USDA Natural Resources
Conservation Service

Ecological site R007XY120WA
Stony

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General information

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

MLRA notes

Major Land Resource Area (MLRA): 007X–Columbia Basin

This MLRA is in the Walla Walla Plateau section of the Columbia Plateaus province of the Intermontane Plateaus. The Columbia River flows through this MLRA, and the Snake and Yakima Rivers join the Columbia River within it. This MLRA is almost entirely underlain by Miocene basalt flows. Columbia River Basalt is covered in most areas with as much as 200 feet of eolian, lacustrine, and alluvial deposits. The dominant soil orders in this MLRA are Aridisols and Entisols. The soils in the area dominantly have a mesic temperature regime, an aridic moisture regime, and mixed mineralogy. They generally are moderately deep to very deep and well drained to excessively drained.

Classification relationships

Major Land Resource Area (MLRA): 7 – Columbia Basin

LRU – Common Resource Areas (CRA):
7.1 – Sandy Missoula Flood Deposits
7.2 – Silty Missoula Flood Deposits
7.3 – Dry Loess Islands
7.4 – Dry Yakima Folds
7.5 – Yakima Valley – Pleistocene Lake Basins

Ecological site concept

Stony is an upland site occurring on two soil conditions:
(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 (10-20” deep) 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.

Stony and Loamy ecological sites are the same except Stony is a little less productive. In some areas Stony is found on west-facing slopes and Loamy on east-facing 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.

Associated sites

R007XY130WA	**Loamy**
R007XY153WA	**Cool Loamy**
R007XY163WA	**Dry Loamy**
R007XY153WA	**Cool Loamy**
R007XY449WA	**Sandy**
R007XY143WA	**Sandy Loam**

Similar sites

R007XY114WA	**Shallow Stony Sand** Shallow stony sand is 10 to 20 inches to restrictive horizon.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata ssp. wyomingensis*
Herbaceous	(1) *Pseudoroegneria spicata*

Physiographic features

The landscape is part of the Columbia basalt plateau. Stony sites mostly occur on broad ridges, shoulders and plateaus, stream terraces, fans, canyon walls and canyon side-slopes, and south-facing or west-facing hillslopes.

Physiographic Division: Intermontane Plateau
Physiographic Province: Columbia Plateau
Physiographic Sections: Walla Walla Plateau Section

Table 2. Representative physiographic features

Landforms	(1) Terrace (2) Hillslope (3) Outwash plain (4) Structural bench (5) Hills (6) Plateau
Flooding frequency	None
Ponding frequency	None
Elevation	800–2,000 ft
Slope	2–30%
Water table depth	60 in
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Flooding frequency	None
Ponding frequency	None
Elevation	200–3,500 ft
Slope	0–60%
Water table depth	60 in

Climatic features

MLRA 7 is the lowest, driest and hottest portions of the entire Columbia River region and the sagebrush-bluebunch wheatgrass zone. The Wyoming sagebrush-bluebunch wheatgrass areas are both warmer and drier than grasslands or other sites with threetip sage or bitterbrush (Daubenmire).

The climate across MLRA 7 is characterized by moderately cold, wet winters, and hot, dry summers, with limited precipitation due to the rain shadow effect of the Cascades. The average annual precipitation is mostly between 6 and 10 inches. Seventy to seventy-five percent of the precipitation comes late October through March as a mixture of rain and snow. For drier sites and lower elevations, precipitation that comes after March is not as effective for plant growth. But at higher elevations and higher precipitation, April and May rains make the difference between average and great production years. June through early October is dry. Freezing temperatures generally occur from late-October through early-April. Temperature extremes are -10 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.

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.

Soil features

This ecological site components are dominantly Xeric and some Lithic taxonomic subgroup of Haplocambids, Haplargids, Haplodurids great group of the Aridisols taxonomic orders. Soils are dominantly deep and very deep but can range to shallow. Soil parent material is dominantly loess, colluvium and glacial outwash. The associated soils are Burke, Drino, Kiona, Sagemoor, Scoon, Scooteney, Starbuck and similar soils. The associated soils are Burke, Drino, Kiona, Sagemoor, Scoon, Scooteney, Starbuck and similar soils. Dominant soil surface texture is silt loam to very stony very fine sandy loam. Dominant particle-size class is fine-loamy to loamy skeletal.

Table 4. Representative soil features

Parent material	(1) Loess (2) Colluvium (3) Outwash
Surface texture	(1) Silt loam (2) Very stony very fine sandy loam
Drainage class	Well drained
Permeability class	Moderately rapid
Depth to restrictive layer	20–60 in
Surface fragment cover <=3"	15%
Surface fragment cover >3"	10%
Available water capacity (0-40in)	3 in
Calcium carbonate equivalent (0-15in)	10%
Electrical conductivity (Depth not specified)	Not specified

Sodium adsorption ratio (0-80in)	Not specified
Soil reaction (1:1 water) (0-10in)	Not specified
Subsurface fragment volume <=3" (0-80in)	10%
Subsurface fragment volume >3" (0-80in)	15%

Table 5. Representative soil features (actual values)

Drainage class	Not specified
Permeability class	Not specified
Depth to restrictive layer	Not specified
Surface fragment cover <=3"	0–30%
Surface fragment cover >3"	0–25%
Available water capacity (0-40in)	1.1–8.1 in
Calcium carbonate equivalent (0-15in)	Not specified
Electrical conductivity (Depth not specified)	0–2 mmhos/cm
Sodium adsorption ratio (0-80in)	0–2
Soil reaction (1:1 water) (0-10in)	6.1–9
Subsurface fragment volume <=3" (0-80in)	0–35%
Subsurface fragment volume >3" (0-80in)	0–25%

Ecological dynamics

Stony sites produce about 300-750 pounds/acre of biomass annually.

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

Wyoming sagebrush in 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 wheatgrass provides a crucial and extensive network of roots to the upper portions (up to 48 inches 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 8 for more details about bluebunch wheatgrass 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 wheatgrass that holds the system together. If we lose the bluebunch wheatgrass 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 to 20 years (Miller). The FRI increases as one moves to wetter forested sites or to dries shrub steppe communities. Given the uncertainties and opinions of reviewers, a mean of 75 years and a range of 50 to 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. Needle and thread is one native species that can increase via new seedlings

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 spaces that are 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. In the spring most regrowth comes from photosynthesis.

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 1 to June 30). And each pasture should be rested the entire growing season every third year (approximately

March 1 to June 30).

In the spring each year it is important to monitor and maintain an adequate topgrowth: (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.

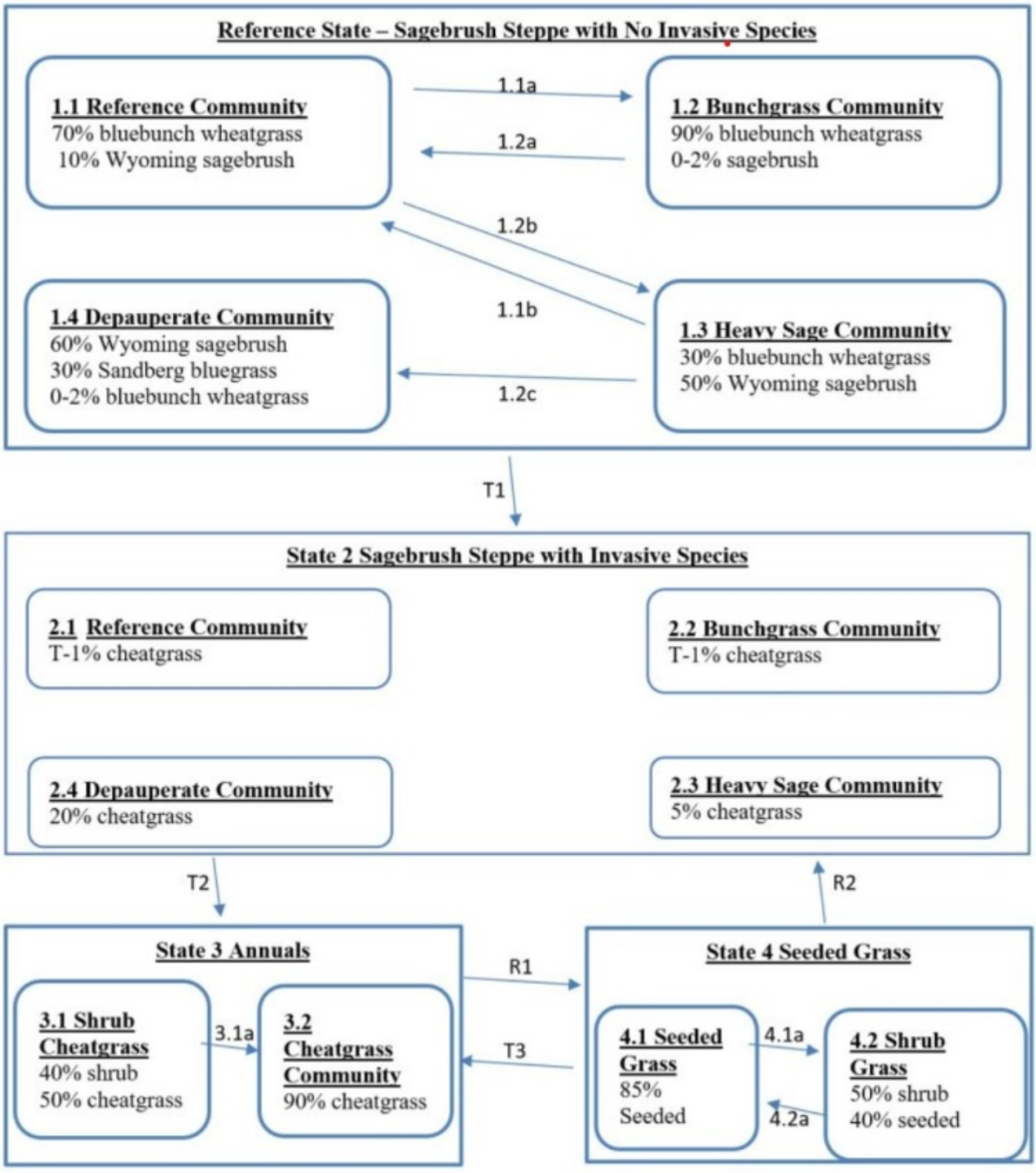
Bluebunch wheatgrass remains competitive if:
(1) Basal buds are replaced annually,
(2) Enough top-growth is maintained for growth and protection of growing points, and
(3) The timing of grazing and non-grazing is managed over a several-year period. Careful management of late spring grazing is especially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

Stony ecological sites often receive less grazing pressure than Loamy sites, and are thus, more stable.

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

State and transition model



State 1
Reference

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 Community 1.1 is dominated by bluebunch wheatgrass with some sagebrush. Community 1.2 is even more strongly bunchgrass dominated. Community 1.3 has a heavy sage canopy but bluebunch remains a vital component in the community. 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 1.4, Depauperate, is dominated by sagebrush with Sandberg bluegrass as sub-dominate. There is not enough bluebunch remaining for community

1.4 to shift back to the other communities in the reference state.

Community 1.1
Bluebunch Wheatgrass and Wyoming Big Sagebrush

Dominant plant species

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

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	–	85	–
Grass/Grasslike	–	530	–
Forb	–	65	–
Total	**–**	**680**	**–**

Community 1.2
Bluebunch Wheatgrass

Dominant plant species

- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass

Community 1.3
Heavy Sage, Wyoming Big Sagebrush and Bluebunch Wheatgrass

Dominant plant species

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

Community 1.4
Depauperate, Wyoming Big Sagebrush and Sandberg Bluegrass

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- Sandberg bluegrass (*Poa secunda*), grass

Pathway 1.1A
Community 1.1 to 1.2

Result: Shift from Reference community to Bunchgrass community. Sagebrush cover is all but eliminated, while bluebunch wheatgrass has a moderate increase in cover. 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. Most areas burn complete while other areas are unburned to lightly burned. 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 deferments 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. Fire conditions and post-fire grazing management allows bluebunch wheatgrass and other bunchgrasses

to thrive and expand.

Pathway 1.2B
Community 1.1 to 1.3

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

Result: Shift from Bunchgrass community to Reference community. There is a minor 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. With a slight increase in shade perennial bunchgrasses experience a slight decline.

Pathway 1.1B
Community 1.3 to 1.1

Result: Shift from Heavy Sage community to Reference community. There is a major decrease in sagebrush cover and a major 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

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 suffers 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 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 contributes 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 2.1
Reference with Invasives, Bluebunch Wheatgrass and Wyoming Big Sagebrush

Dominant plant species

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

Community 2.2
Bunchgrass with Invasives, Bluebunch Wheatgrass

Dominant plant species

- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass

Community 2.3
Heavy Sage with Invasives, Wyoming Big Sagebrush and Bluebunch Wheatgrass

Dominant plant species

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

Community 2.4
Depauperate with Invasives, Wyoming Big Sagebrush and Sandberg Bluegrass

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- Sandberg bluegrass (*Poa secunda*), grass
- cheatgrass (*Bromus tectorum*), grass

Pathway 2.1A
Community 2.1 to 2.2

Pathway 2.1B
Community 2.1 to 2.3

Pathway 2.2A
Community 2.2 to 2.1

Pathway 2.3A
Community 2.3 to 2.1

Pathway 2.3B
Community 2.3 to 2.4

State 3
Annual

State 3 represents communities dominated by invasive annual species and has crossed a biological threshold. Virtually all the native functional, structural groups are missing. This state can occur with or without sagebrush.

Community 3.1
Wyoming Big Sagebrush and Cheatgrass

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- cheatgrass (*Bromus tectorum*), grass

Community 3.2
Cheatgrass

Dominant plant species

- cheatgrass (*Bromus tectorum*), grass

Pathway 3.1A
Community 3.1 to 3.2

Result: shift from shrub-cheatgrass to cheatgrass. Causes: Moderate intensity fire kills most or all sagebrush. Cheatgrass and other invasive species fully occupy the site.

State 4
Seeded

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 0.8 plant / sq. ft. or greater of the desired bunchgrasses is maintained.

Community 4.1
Seeded Grass

Community 4.2
Shrub and Seeded Grass

Pathway 4.1A
Community 4.1 to 4.2

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

Result: Shift from Shrub - Seeded 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 T1A
State 1 to 2

Result: Transition from Reference State to State 2 (Sagebrush Steppe with Invasive Species). 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 T2A
State 2 to 3

Result: Shift 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 wheatgrass 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 the 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 T3A
State 3 to 4

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 perennial bunchgrasses, even if they are not native. 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 wheatgrass 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. 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.

Restoration pathway R4A
State 4 to 2

Result: Shift from State 4 back to State 2. This restoration transition is not likely to occur without a significant commitment of time & resource inputs to restore ecological processes, perennial bunchgrasses, Wyoming big sagebrush and native forb species. 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.

Restoration pathway R4B
State 4 to 3

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 the dominate the community. Indicators: shrinking crowns and mortality of desirable species, increasing caps gaps between perennial species, increasing cover by annual grasses.

Additional community tables

Table 7. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Shrub/Vine					
1	**Non-Sprouting Shrubs - Subdominant**			65	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	–	–
	antelope bitterbrush	PUTR2	*Purshia tridentata*	–	–
2	**Sprouting Shrubs - Minor**			20	
	chrysactinia	CHRYS	*Chrysactinia*	–	–
	currant	RIBES	*Ribes*	–	–
	rose	ROSA5	*Rosa*	–	–
	purple sage	SADOI	*Salvia dorrii ssp. dorrii var. incana*	–	–
Grass/Grasslike					
3	**Dominant Mid-Size Bunchgrass**			450	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	–	–
4	**Other Mid-Size Bunchgrasses - Minor**			20	
	squirreltail	ELEL5	*Elymus elymoides*	–	–
	Thurber's needlegrass	ACTH7	*Achnatherum thurberianum*	–	–

	needle and thread	HECO26	*Hesperostipa comata*	–	–
	sixweeks fescue	VUOC	*Vulpia octoflora*	–	–
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	–	–
5	**Short Grass - Minor**			65	
	Sandberg bluegrass	POSE	*Poa secunda*	–	–
Forb					
6	**Native Forbs - Minor**			65	
	Carey's balsamroot	BACA3	*Balsamorhiza careyana*	–	–
	Hooker's balsamroot	BAHO	*Balsamorhiza hookeri*	–	–
	lupine	LUPIN	*Lupinus*	–	–
	hawksbeard	CREPI	*Crepis*	–	–
	longleaf phlox	PHLO2	*Phlox longifolia*	–	–
	spiny phlox	PHHO	*Phlox hoodii*	–	–
	granite prickly phlox	LIPU11	*Linanthus pungens*	–	–
	Indian paintbrush	CASTI2	*Castilleja*	–	–
	common yarrow	ACMI2	*Achillea millefolium*	–	–
	trumpet	COLLO	*Collomia*	–	–
	Munro's globemallow	SPMU2	*Sphaeralcea munroana*	–	–
	fleabane	ERIGE2	*Erigeron*	–	–
	desertparsley	LOMAT	*Lomatium*	–	–
	woollypod milkvetch	ASPU9	*Astragalus purshii*	–	–
	milkvetch	ASTRA	*Astragalus*	–	–
	silverpuffs	MICRO6	*Microseris*	–	–
	woolly plantain	PLPA2	*Plantago patagonica*	–	–
	low pussytoes	ANDI2	*Antennaria dimorpha*	–	–
	mariposa lily	CALOC	*Calochortus*	–	–
	western stoneseed	LIRU4	*Lithospermum ruderale*	–	–
	Cusick's sunflower	HECU2	*Helianthus cusickii*	–	–

Inventory data references

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.

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Approval

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Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	07/26/2023
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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5. **Number of gullies and erosion associated with gullies:**

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6. **Extent of wind scoured, blowouts and/or depositional areas:**

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7. **Amount of litter movement (describe size and distance expected to travel):**

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

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14. **Average percent litter cover (%) and depth (in):**

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

17. **Perennial plant reproductive capability:**