly from cattle or horses, in sagebrush habitat types is greatest when high clay content soils are wet. In drier areas with more gravelly soils, no serious trampling damage occurs, even when the soils are wet (Hironaka et al. 1983).

Antelope bitterbrush is critical browse for mule deer (Odocoileus heminous), as well as domestic livestock, pronghorn (Antilocapra americana), and elk (Cervus canadensis) (Wood et al. 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).

Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping date on basal area of five bunchgrasses in eastern Oregon and found grazing from August to October (after seed set) has the least impact. Heavy grazing, year after year during the growing season, will reduce perennial bunchgrasses and increase sagebrush. Abusive grazing by cattle or horses will likely increase sagebrush, rabbitbrush and deep-rooted perennial forbs such as arrowleaf balsamroot (Balsamorhiza spp.). Annual non-native weedy species such as cheatgrass and mustards, and potentially medusahead might invade.

The Thurber's needlegrass component of this plant community 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 et al. 2007).

Reduced bunchgrass vigor or density due to inappropriate grazing enables Sandberg bluegrass, mat forming forbs cheatgrass or both, and other invasive species to occupy interspaces. Sandberg bluegrass, a minor component in this group, 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.

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 food for 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 to graze the foliage. The understory species also provide critical browse for deer. The trees provide important cover for mule deer, elk, wild horses, mountain lion (Puma concolor), bobcat (Lynx rufus) and pronghorn (Gottfried and Severson 1994, Coates and Schemnitz 1994, Logan and Irwin 1985, Evans 1988).

Mule deer is considered the dominant big game species in the pinyon-juniper woodland and depend heavily on these woodlands for cover, shelter, and emergency forage during severe winters (Frischknecht 1975). Mule deer will eat singleleaf pinyon and juniper foliage, using the foliage moderately in winter, spring, and summer (Kufeld et al. 1973). Deep snows in higher elevation forest zones force mule deer and elk down into pinyon-juniper habitats during winter. This change in habitat allows mule deer and elk to browse the dwarf trees and shrubs (Gottfried and Severson 1994).

The diet of pronghorn antelope varies considerably; however, singleleaf pinyon was shown to comprise 1 to 2 percent of winter diet of pronghorn antelope that occur in pinyon-juniper habitat. Desert bighorn sheep (Ovis nelson) 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 scat 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.

General State and Transition Model Narrative for Group 18:

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 18.

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 tree 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 drought, and/or insect or disease attack. Fires within this community are infrequent and likely small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community Phase 1.1:
This phase is characterized by widely dispersed old-growth pinyon and juniper trees with a Wyoming big sagebrush, perennial bunchgrass understory. The visual aspect is dominated by singleleaf pinyon and Utah juniper with over 15 percent canopy cover (USDA 1997). Trees have reached maximal or near maximal heights for the site and many tree crowns might be flat- or round-topped. Thurber's needlegrass is most prevalent grass in the understory. Wyoming big sagebrush is the primary understory shrub. Forbs such as phlox, and Eriogonum are minor components. Overall, the understory is sparse with production ranging between 200 to 400 pounds per acre.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:

This community phase pathway is a result of a high-severity crown fire which will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.4:
This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual infilling of singleleaf pinyon and Utah juniper.

Community Phase 1.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass and other perennial grasses dominate. Forbs might increase after a fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 4 feet in height might be present. Wyoming 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:
This community phase pathway is a result of time without disturbances such as fire, drought, or disease which will allow for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Wyoming big sagebrush reestablishes. Excessive herbivory might also reduce perennial grass understory.

Community Phase 1.3:
This community phase is characterized by an immature woodland, with pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation is dominated by Wyoming big sagebrush and perennial bunchgrasses as well as smaller tree seedling and saplings.

Community Phase Pathway 1.3a, from 1.3 to 1.4:
This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues. Excessive herbivory might also reduce the perennial grass understory.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
This community phase pathway occurs when fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase 1.4 (at-risk):
This community phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover might be 30 percent or greater. The density and vigor of the Wyoming big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs such as phlox might increase. 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 1.4a, from Phase 1.4 to 1.1:
This community phase pathway is a result of low intensity fire, insect infestation, or disease which kills individual trees within the stand reducing canopy cover to less than 30 percent. Over time young trees mature to replace and maintain the old-growth woodland. The Wyoming big sagebrush and perennial bunchgrass community increases in density and vigor.

Community Phase Pathway 1.4b, from Phase 1.4 to 1.2:
This community phase pathway is a result of a high-severity crown fire which will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component allowing 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 herbivory that favors shrub and tree dominance.
Slow variables: Over time the abundance and size of trees will increase.
Threshold: Pinyon and juniper canopy cover is greater than 40 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 tree 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. Negative feedbacks include: (a) the presence of all structural and functional groups, (b) low fine fuel loads and (c) retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. Positive feedbacks include: (a) the non-natives' high seed output, (b) persistent seed bank, (c) rapid growth rate, (d) ability to cross pollinate, and (e) adaptations for seed dispersal. Fires within this community with the small amount of non-native annual species present are likely 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 pinyon and juniper trees with a Wyoming big sagebrush perennial bunchgrass understory. The visual aspect is dominated by singleleaf pinyon and Utah juniper with canopy cover of 15 percent or more (USDA 1997).
Trees have reached maximal or near maximal heights for the site and many tree crowns might be flat- or round-topped. Thurber's needlegrass is the most prevalent grass in the understory. Wyoming big sagebrush is the primary understory shrub. Forbs such as phlox and Eriogonum are minor components. Overall, the understory is sparse with production ranging between 200 to 400 lbs. per acre.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
This community phase pathway is a result of a high-severity crown fire which will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.4:
This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual infilling of singleleaf pinyon and Utah juniper.

Community Phase 2.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass and other perennial grasses dominate. Forbs might increase post-fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 4 feet in height might be present. Wyoming 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:
This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Wyoming 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 pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation is dominated by Wyoming big sagebrush and perennial bunchgrasses as well as smaller tree

seedling and saplings. Annual non-native species are present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.4:
This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
This community phase pathway occurs when fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase 2.4 (at-risk):
This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the Wyoming 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. 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:
This community phase pathwat occrs when low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 30 percent. Over time young trees mature to replace and maintain the old-growth woodland. The Wyoming 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:
This community phase pathway is a result of a high-severity crown fire which eliminates or reduces the singleleaf pinyon and Utah juniper overstory and the shrub component allowing 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 be coupled with inappropriate grazing management that favors shrub and tree dominance.
Slow variables: Over time the abundance and size of trees will increase.
Threshold: Singleleaf pinyon and Utah juniper canopy cover is greater than 40 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 the 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 that are characterized by the dominance of Utah juniper and singleleaf pinyon in the overstory. This state is identifiable by over 40 percent cover of Utah juniper and singleleaf pinyon, exhibiting 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:
This phase is when ingleleaf pinyon and Utah juniper dominate the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse, and Wyoming 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 40

percent. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent. This community phase is typically described as a Phase II woodland (Miller et al. 2008).

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
This community phase pathway is a result of time without disturbances such as fire, drought, or disease whichallows for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

Community Phase 3.2 (at risk):
This community phase is a result of singleleaf pinyon and Utah juniper dominate the aspect. Tree canopy cover exceeds 40 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses if present exist in the drip line or under the canopy of trees. Wyoming big sagebrush skeletons are common, or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg bluegrass (*Poa secunda*) 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: Canopy fire reduces the pinyon and juniper overstory and facilitates the annual non-native species in the understory to dominate the site.
Slow variables: Over time, cover, production and seed bank of annual non-native species increases.
Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes temporal and spatial nutrient capture and cycling within the community. Increase in canopy cover of trees increases rainfall interception and reduces soil moisture for understory species. Increased canopy cover of trees increases the risk for severe stand-replacing crown fire. The increased seed bank of non-native, annual species responds positively to post-fire conditions facilitating the transition to an Annual State.

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

Annual State 4.0:

This state has one community phase that is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Time since fire might facilitate the maturation of sprouting shrubs such as rabbitbrush. 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
observed 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:

This community phase is when 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.

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 invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Pinyon and juniper dominated plant communities in the cold desert of the Intermountain West occupy over 18 million ha (44,600,000 acres) (Miller and Tausch 2001). In the mid to late 1900's, the number of pinyon and juniper trees establishing per decade began to increase compared to the previous several hundred years. The substantial increase in conifer establishment is attributed to a number of factors the most important being (1) cessation of the aboriginal burning (Tausch 1999), (2) change in climate with rising temperatures (Heyerdahl et al. 2006), (3) the reduced frequency of fire likely driven by the introduction of domestic livestock, (4) a decrease in wildfire frequency along with improved wildfire suppression efforts and (5) potentially increased CO2 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/ac. The research strongly suggests that for over 200 years prior to settlement, woodlands in the Great Basin were relatively low density with limited rates of establishment (Miller et al. 2008, Miller and Tausch 2001). This evidence strongly suggests that tree canopy cover of 10 to 20 percent may 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 2 percent of the stands sampled in Nevada, Oregon, and Utah (Miller et al. 2008, Miller and Tausch 2001, Miller et al. 1999). However, the proportion of old-growth can vary depending on disturbance regimes, soils and climate. Some ecological sites are capable of supporting persistent woodlands, likely due to specific soils and climate resulting in infrequent stand replacement disturbance regimes. In the Great Basin, old-growth trees have been found to typically grow on rocky shallow or sandy soils that support little understory vegetation to carry a fire (Holmes et al. 1986, Miller and Rose 1995, West et al. 1998, 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). Pinyon is slow-growing and very intolerant to shade with the exception of young plants, usually first year seedlings (Tueller and Clark 1975). Singleleaf pinyon seedling establishment is episodic. Population age structure is affected by drought, which reduces seedling and sapling recruitment more than other age classes. The ecotones between singleleaf pinyon woodlands and adjacent shrublands and grasslands provide favorable microhabitats for singleleaf pinyon seedling establishment since they are active zones for seed dispersal, nurse plants are available, and singleleaf pinyon seedlings are only affected by competition from grass and other herbaceous vegetation for a couple of years.

The pinyon jay (Gymnorhinus cyanocephalus) and other members of the seed caching corvids play an important role in pinyon pine regeneration. These birds cache the seeds in the soil for future use. Those seeds that escape harvesting by the birds and rodents have the opportunity to germinate under favorable soil and climatic conditions (Lanner 1981). A mutualistic relationship exists between the trees that produce food and the animals that disperse the seeds, thereby insuring perpetuation of the trees. Large crops of seeds may stimulate reproduction in birds, especially the pinyon jay (Ligon 1974).

Pinyon and juniper growth is dependent mostly upon soil moisture stored from winter precipitation, mainly snow. Much of the summer precipitation is ineffective, being lost in runoff after summer convection storms or by evaporation and interception (Tueller and Clark 1975). Pinyon and juniper are highly resistant to drought which are common in the Great Basin. Tap roots of pinyon and juniper have a relatively rapid rate of root elongation and are thus able to persist until precipitation conditions are more favorable (Emerson 1932).

Infilling by younger trees increases canopy cover and causes a decline in understory perennial vegetation because of increased competition for water and sunlight. There is also some evidence that phenolic compounds in juniper litter may 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 a number of variables such as plant species present at the time of disturbance and their individual responses to disturbance, past management, type and size of disturbance, available seed sources in the soil or adjacent areas, and site and climatic conditions throughout the successional process.

Insects and diseases of western juniper are not well understood or studied (Eddleman et al. 1994). Utah juniper can be killed by a fungus called Juniper Pocket Rot (Pyrofomes demidoffi), also known as white trunk rot (Eddleman et al. 1994 and Durham 2014). Pocket rot enters the tree through any wound or opening that exposes the heartwood. In an advanced stage, this fungus can cause high mortality (Durham 2014). Dwarf mistletoe (Phorandendron spp.) a parasitic plant, may also affect Utah juniper and without treatment or pruning, may kill the tree 10-15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: dwarf mistletoe (Arceuthobium spp.) that may weaken trees; leaf rust (Gymnosporangium sp.) on leaves and young branches; and juniper blight (Phomopsis sp.). Flat-head borers (Chrysobothris sp.) attack the wood; long-horned beetles (Methia juniper, Styloxus bicolor) girdle limbs and twigs; and round-head borers (Callidium spp.) attack twigs and limbs (Tueller and Clark 1975).

Phillips (1909) recognized that the pinyons are more resistant to disease than most of the conifers with which it associates. Hepting (1971) lists several diseases affecting pinyon including: foliage diseases, a tarspot needle cast, stem diseases such as blister rust and dwarf mistletoe, root diseases and trunk rots, red heart rot, and but rot. The pinyon ips beetle (Ips confuses) and pinyon needle scale (Matsucoccus acalyptus) are both native insects to Nevada that attack pinyon pines throughout their range. The pinyon needle scale weakens trees by killing needles older than 1 year. Sometimes small trees are killed by repeated feeding and large trees are weakened to the point that they are attacked by the pinyon ips beetle. The beetle typically kills weak and damaged trees (Phillips 2014). During periods of chronic drought the impact of these two insects on singleleaf pinyon can be substantial.

In the Great Basin, the majority of annual precipitation is received during the winter and early spring. This continental semiarid climate regime favors growth and development of deep-rooted shrubs and herbaceous cool season plants using the C3 photosynthetic pathway (Comstock and Ehleringer 1992). Winter precipitation and slow melting of snow results in deeper percolation of moisture into the soil profile. 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 and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

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 usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Dobrowolski et al. 1990).

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

Low sagebrush, which is dominant on three sites in this group, is fairly drought tolerant but also tolerates perched water tables during some portion of the growing season. Low sagebrush is also susceptible to the sagebrush defoliator, Aroga moth (Aroga websteri). While Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), research is inconclusive of the damage sustained by low sagebrush populations.

Thurber’s needlegrass has somewhat shallower root system than Wyoming big sagebrush and low sagebrush, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m. However, Thurber’s needlegrass root densities 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.

Annual Invasive 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 26percent 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 there is ongoing work to try to predict where they occur, in the hopes of aiding 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, are able to 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 100percent control of ventenata and medusahead and greater than 95percent control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, 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 oz./ac 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 likely 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). Results were less conclusive in a similar study in the Bodie Hills, however it was apparent that old (300+ yr) pinyon primarily survived in protected, low-fuel areas. 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 does occur when 60percent 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 may have a relatively greater effect on the establishment of pinyon than juniper.

Initial response of native understory species following fire correlates closely with percent crown cover. In general, research indicates that understory response to disturbance is most productive when crown cover is at or below 20percent while beyond 30percent there is a rapid decline in understory species and soil seed reserves (Huber et al. 1999). The reference community understory vegetation of Wyoming big sagebrush and Thurber’s needlegrass further supports the evidence of a pre-settlement community with an open overstory and infrequent ground fire.

Wyoming big sagebrush communities historically had low fuel loads. Patchy fires that burned in a mosaic pattern were common at 10 to 70 year return intervals (Young et al. 1978, West and Hassan 1985, Bunting et al. 1987), however newer research suggests longer return intervals. Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50-100 years. More recently, Baker (2011) estimates fire rotation to be 200 to 350 years in Wyoming big sagebrush communities. Wyoming big sagebrush is killed by fire and only regenerates from seed. Recovery time for Wyoming big sagebrush may require 50 to 120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

Low sagebrush is killed by fire and does not sprout (Young 1983). Establishment after fire is from seed, generally blown in and not from the seed bank (Bradley et al. 1992). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Recovery time of low sagebrush following fire is variable (Young 1983). After fire, if regeneration conditions are favorable, low sagebrush recovers in 2 to 5 years, however on harsh sites where cover is low to begin with and/or erosion occurs after fire, recovery may require more than 10 years (Young 1983). Slow regeneration may subsequently worsen erosion (Blaisdell et al. 1982).

Antelope bitterbrush, the second most abundant shrub on sites in this group, is moderately fire tolerant (McConnell

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

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). However, season and severity of the fire will influence plant response. Plant response will vary depending on post-fire soil moisture availability.

Burning has been found to decrease the vegetative and reproductive vigor of Thurber’s needlegrass (Uresk, Cline, & Rickard, 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber’s needlegrass (Carlton M. Britton, Guy R. McPherson, & Forrest A. Sneva, 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). Fall prescribed burns did not significantly affect cover of Thurber’s needlegrass over the course of two years, indicating that fall fire is not detrimental to this plant (Davies and Bates, 2008). Thurber’s needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Britton et al. 1990, Koniak 1985). Reestablishment on burned sites has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Evans and Young, 1978). Thurbers needlegrass was shown to decrease in density following a spring fire, but it produced more reproductive culms the year after a fall fire (Ellsworth and Kauffman 2010). Thurber’s needlegrass is tolerant to barley yellow dwarf virus and shows no adverse symptoms when infected (Ingwell and Bosque-Perez, 2015).

Muttongrass, a minor component in this group, is top killed by fire but will sprout 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 mutton grass.

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 they supported a diverse understory that provided forage for both livestock and wildlife. Historic livestock overuse and increased stand densities have reduced the carrying capacity of these pinyon-juniper stands and many current stands only provide shade and shelter for livestock.

Generally, Wyoming sagebrush is the least palatable of the big sagebrush taxa (Bray et al. 1991, Sheehy and Winward 1981), however, it may receive light or moderate use depending upon the amount of understory herbaceous cover (Tweit and Houston 1980). Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush to be intermediately palatable to mule deer when compared to mountain big sagebrush (most palatable) and black sagebrush (least palatable).

Domestic sheep and, to a much lesser degree, cattle, consume low sagebrush particularly during the spring, fall, and winter (Sheehy and Winward 1981). Heavy dormant season grazing by sheep will reduce sagebrush cover and increase grass production (Laycock 1967). Severe trampling damage to supersaturated soils could occur if sites are used in early spring when there is abundant snowmelt. Trampling damage, particularly from cattle or horses, in sagebrush habitat types is greatest when high clay content soils are wet. In drier areas with more gravelly soils, no serious trampling damage occurs, even when the soils are wet (Hironaka et al. 1983).

Antelope bitterbrush is critical browse for mule deer (Odocoileus heminous), as well as domestic livestock, pronghorn (Antilocapra americana), and elk (Cervus canadensis) (Wood et al. 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).

Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping date on basal area of five bunchgrasses in eastern Oregon, and found grazing from August to October (after seed set) has the least impact. Heavy grazing, year after year during the growing season, will reduce perennial bunchgrasses and increase sagebrush. Abusive grazing by cattle or horses will likely increase sagebrush, rabbitbrush and deep-rooted perennial forbs such as arrowleaf balsamroot (Balsamorhiza spp.) Annual non-native weedy species such as cheatgrass and mustards, and potentially medusahead may invade.

The Thurber’s needlegrass component of this plant community 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 may increase in crude protein content after grazing (Dave et al. 2007).

Reduced bunchgrass vigor or density due to inappropriate grazing provides an opportunity for Sandberg bluegrass, mat forming forbs, and/or cheatgrass and other invasive species to occupy interspaces. Sandberg bluegrass, a minor component in this group, increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer, and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management. Field surveys indicate native mat-forming forbs may also increase with decreased bunchgrass density.

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 food for 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, elk, wild horses, mountain lion (Puma concolor), bobcat (Lynx rufus) and pronghorn (Gottfried and Severson 1994, Coates and Schemnitz 1994, Logan and Irwin 1985, Evans 1988).

Mule deer is considered the dominant big game species in the pinyon-juniper woodland and depend heavily on these woodlands for cover, shelter, and emergency forage during severe winters (Frischknecht 1975). Mule deer will eat singleleaf pinyon and juniper foliage, using the foliage moderately in winter, spring, and summer (Kufeld et al. 1973). Deep snows in higher elevation forest zones force mule deer and elk down into pinyon-juniper habitats during winter. This change in habitat allows mule deer and elk to browse the dwarf trees and shrubs (Gottfried and Severson 1994).

The diet of pronghorn antelope varies considerably; however, singleleaf pinyon was shown to comprise 1 to 2 percent of winter diet of pronghorn antelope that occur in pinyon-juniper habitat. Desert bighorn sheep (Ovis nelson) may utilize pinyon-juniper habitat, but only where the terrain is rocky and steep (Gottfried et al. 2000). Gray foxes, bobcats (Lynx rufus), coyotes (Canis latrans), weasels (Mustela frenata), skunks (Mephitis spp.), badgers (Taxidea taxus), and ringtail cats (Bassariscus astutus) search for prey in pinyon-juniper habitat woodlands (Short and McCulloch 1977).

Juniper "berries" or berry-cones are eaten by black-tailed jackrabbits (Lepus californicus) and coyotes (Gese et al. 1988, Kitchen et al. 2000). A study by Kitchen et al (1999) conducted in juniper-pinion habitat found vegetation in coyote scats was mainly grass seeds or juniper berries. Jackrabbits are a major dispenser of juniper seeds (Schupp et al. 1999). The pinyon mouse (Peromyscus truei) is a pinyon-juniper obligate and uses the woodlands for cover and food (Hoffmeister 1981). Other small mammals include the porcupine (Hystricomorph hystricidae), desert cottontail (Sylvilagus audubonii), Nuttall's cottontail (S. nuttallii), deer mouse (Peromyscus maniculatus), Great Basin pocket mouse (Perognathus parvus), chisel-toothed kangaroo rat (Dipodomys microps) and desert woodrat (Neotoma lepida) (Turkowski and Watkins 1976).

Many bird species are associated with the pinyon-juniper habitat; some are permanent residents, some summer residents, and some winter residents, depending upon location. For birds and bats, the woodland provides structure for nesting and roosting, and locations for foraging. Singleleaf pinyon provides a number of cavities and the stringy, fibrous bark provides quality nesting material as well as the food provided by the tree's seeds and berries (Short and McCulloch 1977). Many bird species depend on juniper berry-cones and pine nuts for fall and winter food (Balda and Masters 1980). Several bird species are obligates including (gray flycatcher (Epidonax wrightii), scrub jay (Aphelocoma californica), plain titmouse (Parus inornatus ridgwayi), and gray vireo (Vireo vicinior) and several species are semi-obligates including black-chinned hummingbird (Archilochus alexandri), ash-throated flycatcher (Myiarchus cinerascens), pinion jay (Gymnorhinus cyanocephalus), American bushtit (Psaltriparus minimus), Bewick's wren (Thryomanes bewickii), Northern mockingbird (Mimus polyglottos), blue-gray gnatcatcher (Polioptila caerulea), black-throated gray warbler (Dendroica nigrescens), house finch (Haemorhous mexicanus), spotted towhee (Pipilo maculatus), lark sparrow (Chondestes grammacus) and black-chinned sparrow (Zonotrichia atricapilla) (Balda and Masters 1980). Ferruginous hawk (Buteo regalis), a conservation priority species due to recent population declines in Nevada, nest in older trees of sufficient size and structure to support their large nest platforms. (Holechek 1981).

Diurnal reptiles include the sagebrush swift (Sceloporus graciosus), the blue-bellied lizard (Sceloporus elongates) the western collard lizard, the Great Basin rattlesnake, the Great Basin gopher snake (Pituophis catenifer) and horned lizard, also occur in Utah juniper habitat (Frischknecht 1975). However, the distribution of most of herpetofauna present in pinyon-juniper woodlands is poorly understood and more research and management are needed.

General State and Transition Model Narrative for Group 18:

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 18.

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 tree 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 drought, and/or insect or disease attack. Fires within this community are infrequent and likely small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community Phase 1.1:
This phase is characterized by widely dispersed old-growth pinyon and juniper trees with a Wyoming big sagebrush, perennial bunchgrass understory. The visual aspect is dominated by singleleaf pinyon and Utah juniper with over 15 percent canopy cover (USDA 1997). Trees have reached maximal or near maximal heights for the site

and many tree crowns may be flat- or round-topped. Thurber's needlegrass is most prevalent grass in the understory. Wyoming big sagebrush is the primary understory shrub. Forbs such as phlox, and Eriogonum are minor components. Overall, the understory is sparse with production ranging between 200 to 400 pounds per acre.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual infilling of singleleaf pinyon and Utah juniper.

Community Phase 1.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass and other perennial grasses dominate. Forbs may increase after a fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 4 feet in height may be present. Wyoming big sagebrush may be present in unburned patches. Burned tree skeletons may 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 disturbances such as fire, drought, or disease will allow for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Wyoming big sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Community Phase 1.3:
This community phase is characterized by an immature woodland, with pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation is dominated by Wyoming big sagebrush and perennial bunchgrasses as well as smaller tree seedling and saplings.

Community Phase Pathway 1.3a, from 1.3 to 1.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues. Excessive herbivory may also reduce the perennial grass understory.

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

Community Phase 1.4 (at-risk):
This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover may be 30percent or greater. The density and vigor of the Wyoming big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs such as phlox may increase. This community is at risk of crossing a threshold; without proper management this phase will transition to the infilled tree state 3.0. 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 30percent. Over time young trees mature to replace and maintain the old-growth woodland. The Wyoming 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 and Utah juniper 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; may be coupled with inappropriate herbivory that favors shrub and tree dominance.
Slow variables: Over time the abundance and size of trees will increase.
Threshold: Pinyon and juniper canopy cover is greater than 40percent. 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 tree 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/most of the following community phases within this state.

Community Phase 2.1:
This phase is characterized by a widely dispersed old-growth pinyon and juniper trees with a Wyoming big sagebrush perennial bunchgrass understory. The visual aspect is dominated by singleleaf pinyon and Utah juniper with canopy cover of 15 percent or more (USDA 1997). Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Thurber’s needlegrass is the most prevalent grass in the understory. Wyoming big sagebrush is the primary understory shrub. Forbs such as phlox and Eriogonum are minor components. Overall, the understory is sparse with production ranging between 200 to 400 lbs. per acre.

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

Community Phase Pathway 2.1b, from Phase 2.1 to 2.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual infilling of singleleaf pinyon and Utah juniper.

Community Phase 2.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber’s needlegrass and other perennial grasses dominate. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 4 feet in height may be present. Wyoming big sagebrush may be present in unburned patches. Burned tree skeletons may be present; however, these have little or no effect on the understory vegetation. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.3:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Wyoming big sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Community Phase 2.3:
This community phase is characterized by an immature woodland, with pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation is dominated by Wyoming big sagebrush and perennial bunchgrasses as well as smaller tree seedling and saplings. Annual non-native species are present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

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

Community Phase 2.4 (at-risk):
This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the Wyoming big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs may increase. Annual non-native species are present primarily under tree canopies. This community is at risk of crossing a threshold, without proper management this phase will transition to the infilled tree state 3.0. 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 30 percent. Over time young trees mature to replace and maintain the old-growth woodland. The Wyoming 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 and Utah juniper overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site. Annual non-native grasses typically respond positively to fire and may increase in the post-fire community.

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; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Slow variables: Over time the abundance and size of trees will increase.
Threshold: Singleleaf pinyon and Utah juniper canopy cover is greater than 40 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 that are characterized by the dominance of Utah juniper and singleleaf pinyon in the overstory. This state is identifiable by over 40 percent cover of Utah juniper and singleleaf pinyon, exhibiting a mixed age class. Older trees are at maximal height and upper crowns may 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 and Utah juniper dominate the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and Wyoming 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 40 percent. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent. This community phase is typically described as a Phase II woodland (Miller et al. 2008).

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

Community Phase 3.2 (at risk):
Singleleaf pinyon and Utah juniper dominate the aspect. Tree canopy cover exceeds 40 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present exist in the drip line or under the canopy of trees. Wyoming big sagebrush skeletons are common or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg bluegrass (*Poa secunda*) may dominate interspaces. Annual non-native species are present and are typically found under the trees. Bare ground areas are large and interconnected. Soil redistribution may be extensive. This community phase is typically described as a Phase III woodland (Miller et al. 2008).

T3A: Transition from Infilled Tree State 3.0 to Annual State 4.0:
Trigger: Canopy fire reduces the pinyon and juniper overstory and facilitates the annual non-native species in the understory to dominate the site.
Slow variables: Over time, cover, production and seed bank of annual non-native species increases.
Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes temporal and spatial nutrient capture and cycling within the community. Increase in canopy cover of trees increases rainfall interception and reduces soil moisture for understory species. Increased canopy cover of trees increases the risk for severe stand-replacing crown fire. The increased seed bank of non-native, annual species responds positively to post-fire conditions facilitating the transition to an Annual State.

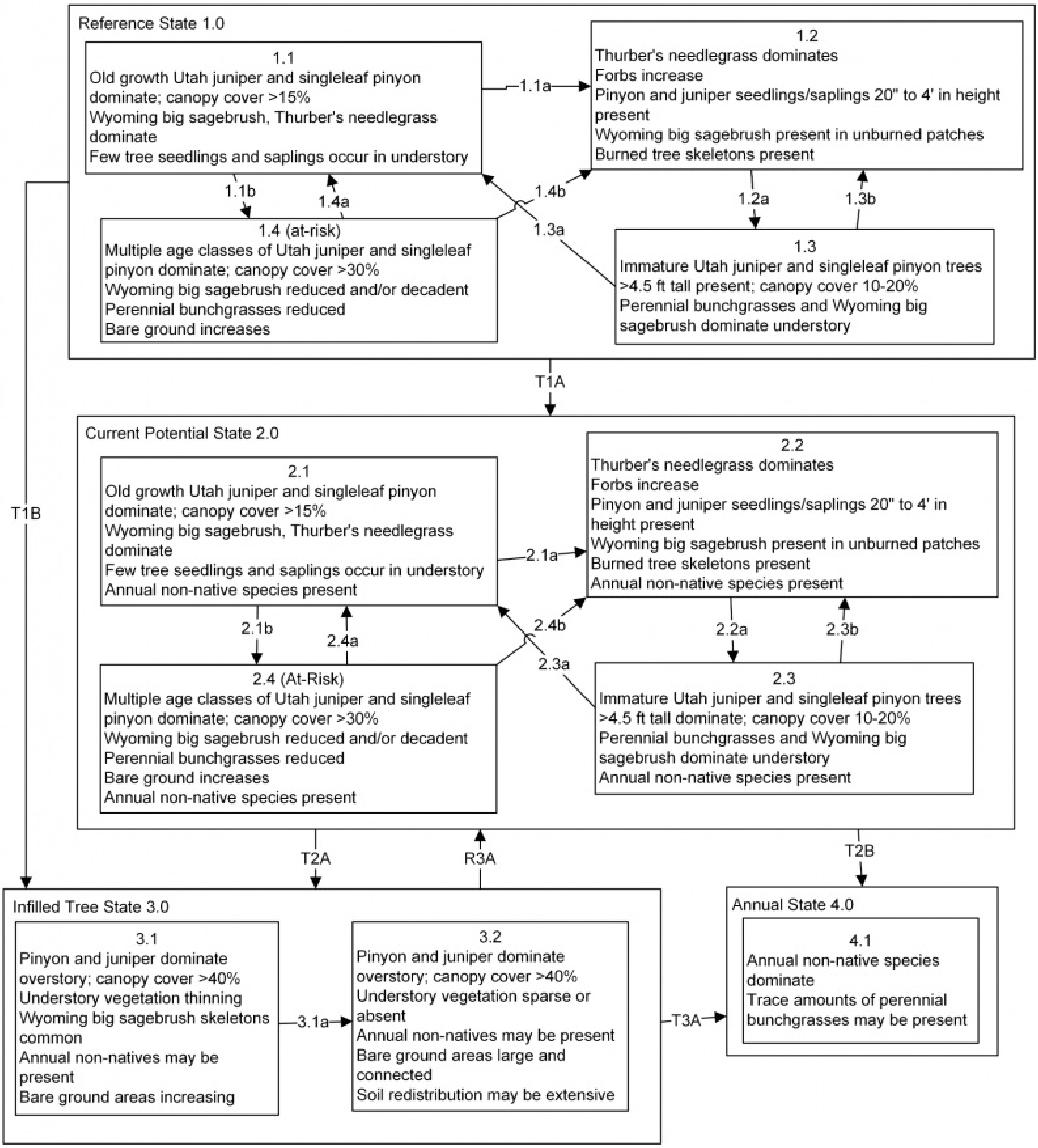
R3A: Restoration from Infilled Tree state 3.0 to Current Potential State 2.0:
Manual or mechanical thinning of trees coupled with seeding. Probability of success is highest from community phase 3.1.

Annual State 4.0:
This state has one community phase that is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Time since fire may facilitate the maturation of sprouting shrubs such as rabbitbrush. 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 may be present. Sprouting shrubs may increase. Burned tree skeletons present.

State and transition model

MLRA 26
Group 18
PIMO/JUOS/ARTRW8/ACTH7
026XY062NV



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Group 18
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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: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire.
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 may also reduce perennial grass understory.
2.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire.
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

Community 1.1

This phase is characterized by widely dispersed old-growth pinyon and juniper trees with a Wyoming big sagebrush, perennial bunchgrass understory. The visual aspect is dominated by singleleaf pinyon and Utah juniper with over 15 percent canopy cover (USDA 1997). Trees have reached maximal or near maximal heights for the site and many tree crowns might be flat- or round-topped. Thurber’s needlegrass is most prevalent grass in the understory. Wyoming big sagebrush is the primary understory shrub. Forbs such as phlox, and Eriogonum are minor components. Overall, the understory is sparse with production ranging between 200 to 400 pounds per acre.

Forest overstory. MATURE FORESTLAND: 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 forestlands. This stage of forestland development is assumed to be representative of this woodland site in a pristine environment.

Forest understory. Understory vegetative composition is about 45 percent grasses, 5 percent forbs and 50 percent shrubs and young trees when the average overstory is medium (20 to 30 percent). Average understory production ranges from 200 to 400 pounds per acre with a medium canopy cover. Understory production includes the total annual production of all species within 4 1/2 feet of the ground surface.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	90	135	180
Shrub/Vine	80	120	160
Tree	20	30	40
Forb	10	15	20
Total	**200**	**300**	**400**

Community 1.2

This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass and other perennial grasses dominate. Forbs might increase after a fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 4 feet in height might be present. Wyoming 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 by an immature woodland, with pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation is dominated by Wyoming big sagebrush and perennial bunchgrasses as well as smaller tree seedling and saplings.

Community 1.4
(at-risk)

This community phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover might be 30 percent or greater. The density and vigor of the Wyoming big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs such as phlox might increase. 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 1.1a
Community 1.1 to 1.2

This community phase pathway is a result of a high-severity crown fire which will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Pathway 1.1b
Community 1.1 to 1.4

This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual infilling of singleleaf pinyon and Utah juniper.

Pathway 1.2a
Community 1.2 to 1.3

This community phase pathway is a result of time without disturbances such as fire, drought, or disease which will allow for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Wyoming big sagebrush reestablishes. Excessive herbivory might also reduce perennial grass understory.

Pathway 1.3b
Community 1.3 to 1.2

This community phase pathway occurs when fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Pathway 1.3a
Community 1.3 to 1.4

This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues. Excessive herbivory might also reduce the perennial grass understory.

Pathway 1.4a
Community 1.4 to 1.1

This community phase pathway is a result of low intensity fire, insect infestation, or disease which kills individual trees within the stand reducing canopy cover to less than 30 percent. Over time young trees mature to replace and maintain the old-growth woodland. The Wyoming big sagebrush and perennial bunchgrass community increases in density and vigor.

Pathway 1.4b
Community 1.4 to 1.2

This community phase pathway is a result of a high-severity crown fire which will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component allowing for the perennial bunchgrasses to dominate the site.

State 2
Current Potential State

Community 2.1

This phase is characterized by widely dispersed old-growth pinyon and juniper trees with a Wyoming big sagebrush perennial bunchgrass understory. The visual aspect is dominated by singleleaf pinyon and Utah juniper with canopy cover of 15 percent or more (USDA 1997). Trees have reached maximal or near maximal heights for the site and many tree crowns might be flat- or round-topped. Thurber’s needlegrass is the most prevalent grass in the understory. Wyoming big sagebrush is the primary understory shrub. Forbs such as phlox and Eriogonum are minor components. Overall, the understory is sparse with production ranging between 200 to 400 lbs. per acre.

Community 2.2

This community phase is characterized by a post-fire shrub and herbaceous community. Thurber’s needlegrass and other perennial grasses dominate. Forbs might increase post-fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 4 feet in height might be present. Wyoming 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 pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation is dominated by Wyoming big sagebrush and perennial bunchgrasses as well as smaller tree seedling and saplings. Annual non-native species are present.

Community 2.4
(at-risk)

This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the Wyoming 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. 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

This community phase pathway is a result of a high-severity crown fire which will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Pathway 2.1b
Community 2.1 to 2.4

This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual infilling of singleleaf pinyon and Utah juniper.

Pathway 2.2a
Community 2.2 to 2.3

This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Wyoming big sagebrush reestablishes. Excessive herbivory might also reduce perennial grass understory.

Pathway 2.3b
Community 2.3 to 2.2

This community phase pathway occurs when fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Pathway 2.3a
Community 2.3 to 2.4

This community phase pathway is a result of time without disturbances such as fire, drought, or disease which allows for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

Pathway 2.4a
Community 2.4 to 2.1

This community phase pathwat occrs when low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 30 percent. Over time young trees mature to replace and maintain the old-growth woodland. The Wyoming 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

This community phase pathway is a result of a high-severity crown fire which eliminates or reduces the singleleaf pinyon and Utah juniper overstory and the shrub component allowing 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

Community 3.1

This phase is when ingleleaf pinyon and Utah juniper dominate the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse, and Wyoming 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 40 percent. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent. This community phase is typically described as a Phase II woodland (Miller et al. 2008).

Community 3.2
(at-risk)

This community phase is a result of singleleaf pinyon and Utah juniper dominate the aspect. Tree canopy cover exceeds 40 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses if present exist in the drip line or under the canopy of trees. Wyoming big sagebrush skeletons are common, or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg bluegrass (*Poa secunda*) 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

This community phase pathway is a result of time without disturbances such as fire, drought, or disease whichallows for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

State 4
Annual State

Community 4.1

This community phase is when 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 herbivory that favors shrub and tree dominance. Slow variables: Over time the abundance and size of trees will increase. Threshold: Pinyon and juniper canopy cover is greater than 40 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 be coupled with inappropriate grazing management that favors shrub and tree dominance. Slow variables: Over time the abundance and size of trees will increase. Threshold: Singleleaf pinyon and Utah juniper canopy cover is greater than 40 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 the 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

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

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Primary Perennial Grasses**			60–126	
	Thurber's needlegrass	ACTH7	*Achnatherum thurberianum*	30–72	–
	muttongrass	POFE	*Poa fendleriana*	15–27	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	15–27	–
2	**Secondary Perennial Grasses**			12–60	
	desert needlegrass	ACSP12	*Achnatherum speciosum*	3–15	–
	squirreltail	ELEL5	*Elymus elymoides*	3–15	–
	needle and thread	HECO26	*Hesperostipa comata*	3–15	–
	Sandberg bluegrass	POSE	*Poa secunda*	3–15	–
Forb					
3	**Perennial**			6–30	
	buckwheat	ERIOG	*Eriogonum*	3–15	–
	phlox	PHLOX	*Phlox*	3–15	–
Shrub/Vine					
4	**Primary Shrubs**			30–72	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	30–72	–
5	**Secondary Shrubs**			9–45	
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	3–15	–
	mormon tea	EPVI	*Ephedra viridis*	3–15	–
	antelope bitterbrush	PUTR2	*Purshia tridentata*	3–15	–
Tree					
6	**Evergreen**			18–42	
	singleleaf pinyon	PIMO	*Pinus monophylla*	15–27	–
	Utah juniper	JUOS	*Juniperus osteosperma*	3–15	–

Table 7. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
singleleaf pinyon	PIMO	*Pinus monophylla*	Native	–	50–85	–	–
Utah juniper	JUOS	*Juniperus osteosperma*	Native	–	15–50	–	–

Animal community

Livestock Interpretations:
This site is suited to cattle and sheep grazing where terrain permits. Grazing management should be keyed to muttongrass and Thurber’s and desert needlegrass production. Muttongrass is highly nutritious and remains palatable through most of the grazing season. Thurber’s and desert needlegrass provide palatable, nutritious feed during the spring and early summer. New plants of these grasses are established entirely from seed and grazing practices should allow for ample seed production and seedling establishment. Many areas are not used because of steep slopes or lack of adequate water.

Stocking rates vary with such factors as kind and class of grazing animal, season of use and fluctuations in climate. Actual use records for individual sites, a determination of the degree to which the sites have been grazed and an evaluation of trend in site condition offer the most reliable basis for developing initial stocking rates.

The forage value rating is not an ecological evaluation of the understory as is the range condition rating for rangeland. The forage value rating is a utilitarian rating of the existing understory plants for use by specific kinds of grazing animals.

The amount and nature of the understory vegetation in a forestland is highly responsive to the amount and duration of shade provided by the overstory canopy. Significant changes in kinds and abundance of plants occur as the canopy changes, often regardless of grazing use.

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 medium to very high. The potential for sheet and rill erosion is moderate to severe depending on slope.

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 trees serve as a food source, as well as providing medicinal, cultural, and spiritual values for American Indians. 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. Other important uses for this tree are for Christmas trees and as a source of nuts for wildlife and human food. Thousands of pounds of nuts are gathered each year and sold throughout the United States. Diseases of singleleaf pinyon include infestations of dwarf mistletoe (a parasite), and blister rust. The mountain pine beetle attacks singleleaf pinyon.

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
This forestland community is of moderately low site quality for tree production. Site index ranges from 40 to about 60 (Howell, 1940). Productivity Class: 0.2 to 0.4
CMAI*: 3.3 to 6.1 ft3/ac/yr;
0.23 to 0.43 m3/ha/yr.
Culmination is estimated to be at 100 years.
*CMAI: is the culmination of mean annual increment or highest average growth rate of the stand in the units specified.

Fuelwood Production: About 4 to 8 cords per acre for stands averaging 5 inches in diameter at 1 foot height with a medium canopy cover. There are about 274,000 gross British Thermal Units (BTUs) heat content per cubic foot of Utah juniper and about 289,000 BTUs heat content per cubic foot of singleleaf pinyon. Firewood is commonly measured by cord, or a stacked unit equivalent to 128 cubic feet. Solid wood volume in a cord varies but usually ranges from 65 to 90 cubic feet. Assuming an average of 75 cubic feet of solid wood per cord, there are about 21 million BTUs of heat value in a cord of mixed singleleaf pinyon and Utah juniper wood.

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

Christmas Trees: About 7 to 12 per acre in stands of medium canopy.

Pinyon Nuts: Annual production varies greatly, but mature woodland stage can yield over 100 pounds per acre in favorable years. MANAGEMENT GUIDES AND INTERPRETATIONS
1. LIMITATIONS AND CONSIDERATIONS
a. Potential for sheet and rill erosion is moderate to severe depending on slope.
b. Moderate equipment limitations on steeper slopes and moderate to severe equipment limitations on sites having extreme surface stoniness.
c. Proper spacing is the key to a well managed, multiple use and multi-product juniper forestland.

2. ESSENTIAL REQUIREMENTS
a. Adequately protect from wildfire.
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+12
b. Prescription burning program to maintain desired canopy cover and manage site reproduction.
c. Mechanical tree removal (i.e. chaining) is usually 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 usually 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 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. Indian ricegrass was traditionally eaten by some Native Americans. The Paiutes used the seed as a reserve food source.

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.

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*	40	60	3	6	100	–	–	
singleleaf pinyon	*PIMO*	40	60	3	6	–	–	–	

Inventory data references

NASIS data for soil survey areas CA686, CA729, NV625, NV629, NV773, NV774, and NV799.

Type locality

Location 1: Carson City County, NV	
General legal description	This site also occurs in Douglas, Lyon, Mineral, Storey and Washoe Counties, Nevada.

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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	04/25/2024
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:**

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

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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

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

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

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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:**

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17. **Perennial plant reproductive capability:**
