Final Report
USDA Ecological Site Description
State-and-Transition Models
Major Land Resource Area 28A and 28B Nevada
February 2015

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Cite as:

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.

Cooperators: USDA Natural Resource Conservation Service, USDA Agricultural Research Service, USDI Bureau of Land Management and Eureka County, NV.

Final Report submitted to USDA Agricultural Research Service as fulfillment of Agreement # 58-5370-2-211

Ecological Sites within Disturbance Response Group 1A:
Modal Site: Shallow Calcareous Loam 8-10” 028AY013NV

Group	Name	Site ID
1A	**Shallow Calcareous Loam 8-10" P.Z. MODAL**	**028AY013NV**
	Shallow Clay Loam 10-12" P.Z.	028AY035NV
	Shallow Calcareous Slope 8-10" P.Z.	028AY004NV
	Shallow Calcareous Hill 8-10" P.Z.	028AY027NV
	Droughty Calcareous Loam 8-10"	028AY047NV
	Shallow Calcareous Hill 6-8" P.Z.	028AY044NV
	Eroded Slope 8-12" P.Z.	028AY130NV

MLRA 28A
Group 1A

Disturbance Response Group (DRG) 1A consists of six ecological sites. The precipitation ranges from 6 inches to 12 inches. Slopes range from 2 to 75% with less than 50% being typical. Elevation ranges from 4,300 to 7,000 feet. Annual production for a normal year ranges from 250 to 400 lbs/acre. Soils are typically derived from limestone parent material and are shallow to moderately deep to a restrictive later that impedes rooting depth. The soils are typified by an ochric epipedon and the majority have a calcic horizon. The available water holding capacity is low to moderate. Soils are well drained, runoff is slow to medium and the potential for sheet and rill erosion is slight to moderate. Reaction is moderately to strongly alkaline and the calcium carbonate equivalent in the control section ranges from 15 to 50%. The soil moisture regime is aridic that borders on xeric and the soil temperature regime is mesic. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by black sagebrush (*Artemisia nova*). Other important shrubs include shadscale (*Atriplex confertifolia*), spiny hopsage (*Grayia spinosa*) and winterfat (*Krascheninnikovia lanata*). The understory is dominated by deep-rooted cool season perennial bunchgrasses primarily Indian ricegrass (*Achnatherum hymenoides*) and needle and thread grass (*Hesperostipa comata*). The occurrence of summer monsoonal precipitation in this area supports the growth of several warm-season grasses including galleta (*Pleuraphis* Torr.), sand dropseed (*Sporobolus cryptandrus*), and threeawn (*Aristida* L.).

Modal Site:
The Shallow Calcareous Loam 8-10" P.Z. ecological site is the modal site that represents this DRG, as it has the most acres mapped. This site occurs on summits and sideslopes of piedmont slopes, hills and lower mountains on all aspects. Slopes range from 2 to 50%, but slope gradients of 2 to 15% are most typical. Elevations for this site range from 4,800 to 6,500 feet. Annual production ranges from 300 lbs/ac in an unfavorable year to 700 lbs/ac in a favorable year. Soils are typically shallow to a duripan and have an ochric epipedon and a calcic horizon. The soils are modified with high volumes of coarse rock fragments throughout the soil profile. Available water holding capacity is low to moderate. The shrub component is dominated by black sagebrush. Fourwing saltbush (*Atriplex canescens*), winterfat and shadscale are other common shrubs. The herbaceous component is dominated by Indian ricegrass and needle and thread. Galleta and sand dropseed are also present in minor amounts.

Disturbance Response Group 1A – ecological sites:

Shallow Calcareous Loam 8-10" P.Z. (Modal)	028AY013NV
Shallow Calcareous Slope 8-10" P.Z. Shallow	028AY004NV
Calcareous Hill 8-10" P.Z.	028AY027NV
Shallow Calcareous Hill 6-8" P.Z.	028AY044NV
Shallow Clay Loam 10-12" P.Z.	028AY035NV
Droughty Calcareous Loam 8-10"	028AY047NV
Eroded Slope 8-12” P.Z	028AY130NV

Ecological Dynamics and Disturbance Response:

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

The ecological sites in this DRG are dominated by deep-rooted cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). However, community types with black sagebrush as the dominant shrub were found to have soil depths and thus available rooting depths of 77 to 81 cm in a study in northeast Nevada (Jensen 1990). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

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

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks especially a sagebrush defoliator, Aroga moth (*Aroga websteri*). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and is ongoing in Nevada since 2004 (Bentz, et al 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), but the research is inconclusive of the damage sustained by black sagebrush populations.

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

The perennial bunchgrasses that are co-dominant with the shrubs include Indian ricegrass, needle and thread, galleta 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 of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource pools by the decomposition of dead

plant material following disturbance. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al 2007).

The range and density of Utah juniper has increased since the middle of the nineteenth century (Tausch 1999, Miller and Tausch 2000). Causes for expansion of Utah juniper into sagebrush ecosystems include wildfire suppression, historic livestock grazing, and climate change (Bunting 1994). Mean fire return intervals prior to European settlement in black sagebrush ecosystems were greater than 100 years, however frequent enough to inhibit the encroachment of Utah juniper (*Juniperus osteosperma*) into these low productive sagebrush cover types (Kitchen and McArthur 2007). Thus, trees were isolated to fire-safe areas such as rocky outcroppings and areas with low-productivity. An increase in crown density causes a decrease in understory perennial vegetation and an increase in bare ground. This allows for the invasion of non-native annual species such as cheatgrass. With annual species in the understory wildfire can become more frequent and increase in intensity. With frequent wildfires these plant communities can convert to annual species with a sprouting shrub and juvenile tree overstory.

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Six possible stable states have been identified for this DRG.

Fire Ecology:
Fire is not a major ecological component of these community types (Winward 2001), and would be infrequent. Fire return intervals have been estimated at 100 to 200 years (Kitchen and McArthur 2007); however, fires were probably patchy and very infrequent due to the low productivity of these sites. Black sagebrush plants have no morphological adaptations for surviving fire and must reestablish from seed following fire (Wright et al. 1979). The ability of black sagebrush to establish after fire is mostly dependent on the amount of seed deposited in the seed bank the year before the fire. Seeds typically do not persist in the soil for more than 1 growing season (Beetle 1960). A few seeds may remain viable in soil for 2 years (Meyer 2008); however, even in dry storage, black sagebrush seed viability has been found to drop rapidly over time, from 81% to 1% viability after 2 and 10 years of storage, respectively (Stevens et al. 1981). Thus, repeated frequent fires can eliminate black sagebrush from a site, however black sagebrush in zones receiving 12 to 16 inches of annual precipitation have been found to have greater fire survival (Boltz 1994). In lower precipitation zones, spiny hopsage and/or shadscale may become the dominant shrub species following fire. Douglas' rabbitbrush (*Chrysothamnus viscidflorus*) and ephedra (*Ephedra nevadensis*) can also sprout after fire and become a dominant shrub on this site often with an understory of galleta, Sandberg bluegrass (*Poa secunda*) and/or cheatgrass and other weedy species.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. The two dominant grasses on this site, Indian ricegrass and needle and thread grass, have different responses to fire. Needle and thread is top-killed by fire but is likely to resprout if fire does not consume above ground stems (Akinsoji 1988, Bradley et al. 1992). In a study by Wright and Klemmedson (1965), season of burn rather than fire intensity seemed to be the crucial factor in mortality for needle and thread grass. Early spring season burning was found to kill the plants while August burning had no effect. Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below ground plant crowns. Indian ricegrass has 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 is necessary for reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Galleta grass, a minor component of these ecological sites, has been found to increase following fire likely due to its rhizomatous root structure and ability to resprout (Jameson 1962). Sandberg bluegrass, another minor component of these ecological sites, has also been found to increase following fire likely due to its low stature and productivity (Daubenmire 1975). Both grass species may retard reestablishment of deeper rooted bunchgrasses. Repeated frequent fire in this community will eliminate black sagebrush, significantly decrease bunchgrass density on the site and facilitate the establishment of an annual weed community with varying amounts of galleta, Sandberg bluegrass, spiny hopsage, shadscale and rabbitbrush.

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). With the low production of the understory vegetation, high severity fires within this plant community were not likely and rarely became crown fires (Bradley et al. 1992, Miller and Tausch 2000). Tree density on this site increases with grazing management that favors the removal of fine fuels and management focused on fire suppression. With an increase of cheatgrass in the understory, fire severity is likely to increase. Utah juniper reestablishes by seed from nearby seed source or surviving seeds. Utah juniper begins to produce seed at about 30 years old (Bradley et al. 1992). Seeds establish best through the use of a nurse plant such as sagebrush and rabbitbrush (Everett and Ward 1984,Tausch and West 1988, Bradley et al. 1992). Utah juniper woodlands reach mature stage between 85 to 150 years after fire (Barney and Frischknecht 1974, Tausch and West 1988).

Livestock/Wildlife Grazing Interpretations:
Black sagebrush palatability has been rated as moderate to high depending on the ungulate and the season of use (Horton 1989, Wambolt 1996). The palatability of black sagebrush increases the potential negative impacts on remaining black sagebrush plants from grazing or browsing pressure following fire (Wambolt 1996). Pronghorn utilize black sagebrush heavily (Beale and Smith 1970). On the Desert Experiment Range, black sagebrush was found to comprise 68% of pronghorn diet even though it was only the third most common plant. Fawns were found to prefer black sagebrush utilizing it more than all other forage species combined (Beale and Smith 1970). Domestic livestock will also utilize black sagebrush. The domestic sheep industry that emerged in the Great Basin in the early 1900s was largely based on wintering domestic sheep in black sagebrush communities (Mozingo 1987). Domestic sheep will browse black sagebrush during all seasons of the year depending on the availability of other forage species, with greater amounts being consumed in fall and winter. Black sagebrush is generally less palatable to cattle than to domestic sheep and wild ungulates (McArthur et al. 1979); however, cattle use of black sagebrush has also been shown to be greatest in fall and winter (Schultz and McAdoo 2002), with only trace amounts being consumed in summer (Van Vuren 1984). Dormant season use of black sagebrush can reduce sagebrush density and increase the density of bunchgrasses such as Indian ricegrass.

Inappropriate grazing management during the growing season will cause a decline in understory plants such as needle and thread and Indian ricegrass. Growing season grazing by cattle may initially cause a

decrease in the bunchgrass component and give a competitive advantage to shrub species including black sagebrush (Eckert et al. 1972).

Specifically, needle and thread grass is most commonly found on warm/dry soils (Miller et al. 2013) and is not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller and Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972). With the reduction in competition from deep rooted perennial bunchgrasses, the rhizomatous galleta grass and short-statured Sandberg bluegrass will likely increase (Jameson 1962, Smoliak et al. 1972)

Indian ricegrass is a deep-rooted, cool season perennial bunchgrass that is adapted primarily to coarse textured soils. Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971), however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck et al. 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1976). Cook and Child (1971) found significant reduction in plant cover after seven years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended. In summary, adaptive management is required to manage this bunchgrass well.

Reduced bunchgrass vigor or density provides an opportunity for galleta and/or Sandberg bluegrass expansion and/or cheatgrass and other invasive species such as halogeton (*Halogeton glomeratus*) to occupy interspaces. Increased cheatgrass cover leads to increased fire frequency and potentially an annual plant community. Galleta and/or Sandberg bluegrass increases under grazing pressure (Jameson 1962, Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors galleta or Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the type of grazing animal, and site conditions, either galleta or Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

State and Transition Model Narrative – Group 1A

Reference State 1.0: The Reference State is a representative of the natural range of variability under pristine conditions. The Reference State has three general community phases; a shrub-grass dominant phase, a shrub dominant phase and a grass dominate phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic long-term drought and/or insect or disease attack. Due to the nature and extent of disturbance in this site, all three plant community phases would likely occur in a mosaic across the landscape. Utah juniper may be present on the site, but will only occur as scattered trees and will not dominate the site.

Community Phase 1.1:
This community is dominated by black sagebrush in the overstory with Indian ricegrass and needle and thread grass dominant in the understory. Utah juniper may be present.

Community Phase Pathway 1.1a: A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring facilitating an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts.

Community Phase Pathway 1.1b: Absence of disturbance over time, significant herbivory, long term drought or combinations of these would allow the sagebrush overstory to increase and dominate the site. This will generally cause a reduction in perennial bunch grasses; however galleta grass may increase in the understory depending on the grazing management. Heavy spring grazing will favor an increase in sagebrush.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early seral community phase. Indian ricegrass and needle and thread and other perennial bunchgrasses dominate. Sprouting shrubs such as Douglas' rabbitbrush, spiny hopsage, and shadscale may increase. Black sagebrush could still be present in unburned patches. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Galleta will generally increase following fire, but may decrease in below-average years of precipitation. Sandberg's bluegrass may also increase.

Community Phase Pathway 1.2a: Time and lack of disturbance will allow sagebrush to establish.

Community Phase 1.3:
Black sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or herbivory. Sandberg's bluegrass and/or galleta may increase in the understory and become the dominant grass on the site. Scattered Utah juniper may be present on the site.

Community Phase Pathway 1.3a: A low severity fire, herbivory or combinations will reduce the sagebrush overstory and create a sagebrush/grass mosaic.

Community Phase Pathway 1.3b: Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be high intensity due to the dominance of sagebrush resulting in removal of the overstory shrub community.

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

Trigger: Introduction of non-native annual plants.
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.

Current Potential State 2.0: This state is similar to the Reference State 1.0 and has three similar community phases. Ecological function has not changed in this state, but the resiliency of the state has been reduced by the presence of invasive weeds. These non-native species 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.

Community Phase 2.1:
This community phase is compositionally similar to the Reference State Community Phase 1.1 with the presence of non-native species in trace amounts. This community is dominated by black sagebrush in the overstory with Indian ricegrass and needle and thread grass dominant in the understory. Utah juniper may be present.

Shallow Calcareous Hill 6-8" (028AY044NV) Phase 2.1 T.K. Stringham, May 2012

Community Phase Pathway 2.1a: A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.1b: Absence of disturbance over time, long term drought, inappropriate grazing management or combinations of these would allow the sagebrush overstory to increase and dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely galleta grass and/or Sandberg bluegrass may increase in the understory.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community where annual non-native species are present. Sagebrush is present in trace amounts; perennial bunchgrasses dominate the site. Depending on fire severity patches of intact sagebrush may

remain. Rabbitbrush or other sprouting shrubs may be increasing. Annual non-native species are stable or increasing within the community.
Galleta will generally increase following fire, but may decrease in below-average years of precipitation. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community Phase Pathway 2.2a: Absence of disturbance over time and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of black sagebrush can take many years.

Community Phase 2.3 (At Risk):
Black sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs or from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Galleta and/or Sandberg bluegrass may increase and become co-dominant with deep rooted bunchgrasses. Utah juniper may be present and without management will likely increase. Annual non-natives species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, long term drought, and fire. This community is at risk of crossing a threshold to either State 3.0 (grazing or fire) or State 4.0 (fire).

Shallow Calcareous Slope 8-10" (028AY004NV) Phase 2.3 T.K. Stringham, April 2013

Community Phase Pathway 2.3a: Grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall/winter grazing may cause mechanical damage to sagebrush promoting the perennial bunchgrass understory. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. Annual non-native species are present and may increase in the community. A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Due to low fuel loads in this State, fires will likely be small creating a mosaic pattern.

Community Phase Pathway 2.3b: Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be high intensity

due to the dominance of sagebrush resulting in removal of the overstory shrub community. Annual non-native species respond well to fire and may increase post-burn.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0

Trigger: To Community Phase 3.1: Inappropriate cattle/horse grazing will decrease or eliminate deep rooted perennial bunchgrasses, increase Sandberg bluegrass and/ or galleta grass and favor shrub growth and establishment. To Community Phase 3.2: Severe fire will remove sagebrush overstory, decrease perennial bunchgrasses and enhance galleta and/or Sandberg's bluegrass. Soil disturbing brush treatments and/or inappropriate sheep grazing will reduce sagebrush and potentially increase sprouting shrubs and Sandberg's bluegrass and/or galleta grass.

Slow variables: Long term decrease in deep-rooted perennial grass density and/or black sagebrush.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter. Loss of long-lived, black sagebrush changes the temporal distribution, and depending on the replacement shrub, the spatial distribution of nutrient cycling.

T2B: Transition from Current Potential State 2.0 to Tree State 4.0

Trigger: Absence of disturbance over time allows for Utah juniper or singleleaf pinyon dominance.

Feedbacks and ecological processes: Trees increasingly dominate use of soil water resulting in decreasing herbaceous and shrub production and decreasing organic matter inputs, contributing to reductions in soil water availability to grasses and shrubs and increased soil erodibility.

Slow variables: Long term increase in juniper and/or singleleaf pinyon density.

Threshold: Trees overtop black sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs in number. There is minimal recruitment of new shrub cohorts. Litter builds up underneath trees while bare ground increases in interspaces; this changes nutrient cycling and levels of organic matter in the soil. Redistribution of soil, organic matter and nutrients may occur with water and wind erosion.

T2C: Transition from Current Potential State 2.0 to Annual State 5.0

Trigger: Catastrophic fire or soil surface disturbance.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes energy and nutrient capture and cycling both spatially and temporally within the community. Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires.

Shrub State 3.0: This state has two community phases, one that is characterized by a black sagebrush overstory and the other with a shadscale or rabbitbrush overstory with a Sandberg bluegrass or galleta grass understory. The site has crossed a biotic threshold and site processes are being controlled by shrubs. Bare ground has increased and pedestalling of grasses may be excessive.

Community Phase 3.1:

Black sagebrush dominates overstory while Sandberg bluegrass or galleta grass dominates the understory. Deep-rooted perennial bunchgrasses have significantly declined. Annual non-native species may be present. Bare ground and soil redistribution may be increasing. If present on the

site, Utah juniper is increasing. The community phase may be at risk of transitioning into a Tree State or Annual State

Shallow Calcareous Loam 8-10" (028AY013NV) Phase 3.1 T.K. Stringham, August 2013

Community Phase Pathway 3.1a: Fire reduces black sagebrush to trace amounts and allows for sprouting shrubs such as rabbitbrush to dominate. Shadscale may also establish post-fire and become dominate. Inappropriate or excessive sheep grazing could also reduce cover of sagebrush and allow for shadscale or sprouting shrubs to dominate the community. Brush treatments with minimal soil disturbance would facilitate sprouting shrubs and galleta and/or Sandberg's bluegrass.

Community Phase 3.2 (At Risk):
Shadscale and/or rabbitbrush dominate the overstory. Broom snakeweed may be present to increasing. Annual non-native species may be increasing and bare ground is significant. This site is at risk for an increase in invasive annual weeds.

Shallow Calcareous Loam 8-10" (028AY013NV) Phase 3.2 T.K. Stringham, May 2012

Community Phase Pathway 3.2a: Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows for the shrub component to recover. The establishment of black sagebrush may take many years.

T3A: Transition from Shrub State 3.0 to Tree State 4.0

Trigger: Absence of disturbance over time allows for Utah juniper or singleleaf pinyon dominance.
Feedbacks and ecological processes: Trees increasingly dominate use of soil water resulting in decreasing herbaceous and shrub production and decreasing organic matter inputs, contributing to reductions in soil water availability to grasses and shrubs and increased soil erodibility.
Slow variables: Long-term increase in juniper and/or singleleaf pinyon density.
Threshold: Trees overtop black sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs in number. There is minimal recruitment of new shrub cohorts. Litter builds up underneath trees while bare ground increases in interspaces; this changes nutrient cycling and levels of organic matter in the soil.

R3A: Restoration from Shrub State 3.0 to Seeded State 6.0: Seeding of deep-rooted introduced bunchgrasses and other desired species; may be coupled with brush management and/or herbicide. Probability of success is low.

T3B: Transition from Shrub State 3.0 to Annual State 5.0

Trigger: Fire or treatments that disturb the soil and existing plant community (ex: failed restoration attempts).
Slow variables: Increased seed production and cover of annual non-native species.
Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

Tree State 4.0: This state has two community phases, which are characterized by a dominance of Utah juniper in the overstory. Singleleaf pinyon may play a significant role in the higher elevation ranges within this site. Black sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients and soil organic matter distribution and cycling have been spatially and temporally altered.

Community Phase 4.1: Juniper trees dominate overstory, sagebrush is decadent and dying, deep rooted perennial bunchgrasses are decreasing. Recruitment of sagebrush cohorts is minimal. Annual non-natives may be present or increasing. Bare ground interspaces are large and connected.

Shallow Clay Loam 10-12" (028AY035NV) Phase 4.1 T.K. Stringham, July 2012

Community Phase Pathway 4.1a: Time and lack of disturbance or management action allows for tree cover and density to further increase and trees to out-compete the herbaceous understory species for sunlight and water.

Community Phase 4.2: Juniper trees dominate overstory. Black sagebrush is decadent and dying with numerous skeletons present or sagebrush may be missing from the system. Bunchgrasses present in trace amounts and annual non-native species may dominate understory. Herbaceous species may be located primarily under the canopy or near the drip line of trees. Bare ground interspaces are large and connected. Soil movement may be apparent.

Shallow Calcareous Slope 8-10" (028AY004NV) Phase 4.2 T.K. Stringham, June 2013

R4A: Restoration Pathway from Tree State 4.0 to Shrub State 3.0: Removal of trees in community phase 4.1. If restoration efforts fail, this site could transition to Annual State 5.0

T4A: Transition from Tree State 4.0 to Annual State 5.0

Trigger: Catastrophic fire causing a stand replacement event. Inappropriate tree removal practices with soil disturbance will also cause a transition to Annual State 5.

Slow variables: Increased production and cover of non-native annual species under tree canopies.
Threshold: Closed tree canopy with non-native annual species dominant in the understory changes the intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impacts nutrient cycling and distribution.

Annual State 5.0: This state has one community phase. In this state, a biotic threshold has been crossed and state dynamics are driven by the dominance and persistence of the annual grass community which is perpetuated by a shortened fire return interval fire. The herbaceous understory is dominated by annual non-native species such as cheatgrass, halogeton, and mustards. Resiliency has declined and further degradation from fire facilitates a cheatgrass and sprouting shrub plant community. Fire return interval has shortened due to the dominance of cheatgrass in the understory and is a driver in site dynamics.

Shallow Calcareous Loam 8-10" (028AY013NV) Phase 5.1 T.K. Stringham, May 2012

Community Phase 5.1:
Cheatgrass, mustards, halogeton and other annuals dominate the site. Halogeton more readily invades this site. Sprouting shrubs may be present. Erosion may be significant.

Seeded State 6.0. This state has two community phases, a grass-dominated phase and a shrub dominated phase. The grass phase is characterized by the dominance of seeded introduced wheatgrass species. Forage kochia and other desired seeded species including black sagebrush and native and non-native forbs may be present. The shrub phase is dominated by black sagebrush which has reestablished on the site.

Community Phase 6.1:
Introduced wheatgrass species and other non-native species such as forage kochia dominate the community. Native and non-native seeded forbs may be present. Trace amounts of black sagebrush may be present. Native bunchgrasses may be present. Annual non-native species present.

Community Phase Pathway 6.1a: Inappropriate grazing management particularly during the growing season reduces perennial bunchgrass vigor and density and facilitates shrub establishment if a seed source is available**.**

Community Phase 6.2:
Black sagebrush and seeded wheatgrass species co-dominate. Native bunchgrasses may be present. Annual non-native species stable to increasing.

Community Phase Pathway 6.2a: Low severity fire, brush management with minimal soil disturbance will reduce the sagebrush overstory and may allow seeded wheatgrass species to become dominant. Native bunchgrasses may be present.

T6A: Transition from Seeded State 6.0 to Tree State 4.0

Trigger: Absence of disturbance over time and/or inappropriate grazing management facilitates the establishment and eventual dominance of Utah juniper or singleleaf pinyon.
Slow variables: Long term increase in juniper and/or singleleaf pinyon density.
Threshold: Trees out-compete understory species for water and sunlight. There is minimal recruitment of new shrub cohorts. Litter builds up underneath trees while bare ground increases in interspaces; this changes nutrient cycling and levels of organic matter in the soil. Redistribution of soil, organic matter and nutrients may occur with water and wind erosion.

T6B: Transition from Seeded State 6.0 to Annual State 5.0

Trigger: Fire, inappropriate grazing management or treatments that disturb the soil and existing plant community (ex: failed restoration attempts).
Slow variables: Increased seed production and cover of annual non-native species.
Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

Potential Resilience Differences with other Ecological Sites in this group:

Shallow Calcareous Slope 8-10" 028AY004NV: Indian ricegrass dominant, less productive. Soils high in lime, shallow rooting depth. Tree state is highly unlikely but may occur where this site is found in association with 028AY021NV JUOS/ARPY Woodland or other sites with a tree potential.

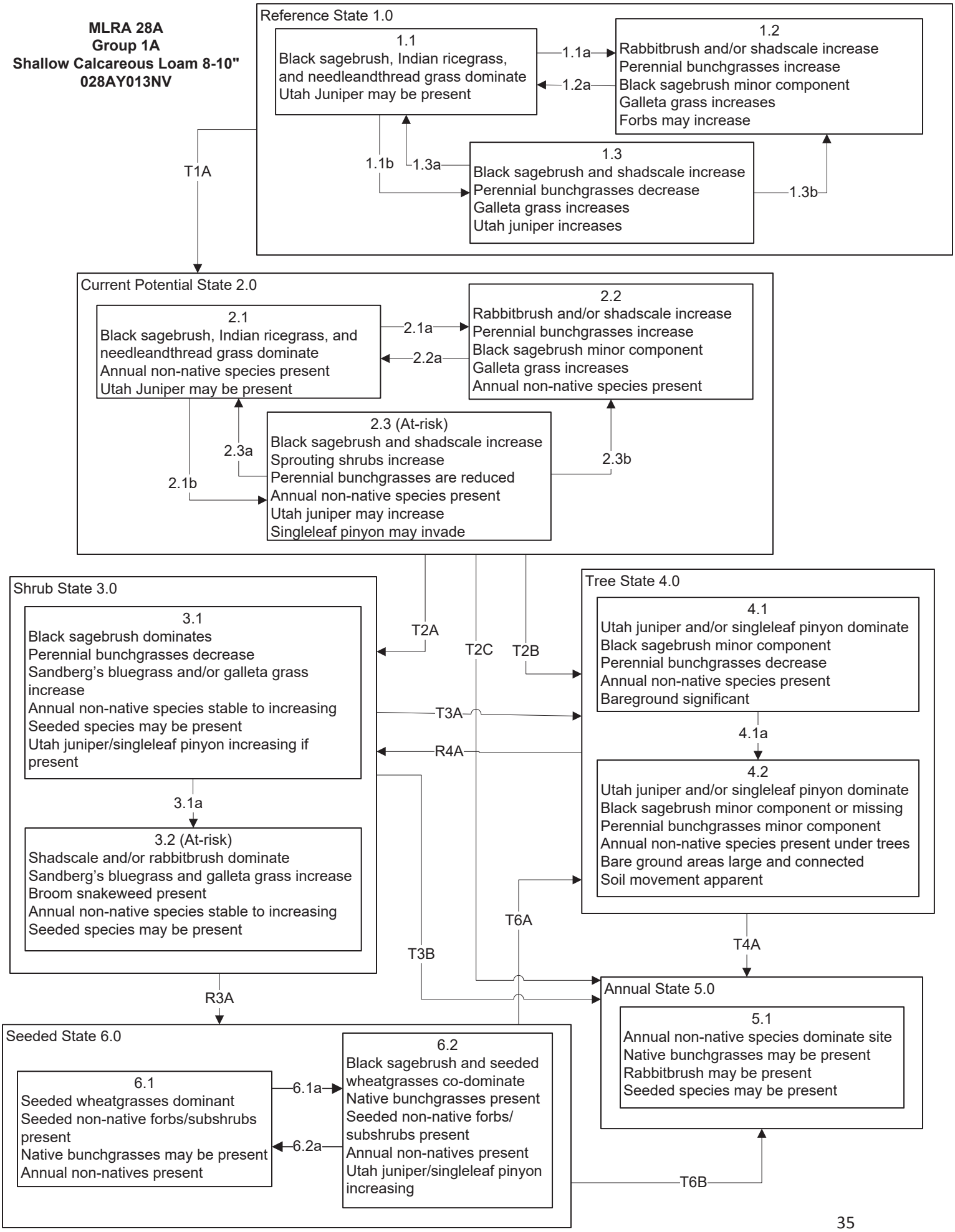
Shallow Calcareous Hill 8-10" 028AY027NV: Indian ricegrass and black sagebrush co-dominate this site. This site is found at higher elevations. Less productive site than the modal.

Shallow Clay Loam 10-12" 028AY035NV: Juniper readily increases/pinyon invades this site. At the upper end of this site's precipitation range, Singleleaf pinyon may become the dominant tree. Soils on this site developed from volcanic rock sources. Rock fragments are found throughout the soil profile and average 35-50%.

Droughty Calcareous Loam 8-10" 028AY047NV: This site is characterized by a greater amount of spiny hopsage in the overstory. This site may be a post-fire phase of the Shallow Calcareous Loam 8-10 (028AY013NV) or Slope (028AY004NV) as noted in the Range Site Description (RL 10/90). It is slightly more productive than the modal.

Shallow Calcareous Hill 6-8” 028AY044NV: May be a fire disclimax or state of Shallow Calcareous Loam 8-10”. If so it would represent State 3 likely phase 1 in the model. No tree state.

MLRA 28A
Group 1A
Shallow Calcareous Loam 8-10"
028AY013NV



MLRA 28A
Group 1A
Shallow Calcareous Loam 8-10"
028AY013NV

Reference State 1.0 Community Pathways
1.1a: Low severity fire resulting in a mosaic pattern.
1.1b: Time and lack of disturbKEYance such as fire, long term drought, herbivory, or combinations of these.
1.2a: Time and lack of disturbance such as fire, long term drought, herbivory, or combinations of these.
1.3a: Low severity fire or herbivory resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native plants.

Current Potential State 2.0 Community Pathways:
2.1a: Fire or brush treatments (i.e. mowing) with minimal soil disturbance.
2.1b: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
2.2a: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
2.3a: Low severity fire creates sagebrush/ grass mosaic. Brush treatment with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community

Transition T2A: Inappropriate cattle/horse grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or inappropriate sheep grazing management will lead to phase 3.2.
Transition T2B: Time and lack of disturbance allows for maturation of the tree community.
Transition T2C: Catastrophic fire or soil disturbing treatments.

Shrub State 3.0 Community Pathways
3.1a: Fire and/or sheep grazing. Brush treatments (i.e. mowing) with minimal soil disturbance.

Transition T3A: Time and lack of disturbance allows for maturation of the tree community. Heavy sheep grazing will expedite this transition.
Transition T3B: Fire and/or soil disturbing treatments.

Restoration Pathway R3A: Drill or aerial seeding of native and non-native wheatgrasses, forbs, and other species.

Tree State 4.0 Community Pathways
4.1a: Time and lack of disturbance allows for maturation of the tree community.

Transition T4A: Catastrophic fire that significantly reduces or eliminates tree and any remaining shrub overstory. Inappropriate tree removal practices may also contribute to this transition.
Restoration Pathway R4A: Removal of trees and seeding of desired species.

Seeded State 6.0 Community Pathways
6.1a: Inappropriate grazing management during the growing season facilitates shrub establishment and dominance.
6.2a: Fire or brush treatments with minimal soil disturbance.

Transition T6A:Time without disturbance allows trees to establish and dominate the site; may be coupled with grazing management that favors reduced perennial grass density and increased tree establishment.
Transition T6B: High severity fire and/or inappropriate grazing management. Soil disturbing brush treatments may also lead to the annual state.

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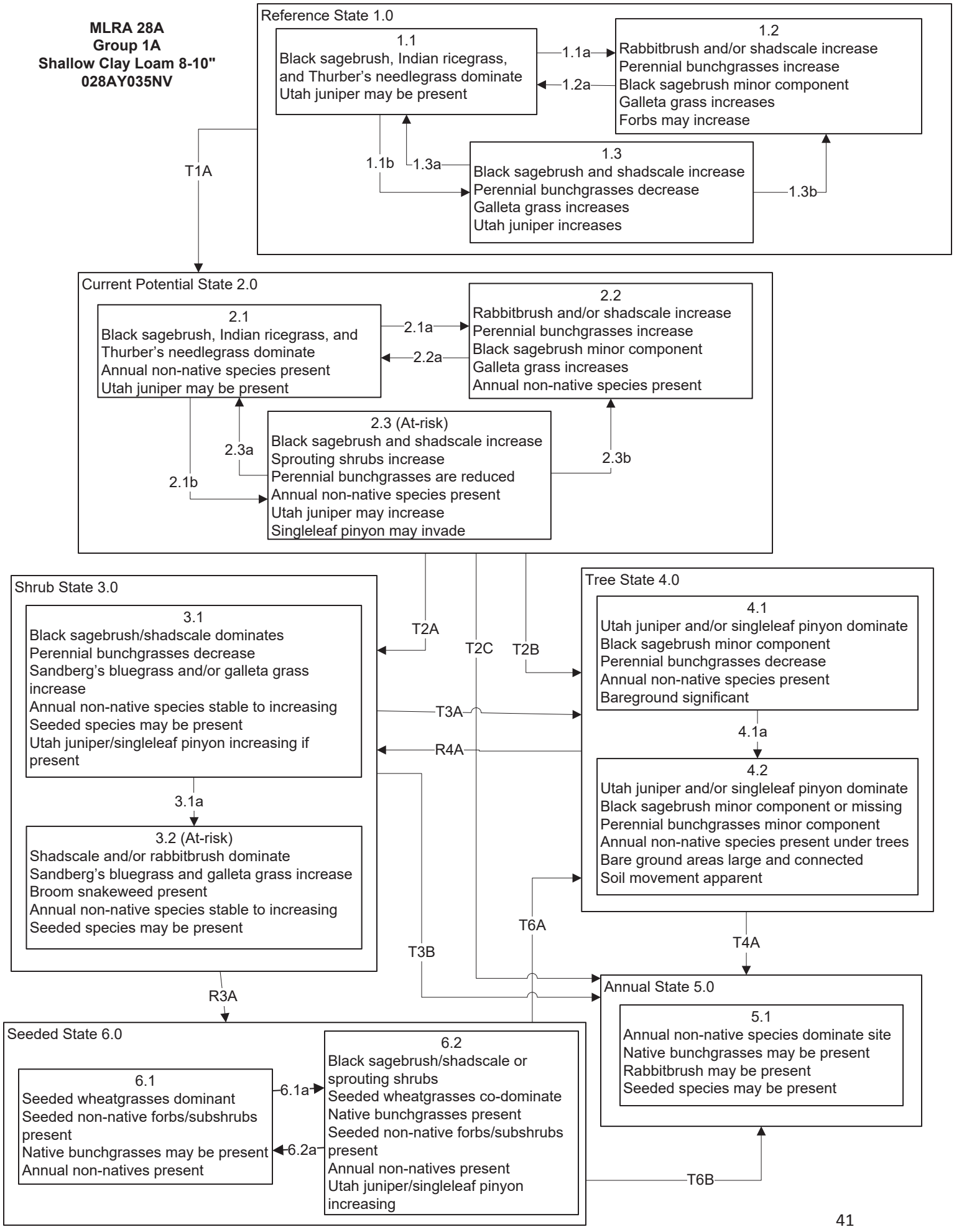
Group 1A:

Additional State - and -Transition Models:

Name	Site ID
Shallow Clay Loam 10-12" P.Z.	028AY035NV
Shallow Calcareous Slope 8-10" P.Z.	028AY004NV
Shallow Calcareous Hill 8-10" P.Z.	028AY027NV
Droughty Calcareous Loam 8-10"	028AY047NV
Shallow Calcareous Hill 6-8" P.Z.	028AY044NV

MLRA 28A
Group 1A
Shallow Clay Loam 8-10"
028AY035NV



MLRA 28A
Group 1A
Shallow Clay Loam 8-10"
028AY035NV

Reference State 1.0 Community Pathways
1.1a: Low severity fire resulting in a mosaic pattern.
1.1b: Time and lack of disturbKEYance such as fire, long term drought, herbivory, or combinations of these.
1.2a: Time and lack of disturbance such as fire, long term drought, herbivory, or combinations of these.
1.3a: Low severity fire or herbivory resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native plants.

Current Potential State 2.0 Community Pathways:
2.1a: Fire or brush treatments (i.e. mowing) with minimal soil disturbance.
2.1b: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
2.2a: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
2.3a: Low severity fire, late fall/winter grazing or brush treatment with minimal soil disturbance creates sagebrush/ grass mosaic.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community

Transition T2A: Inappropriate cattle/horse grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or inappropriate sheep grazing management will lead to phase 3.2.
Transition T2B: Time and lack of disturbance allows for maturation of the tree community.
Transition T2C: Catastrophic fire or soil disturbing treatments.

Shrub State 3.0 Community Pathways
3.1a: Fire and/or sheep grazing. Brush treatments (i.e. mowing) with minimal soil disturbance.

Transition T3A: Time and lack of disturbance allows for maturation of the tree community. Heavy sheep grazing will expedite this transition.
Transition T3B: Fire and/or soil disturbing treatments.

Restoration Pathway R3A: Drill or aerial seeding of native and non-native wheatgrasses, forbs, and other species.

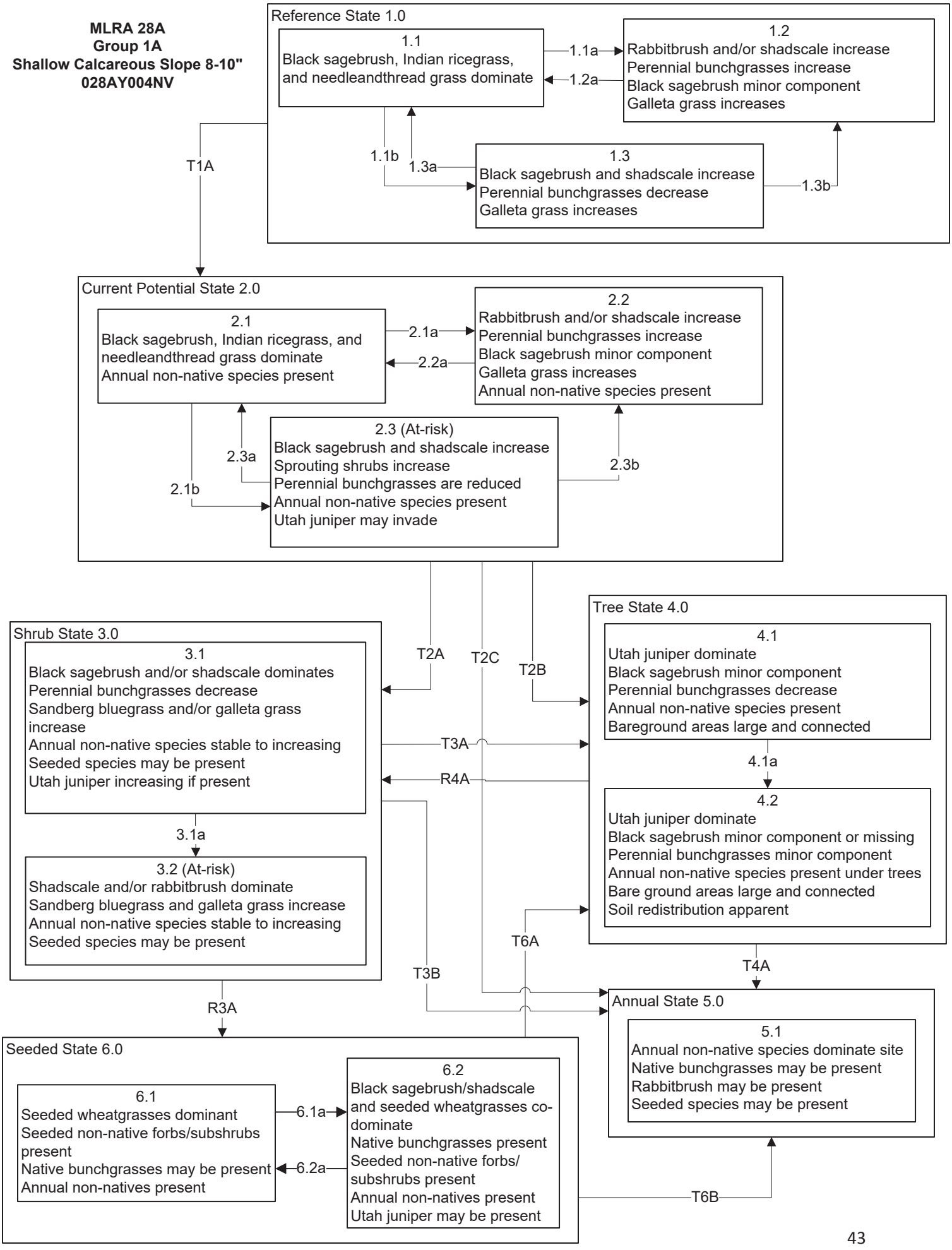
Tree State 4.0 Community Pathways
4.1a: Time and lack of disturbance allows for maturation of the tree community.

Transition T4A: Catastrophic fire that significantly reduces or eliminates tree and any remaining shrub overstory. Inappropriate tree removal practices may also contribute to this transition.
Restoration Pathway R4A: Removal of trees and seeding of desired species.

Seeded State 6.0 Community Pathways
6.1a: Inappropriate grazing management during the growing season facilitates shrub establishment and dominance.
6.2a: Fire or brush treatments with minimal soil disturbance.

Transition T6A:Time without disturbance allows trees to establish and dominate the site; may be coupled with grazing management that favors reduced perennial grass density and increased tree establishment.
Transition T6B: High severity fire and/or inappropriate grazing management. Soil disturbing brush treatments may also lead to the annual state.

MLRA 28A
Group 1A
Shallow Calcareous Slope 8-10"
028AY004NV



MLRA 28A
Group 1A
Shallow Calcareous Slope 8-10
028AY004NV

Reference State 1.0 Community Pathways
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1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native plants.

Current Potential State 2.0 Community Pathways:
2.1a: Fire or brush treatments (i.e. mowing) with minimal soil disturbance.
2.1b: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
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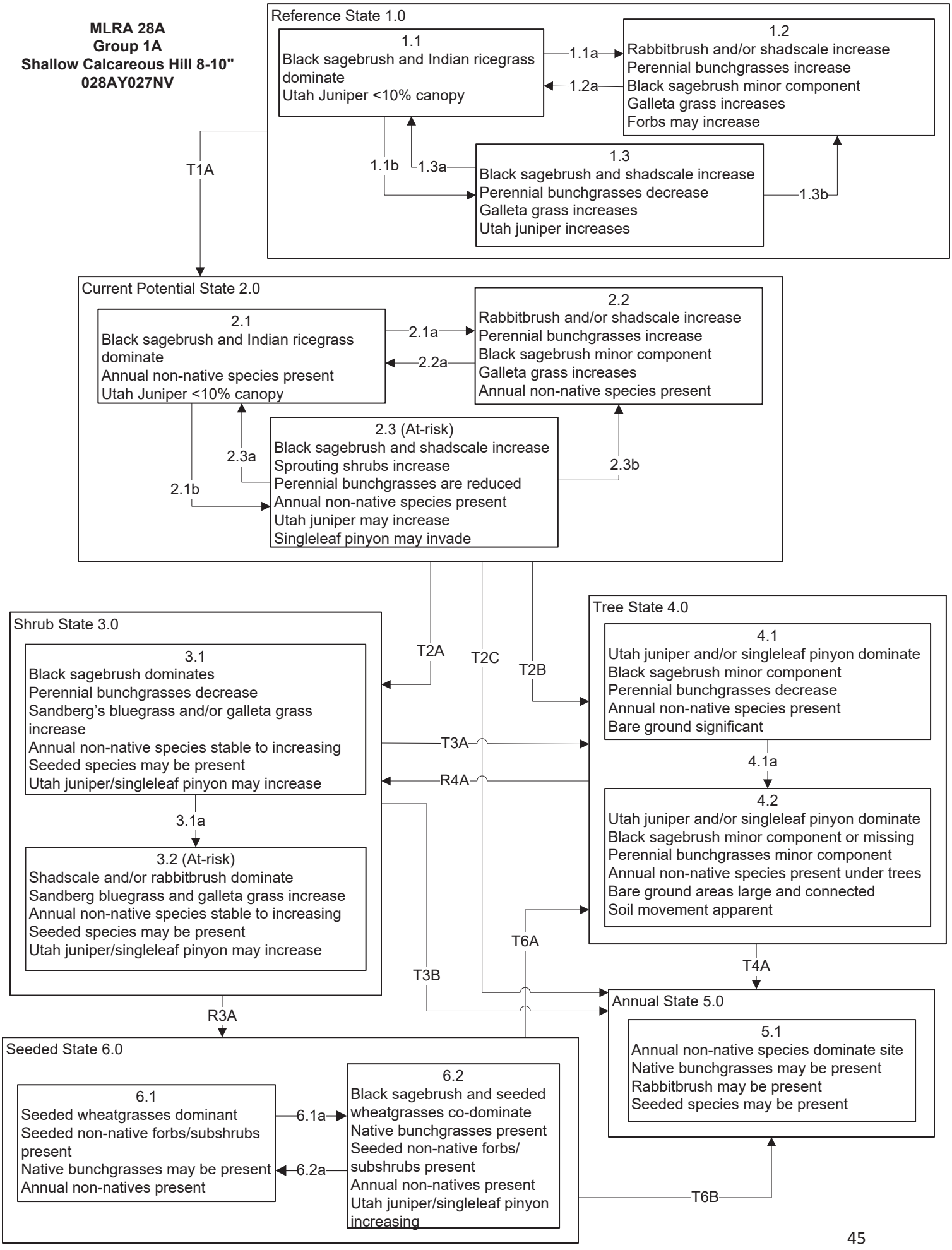
Restoration Pathway R4A: Removal of trees and seeding of desired species.

Seeded State 6.0 Community Pathways
6.1a: Inappropriate grazing management during the growing season facilitates shrub establishment and dominance.
6.2a: Fire or brush treatments with minimal soil disturbance.

Transition T6A:Time without disturbance allows trees to establish and dominate the site; may be coupled with grazing management that favors reduced perennial grass density and increased tree establishment.
Transition T6B: High severity fire and/or inappropriate grazing management. Soil disturbing brush treatments may also lead to the annual state.

MLRA 28A
Group 1A
Shallow Calcareous Hill 8-10"
028AY027NV



MLRA 28A
Group 1A
Shallow Calcareous Hill 8-10"
028AY027NV

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1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native plants.

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2.1a: Fire or brush treatments (i.e. mowing) with minimal soil disturbance.
2.1b: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
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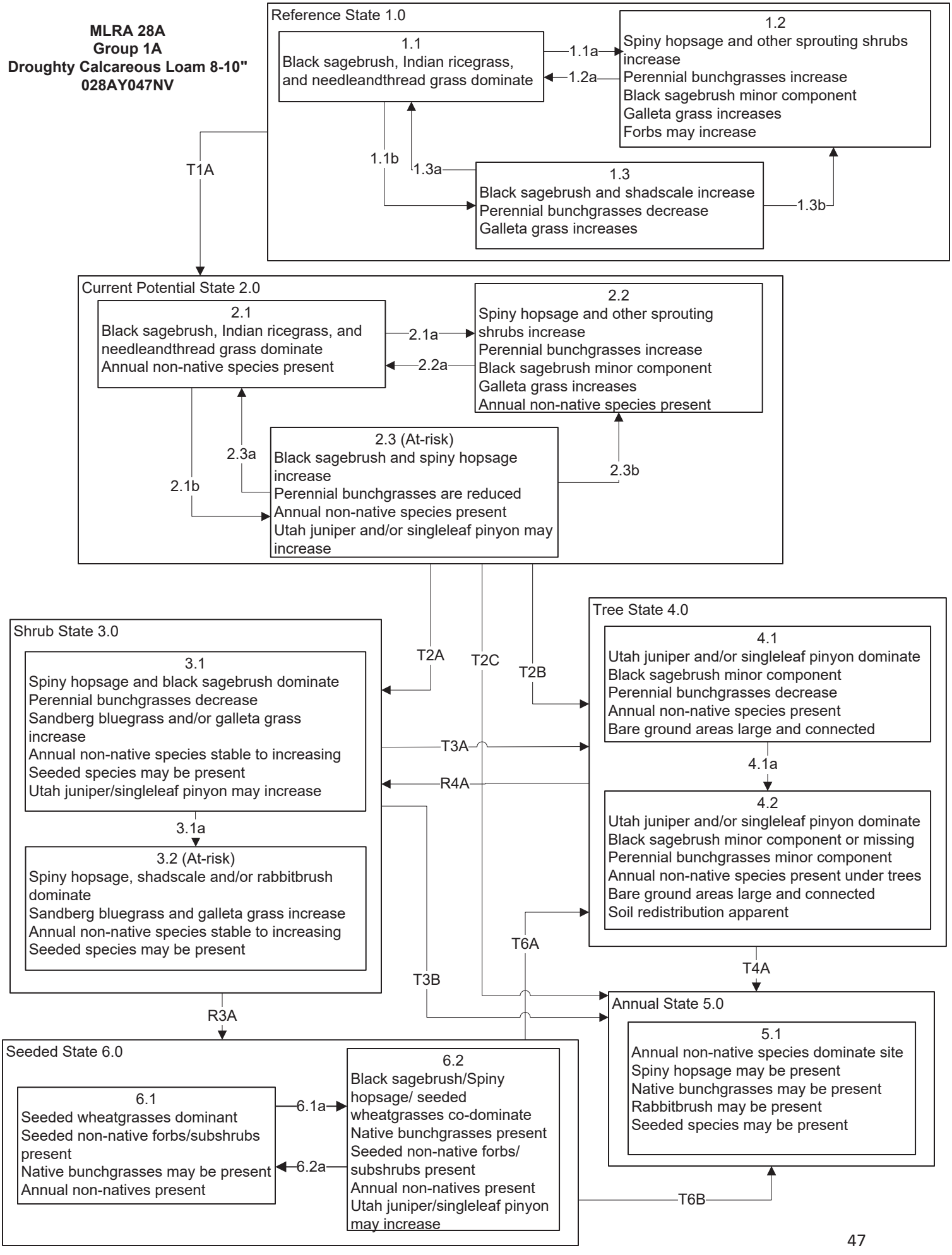
Restoration Pathway R4A: Removal of trees and seeding of desired species.

Seeded State 6.0 Community Pathways
6.1a: Inappropriate grazing management during the growing season facilitates shrub establishment and dominance
6.2a: Fire or brush treatments with minimal soil disturbance.

Transition T6A:Time without disturbance allows Utah juniper and/or piñon pine to establish and dominate the site; may be coupled with grazing management that favors reduced perennial grass density and increased tree establishment.
Transition T6B: High severity fire and/or inappropriate grazing management. Soil disturbing brush treatments may also lead to the annual state.

MLRA 28A
Group 1A
Droughty Calcareous Loam 8-10"
028AY047NV



MLRA 28A
Group 1A
Droughty Calcareous Loam 8-10"
028AY047NV

Reference State 1.0 Community Pathways
1.1a: Low severity fire resulting in a mosaic pattern.
1.1b: Time and lack of disturbKEYance such as fire, long term drought, herbivory, or combinations of these.
1.2a: Time and lack of disturbance such as fire, long term drought, herbivory, or combinations of these.
1.3a: Low severity fire or herbivory resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native plants.

Current Potential State 2.0 Community Pathways:
2.1a: Fire or brush treatments (i.e. mowing) with minimal soil disturbance.
2.1b: Time and lack of disturbance such as fire; chronic long term drought, inappropriate grazing management, or combinations of these would allow the sagebrush overstory to increase and dominate the site.
2.2a: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
2.3a: Low severity fire, late fall/winter grazing or brush treatment with minimal soil disturbance creates sagebrush/ grass mosaic.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community

Transition T2A: Inappropriate cattle/horse grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or inappropriate sheep grazing management will lead to phase 3.2.
Transition T2B: Time and lack of disturbance allows for maturation of the tree community.
Transition T2C: Catastrophic fire or soil disturbing treatments.

Shrub State 3.0 Community Pathways
3.1a: Fire and/or sheep grazing. Brush treatments (i.e. mowing) with minimal soil disturbance.

Transition T3A: Time and lack of disturbance allows for maturation of the tree community. Inappropriate grazing will expedite this transition.
Transition T3B: Fire and/or soil disturbing treatments.

Restoration Pathway R3A: Drill or aerial seeding of native and non-native wheatgrasses, forbs, and other species.

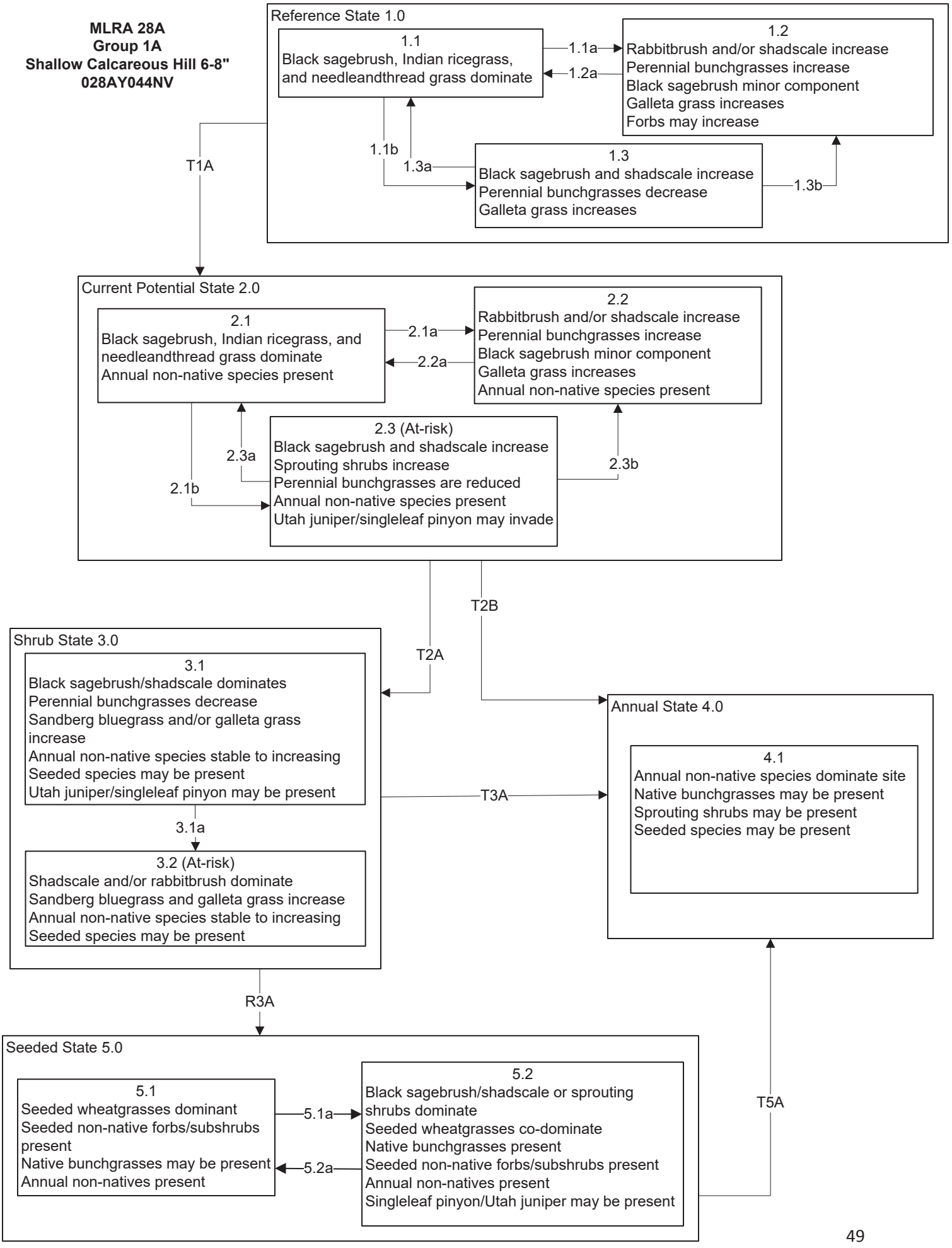
Tree State 4.0 Community Pathways
4.1a: Time and lack of disturbance allows for maturation of the tree community.

Transition T4A: Catastrophic fire that significantly reduces or eliminates tree and any remaining shrub overstory. Inappropriate tree removal practices may also contribute to this transition.
Restoration Pathway R4A: Removal of trees and seeding of desired species.

Seeded State 6.0 Community Pathways
6.1a: Inappropriate grazing management during the growing season facilitates shrub establishment and dominance.
6.2a: Fire or brush treatments with minimal soil disturbance.

Transition T6A:Time without disturbance allows trees to establish and dominate the site; may be coupled with grazing management that favors reduced perennial grass density and increased tree establishment.
Transition T6B: High severity fire and/or inappropriate grazing management. Soil disturbing brush treatments may also lead to the annual state.

MLRA 28A
Group 1A
Shallow Calcareous Hill 6-8"
028AY044NV



MLRA 28A
Group 1A
Shallow Calcareous Hill 6-8"
028AY044NV

Reference State 1.0 Community Pathways
1.1a: Low severity fire resulting in a mosaic pattern.
1.1b: Time and lack of disturbance such as fire, long term drought, herbivory, or combinations of these.
1.2a: Time and lack of disturbance such as fire, long term drought, herbivory, or combinations of these.
1.3a: Low severity fire or herbivory resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native plants.

Current Potential State 2.0 Community Pathways:
2.1a: Fire or brush treatments (i.e. mowing) with minimal soil disturbance.
2.1b: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
2.2a: Time and lack of disturbance such as fire, long term drought, inappropriate grazing management, or combinations of these.
2.3a: Low severity fire, late fall/winter grazing or brush treatment with minimal soil disturbance creates sagebrush/ grass mosaic.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community

Transition T2A: Inappropriate cattle/horse grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or inappropriate sheep grazing management will lead to phase 3.2.
Transition T2B: Catastrophic fire or soil disturbing treatments.

Shrub State 3.0 Community Pathways
3.1a: Fire and/or sheep grazing. Brush treatments (i.e. mowing) with minimal soil disturbance.

Transition T3A: Fire and/or soil disturbing treatments.

Seeded State 5.0 Community Pathways
5.1a: Inappropriate grazing management during the growing season facilitates shrub establishment and dominance
5.2a: Fire or brush treatments with minimal soil disturbance.

Transition T5A: High severity fire and/or inappropriate grazing management. Soil disturbing brush treatments may also lead to the annual state.