USDA Natural Resources Conservation Service

Ecological site F028BY058NV
PIMO-CELE3/ARTRV/PSSPS-POFE

Accessed: 04/20/2024

General information

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

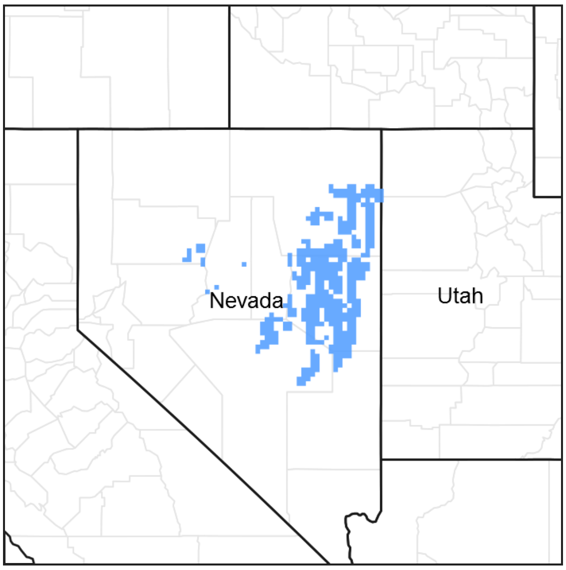

Figure 1. Mapped extent

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

MLRA notes

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

MLRA 28B occurs entirely in Nevada and comprises about 23,555 square miles (61,035 square kilometers). More than nine-tenths of this MLRA is federally owned. This area is in the Great Basin Section of the Basin and Range Province of the Intermontane Plateaus. It is an area of nearly level, aggraded desert basins and valleys between a series of mountain ranges trending north to south. The basins are bordered by long, gently sloping to strongly sloping alluvial fans. The mountains are uplifted fault blocks with steep sideslopes. Many of the valleys are closed basins containing sinks or playas. Elevation ranges from 4,900 to 6,550 feet (1,495 to 1,995 meters) in the valleys and basins and from 6,550 to 11,900 feet (1,995 to 3,630 meters) in the mountains.
The mountains in the southern half are dominated by andesite and basalt rocks that were formed in the Miocene and Oligocene. Paleozoic and older carbonate rocks are prominent in the mountains to the north. Scattered outcrops of older Tertiary intrusives and very young tuffaceous sediments are throughout this area. The valleys consist mostly of alluvial fill, but lake deposits are at the lowest elevations in the closed basins. The alluvial valley fill consists of cobbles, gravel, and coarse sand near the mountains in the apex of the alluvial fans. Sands, silts, and clays are on the distal ends of the fans.
The average annual precipitation ranges from 4 to 12 inches (100 to 305 millimeters) in most areas on the valley floors. Average annual precipitation in the mountains ranges from 8 to 36 inches (205 to 915 millimeters) depending on elevation. The driest period is from midsummer to midautumn. The average annual temperature is 34 to 52 degrees F (1 to 11 degrees C). The freeze-free period averages 125 days and ranges from 80 to 170 days, decreasing in length with elevation.

The dominant soil orders in this MLRA are Aridisols, Entisols, and Mollisols. The soils in the area dominantly have a mesic soil temperature regime, an aridic or xeric soil moisture regime, and mixed or carbonatic mineralogy. They generally are well drained, loamy or loamyskeletal, and shallow to very deep.
Nevada's climate is predominantly arid, with large daily ranges of temperature, infrequent severe storms and heavy snowfall in the higher mountains. Three basic geographical factors largely influence Nevada's climate: continentality, latitude, and elevation. The strong continental effect is expressed in the form of both dryness and large temperature variations. Nevada lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that markedly influences the climate of the State. The prevailing winds are from the west, and as the warm moist air from the Pacific Ocean ascend the western slopes of the Sierra Range, the air cools, condensation occurs and most of the moisture falls as precipitation. As the air descends the eastern slope, it is warmed by compression, and very little precipitation occurs. The effects of this mountain barrier are felt not only in the West but throughout the state, as a result the lowlands of Nevada are largely desert or steppes.
The temperature regime is also affected by the blocking of the inland-moving maritime air. Nevada sheltered from maritime winds, has a continental climate with well-developed seasons and the terrain responds quickly to changes in solar heating. Nevada lies within the midlatitude belt of prevailing westerly winds which occur most of the year. These winds bring frequent changes in weather during the late fall, winter and spring months, when most of the precipitation occurs.
To the south of the mid-latitude westerlies, lies a zone of high pressure in subtropical latitudes, with a center over the Pacific Ocean. In the summer, this high-pressure belt shifts northward over the latitudes of Nevada, blocking storms from the ocean. The resulting weather is mostly clear and dry during the summer and early fall, with occasional thundershowers. The eastern portion of the state receives noteworthy summer thunderstorms generated from monsoonal moisture pushed up from the Gulf of California, known as the North American monsoon. The monsoon system peaks in August and by October the monsoon high over the Western U.S. begins to weaken and the precipitation retreats southward towards the tropics (NOAA 2004).

Ecological site concept

This site occurs on mountain sideslopes of mostly northerly aspects at lower elevations (<7500'), and on all aspects at higher elevations (>7500'). Slopes are typically 30 to 50 percent. Elevations are 7000 to 8500 feet. Soils are shallow to bedrock, well drained and formed in residuum and colluvium derived from andesite, welded tuff and rhyolite. Soils are characterized by a 18cm thick mollic epipedon and a horizon of clay accumulation.
The reference state is dominated by singleleaf pinyon in association with curlleaf mountain mahogany. An overstory canopy of 20 to 35 percent is assumed to be representative. Mountain big sagebrush is the principal understory shrub. Antelope bitterbrush, snowberry and serviceberry are other important shrubs. Bluebunch wheatgrass, basin wildrye and muttongrass are the most prevalent understory grasses. Arrowleaf balsamroot, tapertip hawksbeard, and phlox are common understory forbs. Overstory tree canopy composition is about 80 to 95 percent singleleaf pinyon and 5 to 15 percent curlleaf mountain mahogany along with the occasional Utah juniper. Understory production ranges from 200 to 500 pounds per acre.

Where this site is currently mapped questions exist as to the validity of the site concept. Following a complete review of the soil series correlated to this site concept it has been determined it is a likely community phase or a transition zone. Future work will field check soil map unit components, as well as, collect cover and structure information in order correlate as appropriate.

Associated sites

F028BY060NV	**PIMO-JUOS/ARNO4/PSSPS-ACHY**
F028BY062NV	**PIMO-JUOS/ARTRV/PSSPS-ACTH7**
R028BY007NV	**LOAMY 10-12 P.Z.**
R028BY087NV	**GRAVELLY CLAY 12-14 P.Z.**
R028BY093NV	**SHALLOW CLAY LOAM 12-14 P.Z.**

Similar sites

F028BY062NV	**PIMO-JUOS/ARTRV/PSSPS-ACTH7** Lower site index. Curlleaf mountain mahogany sparse to absent.

F028BY076NV	**Cobbly Mountain Slopes 12-16 PZ** Lower site index. Curlleaf mountain mahogany absent. Less understory production

Table 1. Dominant plant species

Tree	(1) *Pinus monophylla*
Shrub	(1) *Cercocarpus ledifolius* (2) *Artemisia tridentata subsp. vaseyana*
Herbaceous	(1) *Pseudoroegneria spicata subsp. spicata* (2) *Poa*

Physiographic features

This site occurs on mountain sideslopes of mostly northerly aspects at lower elevations (7000 to 7500 feet), and on all aspects at higher elevations (greater than 7500 feet). Slopes range from 8 to over 75 percent, but are typically 30 to 50 percent. Elevations typically range from 7000 to 8500 feet, but may occur above 9000 feet.

Table 2. Representative physiographic features

Landforms	(1) Mountain (2) Hill
Elevation	7,000–8,500 ft
Slope	30–50%
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 for this site ranges from 14 to 22 inches. Mean annual air temperature is about 40 to 43 degrees F. The average growing season is 50 to 70 days.

Mean annual precipitation at the OLD RUTH, NEVADA climate station (265760) is 14.15 inches.

Monthly mean precipitation is:
January 1.33; February 0.95; March 1.61; April 0.73;
May 1.31; June 0.42; July 0.89; August 1.46;
September 1.72; October 1.54;
November 1.02; December 1.16.

Table 3. Representative climatic features

Frost-free period (average)	91 days
Freeze-free period (average)	119 days
Precipitation total (average)	14 in

Climate stations used

- (1) RUTH [USC00267175], Ely, NV

Influencing water features

Influencing water features are not associated with this site.

Soil features

The soils associated with this site are shallow to bedrock, well drained and formed in residuum/colluvium derived from volcanic parent material. They are characterized by a 18cm thick mollic epipedon and an argillic horizon. A typical soil profile is skeletal with over 60 percent by volume rock fragments. The soil temperature regime is frigid and the soil moisture regime xeric. Available water holding capacity is very low to low. Trees and shrubs extend their roots into fractures in the bedrock allowing them to utilize deep moisture. Runoff is high to very high and the potential for sheet and rill erosion is moderate to severe, depending on slope. The soil series correlated to this site include: Cavehill, Clanalpine, Cropper, Grandeposit and Ravenswood.

The representative soil component is Cropper (NV780, MU 481), classified as a Loamy-skeletal, mixed, superactive, frigid Aridic Lithic Argixerolls. Diagnostic horizons include a mollic epipedon from the soil surface to 18cm and an argillic horizon from 10 to 41cm. Bedrock occurs below 41cm. Clay content in the particle size control section average 27 to 35 percent. Rock fragments range from 60 to 75 percent, mostly gravel. Reaction is neutral to slightly alkaline. Parent material consists of andesite, welded tuff and rhyolite.
Where this site is currently mapped questions exist as to the validity of the site concept. Following a comprehensive review of soil map unit components and ecological site concepts, in 2016, it has been determined this site is a likely community phase or a transition zone. Future work will field check soil map unit components, as well as, collect cover and structure information in order correlate as appropriate. Land managers and others should be aware that individual soil map unit components currently correlated to this site may be better represented by a different site concept.

Table 4. Representative soil features

Parent material	(1) Residuum–andesite (2) Colluvium–welded tuff (3) Colluvium–rhyolite
Surface texture	(1) Very cobbly loam (2) Very gravelly loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderate to moderately rapid
Soil depth	14–20 in
Surface fragment cover <=3"	10–25%
Surface fragment cover >3"	3–20%
Available water capacity (0-40in)	1.1–3 in
Calcium carbonate equivalent (0-40in)	0–5%
Electrical conductivity (0-40in)	0 mmhos/cm
Sodium adsorption ratio (0-40in)	0–1
Soil reaction (1:1 water) (0-40in)	6.6–7.8
Subsurface fragment volume <=3" (Depth not specified)	60–75%
Subsurface fragment volume >3" (Depth not specified)	0–30%

Ecological dynamics

An ecological site is the product of all the environmental factors responsible for its development and 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 including: (1) cessation of the aboriginal burning (Tausch 1999), (2) change in climate with rising temperatures (Heyerdahl et al. 2006), (3) the reduced frequency of fire likely driven by the introduction of domestic livestock, (4) a decrease in wildfire frequency along with improved wildfire suppression efforts and (5) potentially increased CO_2 levels favoring woody plant establishment (Tausch 1999, Bunting 1994). Miller et al. (2008) found presettlement tree densities averaged 2 to 11 per acre in six woodlands studied across the Intermountain West. Current stand densities range from 80 to 358 trees/ac. In Utah, Nevada, and Oregon, trees establishing prior to 1860 accounted for only 2 percent or less of the total population of pinyon and juniper (Miller et al. 2008). 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); thus, tree canopy cover of 10 to 20% may be more representative of these sites in pristine condition. Increases in pinyon and juniper densities post-settlement were the result of both infill in mixed age tree communities and expansion into shrub-steppe communities. Pre-settlement trees accounted for less than 2 percent of the stands sampled in Nevada, Oregon and Utah (Miller et al. 2008, Miller and Tausch 2001, Miller et al. 1999). However, the proportion of old-growth can vary depending on disturbance regimes, soils and climate. Some ecological sites are capable of supporting persistent woodlands, likely due to specific soils and climate resulting in infrequent stand replacement disturbance regimes. In the Great Basin, old-growth trees have been found to typically grow on rocky shallow or sandy soils that support little understory vegetation to carry a fire (Holmes et al. 1986, Miller and Rose 1995, West et al. 1998).

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

The pinyon jay (Gymnorhinus cyanocephalus) and other members of the seed caching corvids play an important role in pinyon pine regeneration. These birds cache the seeds in the soil for future use. Those seeds that escape harvesting by the birds and rodents have the opportunity to germinate under favorable soil and climatic conditions (Lanner 1981). 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 juniper trees increase in density so does 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 juniper stands are dependent on a number of variables such as plant species present at the time of disturbance and their individual responses to disturbance, past management, type and size of disturbance, available seed sources in the soil or adjacent areas, and site and climatic conditions throughout the successional process.

Utah juniper can be killed by a fungus called juniper pocket rot (Pyrofomes demidoffi), also known as white truck rot (Eddleman et al. 1994 and Durham 2014). Pocket rot enters the tree through any wound or opening that exposes the heartwood. In an advanced stage, this fungus can cause high mortality (Durham 2014). Dwarf mistletoe (Phorandendron spp.), a parasitic plant, may also affect Utah juniper and without treatment or pruning, may kill the tree 10-15 years after infection. Seedlings and saplings are most susceptible to dwarf mistletoe (Christopherson 2014). Other diseases affecting juniper include: witches'-broom (Gymnosporangium sp.), which may girdle and kill branches; leaf rust (Gymnosporangium sp.) on leaves and young branches; and juniper blight (Phomopsis sp.). Insects include flat-head borers (Chrysobothris sp.), which attack the wood; long-horned beetles (Methia juniper (Styloxus bicolor) which girdle limbs and twigs; and round-head borers (Callidium spp.), which attack twigs and limbs (Tueller and Clark 1975).

Phillips (1909) recognized that the pinyons are more resistant to disease than most of the conifers with which it associates. Hepting (1971) lists several diseases affecting pinyon including foliage diseases, a tarspot needle cast, stem diseases such as blister rust and dwarf mistletoe, root diseases and trunk rots, red heart rot, and but rot. The pinyon ips beetle (Ips confuses) and pinyon needle scale (Matsucoccus acalyptus) are both native insects to Nevada that attack pinyon pines throughout their range. The pinyon needle scale weakens trees by killing needles older than 1 year. Small trees can be killed by repeated feeding and large trees are weakened to the point that they are attacked by the pinyon ips beetle, which 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 basin wildrye. Other common grasses include muttongrass, Sandberg bluegrass (*Poa secunda*), and squirreltail (*Elymus elymoides*). 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.

Curl-leaf mountain mahogany is a multi-branched, evergreen shrub or tree extending from 3 to over 20 feet in height. The rooting of mountain mahogany is spreading and limited by the depth to bedrock. Youngberg and Hu (1972) reported in an Oregon study that curl-leaf mountain mahogany produces nitrogen-fixing root nodules. They also reported that nodulated plants had the highest amounts of nitrogen in the leaves. Most often, curl-leaf mountain mahogany stands occur on warm, dry, rocky ridges or outcrops where fire would be an infrequent occurrence (USDA 1937). Dealy (1975) and Scheldt (1969) found that mahogany trees were larger and older on fire-resistant rocky sites and were the seed source if fire destroyed the non-rocky portion of the site.

Curl-leaf mahogany plants are long-lived and can reach 1,300+ years of age (Schultz 1987, Schultz et al. 1990). As mahogany stands increase in average age, average canopy volume and height of the individuals present also increases. As average canopy height and volume increase, stand density declines (Schultz et al 1991). Stands with a closed, or nearly closed canopy often have few or no young curl-leaf mahogany (i.e., recruitment) in the understory (Schultz et al. 1990, 1991), despite high seed density beneath trees (Russell and Schupp 1998, Ibanez and Schupp 2002). Intraspecific competition reduces the growth rates of all age classes below the potential growth rates for the species. Competition may also increase mortality in the younger plants.

Curl-leaf mahogany plants are very self-compatible for pollination and most developing seed matures and is viable (Russell et al. 1998). The deep litter throughout stands with high canopy cover appears to facilitate seed germination but retard seedling survival due to poor contact between the root and the soil (Schultz et al. 1996, Ibanez and Schupp 2001). Reproduction in large stands with high canopy cover occurs most often in canopy gaps where a tree has died and an increase in exposure of bare ground occurs, or around the perimeter of the stand under sagebrush plants where there is less, typically shallow litter cover (Schultz 1987, Schultz et al. 1991).

Mahogany seeds require bare mineral soil to germinate and litter depths over 0.25 inches can impede recruitment (Gruell 1985, Schultz et al. 1991, Ibáñez et al. 1998, Ibáñez 2002). Once germination occurs, the seedlings exhibit rapid growth in relation to top growth, providing some resistance to drought and competition with invasive species (Dealy 1975). Multiple sources (Schultz et al. 1996, Ibáñez et al. 1999) found that mahogany seedlings germinate abundantly under the canopy of adult plants but rarely successfully establish there due to shading and higher litter amounts. In addition, Schultz et al. (1996) found that seedlings had significantly higher long-term success in areas dominated by sagebrush canopy than in areas under mahogany canopy or in interspaces. Some hypothesize that the light shading and hydraulic lift provided by sagebrush may create a microsite facilitating mahogany recruitment (Gruell 1985, Ibáñez et al. 1999). Dealy (1975) reported that curl-leaf mahogany seedlings have a mean taproot length of 0.97 meters after 120 days. The mean top height was slightly less than 2.5 centimeters. Multiple sources (Schultz et al. 1996, Ibáñez et al. 1998) found that mahogany seedlings germinate abundantly under the canopy of adult plants but rarely successfully establish there due to shading and higher litter amounts. In addition, Schultz et al. (1996) found that seedlings had significantly higher long term success in areas dominated by sagebrush canopy than in areas under mahogany canopy or in interspaces.

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 ecological 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 ecological site.

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

Utah juniper is usually killed by fire, and is most vulnerable to fire when it is under four feet tall (Bradley et al. 1992). Larger trees, because they have foliage farther from the ground and thicker bark, can survive low severity fires but mortality does occur when 60% or more of the crown is scorched (Bradley et al. 1992). Singleleaf 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 Utah juniper reestablish by seed from nearby seed sources or surviving seeds. Junipers have a long-lived seed bank due to delayed germination by impermeable seed coats, immature or dormant embryos and germination inhibitors (Chambers et al. 1999). Singleleaf pinyon trees have relatively short-lived seeds with little innate dormancy that form only temporary seed banks with most seeds germinating the spring following dispersal (Meewig and Bassett 1983). Density of pinyon seeds in the seed bank is dependent upon the current year’s cone crop. Singleleaf pinyon are known to have favorable cone production every two to three years thus the potential for a large temporary seed bank is high during mast years and likely low during non-mast years (Chambers et al.

1999). The role of nurse plant requirements between the two tree species is important to post-fire establishment. Chambers et al. (1999) found that singleleaf pinyon seedlings rarely establish in interspaces or open environments. In contrast, Utah juniper seedlings were found capable of establishing in interspace microhabitats as frequently as under sagebrush. Therefore, fire that removes both trees and understory shrubs in pinyon-juniper woodlands may have a relatively greater effect on the establishment of pinyon than juniper.

Most often curl-leaf mountain mahogany stands occur on warm, dry, rocky ridges or outcrops where fire would be an infrequent occurrence (USDA Forest Service 1937). Dealy (1974) and Scheldt (1969) found that mahogany trees were larger and older on fire-resistant rocky sites and were the seed source if fire destroyed the non-rocky portion of the site. Mahogany will persist longest in rocky areas where it is protected from fire. Because of their thicker bark, mature trees can often survive low-severity fires (Gruell 1985). Curl-leaf mountain mahogany is considered a weak sprouter after fire. It is usually moderately to severely damaged by severe fires and the recovery time of these sites is variable; some measurements show that stands lack recruitment for up to 30 years post-fire (Gruell 1985).

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 such as 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, though 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, but 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 factor into the individual species' responses. 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.

Sandberg bluegrass (*Poa secunda*) 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 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 muttongrass.

State and transition model

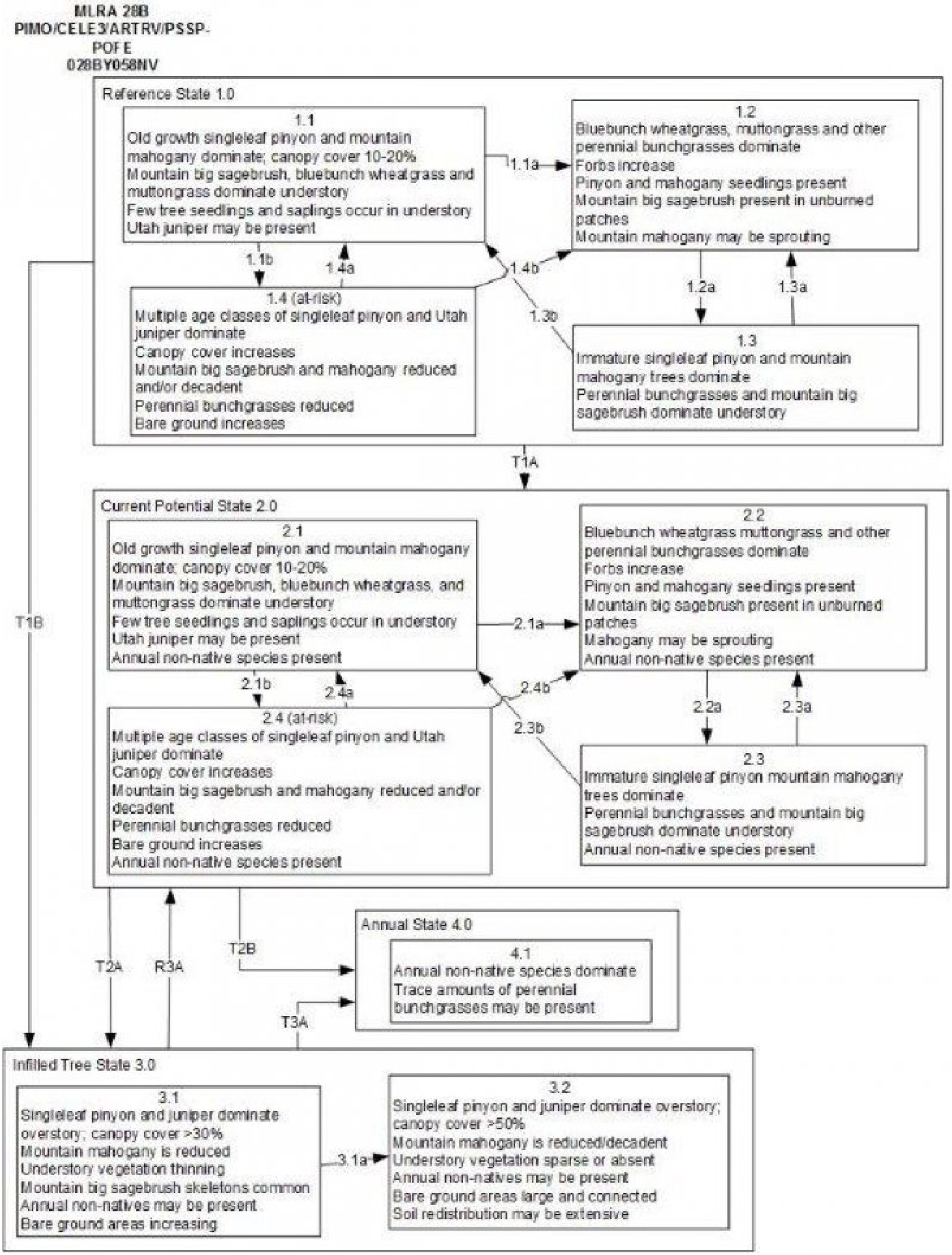

Figure 6. State and Transition Model

MLRA 28B
PIMO/CELE3/ARTRV/PSSP
028BY058NV

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 drought allows younger trees to infill.

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

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

Annual State 4.0 Community Pathways
None.

Transition T4A: Catastrophic fire or multiple fires.

Eroded State 5.0 Community Pathways
None.

Figure 7. Legend

State 1
Reference State

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 with curlleaf mountain mahogany occurring sporadically in the tree canopy. An overstory canopy of 10 to 25 percent is assumed to be representative of tree dominance on this site in the pristine environment. Mountain big sagebrush is the principal understory shrub. Antelope bitterbrush, snowberry, serviceberry, and curlleaf mountain mahogany are other important shrubs in the understory community. Bluebunch wheatgrass, basin wildrye and muttongrass and other bluegrass species are the most prevalent understory grasses. Arrowleaf balsamroot, tapertip hawksbeard, and phlox are common understory forbs. Overstory tree canopy composition is about 80 to 95 percent singleleaf pinyon, 5 to 15 percent curlleaf mountain mahogany and 10 percent or less Utah juniper.

Forest overstory. MATURE FORESTLAND: The visual aspect and vegetal structure are dominated by singleleaf pinyon that have reached or are near maximal heights for the site. Dominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns of singleleaf pinyon are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges from 10 to 25 percent. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic wildfire is a natural actor influencing the understory of mature pinyon forestlands. Few seedlings and/or saplings of singleleaf pinyon occur in the understory.

Forest understory. Understory vegetative composition is about 45 percent grasses, 10 percent forbs and 45 percent shrubs and young trees when the average overstory canopy is medium (10 to 25 percent). Average understory production ranges from 250 to 500 pounds per acre with a medium canopy cover. Understory production includes the total annual production of all species within 4½ feet of the ground surface.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	90	135	225
Shrub/Vine	60	90	150
Tree	30	45	75
Forb	20	30	50
Total	**200**	**300**	**500**

Community 1.2
Community Phase

This community phase is characterized by a post-fire shrub and herbaceous community. Sprouting shrubs, bluebunch wheatgrass and other perennial grasses dominate. 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 overstory. Various amounts of tree seedlings (less than 20 inches in height) may be present up to the point where they are a major component of the vegetal structure.

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

Community 1.3
Community Phase

This community phase is characterized as an immature woodland with pinyon, juniper trees averaging over 4.5 feet in height. Pinyon and juniper 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 sagebrush.

Forest overstory. IMMATURE WOODLAND: The visual aspect and vegetal structure are dominated by singleleaf pinyon trees greater than 4½ feet in height. The upper crown of dominant and codominant singleleaf pinyon are cone or pyramidal shaped. Dominants are the tallest trees on the site; codominants are 65 to 85 percent of the height of dominant trees. Seedlings and saplings of pinyon and curlleaf mountainmahogany are present in the understory.

Forest understory. The understory is a mix of shrubs, grasses and forbs. Understory vegetation is influenced by a tree overstory canopy of about 10 to 20 percent.Production ranges from 300 to 700 pounds per acre.

Community 1.4
Community Phase

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 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 of singleleaf pinyon are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges from 20 to 35 percent.

Forest understory. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic wildfire is a natural actor influencing the understory of mature pinyon woodlands. Few seedlings and/or saplings of singleleaf pinyon occur in the understory. Production ranges from 200 to 500 pounds per acre.

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 sprouting shrubs and 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.

Pathway b
Community 1.3 to 1.1

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 a
Community 1.3 to 1.2

Fire reduces or eliminates tree canopy, allowing sprouting shrubs and perennial grasses 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. Over time young trees mature to replace and maintain the old-growth woodland. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor.

Pathway b
Community 1.4 to 1.2

A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component which will allow for the sprouting shrubs and 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

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 10 to 25 percent of the overstory canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Bluebunch wheatgrass and muttongrass 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. OLD GROWTH: The visual aspect and vegetal structure are dominated by singleleaf pinyon that have reached or are near maximal heights for the site. Dominant trees average greater than five inches in diameter at one-foot stump height. Few seedlings and/or saplings of singleleaf pinyon occur in the understory. Upper crowns of singleleaf pinyon 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 actor influencing the understory of mature pinyon woodlands. Production ranges from 200 to 500 pounds per acre.

Community 2.2
Community Phase

This community phase is characterized by a post-fire shrub and herbaceous community. Sprouting shrubs, 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 overstory. Various amounts of tree seedlings (less than 20 inches in height) may be present up to the point where they are a major component of the vegetal structure.

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

Community 2.3
Community Phase

This community phase is characterized by an immature woodland, with 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. IMMATURE WOODLAND: The visual aspect and vegetal structure are dominated by singleleaf pinyon trees greater than 4½ feet in height. The upper crown of dominant and codominant singleleaf pinyon are cone or pyramidal shaped. Dominants are the tallest trees on the site; codominants are 65 to 85 percent of the height of dominant trees. Seedlings and saplings of pinyon and curlleaf mountainmahogany are present in the understory.

Forest understory. The understory is a mix of shrubs, grasses and forbs. Understory vegetation is influenced by a tree overstory canopy of about 10 to 20 percent. Production ranges from 300 to 700 pounds per acre.

Community 2.4
Community Phase

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. MATURE WOODLAND: The visual aspect and vegetal structure are dominated by singleleaf pinyon that have reached or are near maximal heights for the site. Dominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns of singleleaf pinyon are typically either irregularly or smoothly flat-topped or rounded. Tree canopy cover ranges from 20 to 35 percent.

Forest understory. Understory vegetation is strongly influenced by tree competition, overstory shading, duff accumulation, etc. Infrequent, yet periodic wildfire is a natural actor influencing the understory of mature pinyon woodlands. Few seedlings and/or saplings of singleleaf pinyon occur in the understory. Production ranges from 200 to 500 pounds per acre.

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 sprouting shrubs and 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.

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

Pathway b
Community 2.4 to 2.2

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

State 3
Infilled Tree State

Infilled Tree State 3.0 This state has two community phases that are characterized by the dominance of Utah juniper and singleleaf pinyon in the overstory. This state is identifiable by 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

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. OVER-MATURE WOODLAND: 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 singleleaf pinyon that have reached maximal heights for the site. Dominant and codominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns are typically irregularly flat-topped or rounded. Tree canopy cover is commonly greater than 30 percent.

Forest understory. Understory vegetation is sparse to absent due to tree competition, overstory shading, duff accumulation, etc. Production ranges from 75 to 250 pounds per acre.

Community 3.2
Community Phase

Singleleaf pinyon and Utah juniper dominate the aspect. Tree canopy cover exceeds 40 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present exist in the 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, muttongrass 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. Tree recruitment is limited. Trees are the dominant vegetation and are controlling ecological processes on this site.

Forest overstory. OVER-MATURE WOODLAND: 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 singleleaf pinyon that have reached maximal heights for the site. Dominant and codominant trees average greater than five inches in diameter at one-foot stump height. Upper crowns are typically irregularly flat-topped or rounded. Tree canopy cover is commonly greater than 50 percent.

Forest understory. Understory vegetation is sparse to absent due to tree competition, overstory shading, duff accumulation, etc. Production ranges is less than 100 pounds per acre.

Pathway a
Community 3.1 to 3.2

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

State 4
Annual State

This community is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Rabbitbrush may dominate the overstory. Annual non-native species dominate the understory.

Community 4.1
Community Phase

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

Transition A
State 1 to 2

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

Transition B
State 1 to 3

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate 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.

Transition A
State 3 to 4

Trigger: 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 (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Primary Perennial Grasses**			90–216	
	basin wildrye	LECI4	*Leymus cinereus*	30–72	–
	muttongrass	POFE	*Poa fendleriana*	30–72	–
	bluebunch wheatgrass	PSSPS	*Pseudoroegneria spicata ssp. spicata*	30–72	–
2	**Secondary Perennial Grasses**			6–30	
	squirreltail	ELEL5	*Elymus elymoides*	3–15	–
	Sandberg bluegrass	POSE	*Poa secunda*	3–15	–
Forb					
3	**Perennial**			6–30	
	arrowleaf balsamroot	BASA3	*Balsamorhiza sagittata*	3–15	–
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	3–15	–
Shrub/Vine					
4	**Primary Shrubs**			75–153	
	mountain big sagebrush	ARTRV	*Artemisia tridentata ssp. vaseyana*	30–72	–
	antelope bitterbrush	PUTR2	*Purshia tridentata*	15–27	–
	snowberry	SYMPH	*Symphoricarpos*	15–27	–
	serviceberry	AMELA	*Amelanchier*	15–27	–
Tree					
5	**Deciduous**			15–27	
	curl-leaf mountain mahogany	CELE3	*Cercocarpus ledifolius*	15–27	–
6	**Evergreen**			18–42	
	singleleaf pinyon	PIMO	*Pinus monophylla*	15–27	–
	Utah juniper	JUOS	*Juniperus osteosperma*	3–15	–

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 and muttongrass. 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.

Field surveys indicate native, mat-forming forbs may also increase with decreased bunchgrass density.

Wildlife Interpretations:

Pinyon-juniper woodlands provide a diversity of habitat for wildlife. Although the foliage of pinyon and juniper varies in palatability among fauna, the pinyon nuts and juniper berries are preferred by many species. The understory species provide fruits and browse for large ungulates, small mammals, birds and beaver (Wildlife Action Plan Team 2012).
Ungulates will use pinyon and juniper trees for cover and graze the foliage. The understory species also provide critical browse for deer. The trees provide important cover for mule deer (Odocoileus heminous), elk (Cervus canadensis) wild horses, mountain lion (Puma concolor), bobcat (Lynx rufus) and pronghorn (Antilocapra americana) (Gottfried and Severson 1994, Coates and Schemnitz 1994, Logan and Irwin 1985, Evans 1988).
Mule deer is considered the dominant big game species in the pinyon-juniper woodland and depend heavily on these woodlands for cover, shelter, and emergency forage during severe winters (Frischknecht 1975). Mule deer will eat singleleaf pinyon and juniper foliage, using the foliage moderately in winter, spring, and summer (Kufeld et al. 1973). Deep snows in higher elevation forest zones force mule deer and elk down into pinyon-juniper habitats during winter. This change in habitat allows mule deer and elk to browse the dwarf trees and shrubs (Gottfried and Severson 1994).
The diet of pronghorn antelope varies considerably; however, singleleaf pinyon was shown to comprise 1 to 2 percent of winter diet of pronghorn antelope that occur in pinyon-juniper habitat. Desert bighorn sheep (Ovis nelson) may utilize pinyon-juniper habitat, but only where the terrain is rocky and steep (Gottfried et al. 2000). Gray foxes, bobcats (Lynx rufus), coyotes (Canis latrans), weasels (Mustela frenata), skunks (Mephitis spp.), badgers (Taxidea taxus), and ringtail cats (Bassariscus astutus) search for prey in pinyon-juniper habitat woodlands (Short and McCulloch 1977).
Juniper "berries" or berry-cones are eaten by black-tailed jackrabbits, Lepus californicus, and coyotes (Gese et al. 1988, Kitchen et al. 2000). A study by Kitchen et al (1999) conducted in juniper-pinion habitat found vegetation in coyote scats was mainly grass seeds or juniper berries. Jackrabbits are a major dispenser of juniper seeds (Schupp et al. 1999). The pinyon mouse (Peromyscus truei) is a pinyon-juniper obligate and uses the woodlands for cover and food (Hoffmeister 1981). Other small mammals include the porcupine (Hystricomorph hystricidae), desert cottontail (Sylvilagus audubonii), Nuttall’s cottontail (S. nuttallii), deer mouse (Peromyscus maniculatus), Great Basin pocket mouse (Perognathus parvus), chisel-toothed kangaroo rat (Dipodomys microps) and desert woodrat (Neotoma lepida) (Turkowski and Watkins 1976).
Many bird species are associated with the pinyon-juniper habitat; some are permanent residents, some summer residents, and some winter residents, depending upon location. For birds and bats, the woodland provides structure for nesting and roosting, and locations for foraging. Singleleaf pinyon provides a number of cavities and the stringy, fibrous bark provides quality nesting material as well as the food provided by the tree’s seeds and berries (Short and McCulloch 1977). Many bird species depend on juniper berry-cones and pine nuts for fall and winter food (Balda and Masters 1980). Several bird species are obligates including (gray flycatcher (Epidonax wrightii) scrub jay (Aphelocoma californica), plain titmouse (Parus inornatus ridgwayi), and gray vireo (Vireo vicinior) and several species are semi-obligates including black-chinned hummingbird (Archilochus alexandri), ash-throated flycatcher (Myiarchus cinerascens), pinion jay (Gymnorhinus cyanocephalus), American bushtit (Psaltriparus minimus), Bewick’s wren (Thryomanes bewickii), Northern mockingbird (Mimus polyglottos), blue-gray gnatcatcher (Polioptila caerulea), black-throated gray warbler (Dendroica nigrescens), house finch (Haemorhous mexicanus), spotted towhee (Pipilo maculatus), lark sparrow (Chondestes grammacus) and black-chinned sparrow (Zonotrichia atricapilla) (Balda and Masters 1980). Ferruginous hawk (Buteo regalis), a conservation priority species due to recent population declines in Nevada, nest in older trees of sufficient size and structure to support their large nest platforms. (Holechek 1981).
Diurnal reptiles include the sagebrush swift (Sceloporus graciosus), the blue-bellied lizard (Sceloporus elongates) the western collard lizard, the Great Basin rattlesnake, the Great Basin gopher snake (Pituophis catenifer) and horned lizard, also occur in Utah juniper habitat (Frischknecht 1975). However, the distribution of most of herpetofauna present in pinyon-juniper woodlands is poorly understood and more research and management are needed.

Hydrological functions

Permeability is moderate to moderately rapid. Runoff is high to very high. 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 (Ffolliott and Gottfried 2012).

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

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

PRODUCTIVE CAPACITY

This site has a moderate site quality for tree production. Site index ranges from 61 to 85 (Howell, 1946).

Productivity Class: 0.5 to 0.7
CMAI*: 6.7 to 10.6 cu ft/ac/yr;
0.47 to 0.74 cu m/hr/yr.
Culmination is estimated to be at 100 years.

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

Fuelwood Production: About 8 to 11 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 wood. 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 22 million BTUs of heat value in a cord of singleleaf pinyon.

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

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

MANAGEMENT GUIDES AND INTERPRETATIONS

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

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

3. SILVICULTURAL PRACTICES
a. Harvest cut selectively or in small patches size dependent upon site conditions) to enhance forage production.
1) Thinning and improvement cutting - Removal of poorly formed, diseased and low vigor trees for fuelwood.
2) Harvest cutting - Selectively harvest surplus trees to achieve desired spacing. Save large, healthy, full-crowned pinyon trees for nut production. Save 4 to 5 foot tall pinyons for Christmas trees. Do not select only "high grade" trees during harvest.
3) Spacing Guide: D+9. (A higher spacing guide is required if managing for Christmas trees.)

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. Thousands of pounds of nuts are gathered each year and sold on the markets throughout the United States. 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. 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. Common snowberry fruit was eaten fresh but was not favored by Native Americans in Washington and Oregon. The fruits were eaten fresh and also dried for winter use. Common snowberry was used on hair as soap, and the fruits and leaves mashed and applied to cuts or skin sores as a poultice and to soothe sore, runny eyes. Tea from the bark was used as a remedy for tuberculosis and sexually transmitted diseases. A brew made from the entire plant was used as a physic tonic. Arrowshafts and pipestems were made from the stems.

Other information

Curlleaf mountainmahogany may be planted to help stabilize soil in disturbed areas such as roadcuts and mine spoils.

Table 7. Representative site productivity

Common Name	Symbol	Site Index Low	Site Index High	CMAI Low	CMAI High	Age Of CMAI	Site Index Curve Code	Site Index Curve Basis	Citation
singleleaf pinyon	*PIMO*	65	85	7	11	–	–	–	

Type locality

Location 1: White Pine County, NV	
Township/Range/Section	T24N R67E S27
Latitude	39° 55′ 41″
Longitude	114° 23′ 16″
General legal description	NE¼ NW¼, South of Tunnel Canyon road, Antelope Range, White Pine County, Nevada. This site is also found in Elko and Eureka Counties, Nevada.

Location 2: White Pine County, NV	
Township/Range/Section	T13 R63 S36
Latitude	38° 57′ 6″
Longitude	114° 50′ 25″
General legal description	About 0.75 miles east of Quaky Spring. USGS White Rock Creek Quadrangle. White Pine County, Nevada

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Rangeland health reference sheet

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

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

Indicators

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

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

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

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

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:**