Final Report
USDA Ecological Site Description
State-and-Transition Models
Major Land Resource Area 28A and 28B Nevada
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Disturbance Response Group 28AB

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Ecological Sites within Disturbance Response Group 28AB:
Modal Site: Limestone Hill 028BY066NV

Group	Name	Site ID
28AB	**Limestone Hill**	**028BY066NV**
	Limestone Hill	028AY029NV

MLRA 28
Group 28AB

Disturbance Response Group (DRG) 28 consists of two sites. One is in MLRA 28A and the other in MLRA 28B. Precipitation ranges from 8 to 14 inches. Slopes range from 8 to 75 percent, but slopes of 15 to 50 percent are most common. Elevations range from 6000 to 8500 feet. These sites occur on mountain shoulders and sideslopes. The soils are shallow to very shallow and well drained. These soils have formed in residuum and colluvium from limestone or dolomite parent materials. The soil profile is modified with up to 70 percent rock fragments and more than half are cobbles and stones. The soil pH is slightly to moderately alkaline and the soils are calcareous throughout the profile. The soil temperature regime is frigid and the soil moisture regime is aridic bordering on xeric. The Reference State is dominated by littleleaf mountain mahogany (*Cercocarpus intricatus*) and Scribner needlegrass (*Achnatherum scribneri*). Indian ricegrass (*Achnatherum hymenoides)* and galleta grass (*Pleuraphis jamesii*) are also common on these sites. Other shrubs found on these sites include black sagebrush (*Artemisia nova)*, spiny greasebush (*Glossopetalon spinescens*) and desert snowberry (*Symphoricarpos longiflorus*). Utah juniper (*Juniperus osteosperma)* may also be present on these sites. Production ranges from 700 to 1000 lbs/acre for a normal year.

Modal Site:
The Limestone Hill ecological site is the modal that represents this DRG as it has the most acres mapped. This site occurs on hills and lower elevation mountain sideslopes on all exposures. Slopes range from 8 to 75 percent, but slope gradients of 15 to 50 percent are most typical. Elevations are 6200 to 8500 feet. Average annual precipitation is 10 to 14 inches. Soils are very shallow to shallow, well drained and have little development. These soils have formed in residuum and colluvium from limestone or dolomite parent materials. The soil profile is modified with up to 70 percent rock fragments and more than half are cobbles and stones. Coarse fragments at the surface provide a stabilizing effect on surface erosion conditions. Runoff is high to very high and permeability is high. Available water holding capacity is very low. The soil temperature regime is frigid and the soil moisture regime is aridic bordering on xeric. The Reference State is dominated by littleleaf mountain mahogany. Black sagebrush, desert snowberry, Scribner needlegrass and Indian ricegrass are important species associated with this site. Annual production ranges from 800 to 1300 pounds per acre.

Disturbance Response Group 28 Ecological sites:

Limestone Hill (Modal)	028BY066NV
Limestone Hill	028AY029NV

Ecological Dynamics and Disturbance Response

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

The ecological sites in this DRG are dominated by the long-lived littleleaf mountain mahogany, deep-rooted cool season perennial bunchgrasses, and other long-lived shrubs (50+ years) with high root to shoot ratios. Littleleaf mountain mahogany occurs rooted in the cracks and crevices of exposed limestone and dolomite (Davis 1990). The perennial bunchgrasses 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 meters. General differences in root depth distributions between grasses and shrubs results in resource partitioning in this system.

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. 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).

Littleleaf mountain mahogany (*Cercocarpus intricatus*) is a long-lived, intricately branched, and occasionally tree-like evergreen shrub. Its height may vary from 0.5 to 2.5m. Littleleaf mahogany is found throughout most of Nevada and Utah, and parts of California, Arizona and Colorado (Davis 1990). It is found mostly on rocky limestone slopes primarily within the pinyon woodland. Where it occurs near curl-leaf mountain mahogany (*Cercocarpus ledifolius*) the two may hybridize (Brayton and Mooney 1966).

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 Scribner needlegrass, Indian ricegrass, bluebunch wheatgrass, muttongrass and squirreltail. 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 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 has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al 2007).

The Limestone Hill is a very stable ecological site. Fire is the main disturbance but will be rare and low severity due to low fuel loads. The majority of fires will be from lightning strikes and produce minor spot burns which create a mosaic of trees, shrubs, grasses, and forbs. Open areas will be dominated by shrubs and bunchgrasses such as bluebunch wheatgrass.

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, precipitation, and nutrient availability. Long-term disturbance response may be influenced by small differences in landscape topography. Concave areas receive run-in from adjacent landscapes and consequently retain more moisture to support the growth of deep-rooted perennial grasses (i.e. bluebunch wheatgrass) whereas convex areas where runoff occurs

are slightly less resilient and may have more shallow-rooted perennial grasses (i.e. Sandberg bluegrass). North slopes are also more resilient than south slopes because lower soil surface temperatures operate to keep moisture content higher on northern exposures. Two possible alternative stable states have been identified for this DRG.

Fire Ecology:
Literature on fire response in littleleaf mountain mahogany communities is scarce, however Kitchen (2012) studied historical fire regimes in the Wah Wah mountains in Utah where numerous forest and woodland openings are dominated by black sagebrush and littleleaf mountain mahogany. Point mean fire interval estimates for areas around these sites ranged from 13.8 to 138.4 years.

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 rabbitbrush may become the dominant shrub species following fire, often with an understory of Sandberg bluegrass 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. 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 also vary depending on post-fire soil moisture availability.

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

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.

Livestock/Wildlife Grazing Interpretations:
Littleleaf mountain mahogany is browsed by wild ungulates and domestic sheep where it is within reach (Francis 2004), however Clary and Beale (1983) noted that pronghorn appeared to make little use of this plant when other forage, such as black sagebrush, was available, even in winter.

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 increase 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). 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. 1982); 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).

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.

Indian ricegrass 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 bluebunch wheatgrass 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 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover after 7 years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended.

STM Narrative Group 25

Reference State 1.0: The Reference State 1.0 is representative of the natural range of variability under pristine conditions. The Reference State has two general community phases: a dominant tree/shrub phase and a dominant tree/grass 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 Phase 1.1:
This community phase is characterized by mature littleleaf mountain mahogany trees. Black sagebrush and desert snowberry are the dominant shrubs in the understory. Scribner needlegrass and Indian ricegrass are the dominant bunchgrasses in the understory. Bottlebrush

squirreltail, bluebunch wheatgrass and Sandberg bluegrass are also present. Perennial forbs such as mock goldenweed (*Stenotus acaulis*), beardtongue (*Penstemon* spp.), fineleaf hymenopappus (*Hymenopappus filifolius*) make up minor components. Utah juniper may be present in small amounts.

Limestone Hill (028AY029NV). Phase 1.1. T. Stringham, August 2013.

Community Phase Pathway 1.1a: A low severity fire would reduce cover of a few shrubs in the understory and allow the perennial bunchgrasses to increase.

Community Phase 1.2:
Littleleaf mountain mahogany is reduced but remains as a major component of the overstory. Black sagebrush is reduced. Yellow rabbitbrush and desert snowberry may be sprouting. Perennial bunchgrasses may be reduced the first season after fire but will likely increase in cover and density due to the reduced competition from shrubs and trees. Forbs may increase the first season after fire, but continue to decline as grasses and shrubs return to pre-burn densities.

Community Phase Pathway 1.2a: Time without disturbance such as fire, long-term drought, or disease will allow for the trees and shrubs to increase in height and density.

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

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass and annual mustards.
Slow variables: Over time the annual non-native species 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 with two similar community phases. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance but will not become dominant within this State. These non-natives can be highly flammable and can promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of

the state. These feedbacks 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 characterized by mature littleleaf mountain mahogany trees. Black sagebrush and desert snowberry are the dominant shrubs in the understory. Scribner needlegrass and Indian ricegrass are the dominant bunchgrasses in the understory. Bottlebrush squirreltail, bluebunch wheatgrass and Sandberg bluegrass are also present. Perennial forbs comprise a minor component in the understory. Annual non-native species are present in the understory. Utah juniper may be present in small amounts.

Limestone Hill (028BY066NV). Phase 2.1. T. Stringham, June 2013.

Community Phase Pathway 2.1a: A low severity fire would reduce the canopy of the shrubs in the understory and allow the perennial bunchgrasses to increase.

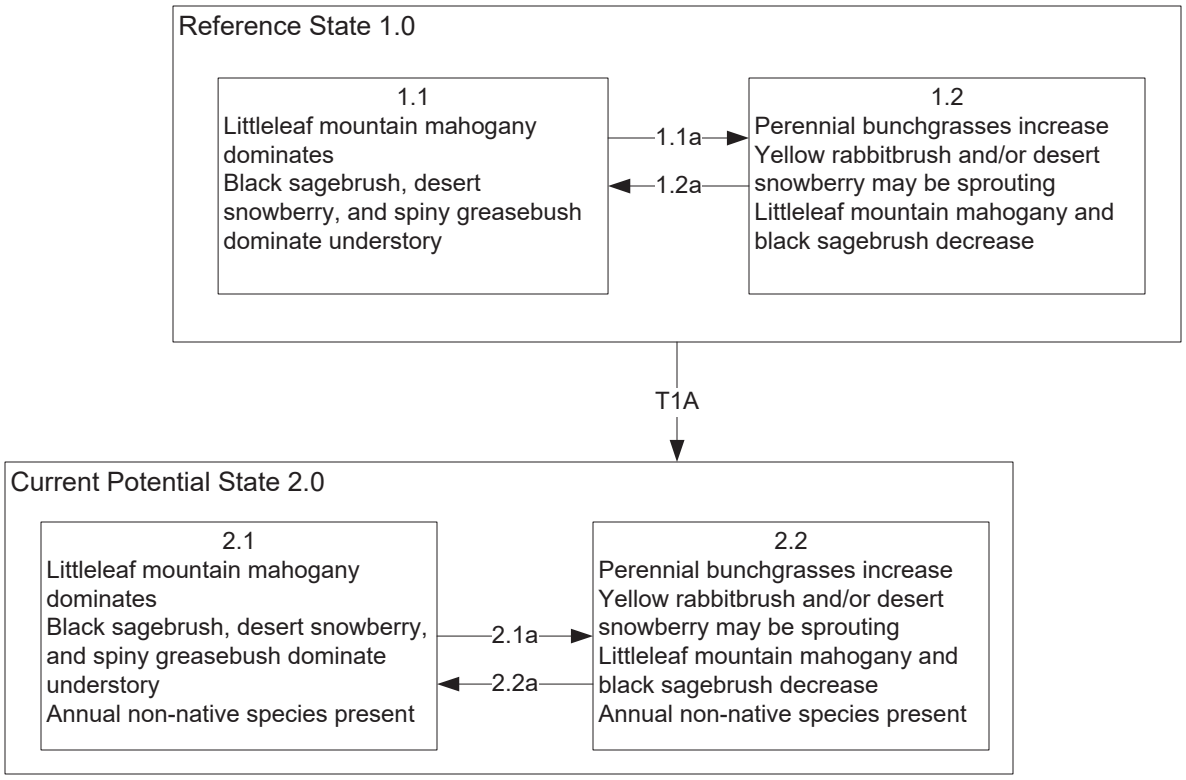
Community Phase 2.2:
Littleleaf mountain mahogany is reduced but remains as a major component of the overstory. Black sagebrush is reduced and desert snowberry may be sprouting. Perennial bunchgrasses may be reduced the first season after fire but will likely increase in cover and density due to the reduced competition from shrubs and trees. Annual non-native species respond well to fire and may increase.

Community Phase Pathway 2.2a: Time without disturbance such as fire, long-term drought, or disease will allow for the trees and shrubs to increase in height and density.

Potential Resilience Differences with other Ecological Sites:

Limestone Hill (028AY029NV): This site is less productive than the modal. Galleta grass is subdominant due to monsoonal rain and climate in MLRA 28A. Galleta grass, a minor component of this ecological site, has been found to increase following fire likely due to its rhizomatous root structure and ability to resprout (Jameson 1962).

MLRA 28AB
Limestone Hill
028BY066NV



Key
MLRA 28AB
Group 28AB
Limestone Hill
028BY066NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates a mosaic pattern of shrubs and grasses.
1.2a: Time and lack of disturbance such as fire, drought, or disease allows for regeneration of littleleaf mountain mahogany and black sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates a mosaic pattern of shrubs and grasses.
2.2a: Time and lack of disturbance such as fire, drought or disease allows for regeneration of littleleaf mountain mahogany and black sagebrush.

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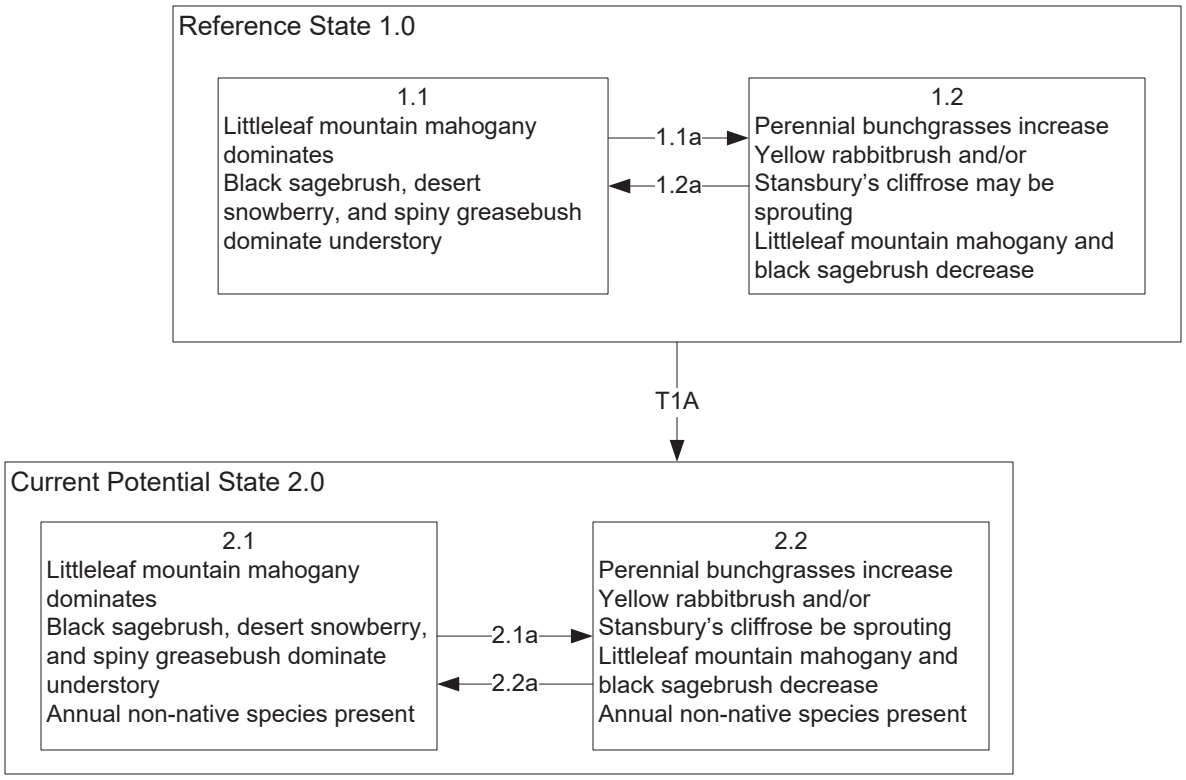
Group 28AB:

Additional State - and -Transition Models:

Name	Site ID
Limestone Hill	028AY029NV

MLRA 28AB
Limestone Hill
028AY029NV



Key
MLRA 28AB
Group 28AB
Limestone Hill
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Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates a mosaic pattern of shrubs and grasses.
1.2a: Time and lack of disturbance such as fire, drought, or disease allows for regeneration of littleleaf mountain mahogany and black sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates a mosaic pattern of shrubs and grasses.
2.2a: Time and lack of disturbance such as fire, drought or disease allows for regeneration of littleleaf mountain mahogany and black sagebrush.