10804

Inter-Mountain Basins Big Sagebrush Shrubland – Upland

BpS Model/Description Version: Aug. 2020

Reviewers: Tanya Anderson, Andrea Laliberte, Louis Provencher, Alan Sands, Joel Tuhy, Bob Unnasch

Vegetation Type

Shrubland

Map Zones

6, 12, 15, 16, 17, 18, 23, 24, 25

**Model Splits or Lumps**

This Biophysical Setting (BpS) is split into Wyoming big sagebrush found on upland soils and those found on semi-desert soils. The upland type receives enough moisture (>10in annual) to support pinyon and juniper trees. The semi-desert type is found in areas with 8-10in of annual precipitation and generally too dry to support trees. These types have different indicator species, fire frequencies, and management strategies. These types can be separated using precipitation data (e.g., Prism).

Geographic Range

This ecological system is found in California, central Nevada, Utah, Colorado, Wyoming, and northern Arizona and New Mexico and is distinct from sagebrush steppe (Inter-Mountain Basins Big Sagebrush Steppe, BpS 1125) found on the Columbia Plateau and in Wyoming. This particular model is specific to the Cold Deserts ecoregion (level 2 ecoregion, Cleland 2007) excluding the Northern Basin and Range and Wyoming Basins ecoregions (level 3 ecoregions).

Biophysical Site Description

This widespread system is common to the Basin and Range province. In elevation, it ranges from 3,000-7,000ft (>4,000ft at lower latitudes) and occurs on well-drained soils on foothills, terraces, slopes, and plateaus. It is found on soil depths >18in and up to 60in+. It is found between Wyoming big sagebrush on semi-desert soils (<10in precipitation zone) at lower elevations and mountain big sagebrush at higher elevations (>12in precipitation zone) where pinyon and juniper can establish. Occurs from 4-14in precipitation zones; however, Wyoming big sagebrush as a species requires 8-12in of effective moisture within this broader range. Thus, other site characteristics (e.g., aspect, drainage) should be considered in identifying this ecotype. At the precipitation extremes, this system generally occurs as small patches and stringers.

Vegetation Description

This BpS is commonly referred to as Wyoming big sagebrush shrubland compared to Wyoming big sagebrush steppe; however, big sagebrush shrubland exists on semi-desert soils (<10in precipitation zone) without pinyon or juniper (semi-desert type) and upland soils (greater than or equal to 10in precipitation zone) where pinyon and juniper might be present (upland type). Shrub canopy cover generally ranges from 5-25% but can exceed 30% at the upper elevation, in deeper soils, and precipitation zones. Herbaceous cover decreases with increasing shrub cover. Wyoming big sagebrush sites have fewer understory species relative to other big sagebrush types. Rubber rabbitbrush may be co-dominant.

Perennial forb cover is usually <10% with perennial grass cover reaching greater than or equal to 20% on the more productive sites. Bluebunch wheatgrass (greater than or equal to 10in precipitation zone) or Thurber needlegrass (<10in precipitation zone) may be dominant species following replacement fires and may be co-dominant after 20yrs. Bottlebrush squirreltail, Sandberg bluegrass, and Indian ricegrass are common. Percent cover and species richness of understory are determined by site limitations. Pinyon (generally *Pinus monophylla*) and juniper (generally *Juniperus osteosperma*) are generally present above the precipitation zone greater than or equal to 10in and south of the northern distributional limit of single-leaf pinyon and Utah juniper. Conifers occasionally reach 90% canopy cover in areas that have escaped fire. In large parts of northern Nevada, pinyon or juniper are absent; however, this model and its description includes classes with trees. The version of this system on upland soils without trees is described in map zones (MZs) 07, 09, and 18. Wyoming big sagebrush is critical habitat for the greater sage-grouse and many sagebrush obligates.

BpS Dominant and Indicator Species

Species names are from the NRCS PLANTS database. Check species codes at http://plants.usda.gov.

Disturbance Description

Fire:

This BpS is characterized by replacement fire in all classes, although fire return intervals (FRIs) vary by class. Mixed-severity and surface fires are absent because sagebrush systems do not underburn. Sagebrush and other shrubs are killed by fire, and the volatile compounds in sagebrush explode when burned. Where pinyon or juniper has encroached after 100yrs without fire, the mean FRI of fire replacement increases. Increasing xeric conditions result in longer FRIs because the cover and continuity of fine fuels and shrub canopies generally decrease.

Aroga Moth:

The Aroga moth is capable of defoliating large areas (i.e., >1,000ac), but usually outbreaks range from 10-100ac. Aroga moth outbreaks either kill or thin older sagebrush classes. Aroga moth outbreaks are more prevalent in the northern part of Nevada near the Idaho and Oregon borders. It is debatable whether the moth’s outbreaks are a significant factor in central Nevada. Aroga moth outbreaks are more prevalent in lower-elevation sagebrush (where there are less flowering plants and nectar to feed the parasitic wasps that attack the moth) and during years when the months of May, June, and July are substantially wetter and warmer than average (Bolshakova and Evans 2014, 2016). The return interval of moth outbreaks is ~15yrs in southern Idaho and Oregon and northern Nevada and Utah based on the examination of the Standard Precipitation Index for June lagged for two months (i.e., May and June) of the same year. Note: Aroga moth was not included in this model because it only applies to the most northern extent of the modeled area (see BpS 10800-1-7-8-9 for how it was applied in the northern Great Basin/Columbia Plateau area).

Weather stress:

Drought is only modeled as *severe drought* based on Biondi et al. (2007). It is assumed that non-severe drought will not appreciably thin or kill patches of sagebrush, salt desert, and subxeric woodlands. Severe drought is defined as 5 or more consecutive years of well-below-average soil moisture (narrow tree rings), and severe drought will kill subxeric shrubs and trees. A severe drought return interval rate of ~142yrs (a rate of 1/142yr = 0.007/yr) is used based on the analysis of a standardized (deviation from the average) 2,300yr time series of western juniper (*Juniperus occidentalis*) tree ring data from the Walker River drainage of eastern California and western Nevada (Biondi et al. 2007). These data highly correlate with other regional datasets for other tree species. To determine severe droughts, all 5yr sequences of below-average tree ring width deviation (i.e., negative deviation) were identified. Second, average tree ring deviations (average of the negative sequence), which were narrower than less than or equal to 1 Standard Deviation Unit, were further identified in those sequences. Fourteen such events occurred during the last 2,300yrs. Modelers calculated the number of years between severe drought events, which yielded an average of 142yrs. In most models and vegetation classes, severe drought generally has two effects: thinning shrubs or trees without causing a transition to another class for 90% of chosen pixels (but age is reset to the youngest age of the class) and thinning shrubs or young trees to the previous succession class for 10% of the remaining pixels (age is reset to the youngest age of that class). (NOTE: LANDFIRE models do not use the proportion function, but the same result is achieved by multiplying the probability times the proportion, e.g., .007 x .9, and using the result as the modeled probability.) Thinning of older pinyon and juniper is more complex and described under Class E. In many shrubland systems, the early-succession reference class, which is grassy, is not affected by severe drought.

Very wet years may also cause mortality and die-back if the soil remains saturated for an extended period of time, especially on flatter areas. This effect, however, is more prevalent at lower elevations in Wyoming big sagebrush on semi-desert soils and in mixed salt desert than in upland soils of Wyoming big sagebrush (this description, where it was not included). In the Great Basin and Utah’s west desert, the return interval of very wet years (e.g., 1983 was a very wet year) is ~55yrs (1/55yrs = 0.0181/yr) based on the analysis of the Standard Precipitation Index for the historic period in north-central Nevada.

Herbivory:

Non-insect herbivory can remove the fine fuel that supports mixed-severity fires and result in woody fuel build-up that leads to severe replacement fires. This effect, however, would require high stocking rates of non-native domestic or wild ungulates.

Fire Frequency

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is the central tendency modeled. Percent of all fires is the percent of all fires modeled in that severity class. Minimum and Maximum FIs show the relative range of fire intervals as estimated by model contributors, if known.

Scale Description

This BpS can occupy vast areas (>100,000ac). Historic disturbance (fire) likely ranged from small (<10ac) to large (>10,000ac) depending on conditions, time since last ignition, and fuel loading. The average patch size is assumed to be 250ac. Aroga moth outbreaks appear to be 10-100ac. Severe drought is regional, but local soil conditions and patchy precipitation result in scales of thinning and mortality of 100-50,000ac. Prolonged soil saturation during very wet years is also regional and depends on the proportion of areas with flat topography. There are no data on these episodic events but a scale of 100-5,000 ac would make sense.

Adjacency or Identification Concerns

The NatureServe description of this BpS includes different species of sagebrush and steppe ecosystems that are structurally and ecologically different such as *Artemisia tridentata* ssp. *tridentata*, *Artemisia tridentata* ssp. *wyomingensis*, and *Artemisia tripartita* ssp. *tripartita*. Review indicated that these species, especially *Artemisia tridentata* ssp. *tridentata*, should be modeled separately, but other reviewers indicated that it would be very difficult to map the types separately using 30m imagery.

Identification concerns include instances of low-statured Wyoming big sagebrush due to reduced effective rooting zone. Low-statured Wyoming big sagebrush can be confused with black sagebrush (BpS 1079) from a distance or a satellite.

This community may be adjacent to mountain big sagebrush (BpS 1126) at elevations >6,500ft or adjacent to pinyon-juniper and ponderosa pine at mid- to high elevations, and salt desert shrub at low elevations. Differentiating between mountain big sagebrush with conifers and Wyoming big sagebrush with conifers is a remote sensing challenge and will require arbitrary splitting using elevation or precipitation zones (12in precipitation boundary). Low sagebrush or black sagebrush may form large islands within this community where soils are shallow or have root-restrictive layers.

Post-settlement conversion to cheatgrass and other non-native annual species is common and results in change in fire frequency and vegetation dynamics. Fire suppression can lead to pinyon-juniper encroachment with subsequent loss of shrub and herbaceous understory. Disturbance of this community may result in establishment of annual grasslands (e.g., cheatgrass) and/or noxious weeds. Lack of disturbance can result in pinyon-juniper encroachment where adjacent to pinyon-juniper woodlands.

Post-settlement issues center on the high amount of big sagebrush with minimal to no understory and whether these decadent stands are related to fire suppression or natural physiological/ ecological progression.

Issues or Problems

Native Uncharacteristic Conditions

Comments

During the 2016 system-wide review, this BpS was reviewed by Louis Provencher, Tanya Anderson, Bob Unnasch, and Joel Tuhy of The Nature Conservancy, and several important changes were made: a) mixed-severity and surface severity were eliminated; b) the generic wind/ weather/stress disturbance was narrowed down to severe drought, which was defined and quantified; and c) it was decided to split big sagebrush shrubland on upland soils (this description) from the semi-desert types immediately lower in elevation or effective precipitation and without a potential for succession to wooded classes. In the model, age reset is set to “yes” for disturbances that do not cause state changes.

Alan Sands also reviewed this BpS in 2017 after the changes described above were implemented. Sands concurred with the revised model and description with two exceptions:

1. Sands felt that as described this BpS is too dry for juniper and would be better classified as Sagebrush Steppe with a pinyon-juniper variant. He commented that >10in annual precipitation (described as the threshold for this system in the Lump/Split field) would result in a rich understory of perennial herbaceous vegetation. Sands suggested making a break between Big Sagebrush Steppe and Big Sagebrush Shrubland at 9-10in annual precipitation, arguing that Big Sagebrush communities <9in are likely to be Big Sagebrush Shrubland. Kori Blankenship evaluated these suggestions but felt that additional input across the range of Sagebrush Shrubland and Sagebrush Steppe was needed before changing the classification of the type.
2. Sands also suggested that the fire frequency for this type should be in line with Big Sagebrush Steppe at ~90-100yrs. He stated that “burning occurred in this type frequently enough to keep junipers from invading these sites. At 120yrs, these areas would be pretty well invaded and may be reaching a density that reduces fire frequency even more.” Blankenship evaluated this suggestion but did not revise the modeled fire frequency, noting that there is considerable debate about the fire regime of sagebrush systems and that there has been disagreement among modelers and reviewers of the major sagebrush system in the west (for example, see BpS 11260-21 description, Baker 2006). However, it was noted that the modeled ca.120yr interval is outside the 10-70yr range reported in a 1999 literature review for *Artemisia tridentata* ssp. *wyomingensis* (Howard 1999). If/ when there is greater consensus on sagebrush fire regimes, the modeled fire frequency should be reevaluated.

Additional MZs were added to the 06, 12, 16, 17, 23, 24 group during the 2017 review of all Big Sagebrush Shrubland models:

1. Both Sands and reviewer Andrea Laliberte suggested that MZ18 could be combined with the MZ06 group for this BpS. Blankenship accepted this suggestion because the MZ18 model was developed from the MZ12/17 model with only minor changes. According to the comments, the original models for these MZs were identical, the minor differences in the description and s-class rules seemed reconcilable, and including MZ18 with the model centered on the Great Basin was consistent with how this zone was treated for the Inter-Mountain Basins Big Sagebrush Steppe (BpS 11250) and Inter-Mountain Basins Montane Sagebrush Steppe (BpS 11260). Furthermore, the MZ18 description included a note about the need to distinguish sites that support trees and those that do not. This distinction is addressed by the upland and semi-desert split made to this BpS in MZ06+ group. The model split also helps address the one major s-class structure difference between the two models (i.e., tree cover in Class E).
2. Sands indicated that descriptions for MZs 15 and 25, which were nearly identical with only a minor difference in the state-and-transition model, described a Montane Sagebrush Steppe system and that it should be rewritten or lumped with a similar MZ. In MZ15, the dominant shrub species was *Artemisia tridentata* ssp. *vaseyana*, an indicator for Montane Sagebrush Steppe (BpS 11260), not Big Sagebrush Shrubland. According to the USDA Plants website, *Artemisia tridentata* ssp. *vaseyana* does not occur in Arizona, which is where most of MZ15 and part of MZ25 are found. Blankenship decided to include MZs 15 and 25 with the MZ06 group. The primary distribution of Big Sagebrush Shrubland in these zones occurs within the Cold Desert ecoregion, so the grouped model would cover most of that ecoregion excluding the Northern Basin and Range and the Wyoming Basins ecoregions. Future review should consider whether MZs 15 and 25 should be split back out from the MZ06 group.

During the BpS Review in 2017, this model was part of a “macro-review” where all models representing this BpS were reviewed and evaluated relative to one another. One goal of the review was to check for logical consistency between the models. Outstanding questions from this review that should be evaluated in the future include:

* Has LANDFIRE appropriately identified and classified the big sage shrubland (BpS 10800) relative to big sage steppe (BpS 11250)? In his system-wide review of these BpSs, Alan Sands indicated that what was mapped and modeled as Big Sage Shrubland should be Big Sage Steppe in the following MZs: 10, 19, 21, 22, 31 and 33. Kori Blankenship consulted NatureServe range maps to evaluate this suggestion and found that they reported Big Sage Shrubland occurring in all these zones. Blankenship felt that more input was needed from local ecologists and NatureServe on the distribution of the types and the distinctions between them before changing the classification. This suggestion should be considered in future review.
* What is an appropriate fire frequency and severity for this BpS? Estimates for these fire regime parameters vary widely, and during LANDFIRE National, there was considerable debate about these values in some areas (see 10801-21-22-28 and 10802-21-22-28).
* Does the Wyoming big sagebrush versus basin big sagebrush split applied in the model representing MZs 21, 22, and 28 apply elsewhere, and can it be successfully mapped from 30m imagery? Descriptions for this BpS in some other zones indicated a need for distinct BpS models and mapping units for the different big sagebrush subspecies, but questions arose about the ability to map the distinctions from satellite imagery.
* Does the upland versus semi-desert split applied in the model representing MZs 06, 12, 15, 16, 17, 18, 23, 24, and 25 apply elsewhere? The split helps distinguish differences in species, fire frequency, and management options for sites on upland soils that receive enough precipitation to support trees from semi-desert sites that cannot.

MZs 06, 12, 16, 17, 23, and 24 were collapsed during 2015 BpS Review. The LANDFIRE National version of this BpS was modeled by Don Major, Gary Medlyn, and Crystal Kolden with review from Tim Christiansen. Contributors were changed during the 2017 review because of substantial revisions to the BpS concept (i.e., separating upland and semi-desert soils) and changes in the model.

The first three development classes chosen for this ecological system correspond to the early, mid, and late seral stages familiar to range ecologists. The two classes with conifer invasion (classes D and E) approximately correspond to Miller and Tausch's (2001) phases 2 and 3 of pinyon and juniper invasion into shrublands.

Succession Classes

**Mapping Rules**

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

**Description**

Class A 15 Early Development 1 - All Structures

Indicator Species

Description

Post-replacement disturbance; grass- and forb-dominated with scattered shrubs representing <10% upper canopy cover. Shrub indicators include yellow rabbitbrush (*Chrysothamnus viscidiflorus*) and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Fuel loading discontinuous.

*Maximum Tree Size Class*  
None

Class B 16 Mid Development 1 - Open

Indicator Species

Description

Shrubs and herbaceous vegetation can be co-dominant; fine fuel bridges the woody fuel, but fuel discontinuities are possible.

*Maximum Tree Size Class*  
None

Class C 25 Mid Development 1 - Closed

Indicator Species

Description

Shrubs dominate the landscape; fuel loading is primarily woody vegetation. Shrub density sufficient in old stands to carry the fire without fine fuel. Establishment of pinyon and juniper seedlings and saplings widely scattered.

*Maximum Tree Size Class*  
None

Class D 24 Late Development 1 - Open

Indicator Species

Description

Pinyon-juniper encroachment where disturbance has not occurred for at least 80yrs (tree species cover <15%). Shrubs may still represent the dominant lifeform, with pinyon and juniper saplings common (1-15% upper canopy cover). Sagebrush cover (<30%) and herbaceous cover decreasing compared to Class C.

*Maximum Tree Size Class*  
Sapling >4.5ft; <5" DBH

Class E 20 Late Development 1 - Closed

Indicator Species

Description

Shrubland encroached with mature pinyon and/or juniper. Shrub cover <10% and graminoids scattered.

Severe drought thins trees in a complex manner: About 10% of events result in a transition to the B class because trees have thinned shrub cover to the level found in the B class, whereas 90% of events either thin trees within the E class to the beginning age of the class up to a succession age of 174 or accelerates tree dominance and succession by a relative age of 5yrs+ through understory elimination after 174yrs. This was not done because it violates a LANDFIRE modeling rule that prohibits the use of AgeMin and AgeMax fields to restrict when a transition can occur within an s-class. However, the model was tested with and without the age restrictions, and the model results did not change.

*Maximum Tree Size Class*  
None

Model Parameters

Deterministic Transitions

Probabilistic Transitions

References

Baker, W.L. 2006. Fire and restoration of sagebrush ecosystems. Wildlife Society Bulletin34(1): 177-185.

Biondi, F., T.J. Kozubowski, A.K. Panorska, and L. Saito. 2007. A new stochastic model of episode peak and duration for eco-hydro-climatic applications. Ecological Modelling 211:383-395.

Bolshakova, V.L.J. and E.W. Evans. 2016. Phenology of the Sagebrush Defoliating Moth Aroga websteri (Lepidoptera: Gelechiidae) with Application to Population Irruptions and Climate Change. Annals of the Entomological Society of America. 109:424-431.

Bolshakova, V.L.J. and E.W. Evans. 2014. Spatial and Temporal Dynamics of Aroga Moth (Lepidoptera: Gelechiidae) Populations and Damage to Sagebrush in Shrub Steppe Across Varying Elevation. Environmental Entomology. 43:1475-1484

Brown, J.K. and J. Kapler-mith, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 257 pp.

Cook, J.G., T.J. Hershey, and L.L. Irwin. 1994. Vegetative response to burning on Wyoming mountain-shrub big game ranges. Journal of Range Management 47: 296-302.

Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal and P.K. Holmgren.1994. Intermountain Flora: Vascular Plants of the Intermountain West, U.S.A. Asterales. Volume 5. New York Botanical Garden, Bronx, NY.

Gruell, G.E. 1999. Historical and modern roles of fire in pinyon-juniper. Pages 24-28 in: S.B. Monsen and R. Stevens, compilers. Proceedings: ecology and management of pinyon-juniper communities within the Interior West; 1997, Provo, UT. Proc. RMRS-P-9. Ogden, UT. USDA Forest Service, Rocky Mountain Research Station.

Howard, Janet L. 1999. Artemisia tridentata subsp. wyomingensis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us/database/feis/plants/shrub/arttriw/all.html [2018, January 6].

Kinney, W.C. 1996. Conditions of rangelands before 1905. Sierra Nevada ecosystem project: Final report to Congress, Vol. II. Davis: University of California, Centers for water and wildland resources. 31-45.

Kuchler, A.W. 1985. Potential natural vegetation (map at scale of 1:7,500,000). In: U.S. Geological survey, The National Atlas of the USA. U.S. Govt. Print. Off. Washington, D.C.

Miller, R.F. and J.A. Rose. 1999. Fire history and western juniper encroachment in sagebrush-steppe. Journal of Range Management. 550-559.

Miller, R.F. and L.L. Eddleman. 2000. Spatial and temporal changes of sage grouse habitat in the sagebrush biome. Oregon State Univ. Agr. Exp. Stat. Technical Bull. 151. 35 pp.

Miller, R.F. and R.J. Tausch. 2001. The role of fire in juniper and pinyon woodlands: a descriptive analysis. Pages 15-30 in: Proceedings: The First National Congress on Fire, Ecology, Prevention, and Management. San Diego, CA, Nov. 27- Dec. 1, 2000. Tall Timbers Research Station, Tallahassee, FL. Miscellaneous Publication 11.

Miller, R.F., T.J. Svejcar and J.R. Rose. 2002 Impacts of western juniper on plant composition and structure. Journal of Range Management 53: 574-585.

NatureServe. 2007. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. Data current as of 10 February 2007.

Tausch, R.J. and R.S. Nowak. 1999. Fifty years of ecotone change between shrub and tree dominance in the Jack Springs Pinyon Research Natural Area. Pages 71-77 in: E. D. McArthur, W.K. Ostler and C.L. Wambolt, compilers. Proceedings: shrubland ecotones. 1998. Ephram, UT. Proc. RMRS-P-11. Ogden, UT. USDA Forest Service, Rocky Mountain Research Station.

Tilsdale, E.W. 1994. Great Basin region: sagebrush types. Pages 40-46. In: T.N. Shiflet, ed. Rangeland Cover Types. Soc. Range Manage., Denver, CO.

USDA-NRCS. 2003. Major Land Resource Area 24 Humboldt Area. Nevada Ecological Site Descriptions. Reno, NV. Available online: http://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx.

USDA-NRCS. 2003. Major Lannd Resource Area 25 Owyhee High Plateau. Oregon and Nevada Ecological Site Descriptions. Reno, NV. Available online: http://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx.

USDA-NRCS. 2003. Major Land Resource Area 27 Fallon-Lovelock Area. Nevada Ecological Site Descriptions. Reno, NV. Available online: http://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx.

USDA-NRCS. 2003. Major Land Resource Area 28A Great Salt Lake Area. Nevada Ecological Site Descriptions. Reno, NV. Available online: http://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx.

USDA-NRCS. 2003. Major Land Resource Area 28B Central Nevada Basin and Range. Nevada Ecological Site Descriptions. Reno, NV. Available online: http://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx.

USDA-NRCS. 2003. Major Land Resource Area 29 Southern Nevada Basin and Range. Nevada Ecological Site Descriptions. Reno, NV. Available online: http://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx.

Vale, T.R. 1973. The sagebrush landscape of the intermountain west. Dissertation. Berkeley: University of California. 508 pp.

Vale, T.R. 1975. Presettlement vegetation in the sagebrush-grass area of the intermountain west. Journal of Range Management 28(1): 32-36.

West, N.E. 1983. Western Intermountain sagebrush steppe. Pages 351-297 in: N.E. West, ed. Ecosystems of the World 5: Temperate deserts and semi-deserts. Elsevier Scientific Publishing Company, New York, NY.