

Ecological site F028BY062NV PIMO-JUOS/ARTRV/PSSPS-ACTH7

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General information

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

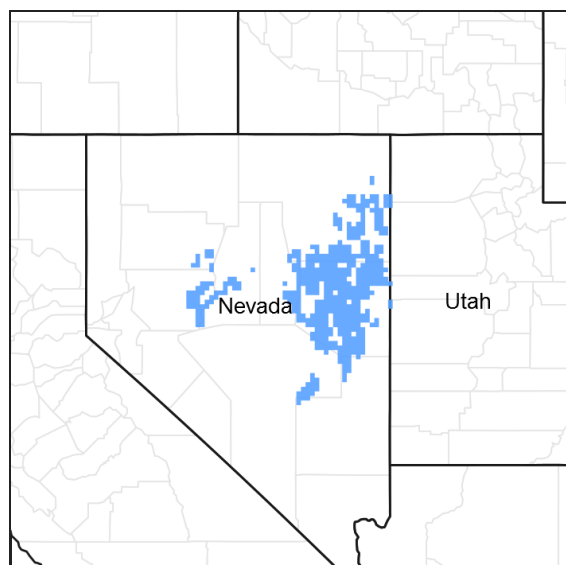


Figure 1. Mapped extent

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

MLRA notes

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

MLRA 28B occurs entirely in Nevada and comprises about 23,555 square miles (61,035 square kilometers). More than nine-tenths of this MLRA is federally owned. This area is in the Great Basin Section of the Basin and Range Province of the Intermontane Plateaus. It is an area of nearly level, aggraded desert basins and valleys between a series of mountain ranges trending north to south. The basins are bordered by long, gently sloping to strongly sloping alluvial fans. The mountains are uplifted fault blocks with steep sideslopes. Many of the valleys are closed basins containing sinks or playas. Elevation ranges from 4,900 to 6,550 feet (1,495 to 1,995 meters) in the valleys and basins and from 6,550 to 11,900 feet (1,995 to 3,630 meters) in the mountains.

The mountains in the southern half are dominated by andesite and basalt rocks that were formed in the Miocene and Oligocene. Paleozoic and older carbonate rocks are prominent in the mountains to the north. Scattered outcrops of older Tertiary intrusives and very young tuffaceous sediments are throughout this area. The valleys consist mostly of alluvial fill, but lake deposits are at the lowest elevations in the closed basins. The alluvial valley fill consists of cobbles, gravel, and coarse sand near the mountains in the apex of the alluvial fans. Sands, silts, and clays are on the distal ends of the fans.

The average annual precipitation ranges from 4 to 12 inches (100 to 305 millimeters) in most areas on the valley floors. Average annual precipitation in the mountains ranges from 8 to 36 inches (205 to 915 millimeters) depending on elevation. The driest period is from midsummer to midautumn. The average annual temperature is 34 to 52 degrees F (1 to 11 degrees C). The freeze-free period averages 125 days and ranges from 80 to 170 days, decreasing in length with elevation.

The dominant soil orders in this MLRA are Aridisols, Entisols, and Mollisols. The soils in the area dominantly have a mesic soil temperature regime, an aridic or xeric soil moisture regime, and mixed or carbonatic mineralogy. They generally are well drained, loamy or loamyskeletal, and shallow to very deep.

Nevada's climate is predominantly arid, with large daily ranges of temperature, infrequent severe storms and heavy snowfall in the higher mountains. Three basic geographical factors largely influence Nevada's climate:

continentality, latitude, and elevation. The strong continental effect is expressed in the form of both dryness and large temperature variations. Nevada lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that markedly influences the climate of the State. The prevailing winds are from the west, and as the warm moist air from the Pacific Ocean ascend the western slopes of the Sierra Range, the air cools, condensation occurs and most of the moisture falls as precipitation. As the air descends the eastern slope, it is warmed by compression, and very little precipitation occurs. The effects of this mountain barrier are felt not only in the West but throughout the state, as a result the lowlands of Nevada are largely desert or steppes.

The temperature regime is also affected by the blocking of the inland-moving maritime air. Nevada sheltered from maritime winds, has a continental climate with well-developed seasons and the terrain responds quickly to changes in solar heating. Nevada lies within the midlatitude belt of prevailing westerly winds which occur most of the year. These winds bring frequent changes in weather during the late fall, winter and spring months, when most of the precipitation occurs.

To the south of the mid-latitude westerlies, lies a zone of high pressure in subtropical latitudes, with a center over the Pacific Ocean. In the summer, this high-pressure belt shifts northward over the latitudes of Nevada, blocking storms from the ocean. The resulting weather is mostly clear and dry during the summer and early fall, with occasional thundershowers. The eastern portion of the state receives noteworthy summer thunderstorms generated from monsoonal moisture pushed up from the Gulf of California, known as the North American monsoon. The monsoon system peaks in August and by October the monsoon high over the Western U.S. begins to weaken and the precipitation retreats southward towards the tropics (NOAA 2004).

Ecological site concept

This site occurs on mountain sideslopes on all aspects. Slopes typically range from 15 to 50 percent. Elevations are 6500 to 9400 feet.

The soils are shallow to bedrock, formed in residuum/colluvium and are characterized by an argillic horizon and mollic epipedon <18cm thick.

The reference state is dominated by singleleaf pinyon and Utah juniper with overstory canopy cover of 20-35 percent. Mountain big sagebrush is the principal understory shrub. Bluebunch wheatgrass, Indian ricegrass and Thurber's needlegrass are the most prevalent understory grasses. Overstory tree canopy composition is typically >70 percent singleleaf pinyon and <30 percent Utah juniper. Understory production ranges from 300 to 700 pounds per acre.

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

Similar sites

F028BY060NV	PIMO-JUOS/ARNO4/PSSPS-ACHY Black sagebrush is dominant understory shrub. Understory production lower.
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Table 1. Dominant plant species

Tree	(1) <i>Pinus monophylla</i> (2) <i>Juniperus osteosperma</i>
Shrub	(1) <i>Artemisia tridentata</i> var. <i>vaseyana</i>
Herbaceous	(1) <i>Pseudoroegneria spicata</i> (2) <i>Achnatherum thurberianum</i>

Physiographic features

This site occurs on mountain sideslopes on all aspects. Occasionally, this site may be found on hills. Slopes range from 8 to over 75 percent, but are typically 15 to 50 percent. Elevations generally range from 6500 to 8000 feet, but may be as low as 6000 feet in some places.

Table 2. Representative physiographic features

Landforms	(1) Mountain (2) Mountain slope
Flooding frequency	None
Ponding frequency	None
Elevation	1,981–2,438 m
Slope	15–50%
Aspect	Aspect is not a significant factor

Climatic features

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

Average annual precipitation ranges from 12 to 14 inches. Mean annual air temperature is about 44 to 47 degrees F. The average growing season is 85 to 100 days. Weather stations with a long term data record are currently not available for this ecological site. Associated climate data will be updated when information becomes available.

Table 3. Representative climatic features

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

Influencing water features

Influencing water features are not associated with this site.

Soil features

The soils are shallow to bedrock, well drained, and formed in residuum/colluvium from mixed sources of volcanic origin. Soils are characterized by an argillic horizon and a mollic epipedon from the soil surface to a maximum of 18cm. The soil moisture regime is xeric and the soil temperature regime is frigid. Available water holding capacity is very low to low, but trees and shrubs extend their roots into fractures in the bedrock allowing them to utilize deep moisture. Runoff is high to very high, and potential for sheet and rill erosion is moderate to severe depending on slope.

Soil series correlated to this site include: Cavehill, Douhide, Itca, Fera, Bartine, Devoy, Tica, Grandeposit, Cropper, Ravenswood, Bobs (shallow), Clanalpine, Atrypa, and Golsum. Any occurrences of this site correlated to soils derived from alluvium (Fairydell or Borvant) should be considered a tree dominated state of a different ecological site.

Following a comprehensive review of ecological site concepts and soil map unit components in 2016, it was determined more field work is need to verify a representative soil series for this ecological site.

Table 4. Representative soil features

Parent material	(1) Residuum–volcanic breccia (2) Colluvium–volcanic breccia
Surface texture	(1) Very stony sandy loam (2) Gravelly loam (3) Cobbly sandy clay loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Very slow to moderate
Soil depth	18–102 cm
Surface fragment cover ≤3"	2–20%
Surface fragment cover >3"	2–10%
Available water capacity (0–101.6cm)	1.02–7.62 cm
Calcium carbonate equivalent (0–101.6cm)	0–50%
Electrical conductivity (0–101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0–101.6cm)	0–5
Soil reaction (1:1 water) (0–101.6cm)	6.4–8.6
Subsurface fragment volume ≤3" (Depth not specified)	5–55%
Subsurface fragment volume >3" (Depth not specified)	2–50%

Ecological dynamics

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2003). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Pinyon and juniper dominated plant communities in the cold desert of the Intermountain West occupy over 18 million 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. In Utah, Nevada, and Oregon, trees establishing prior to 1860 accounted for only two percent or less of the total population of pinyon and juniper (Miller et al. 2008). The research strongly suggests that for over 200 years prior to settlement, woodlands in the Great Basin were relatively low density with limited rates of establishment (Miller et al. 2008, Miller and Tausch 2001). This evidence strongly suggests that tree canopy cover of 10 to 25 percent may be more representative of these sites in pristine condition. Increases in pinyon and juniper densities post-settlement were the result of both infill in mixed age tree communities and expansion into shrub-steppe communities. Pre-settlement trees accounted for less than two percent of the stands sampled in Nevada, Oregon and Utah (Miller et al. 2008, Miller and Tausch 2001, Miller et al. 1999). However, the proportion of old-growth can

vary depending on disturbance regimes, soils and climate. Some ecological sites are capable of supporting persistent woodlands, likely due to specific soils and climate resulting in infrequent stand replacement disturbance regimes. In the Great Basin, old-growth trees have been found to typically grow on rocky shallow or sandy soils that support little understory vegetation to carry a fire (Holmes et al. 1986, Miller and Rose 1995, West et al. 1998).

Singleleaf pinyon and Utah juniper are long-lived tree species with wide ecological amplitudes (Tausch et al 1981, Weisberg and Dongwook 2012, West et al 1998). Maximum ages of pinyon and juniper exceed 1000 years and stands with maximum age classes are only found on steep rocky slopes with no evidence of fire (West et al 1975). Singleleaf pinyon is slow-growing and very intolerant to shade with the exception of young plants, usually first year seedlings (Tueller and Clark 1975). Singleleaf pinyon seedling establishment is episodic. Population age structure is affected by drought, which reduces seedling and sapling recruitment more than other age classes. The ecotones between singleleaf pinyon woodlands and adjacent shrublands and grasslands provide favorable microhabitats for singleleaf pinyon seedling establishment since they are active zones for seed dispersal, nurse plants are available, and singleleaf pinyon seedlings are only affected by competition from grass and other herbaceous vegetation for a couple of years.

The pinyon jay (*Gymnorhinus cyanocephalus*) and other members of the seed caching corvids play an important role in pinyon pine regeneration. These birds cache the seeds in the soil for future use. Those seeds that escape harvesting by the birds and rodents have the opportunity to germinate under favorable soil and climatic conditions (Lanner 1981). 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 is common in the Great Basin. Tap roots of pinyon and juniper have a relatively rapid rate of root elongation and are thus able to persist until precipitation conditions are more favorable (Emerson 1932).

Infilling by younger trees increases canopy cover causing a decrease in understory perennial vegetation and an increase in bare ground. As pinyon and juniper trees increase in density so has their litter. Phenolic compounds of juniper scales can have an inhibitory effect on grass growth (Jameson 1970). Furthermore, infilling shifts stand level biomass from ground fuels to canopy fuels which has the potential to significantly impact fire behavior. The more tree dominated pinyon and juniper woodlands become, the less likely they are to burn under moderate conditions, resulting in infrequent high intensity fires (Gruell 1999, Miller et al. 2008). Additionally, as the understory vegetation declines in vigor and density with increased canopy the seed and propagules of the understory plant community also decrease significantly. The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass and with intensive wildfire the potential for conversion to annual exotics is a serious threat (Tausch 1999, Miller et al. 2008).

Specific successional pathways after disturbance in pinyon-juniper stands are dependent on a number of variables such as plant species present at the time of disturbance and their individual responses to disturbance, past management, type and size of disturbance, available seed sources in the soil or adjacent areas, and site and climatic conditions throughout the successional process.

Utah juniper can be killed by a fungus called Juniper Pocket Rot (*Pyrofomes demidoffi*), also known as white truck rot (Eddleman et al. 1994 and Durham 2014). Pocket rot enters the tree through any wound or opening that exposes the heartwood. In an advanced stage, this fungus can cause high mortality (Durham 2014). Dwarf mistletoe (*Phoradendron* spp.) a parasitic plant, may also affect Utah juniper and without treatment or pruning, may kill the tree 10-15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: witches'-broom (*Gymnosporangium* sp.) that may girdle and kill branches; leaf rust (*Gymnosporangium* sp.) on leaves and young branches; and juniper blight (*Phomopsis* sp.). Flat-head borers (*Chrysobothris* sp.) attack the wood; long-horned beetles (*Methia* juniper, *Styloxus bicolor*) girdle limbs and twigs; and round-head borers (*Callidium* spp.) attack twigs and limbs (Tueller and Clark 1975). Phillips (1909) recognized that the pinyons are more resistant to disease than most of the conifers with which it associates. Hepting (1971) lists several diseases affecting pinyon including: foliage diseases, a tar spot 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 confusus*) 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. The perennial bunchgrasses that are co-dominant with the shrubs include bluebunch wheatgrass and Thurber's needlegrass. Other common grasses include muttongrass, Sandberg bluegrass (*Poa secunda*), squirreltail (*Elymus elymoides*) and basin wildrye (*Leymus cinereus*). These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m but taper off more rapidly than shrubs. Differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems. Mountain big sagebrush and antelope bitterbrush are generally long-lived; therefore it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions. Antelope bitterbrush is most commonly found on soils which provide minimal restriction to deep root penetration such as coarse textured soil, or finer textured soil with high stone content (Driscoll 1964, Clements and Young 2002).

This site has low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Three possible alternative stable states have been identified for this site.

Fire Ecology:

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

Utah juniper is usually killed by fire, and is most vulnerable to fire when it is under four feet tall (Bradley et al. 1992). Larger trees, because they have foliage farther from the ground and thicker bark, can survive low severity fires but mortality does occur when 60% or more of the crown is scorched (Bradley et al. 1992). Singleleaf 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 20% while beyond 30% there is a rapid decline in understory species and soil seed reserves (Huber et al. 1999).

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

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires 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 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.

Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage to fire but is more susceptible in drought years (Young 1983). Plant response will vary depending on season, fire severity, fire intensity and post-fire soil moisture availability.

Thurber's needlegrass is moderately resistant to wildfire (Smith and Busby 1981), but can be severely damaged and have high mortality depending on season and severity of fire. Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Britton et al. 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influenced the response and mortality of Thurber's needlegrass, smaller bunch sizes were less likely to be damaged by fire (Wright and Klemmedson 1965). Thurber's needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Koniak 1985, Britton et al. 1990). Post-fire regeneration usually occurs from seed thus reestablishment has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Evans and Young 1978). Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below ground plant

crowns. Vallentine (1989) cites several studies in the sagebrush zone that classified Indian ricegrass as being slightly damaged from late summer burning. Indian ricegrass has also been found to reestablish on burned sites through seed dispersed from adjacent unburned areas (Young 1983, West 1994). Thus the presence of surviving, seed producing plants facilitates the reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Sandberg bluegrass (*Poa secunda*) a minor component of this ecological site, has been found to increase following fire likely due to its low stature and productivity (Daubenmire 1975). Sandberg bluegrass may retard reestablishment of deeper rooted bunchgrass.

Muttongrass, a minor component on this site, is top killed by fire but will resprout after low to moderate severity fires. A study by Vose and White (1991) in an open sawtimber site found minimal difference in overall effect of burning on mutton grass.

State and transition model

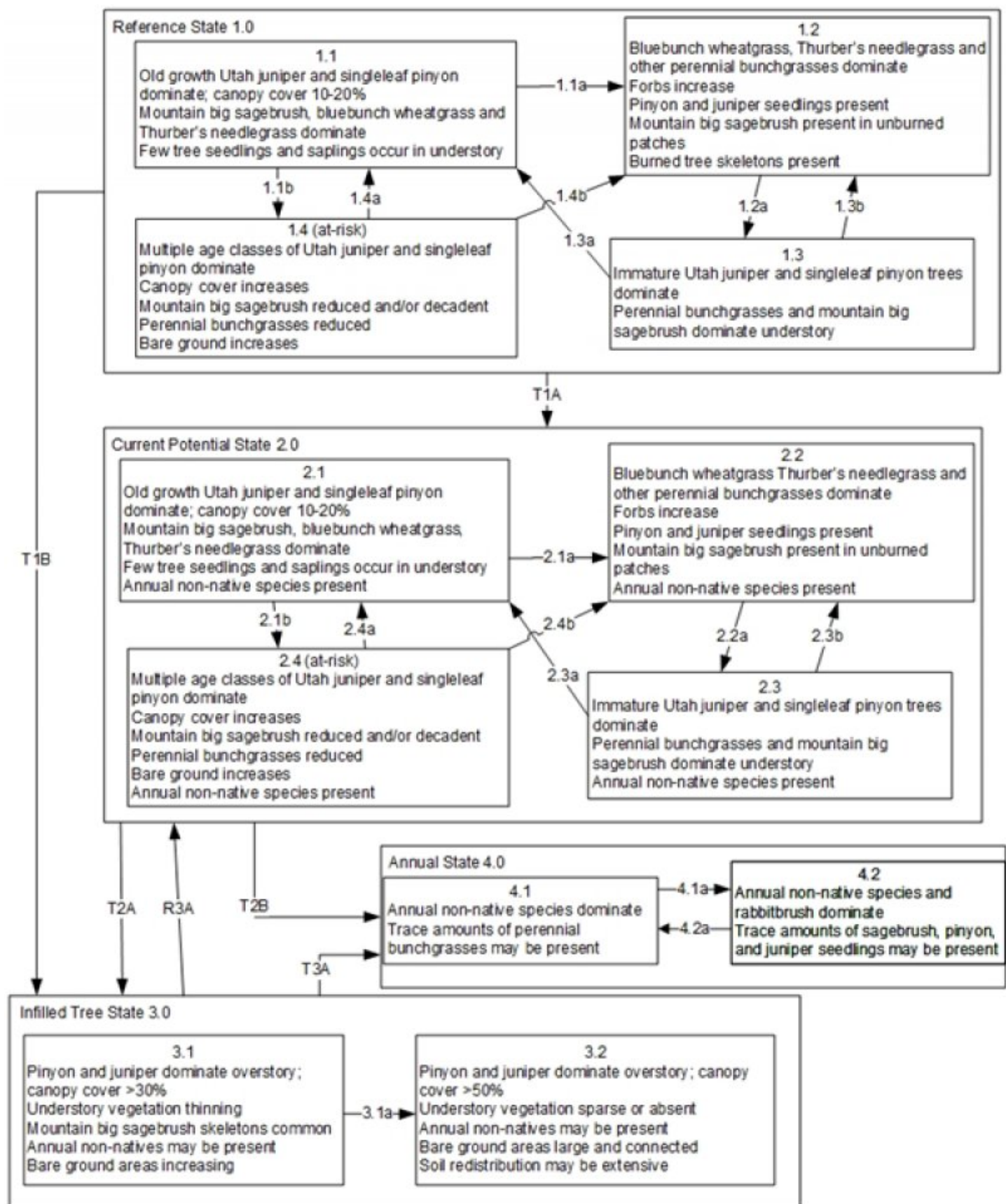


Figure 5. PNovakEchenique 3_2017

Reference State 1.0 Community Pathways

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

Transition T1A: Introduction of non-native annual species.

Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways

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

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Transition T2B: Catastrophic fire.

Infilled Tree State 3.0 Community Pathways

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

Transition T3A: Catastrophic fire.

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

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

Annual State 4.0 Community Pathways

- 4.1a: Time and lack of disturbance.
- 4.2a: Fire.

Figure 6. Legend

State 1 Reference State

Reference State 1.0: The Reference State 1.0 is representative of the natural range of variability under pristine conditions. This Reference State has four general community phases: an old-growth woodland phase, a shrub-herbaceous phase, an immature tree phase, and an infilled tree phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought, and/or insect or disease attack.

Community 1.1

Community Phase

The plant community is dominated by singleleaf pinyon and Utah juniper. An overstory canopy of 10 to 20 percent is assumed to be representative of tree dominance on this site in the pristine environment. Mountain big sagebrush is the principal understory shrub. Bluebunch wheatgrass, Indian ricegrass and Thurber's needlegrass are the most prevalent understory grasses. Overstory tree canopy composition is 70 percent or greater singleleaf pinyon and 30 percent or less Utah juniper.

Forest overstory. The visual aspect and vegetal structure are dominated by Utah juniper and 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. Upper crowns are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges from 10 to 20 percent.

Forest understory. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic wildfire is a natural factor influencing the understory of mature pinyon/juniper forestlands. Few seedlings and/or saplings of juniper and pinyon occur in the understory. Understory vegetative composition is about 50 percent grasses, 10 percent forbs and 40 percent shrubs and young trees. Average understory production ranges from 300 to 700 pounds per acre with a medium canopy cover.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	168	280	392
Shrub/Vine	101	168	235
Tree	34	56	78
Forb	34	56	78
Total	337	560	783

Community 1.2

Community Phase

This community phase is characterized by a post-fire shrub and herbaceous community. Bluebunch wheatgrass and other perennial grasses dominate. Thurber's needlegrass can experience high mortality from fire and may be reduced in the community for several years. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Singleleaf pinyon and Utah juniper seedlings up to 20 inches in height may be present. Mountain 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.

Forest understory. Herbaceous vegetation and woody shrubs dominate the site. Various amounts of tree seedlings (less than 20 inches in height) may be present up to the point where they are obviously a major component of the vegetal structure.

Community 1.3

Community Phase

This community phase is characterized as an immature woodland with pinyon, juniper trees averaging over 5m in height. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation consists of smaller tree seedling and saplings, as well as perennial bunchgrasses and sagebrush.

Forest overstory. The visual aspect and vegetal structure are dominated by singleleaf pinyon and Utah juniper greater than 5m in height. The upper crown of dominant and codominant Utah juniper and singleleaf pinyon are cone or pyramidal shaped.

Forest understory. Seedlings and saplings are present in the understory. Understory vegetation is moderately influenced by a tree overstory canopy.

Community 1.4

Community Phase (at-risk)

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

Forest overstory. The visual aspect and vegetal structure are dominated by Utah juniper and 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. Upper crowns are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges exceeds 25 percent.

Forest understory. Understory vegetation is sparse. Production is typically less than 250 lbs/ac.

Pathway a

Community 1.1 to 1.2

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

Pathway b

Community 1.1 to 1.4

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

Pathway a

Community 1.2 to 1.3

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

Pathway a

Community 1.3 to 1.2

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

Pathway b

Community 1.3 to 1.2

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

Pathway a

Community 1.4 to 1.1

Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 20 percent. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor in canopy openings.

Pathway b

Community 1.4 to 1.1

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

State 2

Current Potential State

Current Potential State 2.0: This state is similar to the Reference State 1.0, with four general community phases: an old-growth woodland phase, a shrub-herbaceous phase, an immature tree phase, and an infilled tree phase. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of non-native species. These non-natives, particularly cheatgrass, can be highly flammable and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal. Fires within this community with the small amount of non-native annual species present are likely still small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community 2.1

Community Phase



Figure 8. T. Stringham 6/2013, NV780 MU1383; Cavehill soil series

This phase is characterized by a widely dispersed old-growth Utah juniper and singleleaf pinyon trees with an understory of mountain big sagebrush and perennial bunchgrasses. The visual aspect is dominated by singleleaf pinyon and Utah juniper which make up 20 to 35 percent of the overstory canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Bluebunch wheatgrass and Thurber's needlegrass are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot, phlox, and tapertip hawksbeard are minor components. Annual non-native species are present in trace amounts.

Forest overstory. The visual aspect and vegetal structure are dominated by Utah juniper and 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. Upper crowns are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges from 10 to 25 percent.

Forest understory. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic wildfire is a natural factor influencing the understory of mature pinyon/juniper woodlands. Few seedlings and/or saplings of juniper and pinyon occur in the understory. Production ranges from 300 to 700 pounds per acre.

Community 2.2

Community Phase

This community phase is characterized by a post-fire shrub and herbaceous community. Bluebunch wheatgrass and other perennial grasses dominate. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 20 inches in height may be present. Mountain 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.

Forest understory. Various amounts of tree seedlings (less than 20 inches in height) may be present up to the point where they are obviously a major component of the vegetal structure. Herbaceous vegetation and woody shrubs dominate the site.

Community 2.3

Community Phase

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

Forest overstory. The visual aspect and vegetal structure are dominated by singleleaf pinyon and Utah juniper greater than 5m in height. The upper crown of dominant and codominant Utah juniper and singleleaf pinyon are cone or pyramidal shaped.

Forest understory. Various amounts of tree seedlings may be present up to the point where they are obviously a major component of the vegetal structure. Understory vegetation is moderately influenced by a tree overstory canopy.

Community 2.4

Community Phase (at-risk)

This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 20 percent. The density and vigor of the mountain 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.

Forest overstory. The visual aspect and vegetal structure are dominated by Utah juniper and 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. Upper crowns are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges from 25 percent and may be as high as 50 percent.

Forest understory. Understory vegetation is sparse and is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic wildfire is a natural factor influencing the understory of mature pinyon/juniper woodlands. Few seedlings and/or saplings of juniper and pinyon occur in the understory.

Pathway a

Community 2.1 to 2.2

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

Pathway b

Community 2.1 to 2.4

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

Pathway a

Community 2.2 to 2.3

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

Pathway a

Community 2.3 to 2.1

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

Pathway b

Community 2.3 to 2.2

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

Pathway a

Community 2.4 to 2.1

Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 20 percent. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor in canopy openings. Annual non-natives present in trace amounts.

Pathway b

Community 2.4 to 2.2

A high-severity crown fire will eliminate overstory and the shrub component which will allow for herbaceous plants to dominate the site. Annual non-native grasses typically respond positively to fire and may increase in the post-fire community.

State 3

Infilled Tree State

This state has two community phases that are characterized by the dominance of Utah juniper and singleleaf pinyon in the overstory. This state is identifiable by 30 to over 50 percent cover of Utah juniper and singleleaf pinyon. This stand exhibits 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 3.1

Community Phase



Figure 9. PIMO-JUOS-ARTRV (028BY062NV) Phase 3.1 T. Stringham May 2014

Singleleaf pinyon and Utah juniper dominate the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and mountain big sagebrush skeletons are as common as live shrubs due to tree competition for soil water, overstory shading, and duff accumulation. Tree canopy cover is greater than 30 percent. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent and soil redistribution is evident.

Forest overstory. In the absence of wildfire or other naturally occurring disturbances, the tree canopy on this site can become very dense. This stage is dominated by juniper and pinyon that have reach maximal heights for the site. Upper crowns are typically irregularly flat-topped or rounded. Tree canopy cover is at a maximum for the site and is commonly greater than 30 percent.

Forest understory. Understory vegetation is sparse to absent due to tree competition. Production ranges from 75 to 250 pounds per acre.

Community 3.2

Community Phase



Figure 10. PIMO-JUOS-ARTRV (R028BY062NV) Phase 3.2 T. Stringham July 2013

Singleleaf pinyon and Utah juniper dominate the aspect. Tree canopy cover exceeds 30 percent and may be as high as 50 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present exist in the dripline or under the canopy of trees. Mountain sagebrush skeletons are common or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg's bluegrass 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.

Forest overstory. In the absence of wildfire or other naturally occurring disturbances, the tree canopy on this site can become very dense. This stage is dominated by juniper and pinyon that have reach maximal heights for the site. Upper crowns are typically irregularly flat-topped or rounded.

Forest understory. Understory vegetation is sparse to absent due to tree competition. Production ranges from 75 to 200 pounds per acre.

Pathway a Community 3.1 to 3.2



Community Phase



Community Phase

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

State 4 Annual State

This state has two community phases that are 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.

Community 4.1 Community Phase

Cheatgrass, mustards and other non-native annual species dominate the site. Trace amounts of perennial bunchgrasses may be present.

Community 4.2

Community Phase

Cheatgrass, mustards and other non-native annual species dominate the understory. Rabbitbrush dominates the overstory and sagebrush may be present in trace amounts. Singleleaf pinyon and Utah juniper seedlings may be present.

Pathway a Community 4.1 to 4.2

Time and lack of disturbance allow sprouting shrubs to recover and mature. Sagebrush, singleleaf pinyon and Utah juniper may re-establish to a limited extent.

Transition A State 1 to 2

Trigger: Introduction of non-native annual species
Slow variables: Over time the annual non-native plants will increase within the community.
Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variability.

Transition B State 1 to 3

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

Transition A State 2 to 3

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

Transition B State 2 to 4

Trigger: Catastrophic crown fire facilitates the establishment of non-native, annual weeds.
Slow variables: Increase in tree crown cover, loss of perennial understory and an increase in annual non-native species.
Threshold: Cheatgrass or other non-native annuals dominate understory. Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. Increased canopy cover of trees allows severe stand-replacing fire. The increased seed bank of non-native, annual species responds positively to post-fire conditions facilitating the transition to an Annual State.

Restoration pathway A State 3 to 2

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

Conservation practices

Brush Management
Range Planting

Transition A

State 3 to 4

Trigger: Crown fire reduces the tree overstory and allows for the annual non-native species in the understory to dominate the site. Soil disturbing treatments such as slash and burn may also reduce tree canopy and allow for non-native annual species to increase. Slow variables: Over time, cover and production of annual non-native species increases. Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes temporal and spatial nutrient capture and cycling within the community. Increased, continuous fine fuels modify the fire regime by increasing frequency, size, and spatial variability of fires.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	Primary Perennial Grasses			140–286	
	bluebunch wheatgrass	PSSPS	<i>Pseudoroegneria spicata</i> ssp. <i>spicata</i>	56–135	–
	Indian ricegrass	ACHY	<i>Achnatherum hymenoides</i>	28–50	–
	Thurber's needlegrass	ACTH7	<i>Achnatherum thurberianum</i>	28–50	–
	basin wildrye	LECI4	<i>Leymus cinereus</i>	28–50	–
2	Secondary Perennial Grasses			11–56	
	squirreltail	ELEL5	<i>Elymus elymoides</i>	6–28	–
	Sandberg bluegrass	POSE	<i>Poa secunda</i>	6–28	–
Forb					
3	Perennial			34–78	
	arrowleaf balsamroot	BASA3	<i>Balsamorhiza sagittata</i>	6–28	–
	tapertip hawksbeard	CRAC2	<i>Crepis acuminata</i>	6–28	–
Shrub/Vine					
4	Primary Shrubs			56–135	
	mountain big sagebrush	ARTRV	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i>	56–135	–
5	Secondary Shrubs			11–56	
	serviceberry	AMELA	<i>Amelanchier</i>	6–28	–
	antelope bitterbrush	PUTR2	<i>Purshia tridentata</i>	6–28	–
Tree					
6	Evergreen			34–78	
	singleleaf pinyon	PIMO	<i>Pinus monophylla</i>	28–50	–
	Utah juniper	JUOS	<i>Juniperus osteosperma</i>	6–28	–

Animal community

Livestock Interpretations:

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

Inappropriate grazing management during the growing season will cause a decline in understory plants such as

bluebunch wheatgrass, Indian rice ricegrass and Thurber's needlegrass. Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975, Britton et al. 1990). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949). Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988). Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971) however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbenieck 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover after 7 years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended. Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass, mat forming forbs and/or cheatgrass and other invasive species to occupy interspaces. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management. Field surveys indicate native, mat-forming forbs may also increase with decreased bunchgrass density.

Wildlife Interpretations:

Pinyon-juniper woodlands provide a diversity of habitat for wildlife. Although the foliage of pinyon and juniper varies in palatability among fauna, the pinyon nuts and juniper berries are preferred by many species. The understory species provide fruits and browse for large ungulates, small mammals, birds and beaver (Wildlife Action Plan Team 2012).

Ungulates will use pinyon and juniper trees for cover and graze the foliage. The understory species also provide critical browse for deer. The trees provide important cover for mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*) wild horses, mountain lion (*Puma concolor*), bobcat (*Lynx rufus*) and pronghorn (*Antilocapra americana*) (Gottfried and Severson 1994, Coates and Schemnitz 1994, Logan and Irwin 1985, Evans 1988). Mule deer is considered the dominant big game species in the pinyon-juniper woodland and depend heavily on these woodlands for cover, shelter, and emergency forage during severe winters (Frischknecht 1975). Mule deer will eat singleleaf pinyon and juniper foliage, using the foliage moderately in winter, spring, and summer (Kufeld et al. 1973). Deep snows in higher elevation forest zones force mule deer and elk down into pinyon-juniper habitats during winter. This change in habitat allows mule deer and elk to browse the dwarf trees and shrubs (Gottfried and Severson 1994).

The diet of pronghorn antelope varies considerably; however, singleleaf pinyon was shown to comprise 1 to 2 percent of winter diet of pronghorn antelope that occur in pinyon-juniper habitat. Desert bighorn sheep (*Ovis nelsoni*) 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-pinyon 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 (*Psaltiriparus minimus*), Bewick's wren (*Thryomanes bewickii*), Northern mockingbird (*Mimus polyglottos*), blue-gray gnatcatcher (*Polioptila caerulea*), black-throated gray warbler (*Dendroica nigrescens*), house finch (*Haemorhous mexicanus*), spotted towhee (*Pipilo maculatus*), lark sparrow (*Chondestes grammacus*) and black-chinned sparrow (*Zonotrichia atricapilla*) (Balda and Masters 1980). Ferruginous hawk (*Buteo regalis*), a conservation priority species due to recent population declines in Nevada, nest in older trees of sufficient size and structure to support their large nest platforms. (Holechek 1981).

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

Hydrological functions

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

Recreational uses

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

Wood products

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.

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 site has a low site quality for tree production. Site index range from about 40 to 60 (Howell, 1946).

Productivity Class: 0.2 to 0.3 to 0.4

CMAI*: 3.3 to 6.1 cu ft/ac/yr;

0.23 to 0.43 cu m/hr/yr.

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

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

Posts (7 foot): 30 to 40 per acre in stands of medium canopy.

Christmas trees: 20 trees per acre per year in stands of medium canopy. Forty trees per acre in stands of sapling stage.

Pinyon nuts: Production varies year to year, but mature woodland stage can yield 150 to 250 pounds per acre in favorable years.

MANAGEMENT GUIDES AND INTERPRETATIONS

1. LIMITATIONS AND CONSIDERATIONS

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

2. ESSENTIAL REQUIREMENTS

- a. Adequately protect from uncontrolled burning.
- b. Protect soils from accelerated erosion.
- c. Apply proper grazing management practices.

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. Selective harvesting can provide income as well as improve stand quality and yield. Tree harvest will also open overstory canopy to increase understory herbaceous production desirable for grazing by livestock and big game. Save large, healthy, full-crowned pinyon trees for nut producers. Save 4 to 5 foot tall pinyons for Christmas trees. Do not select only "high grade" trees during harvest.
 - 3) Spacing Guide: D+10 to D+12.

3. SILVICULTURAL PRACTICES

- b. Prescription burning program to maintain desired canopy cover and manage site reproduction.
- c. Mechanical tree removal (i.e., chaining) on suitable sites to enhance forage production and manage site reproduction.
- d. Pest control - Porcupines can cause extensive damage and populations should be controlled.
- e. Fire hazard - Fire is usually not a problem in mature, grazed stands.

Other products

Singleleaf pinyon is also used for Christmas trees and as a source of nuts for wildlife and human food. These trees have provided the Indians with food for centuries. Pinyon-juniper ecosystems have had subsistence, cultural, spiritual, economic, aesthetic and medicinal value to Native American peoples for centuries, and singleleaf pinyon has provided food, fuel, medicine and shelter to Native Americans for thousands of years. The pitch of singleleaf pinyon was used as adhesive, caulking material, and a paint binder. It may also be used medicinally and chewed like gum. Pinyon seeds are a valuable food source for humans, and a valuable commercial crop. The berries of Utah juniper have been used by Indians for food. Native Americans used big sagebrush leaves and branches for medicinal teas, and the leaves as a fumigant. Bark was woven into mats, bags and clothing.

Table 7. Representative site productivity

Common Name	Symbol	Site Index Low	Site Index High	CMAI Low	CMAI High	Age Of CMAI	Site Index Curve Code	Site Index Curve Basis	Citation
singleleaf pinyon	<i>PIMO</i>	40	60	3	6	—	—	—	

Type locality

Location 1: White Pine County, NV	
Township/Range/Section	T23N R57E S3
Latitude	39° 53' 53"
Longitude	115° 32' 21"
General legal description	NW¼, Approximately 2 miles south of Little Bald Mountain, White Pine County, Nevada. This site is also found in Elko and Eureka Counties, Nevada.

Other references

Anderson, E. W. and R. J. Scherzinger. 1975. Improving quality of winter forage for elk by cattle grazing. *Journal of Range Management* 28:120-125.

Baker, W.L. and D.J. Shinneman, 2004. Fire and restoration of pinon-juniper woodlands in the western United States. A review. *Forest Ecology and Management* 189:1-21.

Balda, R. P. and N. Masters. 1980. Avian communities in the pinyon-juniper woodland: a descriptive analysis. In: DeGraaf, R. M., technical coordinator. *Management of Western Forests and Grasslands for Nongame Birds: Workshop proceedings. 1980 February 11-14; Salt Lake City, UT. Gen. Tech. Rep. INT-86. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. p. 146-169.*

Beardall, L. E. and V. E. Sylvester. 1976. Spring burning of removal of sagebrush competition in Nevada. Pages 539-547 In: *Proceedings- Tall Timbers fire ecology conference and fire and land management symposium. Tall Timbers Research Station.*

Bich, B. S., J. L. Butler, and C. A. Schmidt. 1995. Effects of differential livestock use on key plant species and rodent populations within selected *Oryzopsis hymenoides*/*Hilaria jamesii* communities of Glen Canyon National Recreation Area. *The Southwestern Naturalist* 40:281-287.

Blaisdell, J. P. 1953. Ecological effects of planned burning of sagebrush-grass range on the upper Snake River Plains. Technical bulletin 1075. US Department of Agriculture. p. 39

Blaisdell, J. P. and J. F. Pechanec. 1949. Effects of herbage removal at various dates on vigor of bluebunch wheatgrass and arrowleaf balsamroot. *Ecology* 30:298-305.

Blaisdell, J. P., R. B. Murray, and E. D. McArthur. 1982. Managing intermountain rangelands-sagebrush-grass ranges. Gen. Tech. Rep. INT-134. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. p. 41

Booth, D. T., C. G. Howard, and C. E. Mowry. 2006. 'Nezpar' Indian ricegrass: description, justification for release, and recommendations for use. *Rangelands Archives* 2:53-54.

Bradley, A. F., N. V. Noste, and W. C. Fischer. 1992. Gen. Tech. Rep. INT-287: Fire Ecology of Forests and Woodlands in Utah. . U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT. p. 128

Britton, C. M., G. R. McPherson, and F. A. Sneva. 1990. Effects of burning and clipping on five bunchgrasses in eastern Oregon. *Great Basin Naturalist* 50:115-120.

- Bunting, S. 1994. Effects of Fire on Juniper woodland ecosystems in the great basin. In: Monsen, S.B. and S.G. Kitchen (compilers). Proceedings--ecology and management of annual rangelands, 18-22 May 1992, Boise, ID. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. Gen. Tech. Rep. INT-GTR-313.
- Bunting, S. C., B. M. Kilgore, and C. L. Bushey. 1987. Guidelines for prescribed burning sagebrush-grass rangelands in the northern Great Basin. Gen. Tech. Rep. INT-231. US Department of Agriculture, Forest Service, Intermountain Research Station Ogden, UT, USA. p. 33
- Burkhardt, J. W. and E. W. Tisdale. 1969. Nature and successional status of Western Juniper vegetation in Idaho. *Journal of Range Management* 22:264-270.
- Busso, C. A. and J. H. Richards. 1995. Drought and clipping effects on tiller demography and growth of two tussock grasses in Utah. *Journal of Arid Environments* 29:239-251.
- Caudle, D., J. DiBenedetto, M. Karl, H. Sanchez, and C. Talbot. 2013. Interagency Ecological Site Handbook for Rangelands. Available at: <http://jornada.nmsu.edu/sites/jornada.nmsu.edu/files/InteragencyEcolSiteHandbook.pdf>. Accessed 4 October 2013.
- Chambers, J., B. Bradley, C. Brown, C. D'Antonio, M. Germino, J. Grace, S. Hardegree, R. Miller, and D. Pyke. 2013. Resilience to stress and disturbance, and resistance to *Bromus tectorum* L. invasion in cold desert shrublands of western North America. *Ecosystems*: 1-16.
- Chambers, J.C., E.W. Schupp and S.B. Vander Wall. 1999. Seed dispersal and seedling establishment of pinyon and juniper species within the pinon-juniper woodland. In: Proceedings: Ecology and Management of Pinyon–Juniper Communities Within the Interior West. Ogden, UT, USA: US Department of Agriculture, Forest Service, Rocky Mountain Research Station, RMRS-P-9. p. 29-34.
- Christopherson, J. 2014. Dwarf Mistletoe (*Arceuthobium* spp.). Nevada Division of Forestry, 2478 Fairview Drive Carson City, Nevada 89701.
- Coates, K.P. and S.D. Schemnitz. 1994. Habitat use and behavior of male mountain sheep in foraging associations with wild horses. *Great Basin Naturalist*. 54:86-90
- Conrad, C. E. and C. E. Poulton. 1966. Effect of a wildfire on Idaho fescue and bluebunch wheatgrass. *Journal of Range Management* 19:138-141.
- Daubenmire, R. 1970. *Steppe Vegetation of Washington*. 131 pp.
- Daubenmire, R. 1975. Plant succession on abandoned fields, and fire influences in a steppe area in southeastern Washington. *Northwest Science* 49:36-48.
- Durham, G. 2014. Juniper Pocket Rot (*Pyrofomes demidoffii*). Nevada Division of Forestry, 2478 Fairview Drive, Carson City, Nevada 89701.
- Eckert, R. E., Jr. and J. S. Spencer. 1987. Growth and reproduction of grasses heavily grazed under rest-rotation management. *Journal of Range Management* 40:156-159.
- Eddleman, L.E., P.M. Miller, R.F. Miller, P.L. Dysart. 1994. Western juniper woodlands of the pacific northwest: science assessment. Department of Rangeland Resources, Oregon State University, Corvallis, OR.
- Emerson, F.W. 1932. The tension zone between the grama grass and pinyon-juniper associations in northeastern New Mexico. *Ecology*: 13: 347-358.
- Evans, Raymond A. 1988. Management of pinyon-juniper woodlands. Gen. Tech. Rep. INT-249. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 34 pp.
- Evans, R. A. and J. A. Young. 1978. Effectiveness of rehabilitation practices following wildfire in a degraded big sagebrush-downy brome community. *Journal of Range Management* 31:185-188.

- Everett, R. L. and K. Ward. 1984. Early plant succession on pinyon-juniper controlled burns. *Northwest Science* 58:57-68.
- Ffolliott, P.F. and G.J. Gottfried. 2012. Hydrologic processes in the pinyon-juniper woodlands: A literature review. Gen. Tech. Rep. RMRS-GTR-271. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 20 p.
- Frischknecht, N.C. 1975. Native faunal relationships within the pinyon-juniper ecosystem. Pp. 55-65. In: *Proceedings of The Pinyon-Juniper Ecosystem: A Symposium*. May 1975. Utah State University. Logan, UT.
- Furniss, M. M. and W. F. Barr. 1975. Insects affecting important native shrubs of the northwestern United States. US Intermountain Forest And Range Experiment Station. General Technical Report INT-19. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Ogden UT. p. 64.
- Ganskopp, D. 1988. Defoliation of Thurber needlegrass: herbage and root responses. *Journal of Range Management* 41:472-476.
- Gese, E.M., O.J. Rongstad and W.R. Mytton 1988. Home range and habitat use of coyotes in southeastern Colorado. *Journal of Wildlife Management* 52:640-646.
- Gottfried, G.J. and K.E. Severson. 1994. Managing pinyon-juniper woodlands. *Rangelands* 16:234-236
- Gottfried, G.J.; Ffolliott, P.F.; Baker, M.B., Jr. 2000. Measurement of historical inventory locations to assess changes in forest and woodlands in Arizona. In: Cook, J.E.; Oswald, B.P. (comp). *First Biennial North American Forest Ecology Workshop*. June 24-26, 1997; North Carolina State University, Raleigh, NC. 51-52 p.
- Gruell, G.E. 1999. Historical and modern roles of fire in pinyon-juniper. In: S. B. Monsen, R. Stevens [comps.] *Proceedings: ecology and management of pinyon-juniper communities within the Interior West*. RMRS-P-9. Ogden, UT, USA: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 24-28.
- Hepting, G.H. 1971. *Diseases of Forest and Shade Trees of the United States*. U.S. Department of Agriculture Handbook 386. 658 pp.
- Heyerdahl, E.K., Miller, R.F, and Parsons, R.A. 2006. History of fire and Douglas-fir establishment in a savanna and sagebrush grassland mosaic, southwestern Montana, USA. *Forest Ecology and Management*. 230:107-118.
- Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Bulletin Number 35. University of Idaho, Forest, Wildlife and Range Experiment Station, Moscow, ID.
- Holechek, J. L. 1981. Brush control impacts on rangeland wildlife. *Journal of Soil and Water Conservation* 36: 265-269.
- Holmes, R.L., R.K., Adams, H.C. Fritts. 1986. Tree ring chronologies of western North America: California, eastern Oregon and northern Great Basin. *Chronology Series VI*. Laboratory of Tree Ring Research, University of Arizona, Tucson, AZ 183 pp.
- Hoffmeister, D.F. 1981. Mammalian species: *Peromyscus truei*. *The American Society of Mammologists* 161:1-5.
- Houghton, J.G., C.M. Sakamoto, and R.O. Gifford. 1975. Nevada's Weather and Climate, Special Publication 2. Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno, NV.
- Houston, D. B. 1973. Wildfires in northern Yellowstone National Park. *Ecology* 54:1111-1117.
- Howell, J., 1940. Pinyon and juniper: a preliminary study of volume, growth, and yield. *Regional Bulletin* 71. Albuquerque, NM: USDA, SCS; 90p.

- Huber, A., S. Goodrich, K. Anderson. 1999. Diversity with successional status in the pinyon-juniper/mountain mahogany/bluebunch wheatgrass community type near Dutch John, Utah. In: S. B. Monsen, R. Stevens [comps.] Proceedings ecology and management of pinyon-juniper communities within the Interior West; 1997 September 15-18. RMRS-P-9. US Department of Agriculture, Forest Service, Rocky Mountain Research Station Proceedings. p. 114-117
- Hurst, W.D. 1975. Management strategies within the pinyon-juniper ecosystem. Pp. 187-192. Proceedings of The Pinyon-Juniper Ecosystem: A Symposium. Utah State University, Logan, UT.
- Jameson, D.A. 1970. Degradation and accumulation on inhibitory substances from *Juniperus osteosperma* (Torr.) Little. Plant Soil 33: 213-224.
- Kitchen, A.M., E.M. Gese, and E.R. Schauster. 2000. Changes in coyote activity patterns due to reduced exposure to human persecution. Canada Journal of Zoology. 78:853-857
- Koniak, S. 1985. Succession in pinyon-juniper woodlands following wildfire in the Great Basin. The Great Basin Naturalist 45:556-566.
- Kufeld, R.C., O.C. Wallmo and C. Feddema. 1973. Foods of the Rocky Mountain Mule Deer. Rocky Mountain Forest and Range Experiment Station. USDA Forest Service, Research Paper RM-111. P. 31.
- Lanner, R.M. 1981. The Pinon Pine – A Natural and Cultural history. University of Nevada Press, Reno, NV.
- Laycock, W. A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. Journal of Range Management 20:206-213.
- Ligon, J. D. 1974. Green cones of the pinon pine stimulate late breeding in the pinon jay. Nature 250 (5461): 80-82.
- Logan, K. A., Irwin, L. L. 1985. Mountain lion habitats in the Big Horn Mountains, Wyoming. Wildlife Society Bulletin 13: 257-262.
- McArthur, E. D., A. Blaner, A. P. Plummer, and R. Stevens. 1982. Characteristics and hybridization of important Intermountain shrubs: 3. Sunflower family. En Ref. in Forest. Abstr 43:2176.
- Meewig, R.O. and R.L. Bassett. 1983. Pinyon-juniper. In: R. Burns [comp.] Silvicultural Systems for the Major Forest Types of the United States. Pp. 84-86. Agric. Handbook. 455, Washington, D.C., USA.
- Miller, R.F. and T.J. Rose. 1995. Historic expansion of *Juniperus occidentalis* (western juniper) in southeastern Oregon. Great Basin Naturalist. 55:37-45.
- Miller, R.F. and T.J. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management. 52:550-559.
- Miller, R.F. R.J. Tausch and W. Waichler. 1999. Old-growth juniper and pinyon woodlands. In: Monsen, S.D. and R. Stevens. Comps. Proceedings: Ecology and Management of Pinyon-Juniper communities within the interior West; 1997 September 15-18; Provo, UT. USDA, Forest Service RMRS-P-9: 375-384 Logan Ut.
- Miller, R.F. and R.J. Tausch. 2001. The role of fire in pinyon and juniper woodlands: a descriptive analysis. In: Galley, K.E.M., Wilson, T.P. eds. Invasive Species: the role of fire in the control and spread of invasive species symposium. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, FL. 15-30.
- Miller, R. F. and E. K. Heyerdahl. 2008. Fine-scale variation of historical fire regimes in sagebrush-steppe and juniper woodland: an example from California, USA. International Journal of Wildland Fire 17:245-254.
- Miller, R.F. R.J. Tasuch, E.D. McArthur, D.D. Johnson and S.C. Sanderson. 2008. Age Structure and Expansion of Pinon-Juniper Woodlands: A Regional Perspective in the Intermountain West. Res. Pap. RMRS-RP-69. Fort Collins CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 15

- Mueggler, W. F. 1975. Rate and pattern of vigor recovery in Idaho fescue and bluebunch wheatgrass. *Journal of Range Management* 28:198-204.
- National Oceanic and Atmospheric Administration. 2004. The North American Monsoon. Reports to the Nation. National Weather Service, Climate Prediction Center. Available online: <http://www.weather.gov/>
- Neuenschwander, L. 1980. Broadcast burning of sagebrush in the winter. *Journal of Range Management* 33:233-236.
- Noy-Meir, I. 1973. Desert Ecosystems: Environment and Producers. *Annual Review of Ecology and Systematics* 4:25-51.
- Pearson, L. 1964. Effect of harvest date on recovery of range grasses and shrubs. *Agronomy Journal* 56:80-82.
- Pearson, L. C. 1965. Primary Production in Grazed and Ungrazed Desert Communities of Eastern Idaho. *Ecology* 46:278-285.
- Phillips, F. J. 1909. A study of pinyon pine. *Bot. Gaz.* 48: 216-223.
- Phillips, G. 2014. Pinyon Needle Scales. Nevada Division of Forestry, 2478 Fairview Drive, Carson City, Nevada.
- Quinones, F. A. 1981. Indian ricegrass evaluation and breeding. Bulletin 681. Page 19. New Mexico State University, Agricultural Experiment Station, Las Cruces, NM.
- Robberecht, R. and G. Defossé. 1995. The relative sensitivity of two bunchgrass species to fire. *International Journal of Wildland Fire* 5:127-134.
- Romme, W., C.Allen, J. Bailey, W.Baker, B. Bestelmeyer, P. Brown, K. Eisenhart, L. Floyd-Hanna, D. Huffman, B.Jacobs, R. Miller, E. Muldavin, T. Swetnam, R. Tausch, and P. Weisberg. 2007. Historical and Modern Disturbance Regimes of Pinon-Juniper Vegetation in the Western U.S. 13pp.
- Schupp, E.W., J.C. Chambers, S.B. Vander Wall, J.M. Gomez, M. Fuentes. 1999. Piñon and juniper seed dispersal and seedling recruitment at woodland ecotones. In: E. D. McArthur, K. W. Ostler, L. Carl [comps.] *Proceedings: Shrubland ecotones; 1998 August 12-14; Ephraim UT. Proc. RMRS-P-11. Ogden UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.* p. 66-70.
- Sheehy, D. P. and A. H. Winward. 1981. Relative palatability of seven *Artemisia* taxa to mule deer and sheep. *Journal of Range Management* 34:397-399.
- Short, H.L. and C.Y. McCulloch. 1977. Managing Pinyon-Juniper Ranges for Wildlife. USDA For. Ser. Gen Tech Rept. RM-47. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 10 pp.
- Stringham, T.K., P. Novak-Echenique, P. Blackburn, C. Coombs, D. Snyder and A. Wartgow. 2015. Final Report for USDA Ecological Site Description State-and-Transition Models, Major Land Resource Area 28A and 28B Nevada. University of Nevada Reno, Nevada Agricultural Experiment Station Research Report 2015-01. p. 1524.
- Tausch, R. J. 1999. Historic pinyon and juniper woodland development. In: S. B. Monsen, R. Stevens [comps.] *Proceedings ecology and management of pinyon-juniper communities within the Interior West; 1997 September 15-18. RMRS-P-9. US Department of Agriculture, Forest Service, Rocky Mountain Research Station Proceedings.* p. 12-19.
- Tausch, R. J. and N. E. West. 1988. Differential establishment of pinyon and juniper following fire. *American Midland Naturalist* 119:174-184.
- Tausch, R.J., N.E. West, and A.A. Nabi. 1981. Tree age and dominance patterns in Great Basin pinyon-juniper woodlands. *Journal of Range Management* 34: 259-264.
- Tisdale, E. W. and M. Hironaka. 1981. The sagebrush-grass region: A review of the ecological literature. University

of Idaho, Forest, Wildlife and Range Experiment Station.

Tueller, P.T., and J.E. Clark. 1975. Autecology of pinyon-juniper species of the Great Basin and Colorado Plateau. Pp. 27-40. Proceedings of The Pinyon-Juniper Ecosystem: A Symposium. Utah State University, Logan, UT.

Turkowski, F. J. and R. K. Watkins. 1976. White-throated woodrat (*Neotoma albigula*) habitat relations in modified pinyon-juniper woodland of southwestern New Mexico. *Journal of Mammalogy*. 57: 586-591.

USDA-NRCS Plants Database (Online; <http://www.plants.usda.gov>).

USDA-NRCS. 1980. National Forestry Manual - Part 537. Washington, D.C.

Uresk, D. W., J. F. Cline, and W. H. Rickard. 1976. Impact of wildfire on three perennial grasses in south-central Washington. *Journal of Range Management* 29:309-310.

Vallentine, J. F. 1989. Range Development and Improvements. Academic Press, Inc. San Diego, CA. p. 524.

Vose, J. M. and A. S. White. 1991. Biomass response mechanisms of understory species the first year after prescribed burning in an Arizona ponderosa-pine community. *Forest Ecology and Management* 40:175-187.

Weisberg, P.J. and W.K. Dongwook. 2012. Old tree morphology in singleleaf pinyon pine (*Pinus monophylla*). *Forest Ecology and Management* 263:67-73.

West, N. E. 1994. Effects of fire on salt-desert shrub rangelands. In: S. B. Monsen [ed.] Proceedings--Ecology and Management of Annual Rangelands, General Technical Report INT-313. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Boise, ID. p. 71-74

West, N.E., K.H. Rea, and R.J. Tausch. 1975. Basic synecological relationships in juniper-pinyon woodlands. Pp 41-52. Proceedings of The Pinyon-Juniper Ecosystem: A Symposium. Utah State University, Logan, UT.

West, N.E. R.J. Tausch and P.T. Tueller. 1998. A Management Oriented Classification of Pinyon-juniper Woodlands in the Great Basin. Gen. Tech. Rep. RMRS-GTR-12. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 42

Wildlife Action Plan Team. 2012. Nevada Wildlife Action Plan. Nevada Department of Wildlife, Reno, NV.

Wright, H. A. 1985. Effects of fire on grasses and forbs in sagebrush-grass communities. Pages 12-21 in: K. Sanders, J. Durham [eds.] Rangeland Fire Effects; A Symposium: Boise, ID, USDI-BLM.

Wright, H. A. and J. O. Klemmedson. 1965. Effect of fire on bunchgrasses of the sagebrush-grass region in southern Idaho. *Ecology* 46:680-688.

Wright, H. A. 1971. Why squirreltail is more tolerant to burning than needle-and-thread. *Journal of Range Management* 24:277-284.

Wright, H. A. and J. O. Klemmedson. 1965. Effect of fire on bunchgrasses of the sagebrush-grass region in southern Idaho. *Ecology* 46:680-688.

Young, R. P. 1983. Fire as a vegetation management tool in rangelands of the Intermountain Region. In S. B. Monsen and N. Shaw [TECH CORDS.]. Proceedings: Managing Intermountain Rangelands - Improvement of Range and Wildlife Habitats. Twin Falls, ID: USDA, Forest Service INT-GTR-157. p. 18-31.

Ziegenhagen, L. L. 2003. Shrub reestablishment following fire in the mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* (Rydb.) Beetle) alliance. M.s. Oregon State University.

Ziegenhagen, L. L. and R. F. Miller. 2009. Postfire recovery of two shrubs in the interiors of large burns in the Intermountain West, USA. *Western North American Naturalist* 69:195-205.

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

-
9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**
-
10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**
-
11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**
-
12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**
- Dominant:
- Sub-dominant:
- Other:
- Additional:
-
13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**
-
14. **Average percent litter cover (%) and depth (in):**
-
15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**
-
16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**
-
17. **Perennial plant reproductive capability:**
-