

# Ecological site group R008XG120WA

## Stony, Sagebrush

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### Key Characteristics

None specified

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

### Physiography

Hierarchical Classification

Major Land Resource Area (MLRA): 8 – Columbia Plateau

LRU – Common Resource Areas (CRA):

- 8.1 - Channeled Scablands
- 8.2 - Loess Islands
- 8.3 - Okanogan Drift Hills
- 8.4 - Moist Pleistocene Lake Basins
- 8.5 - Moist Yakima Folds
- 8.6 - Lower Snake and Clearwater Canyons
- 8.7 - Okanogan Valley

Site Concept Narrative:

Diagnostics:

Stony, sagebrush is an upland site occurring on two soil conditions in the sagebrush steppe region of MLRA 8:

(1) 20 inches & deeper skeletal loamy soils. These soils have a stony or cobbly surface and rock fragments (35% or more) throughout the root-growing portion of the soil profile.

(2) shallow non-skeletal loamy soils. Silt loam, fine sandy loam and sandy loam are the most common textures, but a variety of soils and landforms are possible.

As one moves across MLRA 8, the landscape position for Stony, sagebrush changes. At 9 inches of precipitation Stony, sagebrush occurs on all but the north to northeast slopes. But at 12 inches of precipitation Stony, sagebrush may be found only on south to southwest slopes.

Fire-sensitive shrubs dominate the reference state overstory, while perennial bunchgrasses and forbs fill the interspaces. The shrub layer is typically waist- to chest-high Wyoming sagebrush. The natural fire regime maintains a patchy distribution of shrubs. Depending on the time interval since the last fire, the shrub canopy can be as little 0-3% or as much as 40%. Cool-season bunchgrasses form two distinct layers. Bluebunch wheatgrass is the dominant bunchgrass in the top grass layer, while Sandberg bluegrass is the major grass of the lower grass layer.

Principle Vegetative Drivers:

The stones throughout the profile drive the vegetative expression on many Stony, sagebrush sites. The moderately deep to deep soil depth provides unrestricted rooting for most species. But the stones limit the water holding capacity in the profile, and thus, plant production is limited as well.

But on other Stony, sagebrush sites it is the shallow soil depth that drives the vegetation. The soil is a non-skeletal loamy but shallow to bedrock which restricts plant roots and plant production

#### Influencing Water Features:

A plant's ability to grow on a site and overall plant production is determined by soil-water-plant relationships:

1. Whether rain and melting snow run off-site or infiltrate into the soil
2. Whether soil condition remain aerobic or become saturated and anaerobic
3. How quickly the soil reaches the wilting point

With adequate cover of live plants and litter, there are no restrictions on Stony sites with water infiltrating into the soil. These sites are well drained and are saturated for only a short period. Stony sites have less available water and are less productive than Loamy sites.

#### Physiographic Features:

The landscape is part of the Columbia basalt plateau. Stony, sagebrush sites occur on broad ridges, shoulders and plateaus, stream terraces, fans, canyon walls and canyon sideslopes.

Physiographic Division: Intermontane Plateau

Physiographic Province: Columbia Plateau

Physiographic Sections: Walla Walla Plateau Section

Landscapes: Hills, valleys, canyonlands, channel scablands and plateaus

Landform: Sideslopes, ridges, shoulders, terraces, alluvial fans

Elevation: Dominantly 800 to 4,000 feet

Slope: Total range: 0 to 90 percent

Central tendency: 2 to 30 percent

Aspect: Occurs on all aspects

#### Geology:

This MLRA is almost entirely underlain by Miocene basalt flows. Columbia River basalt is covered in many areas with as much as 200 feet of loess and volcanic ash. Small areas of sandstones, siltstones, and conglomerates of the Upper Tertiary Ellensburg Formation are along the western edge of this area. Some Quaternary glacial drift covers the northern edge of the basalt flows, and some Miocene-Pliocene continental sedimentary deposits occur south of the Columbia River, in Oregon.

A wide expanse of scablands in the eastern portion of this MLRA, in Washington, was deeply dissected about 16,000 years ago, when an ice dam that formed ancient glacial Lake Missoula was breached several times, creating catastrophic floods. The geology of the northernmost part of this MLRA is distinctly different from that of the rest of the area. Alluvium, glacial outwash, and glacial drift fill the valley floor of the Okanogan River and the side valleys of tributary streams. The fault parallel with the valley separates pre-Tertiary metamorphic rocks on the west, in the Cascades, from older, pre-Cretaceous metamorphic rocks on the east, in the Northern Rocky Mountains. Mesozoic and Paleozoic sedimentary rocks cover the metamorphic rocks for most of the length of the valley on the west.

## Climate

The Wyoming sagebrush-bluebunch wheatgrass areas are both warmer and drier than grasslands or other shrub steppe sites (Daubenmire). The climate is characterized by moderately cold, wet winters, and hot, dry summers, with limited precipitation due to the rain shadow effect of the Cascades. Taxonomic soil climate is either xeric (12 – 16 inches PPT) or aridic moisture regimes (10 – 12 inches PPT) with a mesic temperature regime.

Mean Annual Precipitation:

Range: 10 – 16 inches

Seventy to seventy-five percent of the precipitation comes late October through March as a mixture of rain and snow. June through early October is mostly dry.

Mean Annual Air Temperature:

Range: 44 to 54 F

Central Tendency: 48 – 52 F

Freezing temperatures generally occur from late-October through early-April. Temperature extremes are 0 degrees in winter and 110 degrees in summer. Winter fog is variable and often quite localized, as the fog settles on some areas but not others.

Frost-free Period (days):

Total range: 90 to 210

Central tendency: 120 to 160

The growing season for Stony, sagebrush is March through mid-July.

## **Soil features**

Edaphic:

The Stony, sagebrush ecological site commonly occurs with Loamy, Very Shallow, Cool Loamy and Loamy Bottom ecological sites.

Representative Soil Features:

This ecological site components are dominantly Aridic, Xeric, Calcic Lithic and Vitrandic taxonomic subgroups of Haploxerolls, Durixerolls, Palexerolls, Argixerolls and Haploxerepts great groups of the Mollisols and Inceptisols taxonomic orders, with Aridisols occurring as well. Soils are shallow to very deep. Average available water capacity of about 1.2 inches (3.1 cm) in the 0 to 40 inches (0-100 cm) depth range.

Soil parent material is dominantly mixed loess, colluvium and residuum, with mixed ash possible and glacial outwash.

The associated soils are Alecanyon, Badge, Brazlan, Cheviot, Clerf, Dezellem, Grinrod, Heytou, Kiona, Owhi, Reeser, Strat, Stubblefield, Tronsen, Whiskeydick and similar soils.

Dominate soil surface is clay loam to very stony fine sandy loamy, with ashy modifier sometimes occurring as well.

Dominant particle-size class is fine to sandy-skeletal

Fragments on surface horizon > 3 inches (% Volume):

Minimum: 0

Maximum: 5

Fragments within surface horizon > 3 inches (% Volume):

Minimum: 0

Maximum: 30

Average: 10

Fragments within surface horizon ≤ 3 inches (% Volume):

Minimum: 5

Maximum: 30

Average: 10

Subsurface fragments > 3 inches (% Volume):

Minimum: 0

Maximum: 40

Average: 20

Subsurface fragments  $\leq$  3 inches (% Volume):

Minimum: 5

Maximum: 45

Average: 25

Drainage Class: Dominantly well drained, but some somewhat excessively

Water table depth: Greater than 60 inches

Flooding:

Frequency: None

Ponding:

Frequency: None

Saturated Hydraulic Conductivity Class:

0 to 10 inches: High to moderately low

10 to 40 inches: High to moderately low

Depth to root-restricting feature (inches):

Minimum: 10

Maximum: Greater than 60 inches

Electrical Conductivity (dS/m):

Minimum: 0

Maximum: 5

Sodium Absorption Ratio:

Minimum: 0

Maximum: 10

Calcium Carbonate Equivalent (percent):

Minimum: 0

Maximum: 25

Soil Reaction (pH) (1:1 Water):

0 - 10 inches: 5.6 to 9.6

10 - 40 inches: 5.6 to 9.0

Available Water Capacity (inches, 0 – 40 inches depth):

Minimum: 0.4

Maximum: 2.4

Average: 1.2

## **Vegetation dynamics**

Ecological Dynamics:

Stony, sagebrush produces about 300-750 pounds/acre of biomass annually

Wyoming big sagebrush and bluebunch wheatgrass are at the core of the Stony, sagebrush ecological site and warrant a degree of understanding.

Wyoming sagebrush is a long-lived, multi-branched, evergreen shrub. Size varies from 3 feet to 5 feet depending on soil and site conditions. Wyoming big sagebrush has a significant rooting system, composed of a two-part rooting structure with a primary deep taproot, and a shallow extensive network of finer roots that spread laterally. This rooting system allows Wyoming big sagebrush to survive in the hottest and driest portions of the sagebrush

range by tapping into groundwater sources deep into the soil profile itself. This also allows Wyoming big sagebrush to be more competitive with bunchgrasses when the landscape positions and/or soils are less ideal for grass species to maintain the competitive advantage.

Bluebunch wheatgrass is a long-lived, mid-sized bunchgrass with an awned or awnless seed head arranged in a spike. Bluebunch provides a crucial and extensive network of roots to the upper portions (up to 48" deep in soils with no root-restrictive horizons) of the soil profile. These roots create a massive underground source to stabilize the soils, provide organic matter and nutrients inputs, and help maintain soil pore space for water infiltration and water retention in the soil profile. The extensive rooting system of mid-sized bunchgrasses leave very little soil niche space available for invasion by other species. This drought resistant root can compete with, and suppress, the spread of exotic weeds.

The stability and resiliency of the reference communities is directly linked to the health and vigor of bluebunch wheatgrass. See page 9 for more details about bluebunch physiology. Research has found that the community remains resistant to medusahead invasion if the site maintains at least 0.8 mid-sized bunchgrass plant/sq. ft. (K. Davies 2008). It is bluebunch that holds the system together. If we lose the bluebunch the ecosystem crashes or unravels.

The natural disturbance regime for grassland communities is periodic lightning-caused fires. The fire return intervals (FRI) listed in research for sagebrush steppe communities is quite variable. Ponderosa pine communities have the shortest FRI of about 10-20 years (Miller). The FRI increases as one moves to wetter forested sites or to drier shrub steppe communities. Given the uncertainties and opinions of reviewers, a mean of 75 years and a range of 50-100 was chosen for Wyoming sagebrush communities (Rapid Assessment Model).

Some fires are spotty or do not burn hot enough to fully remove the sagebrush. Fires with light severity will remove less sagebrush and open smaller patches for grass and forb recovery, whereas the more severe fires will remove almost all the sagebrush and leave vast areas open to return to bunchgrass dominance. This is how the patchy distribution occurs. Rabbitbrush and horsebrush are sprouting shrubs and may also increase following fire.

The effect of fire on the community depends upon the severity of the burn. With a light to moderate fire there can be a mosaic of burned and unburned patches of sagebrush. Sagebrush can return to pre-burn conditions quickly. Bunchgrasses thrive as the fire does not get into the crown. With adequate soil moisture Idaho fescue and bluebunch wheatgrass can make tremendous growth the year after the fire. Other than impacting the sagebrush layer, the community is not affected.

A severe fire puts stress on the entire community. The sagebrush layer is completely removed. Spots or patches with heavy sagebrush are sterilized by the fire and must be seeded to prevent invasive species (annual grasses, tumble mustard) from totally occupying the site. Bluebunch wheatgrass and basin wildrye will have weak vigor for a few years but generally survive. Idaho fescue plants are very much at risk with a severe burn coupled with wind. The result can be "black holes" or ash 2-3 inches into the crown. The death of Idaho fescue plants creates holes in the community, and the opportunity for exotic species to colonize. Needle and thread is one native species that can increase via new seedlings

For most of MLRA 8, Wyoming sagebrush does not recover easily after fire. The sagebrush in Douglas County, however, returns much more readily. For reasons that have not been clearly established, Douglas County may have a genetically different strain of sagebrush or be enough cooler and wetter, to receive more snowpack to get favorable responses. After disturbances sagebrush often becomes very dense and weedy in nature. Research indicates that microbes in the soil profile are essential for sagebrush success from seed.

The longer the site goes without fire and the more grazing pressure added, the more sagebrush cover increases, and the more bunchgrasses decline. As sagebrush cover increases bluebunch wheatgrass cover declines but individual plants may persist underneath the sagebrush. And, the dense sagebrush community phase is more vulnerable to outside pressures. Invasive species take advantage of available soil rooting spaces. The once extensive grass roots are largely absent. Soils are no longer receiving the organic inputs, and there is less surface cover by grass litter. Both water infiltration into the soil, and water percolation through the soil, are affected, leaving open soil space that is drier and more vulnerable to wind and water erosion, and invasion by undesirable species. Once these undesirable species have colonized, the site is at high risk of crossing a threshold if a disturbance such as fire were to occur.

Grazing is another common disturbance that occurs to this ecological site. Grazing pressure can be defined as heavy grazing intensity, or frequent grazing during reproductive growth, or season-long grazing (the same plants grazed more than once). As grazing pressure increases the plant community unravels in stages:

1. Bluebunch wheatgrass declines while Sandberg bluegrass, needle and thread and sagebrush increase
2. As bluebunch wheatgrass continues to decline, invasive species such as cheatgrass and knapweed colonize the site
3. With further decline the site can become a sagebrush-cheatgrass community

Managing sagebrush steppe to improve the vigor and health of native bunchgrasses begins with an understanding of grass physiology. New growth each year begins from basal buds. Bluebunch wheatgrass plants rely principally on tillering, rather than establishment of new plants through natural reseeding. During seed formation, the growing points become elevated and are vulnerable to damage or removal.

If defoliated during the formation of seeds, bluebunch wheatgrass has limited capacity to tiller compared with other, more grazing resistant grasses (Caldwell et al., 1981). Repeated critical period grazing (boot stage through seed formation) is especially damaging. Over several years each native bunchgrass pasture should be rested during the critical period two out of every three years (approximately April 15–July 15). And each pasture should be rested the entire growing-season every third year (approximately March 1 – July 15).

In the spring each year it is important to monitor and maintain an adequate top growth: (1) so plants have enough energy to replace basal buds annually, (2) to optimize regrowth following spring grazing, and (3) to protect the elevated growing points of bluebunch wheatgrass.

Bluebunch wheatgrass remains competitive if:

- (1) Basal buds are replaced annually,
- (2) Enough top-growth is maintained for growth and protection of growing points, and
- (3) The timing of grazing and non-grazing is managed over a several-year period. Careful management of late spring grazing is especially critical

For more grazing management information refer to Range Technical Notes found in Section I Reference Lists of NRCS Field Office Technical Guide for Washington State.

In Washington, Wyoming sagebrush – bluebunch wheatgrass communities provide habitat for sage grouse and other upland wildlife species.

Supporting Information:

Associated Sites:

Stony sagebrush is associated with other ecological sites in the sagebrush steppe areas of MLRA 8, including Shallow Stony, Loamy, Cool Loamy, Stony Foothills and Stony Foothills South Slope. It is also associated with Very Shallow, Biscuit Swale complex, Loamy Bottom, Alkali Terrace and Riparian complex.

Similar Sites:

Stony sagebrush has Wyoming sagebrush – bluebunch wheatgrass. In MLRA 8 Columbia Plateau. Loamy sagebrush in MLRA 8 has a similar composition but without rock on the surface or in the soil profile. MLRA 7 Columbia Basin Stony ecological site is also similar.

Inventory Data References (narrative):

Data to populate Reference Community came from several sources: (1) NRCS ecological sites from 2004, (2) Soil Conservation Service range sites from 1980s and 1990s, (3) Daubenmire's habitat types, and (4) ecological systems from Natural Heritage Program

## **Major Land Resource Area**

MLRA 008X

Columbia Plateau

## **Subclasses**

- R008XY120WA–Stony sagebrush

## **Stage**

Provisional

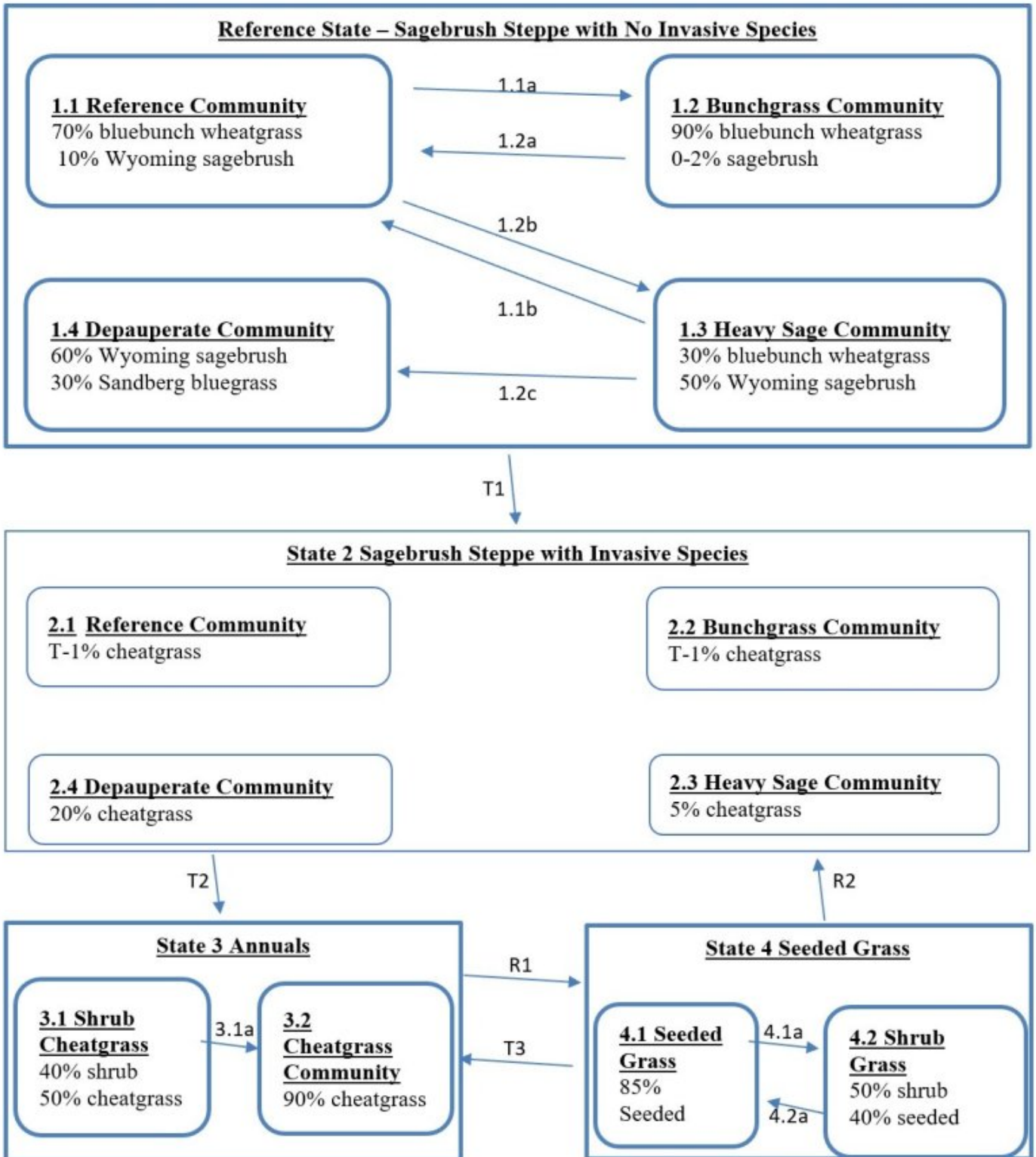
## **Contributors**

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## **State and transition model**

## State and Transition Diagram for Stony, sagebrush in MLRA 8:





## Reference Community 1.1 for Stony, sagebrush in MLRA 8

Percentages for plant species composition below are by weight and are an approximation. The composition of pristine sites can vary somewhat due to variations in site conditions.

Pounds listed below are the maximum allowable for Similarity Index. For drier sites use the low value and the high value for wetter sites. Many numbers have been rounded to not show more precision than our current state of knowledge.

Index	Similarity Index	Similarity		
<b>Non-Sprouting Shrubs – Subdominant</b> <b>(3-7% canopy)</b> 10% 55-75 lbs.		<b>Sprouting Shrubs – Minor</b> less than 5% 20-30 lbs.		
ARTRW8 Wyoming sagebrush		CHRY5 rabbitbrush		
ARTRT basin big sagebrush		RIBES currant		
PUTR2 bitterbrush		ROSA5 rose		
<b>Dominant Mid-Size Bunchgrasses</b> 70% 375-525 lbs.		<b>Other Mid-Size Bunchgrasses – Minor</b> less than 5% 20-30 lbs.		
PSSP6 bluebunch wheatgrass		FEID Idaho fescue		
		ELEL5 bottlebrush squirreltail		
		ACTH7 Thurber needlegrass		
		HECO26 needle and thread		
		ACNE9 Nelson's needlegrass		
<b>Short Grass – Minor</b> 5-10% 55-75 lbs.				
POSE Sandberg bluegrass				
<b>Native Forbs – Minor</b> 5-10% 55-75 lbs.				
BASA3 arrowleaf balsamroot		ERIGE2 fleabane		
LUPIN lupine		LOMAT lomatium / biscuitroot		
CREPI hawksbeard		ASTRA milkvetch / locoweed		
PHLO2 longleaf phlox		PLPA2 woolly plantain		
PHHO spiny phlox		LIRU4 stoneseed		
LIPU11 granite gilia		CALOC Mariposa lily		
ERIOG buckwheat		COLLO collomia		
CASTI2 paintbrush		ANDI2 low pussytoes		
ACMI2 yarrow		MICRO6 microseris		
<b>Estimated Production (pounds / acre)</b>		Below	Normal	Above
Drier sites & south slopes		300	450	550
Wetter sites		300	600	750

### State 1

#### Reference State - Sagebrush Steppe with No Invasive Species

State 1 Narrative: State 1 represents sagebrush steppe with no invasive or exotic weed species. All the functional, structural groups have one or more native species. A diverse native perennial community is more resistant to invasive annual species such as cheatgrass. Reference State Community Phases: 1.1 Reference Bluebunch wheatgrass-Wyoming sagebrush 1.2 Bunchgrass Bluebunch wheatgrass 1.3 Heavy sage Wyoming sagebrush-bluebunch wheatgrass 1.4 Depauperate Wyoming sagebrush-Sandberg bluegrass Dominate Reference State Species: Wyoming big sagebrush, bluebunch wheatgrass At-risk Communities: • All communities in the reference state are at risk of moving to State 2. The seed source of cheatgrass is nearby and blowing onto most sites

annually • Community Phase 1.4, the depauperate community (sagebrush-Sandberg bluegrass), has little to no bluebunch wheatgrass, and is therefore, at considerable risk of moving to State 3 which is dominated by annual species • Any Stony community is at risk when bluebunch cover is low (< 10%) and cheatgrass cover is becoming co-dominant (40% or more). • Any community is at risk when sagebrush cover is high (40%+) and there is little to no bluebunch • Community 1.4, and any site with low cover of bluebunch wheatgrass, and any site with moderate to heavy cover of cheatgrass should be seeded after fire

## **Community 1.1 Reference**

Reference Community 1.1 is dominated by bluebunch wheatgrass with some sagebrush. Communities 1.1, 1.2 and 1.3 have enough bluebunch wheatgrass to shift to the other two communities and back again. These three community phases have high amounts of bunchgrass cover and are at low risk of moving to State 3

## **Community 1.2 Bunchgrass**

Community 1.2 is even more strongly bunchgrass dominated.

## **Community 1.3 Heavy Sage**

Community 1.3 has a heavy sage canopy but bluebunch remains a vital component in the community.

## **Community 1.4 Depauperate**

Community 1.4, Depauperate, is dominated by sagebrush with Sandberg bluegrass as sub-dominant. There are no invasive species in Community 1.4, but there is not enough bluebunch wheatgrass remaining for community 1.4 to shift back to the other communities in the reference state.

## **Pathway 1.1a Community 1.1 to 1.2**

1.1a Result: Shift from reference community to bunchgrass community. Sagebrush cover is all but eliminated, while bluebunch wheatgrass has a moderate increase. The community shifts from a shrub steppe to a bunchgrass appearance. Primary Trigger: Moderate-severity fire is complete enough and hot enough to remove almost all sagebrush. Fire conditions and post-fire grazing management allows bluebunch wheatgrass and other bunchgrasses to thrive and expand. Some areas burn complete while other areas are unburned to lightly burned and fire is not hot enough to affect soil conditions. Fire removes surface vegetation but has no impact on the crown of bunchgrasses. So, bunchgrasses and forbs return post-fire with good vigor. Post-fire the bunchgrasses are now more susceptible to grazing damage. Burned rangeland pastures will need two growing seasons recovery prior to resuming grazing, or to be lightly grazed but only during dormant season the first two years post-fire. Beyond two years for the bunchgrasses to expand, the grazing plan must promote light to moderate grazing intensity, and both critical period & growing season deferrals must be implemented on burned pastures. Ecological process: Fire kills sagebrush and it does not have any sprouting ability. A few sagebrush plants remain, but only in patches that did not burn. The reduction in sagebrush releases resources and increases light for grasses and forbs. Bluebunch wheatgrass and other bunchgrasses have good vigor post-fire and expand via tillering and new seedlings.

## **Pathway 1.2b Community 1.1 to 1.3**

1.2b Result: shift from reference community to heavy sage community. There is a moderate increase in sagebrush while bluebunch wheatgrass has a corresponding moderate decrease. Primary Trigger: With excessive grazing pressure (heavy grazing intensity, season long grazing or frequent late spring grazing) and a period of no fire, sagebrush increases its cover while bluebunch wheatgrass suffers a big decline. Ecological process: With consistent defoliation pressures bluebunch wheatgrass experiences poor plant vigor to such a degree that grass

roots begin to die. So, bluebunch wheatgrass experiences shrinking crowns and some mortality. This gives sagebrush the opportunity to set new seedlings and expand its cover. Increased shade from the new sagebrush plants also plays a role in this process.

## **Pathway 1.2a**

### **Community 1.2 to 1.1**

1.2a Result: Shift from bunchgrass community to reference community. There is a moderate reduction of bluebunch wheatgrass cover and a corresponding increase of sagebrush. Primary Trigger: Over time with no fire, sagebrush will re-enter the community even with good bunchgrass vigor. Ecological process: Spots with soil disturbance receive sagebrush seed from remnant plants in unburned patches or from adjacent sites, seed germinates in the spring and a few sagebrush seedlings establish. For most locations it may take up to 10 years for sagebrush to re-enter the community. But in Douglas County the re-entry period may only be 2-5 years. With a slight increase in shade perennial bunchgrasses experience a slight decline.

## **Pathway 1.1b**

### **Community 1.3 to 1.1**

1.1b Result: Shift from heavy sage community to reference community. There is a major decrease in sagebrush cover and a considerable increase in the cover of bluebunch wheatgrass. The community shift is from sagebrush dominance to bunchgrass dominance. Primary Trigger: Moderate-severity fire is patchy, dependent on temperature, wind, fuel load and fuel moisture. In areas that burn the fire is complete enough and hot enough to remove most sagebrush. Most areas burn complete while other areas are unburned to lightly burned and fire is not hot enough to affect soil conditions. Fire removes surface vegetation but has no impact on the root crown of bunchgrasses. So, bunchgrasses and forbs return post-fire with good vigor. Post-fire the bunchgrasses are now more susceptible to grazing damage. Burned rangeland pastures will need two growing seasons recovery prior to resuming grazing, or to be lightly grazed but only during dormant season the first two years post-fire. Beyond two years, for the bunchgrasses to expand, the grazing plan must moderate grazing intensity, and both critical period & growing season deferments must be implemented on burned pastures. Ecological process: Fire kills sagebrush and it does not have any sprouting ability. Some sagebrush remains, but only in patches that did not burn. The reduction in sagebrush releases resources and, increases light for grasses and forbs. Fire conditions and post-fire grazing management allows bluebunch wheatgrass and other bunchgrasses to thrive and expand via tillering and new seedlings.

## **Pathway 1.2c**

### **Community 1.3 to 1.4**

1.2c Result: Shift from heavy sage community to depauperate community. Sagebrush has a moderate increase while bluebunch is all but eliminated from the community. Invasive annual grasses have not invaded, but Community 1.4 is most at risk to invasion and is the segue between States 1 & 2, and States 1 & 3. Pathway 1.2c is a continuation of the process that started with Pathway 1.2b. Primary Trigger: With excessive grazing pressure (heavy grazing intensity, season long grazing or frequent late spring grazing) and a period of no fire, sagebrush increases its cover while bluebunch wheatgrass bunchgrasses suffers a big decline. Grazing animals selectively target the remaining bluebunch wheatgrass plants eliminating most of the bluebunch wheatgrass plants from the community. Ecological process: With consistent defoliation pressure bluebunch wheatgrass has low vigor, shrinking crowns and a lot of mortality. This gives sagebrush opportunity to set new seedlings and expand its cover. A few bluebunch wheatgrass plants may survive.

## **State 2**

### **Sagebrush Steppe with Invasive Species**

State 2 Narrative: State 2 represents a gradation along the transition between Reference State and State 3. State 2 is sagebrush steppe with the inclusion of invasive annual grasses such as cheatgrass. All the native functional, structural groups are still represented by one or more species. Cheatgrass seed blows onto most sites annually seeking an opportunity to invade and colonize. With each loss of a native perennial plant, the site becomes less and less resistant to invasion. When cheatgrass makes seed for the next generation, the site has been colonized and will likely remain a component of the community. The loss of biological soil crust is also a contributor to invasion by

cheatgrass. For communities 2.1, 2.2, and 2.3 the amount of cheatgrass is minor. Cheatgrass is more prominent in community 2.4. Once a community has been invaded by cheatgrass the chance of going back to State 1 is small. This state can occur with or without sagebrush. Community Phases for State 2: Same as Reference State. Dominate State 2 Species: Wyoming big sagebrush – bluebunch wheatgrass Pathways within State 2 The pathways in State 2 are basically the same as in the Reference State. Community 2.4 is most at risk of transitioning to State 3.

#### **Dominant plant species**

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass

#### **Community 2.1 Reference**

#### **Community 2.2 Bunchgrass**

#### **Community 2.3 Heavy Sage**

#### **Community 2.4 Depauperate**

#### **State 3 Annuals**

State 3 Narrative: State 3 represents communities dominated by invasive annual species and has crossed a biological threshold. Virtually all the native functional, structural groups are missing. Community Phases for State 3: 3.1 Shrub – Annual Grass Sagebrush – cheatgrass 3.2 Annual Grass Cheatgrass Dominate State 3 Species: Cheatgrass with or without sagebrush The main species can include annual bromes, medusahead, ventenata, mustard, prickly lettuce and diffuse knapweed. This state can occur with or without sagebrush.

#### **Dominant plant species**

- sagebrush (*Artemisia*), shrub
- cheatgrass (*Bromus tectorum*), grass

#### **Community 3.1 Shrub Cheatgrass**

#### **Community 3.2 Cheatgrass**

#### **Pathway 3.1a Community 3.1 to 3.2**

3.1a Result: shift from shrub-cheatgrass to cheatgrass. Primary Trigger: Moderate intensity fire kills most or all sagebrush. Ecological process: due to a lack of native species in the community there is limited competition and invasive annuals such as cheatgrass fully occupy the site.

#### **State 4 Seeded Grass**

Note: Stony ecological sites have mild to moderate equipment limitations due to surface rock. State 4 Narrative: State 4 represents a site that has been seeded to desirable grasses such as Secar Snake River wheatgrass, Sherman big bluegrass, crested wheatgrass or intermediate wheatgrass. State 4 has two community phases that

are stable if they maintain 0.8 plant / sq. ft. or greater of the desired bunchgrasses Community Phases for State 4:  
4.1 Seeded Grasses 4.2 Shrub – Seeded Grasses Dominate State 4 Species: Desirable seeded grasses with or without sagebrush and legumes

## **Community 4.1 Seeded Grasses**

## **Community 4.2 Shrub Grass**

### **Pathway 4.1a Community 4.1 to 4.2**

4.1a Result: Shift from seeded grass to shrub – seeded grass community. Shrubs colonize the site and increase cover and density while seeded grasses decline Primary Trigger site has not burned. Heavy grazing pressure on seeded grasses reduce plant vigor. Ecological process: Consistent defoliation pressures that reduced plant vigor to such a degree that that grass roots begin to die, seeded grass crowns shrink, and some seeded grasses die. This opens the soil for seedling shrubs to establish.

### **Pathway 4.2a Community 4.2 to 4.1**

4.2a Result: Shift from shrub-grass to seeded grass community. Shrubs are decreased to all but eliminated and grasses increase to dominate the community. Primary Trigger: community treatment activities. (1) For communities with fire sensitive shrubs (sagebrush, bitterbrush) and a good population of desirable grasses, the best course of action is to reduce the shrubs by fire, chemical or mechanical treatment, and use proper grazing management to ensure grasses recover. (2) For communities with fire tolerant shrubs (rabbitbrush, three-tip sage) and a good population of desirable grasses, the best course of action is to reduce the shrubs by chemical treatment and use proper grazing management to ensure grasses recover. (3) Communities that do not have much seeded grass remaining will require a seedbed to be prepared and a seeding operation. Seedbed preparation can use a combination of fire, mechanical tillage and chemical application. Post-seeding the site will need 1-2 years of rest while the seeded grasses are established. Broadleaf weed control may also be necessary. Afterward, proper grazing must be used to maintain the stand. Ecological Process: with removal of the shrub layer the vigorous seeded grasses increase via tillering and new seedlings

## **Transition T1 State 1 to 2**

T1 Result: transition from Reference State to State 2 (shrub steppe w/ a few annuals). The Reference State does not have invasive species. State 2 has the same communities but with minor additions of invasive annual grasses such as cheatgrass. Ecological process. Most sites in the Reference State have some scattered cheatgrass seed. This seed is waiting for enough moisture to germinate and to compete with the native species for space, light and moisture. When the right year happens even pristine communities in the Reference State are susceptible to colonization by cheatgrass. Primary Trigger: The transition occurs during a high moisture year that causes a micro-flush of cheatgrass and is the principle means of colonization. A second trigger would be spots of soil disturbance. Indicators: The occurrence of annual grasses on sites where they had been absent.

## **Transition T2 State 2 to 3**

T2 Result: Transition from State 2 to State 3 which is dominated by annuals. This transition occurs once the cover of bluebunch wheatgrass decline to less than 10% while invasive species cover is at least 40%. This transition can occur with or without sagebrush in the community. Community 2.4 has limited amount of bluebunch and is the community most at risk and is also the pathway for crossing the threshold from State 2 into State 3. Community 2.4 is the segue between State 2 and State 3. Primary Trigger: Chronic heavy grazing, season-long grazing, or late spring grazing. Native species are all but eliminated. Note: chronic season-long grazing in 1880s-1940s created thousands of acres of annual grass-sagebrush community, and then fire turned that into annual grasses. A

secondary trigger would be frequent fires that weaken the entire community. In either case, annuals such as cheatgrass have the competitive advantage. The site has lost its primary species that stabilize and protect the soil from wind and water erosion and has also lost the ability to retain sufficient soil moisture for many of the native perennial species. Ecological Process: Consistent defoliation pressure to bluebunch wheatgrass causes poor vigor, shrinking crowns and plant mortality. With more and more of the soil surface and upper soil rooting surface open, opportunistic, exotic weeds that take advantage of the available niche space to colonize and expand until they dominate the community. Indicators: Decreasing cover of bluebunch wheatgrass and increasing cover of invasive annual species. Increasing distance between native bunchgrasses. Decreasing soil organic matter, soil water retention, limited water infiltration and percolation in the soil profile.

## **Restoration pathway R1 State 3 to 4**

Most Stony, sagebrush ecological site soils have surface rock and rock throughout the profile. Other soils do not have surface rock but are shallow to bedrock. Equipment limitations that will cause issues and some treatment options may not be feasible on some sites. R1 Result: Shift from State 3 (a community dominated by invasive annual species) to State 4, which is predominately desirable seeded grasses. This transition occurs when active management decisions are attempted to alter the annual dominated state to one with persistent perennial bunchgrasses, even if they are not native ones. This requires a commitment of two years or more for weed control. Care must be taken to maintain soil structure so that the seedbed has many safe sites for the seed. Seed placement must be managed to achieve seed-soil contact at very shallow depth (about 1/8 inch is desired). Proper grazing management is essential to maintain the stand post-seeding. Secar Snake River wheatgrass, thickspike wheatgrass, Sherman big bluegrass, Sandberg bluegrass, and crested or Siberian wheatgrass are typical species seeded on Stony ecological site. The actual transition occurs when the seeded species have successfully established and are outcompeting the annual species for cover and dominance of resources.

## **Restoration pathway R2 State 4 to 2**

R2 Result: Shift from State 3 back to State 2. This restoration transition does not occur without a significant commitment of time & resource inputs to restore ecological processes, native bunchgrasses, Wyoming sagebrush and native forb species. Shifting from State 3 to State 4: If the goal is to restore back to a native plant community, State 3 must first be shifted to State 4. It will take two years or longer to kill annual species and to exhaust the seedbank of invasive species. Site will then need to be seeded to perennial species such as crested wheatgrass to restore soil properties before native species can survive and thrive on site. The seeded species rebuild some of the basic soil properties including increased soil organic matter, increased soil moisture, and likely would also require the soil's pore spaces, bulk density and soil microorganisms to return before the native species that used to survive in this ecological site can return. The site would also need several years of no significant fires and proper grazing management as well. See narrative for R1 transition above. Shifting from State 4 to State 2: This assumes that the shift from State 3 to State 4 has been successful. Introduced grasses must be killed before the seeding of native species. The seeding of native species should occur in two steps: (1) a seeding of native bunchgrasses so that broadleaf weeds may be controlled, (2) a re-introduction of sagebrush and native forbs. The site would also need several years of no significant fires and proper grazing management as well to ensure plant establishment and vigor. See narrative for R1 transition above.

## **Transition T3 State 4 to 3**

T3 Result: Shift from seeded grass State 4 to State 3 which is dominated by invasive annual species. Primary Trigger: This transition occurs when chronic heavy grazing has removed too much of the perennial bunchgrass cover allowing invasive annual species to colonize the site. As this continues the competitive advantage goes to the exotic species which are opportunistic and take most of the site's resources. Little of the resources remain for the desirable species. Secondary Trigger: Frequent fires or a severe fire that removes too much of the perennial bunchgrass cover and gives the competitive advantage to the invasive species. Ecological Process: Consistent defoliation pressure to seeded grasses cause poor vigor, shrinking crowns and plant mortality. With more and more of the soil surface and upper soil rooting surface open, opportunistic, exotic weeds that take advantage of the available niche space to colonize and expand until they dominate the community. Indicators: shrinking crowns and

mortality of desirable species, increasing caps gaps between seeded plants, increasing cover by annual grasses.

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## **Citations**