USDA Natural Resources
Conservation Service

Ecological site DX032X01A167
Shallow To Gravel (SwGr) Big Horn Basin Core

Last updated: 9/16/2020
Accessed: 05/05/2024

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): 032X–Northern Intermountain Desertic Basins

032X – Northern Intermountain Desertic Basins – This MLRA is comprised of two major Basins, the Big Horn and Wind River. These two basins are distinctly different and are split by land resource units (LRUs) to allow individual ecological site descriptions (ESDs). These warm basins are surrounded by uplifts and rimmed by mountains, creating a unique set of plant responses and communities. U nique characteristics of the geology and geomorphology single out these two basins.

Further information regarding MLRAs, refer to: United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. Available electronically at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053624#handbook.

LRU notes

Land Resource Unit (LRU):

32X01 (WY): This LRU is the core of the Big Horn Basin, comprised of the eroded basin floor. As the LRU shifts toward the outer edges, aspect and relation to the major bodies of water and taller landforms create minor shifts in soil chemistry influencing the variety of ecological sites and to plant interactions. The extent of soils currently correlated to this ecological site does not fit within the digitized boundary. Many of the noted soils are provisional and will be reviewed and corrected in mapping update projects. Other map units are correlated as small inclusions within other MLRAs and LRUs based on elevation, landform, and biological references.

Moisture Regime: Typic Aridic. Prior to 2012, there were map units that cross over to ustic aridic or ustic aridic was correlated into this core area. As progressive mapping continues and when the opportunity arises to do update projects, these overlapping map units will be corrected.

Temperature Regime: Mesic
Dominant Cover: Rangeland, with saltbush flats as the dominant vegetative cover for this LRU/ESD
Representative Value (RV) Effective Precipitation: 5-9 inches (127 –229 mm)
RV Frost-Free Days: 110-150 days

Classification relationships

Relationship to Other Established Classification Systems:

National Vegetation Classification System (NVC):
3 Xeromorphic Woodland, Scrub & Herb Vegetation Class
3.B Cool Semi-Desert Scrub & Grassland Subclass

3.B.1 Cool Semi-Desert Scrub & Grassland formation
3.B.1.NE Western North American Cool Semi-Desert Scrub & Grassland Division
M169 Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe Macrogroup
G302 Artemisia Tridentata - Artemisia tripartita - Purshia tridentata Big Sagebrush Steppe Group
CEGL001535 - Artemisia tridentata ssp. wyomingensis/Pseudoroegneria spicata Herbaceous Vegetation or
CEGL001009 - Artemisia tridentata ssp. wyomingensis/Pseudoroegneria spicata Shrubland

Ecoregions (EPA):
Level I: 10 North American Deserts
Level II: 10.1 Cold Deserts
Level III: 10.1.18 Wyoming Basin
Level IV: 10.1.18.g Big Horn Salt Desert Shrub Basin

Ecological site concept

• Site receives no additional water.
• Slope is <30%.
• Soils are:
o Not saline or saline-sodic.
o Moderately deep to very deep
o None to Slight effervescence throughout top 20” (51 cm) of mineral soil surface.
o <3% stone and boulder cover and <20% cobble and gravel cover.
o Not skeletal (<35% rock fragments) within 10” (51 cm) of mineral soil surface, but rock fragments increase with depth. The particle size control section may classify as loamy skeletal or fine-loamy over sandy/sandy-skeletal.
o Textures range from very fine sandy loam to clay loam in top 4” (10 cm) of mineral soil surface. Clay content is =32% in top 4” (10 cm) of mineral soil surface. Each following subsurface horizon has a clay content of <35%.

This site is a variance from the loamy to the gravelly where the surface cap is loamy over a sandy-skeletal profile, creating a site that is more droughty and less productive than the Loamy, but has more productivity and higher selection of plant species than the gravelly site.

Associated sites

DX032X01A112	**Gravelly (Gr) Big Horn Basin Core** See description in the Similar Sites Section.
DX032X01A122	**Loamy (Ly) Big Horn Basin Core** See description in the Similar Sites Section.
DX032X01A150	**Sandy (Sy) Big Horn Basin Core** Sandy ecological sites will occur in similar positions as the Shallow to Gravel site, however, is in zones where fewer gravels were deposited.

Similar sites

DX032X01B167	**Shallow To Gravel (SwGr) Big Horn Basin Rim** Shallow to Gravel Big Horn Basin Rim has higher production over all and threadleaf sedge and fringed sagewort begin to be more prominent players in the plant community.
DX032X01A112	**Gravelly (Gr) Big Horn Basin Core** Gravelly sites occur where finer depositions did not occur (relict gravel bars, scour areas) or have been eroded away. Water holding capacity is extremely low and so pin cushion forbs and dwarf shrubs are the primary ground cover. Grasses are limited are low in stature.
DX032X01A122	**Loamy (Ly) Big Horn Basin Core** Loamy sites occur on areas with greater deposition of finer materials(relict or possibly current) leaving a thicker solemn without rock fragments. Water retention is higher and so have greater production, denser canopy cover (less bare ground), and is more resilient in extended periods of drought.

DX032X01A109	**Cobbly Upland (CoU) Big Horn Basin Core** Cobbly Upland is very similar in characteristics, but instead of transition to coarser soils within the skeletal (gravelly) portion of the solemn, the soils maintain a finer texture throughout the profile, increasing water retention. Production is higher, plant communities maintain a higher grass component, composition is more similar to a loamy or clayey site.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata ssp. wyomingensis* (2) *Atriplex confertifolia*
Herbaceous	(1) *Pseudoroegneria spicata* (2) *Hesperostipa comata*

Legacy ID

R032XA167WY

Physiographic features

The Shallow to Gravel ecological site generally occurs on slopes ranging from nearly level to moderately steep (0-30 percent). Fan remnants, relict stream terraces, and alluvial fans are the major landforms where this site exists.

The complexes of soil components mapped across most landforms typically are separated by depth to rock fragments in the soil profile or depth to bedrock (lithic or paralithic). Many of these landforms are erosional remnants and have soils ranging from shallow to very deep. The variability of soils across the landform is influenced by the geology and its inherent chemistry.

The variability of soils will create pockets of calcareous, saline, or sodic soils as well as areas that are not influenced by chemistry. Higher infiltration rates associated with the Shallow to Gravel ecological site result in leaching of salts, carbonates, and other chemistry to a depth that no longer influences this plant community.

The Shallow to Gravel ecological site is most prominent on the central extent of fans. Loamy and Clayey ecological sites increase in occurrence as the landscape shifts away from steeper slopes with prominent rock outcrop, towards the distal end of the landform. Wind effects are common with this site and can relate to the proximity to taller landforms and will see the ecological site shift to Gravelly.

Table 2. Representative physiographic features

Landforms	(1) Intermontane basin > Fan remnant (2) Intermontane basin > Stream terrace (3) Intermontane basin > Alluvial fan
Runoff class	Low to very high
Elevation	1,036–1,463 m
Slope	0–30%
Aspect	Aspect is not a significant factor

Climatic features

Annual precipitation and modeled relative effective annual precipitation ranges from 5 to 9 inches (127–229 mm). The normal precipitation pattern shows peaks in May and June and a secondary peak in September. The noted peaks account for approximately 50 percent of the mean annual precipitation. Much of the moisture that falls in the latter part of the summer time is lost by evaporation and much of the moisture that falls during the winter months is lost by sublimation.

Average snowfall in the Big Horn Basin Core is about 20 inches annually. Wide fluctuations may occur in yearly

precipitation and result in more dry years than those with more than normal precipitation. Temperatures show a wide range between the summer and winter months and between daily maximums and minimums, due to the high elevation and dry air, which permits rapid incoming and outgoing radiation. Cold air outbreaks from Canada in winter move rapidly from northwest to southeast and account for extreme minimum temperatures. Chinook winds may occur in winter time and bring rapid rises in temperature. Extreme storms may occur during the winter months, but most severely affect ranch operations during the late winter and spring months. High winds generally are blocked from the basin by high mountains but can occur in conjunction with an occasional thunderstorm.

Growth of native cool-season plants begins approximately on April 1st and continues through to July 1st. Cool weather and moisture in September may produce some green-up of cool-season plants that will continue to late October. For detailed information visit the Natural Resources Conservation Service National Water and Climate Center at http://www.wcc.nrcs.usda.gov/. Basin, Emblem, Greybull, Lovell, Worland FAA AP and Worland are the representative weather stations for LRU A. The following graphs and charts are a collective sample representing the averaged normals and 30-year annual rainfall data for the selected weather stations from 1981 to 2010.

Table 3. Representative climatic features

Frost-free period (characteristic range)	110-115 days
Freeze-free period (characteristic range)	131-142 days
Precipitation total (characteristic range)	178-203 mm
Frost-free period (actual range)	105-119 days
Freeze-free period (actual range)	130-150 days
Precipitation total (actual range)	152-203 mm
Frost-free period (average)	112 days
Freeze-free period (average)	138 days
Precipitation total (average)	178 mm

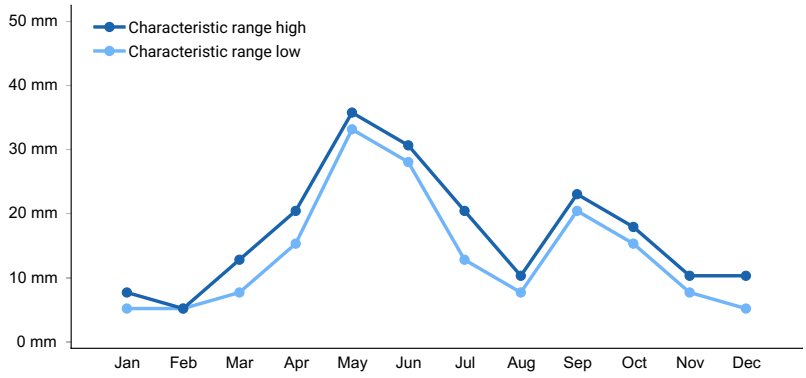


Figure 1. Monthly precipitation range

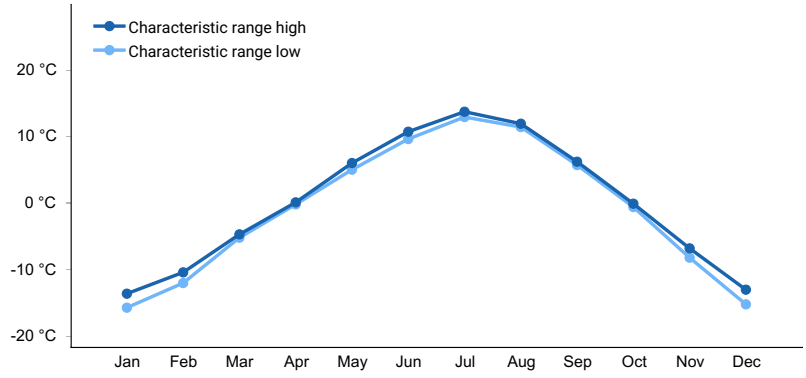


Figure 2. Monthly minimum temperature range

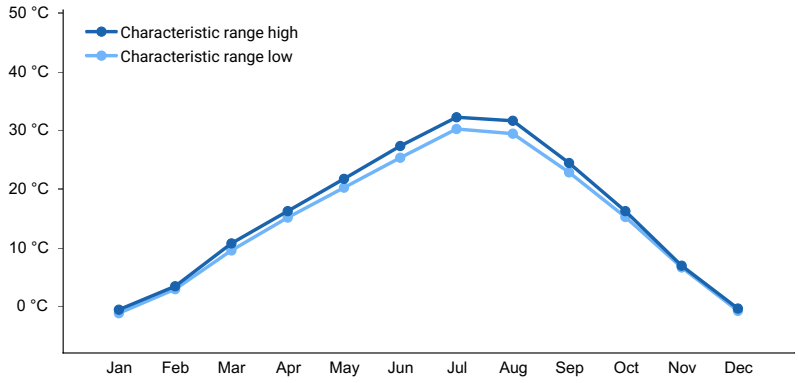


Figure 3. Monthly maximum temperature range

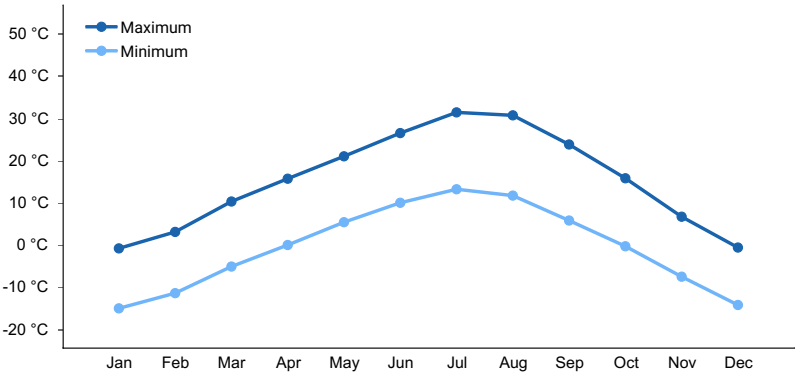


Figure 4. Monthly average minimum and maximum temperature

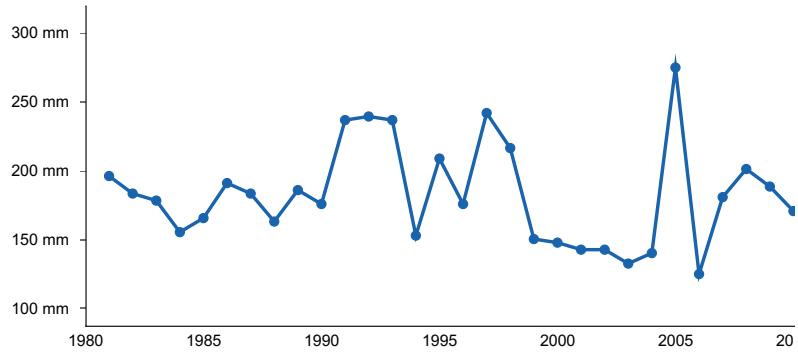


Figure 5. Annual precipitation pattern

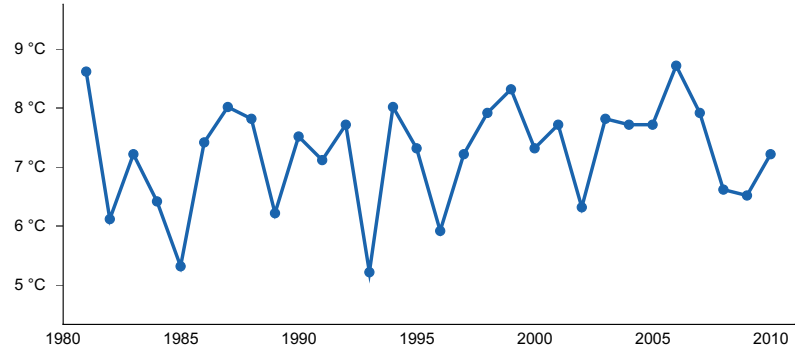


Figure 6. Annual average temperature pattern

Climate stations used

- (1) EMBLEM [USC00483031], Burlington, WY
- (2) WORLAND [USW00024062], Worland, WY
- (3) BASIN [USC00480540], Basin, WY

- (4) GREYBULL [USC00484080], Greybull, WY
- (5) WORLAND [USC00489770], Worland, WY
- (6) LOVELL [USC00485770], Lovell, WY

Influencing water features

The characteristics of these upland soils have no influence from ground water (water table below 60 inches (150 cm)) and have minimal influence from surface water or overland flow. There may be isolated features that are affected by snowpack that persists longer than surrounding areas due to position on the landform (shaded or protected pockets). No streams are classified within the Shallow to Gravel ecological site.

Soil features

The soils of this site are moderately deep (greater than 20 inches to bedrock) to very deep, well drained soils that formed in alluvium, colluvium or slope alluvium over residuum. These soils have slow to moderately rapid permeability. The surface soil will vary from 3 to 6 inches deep. The soil characteristic having the most influence to the plant community is high volume of coarse fragments lower in the profile, which reduces plant density and available moisture.

Major soil series correlated to this site include: Mesa-like, Preatorson, Sharland, and Sierravista-like. This list of soil series is subject to change upon completion and correlation of the initial soil surveys in the area: WY629, WY603, and WY617; as well as revisions to completed soil surveys in the area: WY043 and MT611.

Figure 7. Hand excavated soils pit for the Shallow to Gravel ecological site. Notice the deeper horizons of sandy skeletal material.

Table 4. Representative soil features

Parent material	(1) Alluvium–igneous, metamorphic and sedimentary rock (2) Slope alluvium–interbedded sedimentary rock (3) Colluvium (4) Residuum–conglomerate
Surface texture	(1) Gravelly fine sandy loam (2) Loam (3) Sandy clay loam
Family particle size	(1) Fine-loamy over sandy or sandy-skeletal (2) Loamy-skeletal over sandy or sandy-skeletal (3) Loamy-skeletal
Drainage class	Well drained to somewhat excessively drained
Permeability class	Slow to moderately rapid
Soil depth	51 cm
Surface fragment cover <=3"	0–20%

Surface fragment cover >3"	0–15%
Available water capacity (Depth not specified)	5.08–14.99 cm
Calcium carbonate equivalent (Depth not specified)	0–5%
Clay content (0-25.4cm)	18–35%
Electrical conductivity (Depth not specified)	0–2 mmhos/cm
Soil reaction (1:1 water) (Depth not specified)	7.8–8.4
Subsurface fragment volume <=3" (25.4-198.1cm)	15–50%
Subsurface fragment volume >3" (25.4-198.1cm)	0–20%

Ecological dynamics

Potential vegetation on this site is dominated by mid-stature cool-season perennial grasses. Other significant vegetation includes Wyoming Big Sagebrush, and a variety of forbs. The expected potential composition for this site is 70% grasses, 15% forbs, and 15% woody plants. The composition and production will vary naturally due to historic use, fluctuating precipitation and fire frequency.

As this site deteriorates species such as blue grama, Sandberg bluegrass, and Wyoming big sagebrush will increase. Plains prickly pear and weedy annuals will invade. Cool-season grasses such as bluebunch wheatgrass, needle and thread, and Indian ricegrass will decrease in frequency and production.

Wyoming Big Sagebrush may become dominant on areas with little use on sagebrush, and in the long-term absence of fire and sufficient amount of precipitation. Wildfires are infrequent or rare, but do play a minor roll in this ecological site. Fire has been actively controlled, and as a result dense, aged stands of Wyoming big sagebrush persist. Recently, prescribed burning and mowing has regained some popularity to aid in wildlife habitat improvement (sage grouse).

Wyoming big sagebrush component lacks resilience due to the mesic and aridic nature of this subset. Once sagebrush is reduced significantly or removed from the canopy, hydrologic loss limits sagebrush's ability to re-establish as well as sustaining a viable composition. On these open canopies, blue grama may become dominant with stress from frequent and severe grazing (year-long). As a result, a dense sod cover of blue grama will become established.

The Reference plant community (description follows the plant community diagram) has been determined by study of rangeland relic areas, or areas protected from excessive disturbance. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

The range in plant community composition is influenced by the depth of the soil profile, chemistry, as well as the soil texture within established breaks. When aligning the ecological site concepts with the soil classification guidelines, there are soils that classify to a particle-size class that does not fit the pre-conceived notion of the ecological site that it would typically follow. Plants respond to the mixed texture of the top 8 to 10 inches (20-25 cm) of the soil profile.

Many of the soils that have been mapped in the Big Horn Basin have a sandy cap over an accumulation of clays in the profile, better referred to as an argillic horizon, but then as you move further down into the soil profile, the soils become coarser as the clays decrease. The depth of the start of this clay bulge (or argillic) can have a significant influence on the classification of the soils, swaying the classification to a fine-loamy when the plant response to the soils will maintain a sandy response. The reverse is also common where the clay bulge is high enough in the profile or the sandy cap is not present, and the clay percent drops below 18% below the 10 inches (25 cm) swaying the classification to coarse-loamy while the plants maintain a loamy response. The shallow depth to the sandy gravel

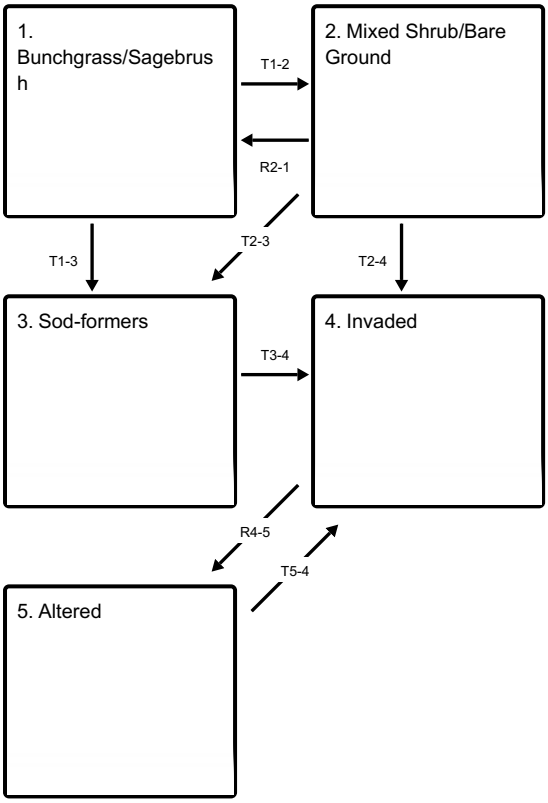
layer allows moisture to move through the site quicker making the community act more droughty.

The following is a State and Transition Model (STM) Diagram for this ecological site. An STM has five fundamental components: states, transitions, restoration pathways, community phases and community pathways. The state, designated by the bold box, is a single community phase or suite of community phases. The reference state is recognized as State 1. It describes the ecological potential and natural range of variability resulting from the natural disturbance regime of the site. The designation of alternative states (State 2, etc) in STMs denotes changes in ecosystem properties that cross a certain threshold.

Transitions are represented by the arrows between states moving from a higher state to a lower state (State 1 - State 2) and are denoted in the legend as a “T” (T1-2). They describe the variables or events that contribute directly to loss of state resilience and result in shifts between states. Restoration pathways are represented by the arrows between states returning back from a lower state to a higher state (State 2 - State1 or better illustrated by State 1

State and transition model

Ecosystem states



T1-2 - Frequent or high-intensity herbivory weakens the ability of the grasses to persist, especially during prolonged drought. Removal of or significant decrease in key grasses and a shift to a more pronounced sagebrush community renders a site difficult to restore back to the Reference State without mechanical or similar treatments.

T1-3 - Long duration, high-intensity grazing reduces the bunchgrass component and encourages the mat- or sod-forming species. Prolonged drought stresses plants, opening the canopy for sod-formers. Removal of sagebrush by disturbances opens the canopy, aiding the transition.

R2-1 - Removal or thinning of the sagebrush by mechanical or chemical means or by fire with remnant populations of native perennial desired grass species will lead to this community, if time is given for recovery and seedling establishment. Frequent use of this community during the dormant season will work to reduce the sagebrush through trampling and grazing but may encourage shorter-statured, more tolerant species and not the more desired species.

T2-3 - Sod-forming species such as blue grama can tolerate high levels of use and will maintain as other native species decline. This decline creates a sagebrush–sod-former community that is resistant to change with management. Impacts to sagebrush by disease or insect damage will shift this to the secondary community phase.

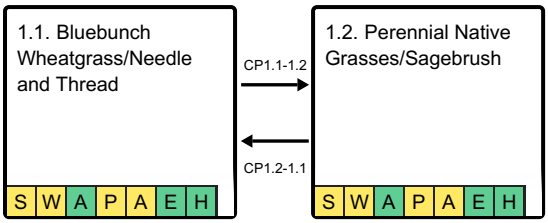
T2-4 - When seed sources are prevalent for invasive species, stress from drought, wildfire, or other natural and man disturbances, removes or exposes the soil and presents a niche for invasion by undesirable weeds.

T3-4 - The interstitial spaces within the patchy canopy of sod-formers leaves areas for weedy species to establish, especially with disturbance or high traffic areas.

R4-5 - Integrated pest management plan and intense weed control after and possibly before seedbed preparation will be necessary to overcome a severe weed infestation.

T5-4 - After a land disturbance occurs or with reclamation processes, if no management is put into place to prevent further disturbance, or to encourage seeding establishment and prevent an infestation of weeds, the community will revert or transition to an invaded state.

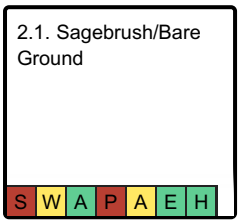
State 1 submodel, plant communities



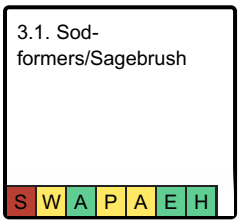
CP1.1-1.2 - Historic use patterns, drought, and climatic shifts have attributed to the decline in needle and thread and encouraged blue grama.

CP1.2-1.1 - Removal of the historic use patterns in favor of a rest rotation system, and the implementation of wildlife management programs has helped to reduce the grazing pressure and allow rest for recovery.

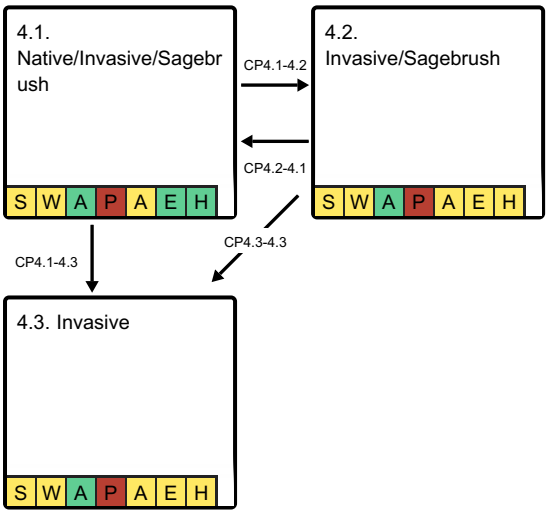
State 2 submodel, plant communities



State 3 submodel, plant communities



State 4 submodel, plant communities



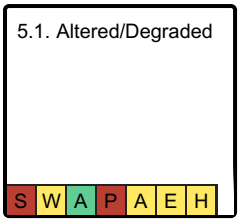
CP4.1-4.2 - Drought stress or grazing pressure will allow invasive species to become dominant, leaving only remnant populations of natives.

CP4.1-4.3 - A major disturbance that removes sagebrush as well as other native herbaceous species leaves the community vulnerable to becoming invader dominated.

CP4.2-4.1 - The integration of a pest management with intensive grazing management, over time, will encourage the remnant populations of natives to expand.

CP4.3-4.3 - Loss of sagebrush by major disturbance (fire, mechanical alteration, chemical means) will encourage the invasive species to become a near-monoculture population.

State 5 submodel, plant communities



State 1
Bunchgrass/Sagebrush

The Reference State, State 1, is labeled as the Bunchgrass/Sagebrush State. Wyoming big sagebrush and mid-stature bunchgrasses are the dominant contributors to composition with a notable cover of perennial forbs. Cover in this Reference State is reduced (increased bare ground) from similar ecological sites (Loamy and Sandy), due to the gravel substratum that reduces the available moisture in the lower soil profile.

Characteristics and indicators. This State is characterized by ten percent or less composition by cover of Wyoming big sagebrush, with a dominant understory of bluebunch wheatgrass, needle and thread, and Indian ricegrass (30-50 percent composition). Areas of western wheatgrass exist with the other minor components including prairie Junegrass, bottlebrush squirreltail, Sandberg bluegrass, and blue grama.

Resilience management. The plant community is diverse and is adapted to the arid and unpredictable nature of the environment creating a resilient community. In extended periods of drought, species such as needle and thread and western wheatgrass are able to limit production until conditions are suitable. Once conditions have improved they are prolific producers. Sandberg bluegrass is another species that can respond quickly to the drastically changing precipitation and climate patterns of the Big Horn Basin. Historically, the Reference State evolved under a low fire frequency, estimated to be 195 to 235 years between burns on the same community patch, and sagebrush has a post-fire recovery time of 50-120 years or more in arid systems (Baker, 2006) and with grazing pressure by large ungulates (elk, bison, deer, or antelope).

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- shadscale saltbush (*Atriplex confertifolia*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass
- needle and thread (*Hesperostipa comata*), grass
- Indian ricegrass (*Achnatherum hymenoides*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- scarlet globemallow (*Sphaeralcea coccinea*), other herbaceous
- spiny phlox (*Phlox hoodii*), other herbaceous
- fleabane (*Erigeron*), other herbaceous

Community 1.1
Bluebunch Wheatgrass/Needle and Thread

Figure 8. This community has a moderate canopy of sagebrush with bluebunch wheatgrass and needle and thread as the dominant herbaceous cover.

This community (1.1) is captured as the Reference Plant Community; however, it is declining in occurrence on the landscape. Change or shifts in timing of precipitation, temperature shifts (spring warm-up or fall freeze), or lack of precipitation could be the dominant driving factors for this occurrence. This state evolved with grazing by large herbivores. The potential vegetation cover is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. Dominant grasses include needle and thread, bluebunch wheatgrass, and rhizomatous wheatgrasses. Grasses and grass-like species of secondary importance include Sandberg bluegrass, prairie Junegrass, bottlebrush squirreltail, and blue grama. A variety of forbs are found in this community including fleabanes, wild parsley, and and milkvetch. Wyoming big sagebrush, is a conspicuous component of the community, and can make up to 10 percent of the annual production. The total annual production (air-dry weight) of this community phase is about 300 lbs./acre, but it can range from about 150 lbs./acre in unfavorable years to about 400 lbs./acre in above-average years.

Resilience management. Species diversity of this community provides a high tolerance to drought, allowing persistence in the limiting climatic conditions of the Big Horn Basin. The structural diversity of Wyoming big sagebrush in conjunction with the mid-statured bunchgrasses (needle and thread and bluebunch wheatgrass), rhizomatous species (western wheatgrass and thickspike wheatgrass), and the short-statured bunchgrasses (prairie Junegrass, Sandberg bluegrass, and bottlebrush squirreltail) helps to provide snow catch and shade, to capture and hold moisture in order to maximize availability during the growing season. This key to the hydrologic function as well as the adaptability of the community to the variability in timing of precipitation helps to provide cover, through a variety of conditions. Needle and thread is dependent upon early spring moisture to perform well; years with late spring early summer moisture will produce minimal to no needle and thread, but will have an excellent cover of prairie Junegrass. Whereas a year with late fall moisture and a slow warm up with spring moisture will produce an excellent cover of Sandberg bluegrass but minimal production for prairie Junegrass and needle and thread. The persistence and adaptability from year to year of these species allows for quick recovery once normal precipitation returns. This natural variability will cause the transition between phase 1.1 and 1.2, but is not at risk of transitioning into a different state unless a significant (catastrophic) impact occurs. Extended periods of drought, use changes, and other natural and human-derived impacts further force this change. This community, as Reference, is indicative of rangeland health which is based on site and soil stability, watershed function, and biologic integrity.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- needle and thread (*Hesperostipa comata*), grass
- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- scarlet globemallow (*Sphaeralcea coccinea*), other herbaceous
- desertparsley (*Lomatium*), other herbaceous
- milkvetch (*Astragalus*), other herbaceous

Dominant resource concerns

- Sheet and rill erosion

- Aggregate instability
- Plant structure and composition
- Terrestrial habitat for wildlife and invertebrates
- Inadequate livestock shelter
- Inadequate livestock water quantity, quality, and distribution

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	112	224	280
Shrub/Vine	50	84	112
Forb	6	28	56
Total	**168**	**336**	**448**

Table 6. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0-5%
Litter	5-15%
Surface fragments >0.25" and <=3"	0-35%
Surface fragments >3"	0-10%
Bedrock	0%
Water	0%
Bare ground	20-35%

Table 7. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	0-5%	5-25%	0-5%
>0.15 <= 0.3	–	0-10%	5-50%	0-10%
>0.3 <= 0.6	–	0-2%	0-5%	0-2%
>0.6 <= 1.4	–	–	–	–
>1.4 <= 4	–	–	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

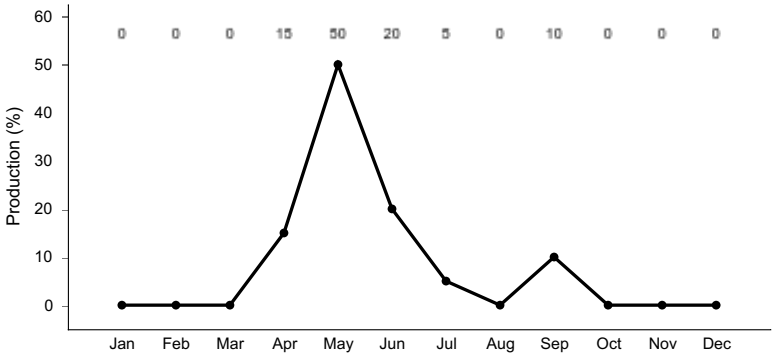


Figure 10. Plant community growth curve (percent production by month). WY0501, 5-9BH Upland sites. Monthly percentages of total annual growth for all upland sites with dominantly C3 Cool season plants..

Community 1.2
Perennial Native Grasses/Sagebrush

Figure 11. The sagebrush canopy has become more significant in this community with a reduced cover of the key herbaceous species.

The secondary phase of the Reference Community (1.2), is captured as the At-Risk Community. Although it is similar with only minor shifts in composition and function, the decrease in needle and thread and the increase in woody cover leaves this site at risk of further degradation with continued stress or pressure by herbivory. The community can be found on areas that are within the scope of historic disturbances such as herbivory by large ungulates. Properly managed locations with grazing with periodic short intervals of rest support this plant community and production potential. The vegetation composition is 65 percent grasses or grass-like plants, 10 percent forbs, and 25 percent woody plants. The major understory of grasses and grass-like plants includes needle and thread, rhizomatous wheatgrasses, blue grama, Sandberg bluegrass, and bottlebrush squirreltail. The variety of forbs and half-shrubs commonly found include scarlet globemallow, milkvetches, and spiny phlox. Wyoming big sagebrush can make up 25 percent of the annual production. The overstory of Wyoming big sagebrush and understory of grasses and forbs maintain the diverse structure of the plant community. Blue grama has increased within this community, as has Wyoming big sagebrush; however, they are not the most prevalent species. The shift in species has an impact on moving or changing the hydrology of the site. Plains pricklypear cactus will also have increased but occurs only in small patches. Needle and thread has decreased and may occur in only trace amounts under the sagebrush canopy or within the patches of pricklypear; whereas rhizomatous wheatgrasses and bottlebrush squirreltail have maintained and are a common component in this community. The total annual production (air-dry weight) of this community is about 250 pounds per acre, but it can range from about 150 lbs./acre in unfavorable years to about 450 lbs./acre in above average years.

Resilience management. This plant community is resistant to change. The herbaceous cover is intact, and plant vigor and replacement capabilities are enough to maintain during periods of moderate grazing pressure with recovery periods; however, species composition can be altered through long-term overgrazing or increased intensity of defoliation. The overall canopy is adequate, but the shift in structure of cover and increase in bare ground opens a niche for weedy species and may intensify the droughty nature of the soils with increased water

demands by the woody species as well as shallower-rooted annuals. Bare ground averages 30 to 45 percent, woody coverage has increased (due to reduced herbaceous cover, to an average of 20 to 35 percent cover. Litter overall appears to be similar across this state (State 1); similarly, the biological crust cover does not vary. Water flow patterns and litter movement may be occurring but only on steeper slopes. Incidence of pedestalling is minimal, and soils mostly are stable with only minimum evidence of soil loss. The watershed is functioning, and the biotic community is intact.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- Sandberg bluegrass (*Poa secunda*), grass
- spiny phlox (*Phlox hoodii*), other herbaceous
- scarlet globemallow (*Sphaeralcea coccinea*), other herbaceous
- milkvetch (*Astragalus*), other herbaceous

Dominant resource concerns

- Sheet and rill erosion
- Compaction
- Aggregate instability
- Plant productivity and health
- Plant structure and composition
- Terrestrial habitat for wildlife and invertebrates
- Inadequate livestock shelter
- Inadequate livestock water quantity, quality, and distribution

Table 8. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	112	168	252
Grass/Grasslike	50	84	196
Forb	6	28	56
Total	**168**	**280**	**504**

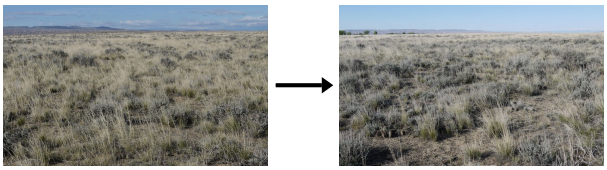
Table 9. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0-5%
Litter	5-15%
Surface fragments >0.25" and <=3"	0-30%
Surface fragments >3"	0-15%
Bedrock	0%
Water	0%
Bare ground	25-40%

Table 10. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	0-10%	0-30%	0-10%
>0.15 <= 0.3	–	5-20%	0-20%	0-5%
>0.3 <= 0.6	–	0-5%	0-15%	–
>0.6 <= 1.4	–	–	–	–
>1.4 <= 4	–	–	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Pathway CP1.1-1.2
Community 1.1 to 1.2



Bluebunch Wheatgrass/Needle and Thread

Perennial Native Grasses/Sagebrush

Timing of grazing, Drought, Climatic shifts – Historically, the large expanses of federal lands were used during the summer exclusively or were utilized in the spring and then again in fall as sheep were trailed to forest allotments and then home again. The repetitive timing of use would have slowly removed more desirable species from the system, encouraging the rhizomatous and low-statured bunchgrasses. Long periods of drought and shifts in spring precipitation patterns have weakened and impacted the productivity and vigor of most species and has encouraged the low-statured warm-season grass species such as blue grama. Although the species of herbivory and timing has changed with the installation of more grazing management, drought and other climatic patterns still pose a continual threat to the integrity of this plant community. The shift in this community is marked by the decline of needle and thread, with an increase in rhizomatous wheatgrasses, Sandberg bluegrass, bottlebrush squirreltail, and blue grama.

Context dependence. Changes in herbivory pressure by sheep and wildlife in the area have allowed Wyoming big sagebrush to become increasingly woody and decadent. Although this has created a slight perception of increased woody canopy, the community is still dominated by cool-season perennial grasses. Overall, a stronger presence of short-statured grasses (blue grama, Sandberg bluegrass) have increased across the entire basin but has remained as a secondary component in these reference communities.

Pathway CP1.2-1.1
Community 1.2 to 1.1

Perennial Native Grasses/Sagebrush

Bluebunch Wheatgrass/Needle and Thread

Long-term Prescribed Grazing, Brush Management - Integration of a rotational grazing system or rest-rotation with management to reduce or improve quality of the shrub canopy, will encourage the native bunchgrasses to reestablish in this community. An extended period of time (estimated at 5 to 10 years) may pass before significant change is noticed. Prescribed grazing, especially following sagebrush canopy treatments, helps to remove woody debris and expose the existing seedbank, encouraging native species. Allowing rest during critical seedling establishment and reducing competition will help recovery. Hoof action helps to incorporate the seed and litter to

allow the desired bunchgrasses (needle and thread, bluebunch wheatgrass) and rhizomatous wheatgrasses to reestablish or to increase, driving the recovery to the Reference Community (1.1). This hoof action, and brush treatment can be a tool to limit mat-forming species, maintaining the hydrologic cycle, reducing runoff. A long-term management strategy may be required before any trend towards the Reference State is noticed. The overstory of Wyoming big sagebrush may be the one factor that could require further manipulation to reduce canopy and composition to the desired 10 percent cover.

Conservation practices

Brush Management
Critical Area Planting
Prescribed Grazing
Grazing Land Mechanical Treatment
Heavy Use Area Protection
Integrated Pest Management (IPM)
Upland Wildlife Habitat Management

State 2
Mixed Shrub/Bare Ground

Persistence of drought or frequent and severe use by livestock or wildlife leads to a decline of the herbaceous species, creating the Mixed Shrub/*Bare Ground* State. This State can be exacerbated by insects and other natural and human disturbances. The total woody canopy cover does not necessarily always increase with this community, but the percentage of composition by cover and production is swayed by the decrease of herbaceous vegetation and the relative stability of woody production, creating the appearance of increased canopy by shrubs.

Characteristics and indicators. The gravelly and coarse textured lower soil profile provides the opportunistic shrubs such as shadscale, yellow and rubber rabbitbrush, and spiny hopsage to establish along with Wyoming big sagebrush. These shrubs provide a protective niche for most herbaceous understory to maintain a minimal cover in difficult conditions. The additional moisture provided by the shade of the canopy as well as protection from grazing benefit most native grasses.

Resilience management. As the grass cover declines and the plant community continues to weaken, the sagebrush and other shrub cover is susceptible to attack by insects, disease, and age. The loss of the woody cover from the system places this State at-risk of invasion or transition to a more degraded state. The lack of water retention lower in the soil profile exacerbates the impact of drought and limits the resiliency of the Shallow to Gravel Ecological site. Animal trailing, foot and vehicle trails and other erosional patterns are highly visible in this State. Loss of top soil exposing the gravel layers is a potential with the increased wind and water erosion risks within this State. Risk of wildfire within this state is minimal due to the lack of fine fuels within the understory, but the canopy of the woody vegetation will carry a fire under certain weather conditions. Fire is a significant risk to this community because of the potential to remove all native vegetation. The exposed community is vulnerable to invasion to cheatgrass with no native competition and a lack of native seed source to allow recovery. Loss of sagebrush reduces the hydrology further hindering the recovery potential.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- shadscale saltbush (*Atriplex confertifolia*), shrub
- Sandberg bluegrass (*Poa secunda*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- squirreltail (*Elymus elymoides*), grass
- plains pricklypear (*Opuntia polyacantha*), other herbaceous
- scarlet globemallow (*Sphaeralcea coccinea*), other herbaceous
- woolly plantain (*Plantago patagonica*), other herbaceous

Community 2.1
Sagebrush/Bare Ground

This plant community is the result of frequent and severe grazing and a lack of fire or removal of sagebrush. Wyoming big sagebrush dominates this plant community, as the annual production of sagebrush exceeds 25 percent. The desirable mid-statured cool-season grasses have been greatly reduced, and typically reside within the crown cover of sagebrush. The dominant grasses are needle and thread, Sandberg bluegrass, prairie Junegrass, and blue grama with dispersed areas of threadleaf sedge. Patches of pricklypear cactus are more noticeable on the landscape, and the amount of bare ground is more prevalent. As compared with the Reference Plant Community 1.1, the annual production is slightly lower. Sagebrush, other woody cover, and cactus maintain production even though herbaceous production has declined. This community is vulnerable to invasive weeds such as cheatgrass, Russian knapweed, or flixweed if a seed source is available. This community is at-risk of transitioning to the Invaded State. The total annual production (air-dry weight) of this state averages 250 pounds per acre, but it can range from 100 lbs./acre in unfavorable years to 400 lbs./acre in above average years.

Resilience management. Changes in management alone has minimal impact in this community, it is relatively resistant to change for native cover. Plant diversity is moderate to poor and replacement capabilities are limited due to the reduced number of mid-statured cool-season grasses. Plant litter is noticeably less when compared to the Reference Plant Community. Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced, and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- western wheatgrass (*Pascopyrum smithii*), grass
- squirreltail (*Elymus elymoides*), grass
- Sandberg bluegrass (*Poa secunda*), grass
- spiny phlox (*Phlox hoodii*), other herbaceous
- plains pricklypear (*Opuntia polyacantha*), other herbaceous
- woolly plantain (*Plantago patagonica*), other herbaceous

Dominant resource concerns

- Sheet and rill erosion
- Ephemeral gully erosion
- Aggregate instability
- Plant productivity and health
- Plant structure and composition
- Terrestrial habitat for wildlife and invertebrates
- Feed and forage imbalance
- Inadequate livestock water quantity, quality, and distribution

Table 11. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	84	168	280
Grass/Grasslike	22	84	112
Forb	6	28	56
Total	**112**	**280**	**448**

State 3
Sod-formers

The dominant sod-forming grass that currently exists within this LRU and subset is blue grama. Blue grama persists as a component of the perennial vegetation naturally (in Reference communities) within this ecological site. The

general tendency is for these species to increase with prolonged drought or under grazing pressure, becoming dominant.

Characteristics and indicators. This community is characterized by a dominance of blue grama. Remnants of the other vegetation natural to this site will persist, but is restricted by the dense mats of blue grama to the protective niche within sagebrush canopy or cactus clumps.

Resilience management. Blue grama effectively alters the hydrology of the site by increasing the surface runoff from the dense shallow root system that inhibits the movement of water through the soil surface. This root mat directs surface flow around the edge of the mat concentrating flow into channel-like patterns and off-site. This loss of surface moisture creates a drier environment for native grass species and forbs to persist.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- shadscale saltbush (*Atriplex confertifolia*), shrub
- blue grama (*Bouteloua gracilis*), grass
- needle and thread (*Hesperostipa comata*), grass
- Sandberg bluegrass (*Poa secunda*), grass
- plains pricklypear (*Opuntia polyacantha*), other herbaceous
- scarlet globemallow (*Sphaeralcea coccinea*), other herbaceous
- woolly plantain (*Plantago patagonica*), other herbaceous

Community 3.1
Sod-formers/Sagebrush

Figure 14. Sod-bound community with cheatgrass establishing. This community is right on the transitional threshold to a 4.1 community phase.

Dense, interspersed patches of blue grama sod is the major component of this community. Incidental occurrences of other perennial natives occur within the sagebrush canopy or the protective ring of the pricklypear cactus clumps. Overall, Wyoming big sagebrush has been reduced in vigor and abundance across this community phase, but it persists on the landscape (average of 5-10 percent canopy cover). This plant community is the result of continuous season-long grazing, or prolonged drought. This plant stress has adversely affected the perennial grasses and shrub component, in turn encouraging the low-statured, mat-forming (tillering) grasses to expand. The effect of blue gramas short, dense root structure is decreased water infiltration which increases channelization of runoff between vegetation patches. Decreased infiltration coupled with the lack of structure to hold moisture and compounded by drought will reduce the shrub component further. When compared to the Reference Plant Communities 1.1 and 1.2, blue grama has increased significantly, making up 30 to 60 percent of the canopy. Pricklypear cactus is prevalent on the site, and other cool-season mid-statured grasses, perennial forbs, and most shrubs have been greatly reduced. Production has significantly decreased and bare ground is variable. The total annual production (air-dry weight) of this community phase is about 150 pounds per acre, but it can range from about 75 lbs./acre in unfavorable years to about 300 lbs./acre in above average years.

Resilience management. The short-statured tillering plants are resistant to change. No added effect to the plant composition or structure is apparent with continued frequent and severe use. Removal of grazing (non-use) shows

little to no improvement of the community. The shrub component is at-risk of degradation under any management. The biotic integrity of this community phase is not functional and plant diversity is extremely low. The plant vigor is weakened, and replacement capabilities are limited due to the reduced number of mid-statured cool-season bunchgrasses. This sod-bound plant community significantly reduces water infiltration, increasing runoff. The sod covered soil is protected, however interspaces or edges are affected by excessive runoff that can cause rills and gully erosion. Water flow patterns are obvious in areas of bare ground, and pedestalling is prominent along the sod edges. Rill channels are noticeable in the interspaces and down slope. The watershed function is degraded with the impact of runoff and its affects to adjoining sites. This community can improve with intensive management requiring mechanical manipulation and seeding. However, this community is not capable of returning to the Reference State. Extended periods of drought stress creates a die off or die-back of blue grama. When the blue grama plant dies, it tends to die from the center out, but will remain intact until disturbed (trampling, vehicle traffic, ground disturbances). Surface disturbances will break up the mat crowns in their fragile state, leaving the surface more vulnerable to erosion.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- blue grama (*Bouteloua gracilis*), grass
- Sandberg bluegrass (*Poa secunda*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- woolly plantain (*Plantago patagonica*), other herbaceous
- madwort (*Alyssum*), other herbaceous
- plains pricklypear (*Opuntia polyacantha*), other herbaceous

Dominant resource concerns

- Sheet and rill erosion
- Ephemeral gully erosion
- Classic gully erosion
- Sediment transported to surface water
- Plant productivity and health
- Plant structure and composition
- Terrestrial habitat for wildlife and invertebrates
- Feed and forage imbalance
- Inadequate livestock water quantity, quality, and distribution

Table 12. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	56	106	224
Shrub/Vine	28	56	84
Forb	–	6	28
Total	**84**	**168**	**336**

State 4
Invaded

Wyoming rangelands, much like the neighboring states, has quickly fallen victim to the aggressive invasion of cheatgrass, also called downy brome (*Bromus tectorum*). The rapid development of an extensive seedbank and duff layer forms with the potential for multiple growth cycles throughout a year. The advantageous ability of cheatgrass to persist through the winter under a blanket of snow and sprout early makes it difficult for natives to outcompete it for limited resources. Shifts in climatic patterns, changes in management, and exposure to human activity are a few of the explanations for the current flush and rapid expansion across the western United States. Although cheatgrass is the most prevalent large-scale threat for rangeland managers, a variety of knapweeds (spotted, Russian, etc.), in combination with other aggressive invaders such as whitetop (hoary cress), black henbane, field bindweed, and leafy spurge are increasing in density and frequency, producing their own set of

challenging management issues. As more species are found or as other species become more prevalent on a large scale, the community dynamics in this state will shift in response to the concerns of the identified species.

Characteristics and indicators. The Invaded State is characterized by the presence and eventual dominance of invasive and non-native species. The open canopy of the arid native community combined with extended periods of drought, extensive grazing impacts, insect damage, other natural disturbance or any combination there of, has weakened the native composition allowing invasion.

Resilience management. The competitive nature of annuals and other invasive species creates a hostile environment that restrict the native species, inhibits control and makes it implausible to attain complete eradication once an invasive species has established on the landscape. Severity and scale of invasion will make a difference in the limitations of the site.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- cheatgrass (*Bromus tectorum*), grass
- Sandberg bluegrass (*Poa secunda*), grass
- blue grama (*Bouteloua gracilis*), grass
- plains pricklypear (*Opuntia polyacantha*), other herbaceous
- spiny phlox (*Phlox hoodii*), other herbaceous
- mustard (*Brassica*), other herbaceous

Community 4.1
Native/Invasive/Sagebrush

The Perennial Grasses/Invasive Species/Wyoming Big Sagebrush Community Phase has maintained a representative composition of native perennial grasses and forbs that are key to this ecological site with the accompanying Wyoming big sagebrush component. Although this community phase is very vulnerable of becoming an invader-driven system, if the invader can be maintained at 5 to 10 percent composition, the probability of the community to persist and possibly improve is retained. However, extent of improvement and exorbitant costs and labor required limit the economic feasibility. Further degradation of this site increases the cost and reduces feasibility of restoring a desired community, which makes this community phase the At-Risk Community. This community phase is characterized by a marked composition of invasive species (5 percent or greater) on the landscape; with a wide-scale distribution, not one isolated patch in an isolated portion of the landscape). The composition still includes a significant native population, and litter has not become inhibiting at this phase in degradation. Production yields of the perennial grasses and forbs are slightly reduced but the total production will maintain or may be slightly elevated due to the overall biomass and expanded growth potential of many of the annual or invasive species. A specific production range is not provided due to the variability of composition that will affect overall production.

Resilience management. This plant community's susceptibility to fire increases as fine fuels increase with the added biomass and litter produced by invaders (most specific to cheatgrass). Plant diversity is maintained by the remnants of native perennial grasses and shrubs. The plant vigor is diminished, and replacement capabilities are

limited due to the reduced cover of cool-season grasses. Limited resources (moisture and nutrients) also inhibits native vigor and persistence in the community. Litter cover and soil erosion for this phase has had minimal to no noticeable change in this community phase. Water flow patterns and pedestalling may be slightly more visible in response to the loss of some native cover. Infiltration is unaltered or slightly reduced; however, as the duff layer or litter builds infiltration and runoff will increase.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- Sandberg bluegrass (*Poa secunda*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- needle and thread (*Hesperostipa comata*), grass
- cheatgrass (*Bromus tectorum*), grass
- plains pricklypear (*Opuntia polyacantha*), other herbaceous
- spiny phlox (*Phlox hoodii*), other herbaceous
- woolly plantain (*Plantago patagonica*), other herbaceous

Dominant resource concerns

- Aggregate instability
- Plant productivity and health
- Plant structure and composition
- Plant pest pressure
- Wildfire hazard from biomass accumulation
- Inadequate livestock water quantity, quality, and distribution

Community 4.2
Invasive/Sagebrush

Community Phase 4.2 is characterized by the dominance of invasive species with a component of sagebrush. However, only remnant populations of native species persist in the community and little or no native recruitment is occurring . As the native populations of perennial grasses and forbs are removed through severe use or disturbance, the site becomes invader-driven. Continued environmental- or management-derived impacts to the shrub component places this community at risk of crossing a threshold. Wyoming big sagebrush can compete and maintain a strong community under a heavy infestation level of most invasive species, unless fire or similar disturbance removes the woody cover. The canopy of the sagebrush serves as a protective niche in the system for native grasses and forbs, allowing remnant populations to persist. But the system is low in resistance and even lower in resilience. The fine fuels or biomass produced by cheatgrass raises a significant threat of fire and increases the potential frequency of occurrence and intensity. Strategies to control or manage for invasive species, namely cheatgrass, are the subject of research across the western United States. High-intensity grazing with chemical control and the use of biological agents are techniques that have been given trials with varying levels of success. The key management strategies must be to maintain the remnant populations of native grasses and to reduce the risk of fire to allow the persistence of Wyoming big sagebrush. This will maintain the reduced biotic integrity (maintaining species richness, providing structure and a range of growth traits allowing adaptability of the site to varying climatic swings) and help to support the hydrologic function (providing snow catchment, and shade to allow a slow release of winter precipitation during spring melt, which gives a longer moist season for optimal growth of native species). Each location must be addressed individually to determine the best management strategies to utilize the native species present in the system and to determine the limitations of the resources.

Resilience management. This plant community is resistant to change in relation to returning to a native dominant system, but as the pressure from invasive species continues, it loses its resistance as it shifts to an invader-only community. These areas may be more prone to fire as fine fuels are more available with increased biomass and plant density as the annual invaders fill interspaces. Plant diversity is poor. The plant vigor is diminished, and adaptability and replacement capabilities are limited due to the reduced number of cool-season grasses. Plant litter is noticeably more when compared to the Reference communities due to the potential biomass produced by the invasive species (species-dependent). Soil erosion is variable depending upon the species of invasion and the litter accumulation thus associated. The variability of the water flow and pedestalling, as well as infiltration and runoff, is determined again by the species that establishes on this site.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- cheatgrass (*Bromus tectorum*), grass
- woolly plantain (*Plantago patagonica*), other herbaceous
- plains pricklypear (*Opuntia polyacantha*), other herbaceous

Dominant resource concerns

- Aggregate instability
- Plant productivity and health
- Plant structure and composition
- Plant pest pressure
- Wildfire hazard from biomass accumulation
- Terrestrial habitat for wildlife and invertebrates
- Feed and forage imbalance
- Inadequate livestock water quantity, quality, and distribution

Community 4.3
Invasive

Downy brome, better known as cheatgrass (*Bromus tectorum*), can green-up and grow late into the fall and green-up early spring before snow melt. This growth pattern allows cheatgrass to utilize fall and spring resources, that are otherwise stored for the cool-season native vegetation, before they can break dormancy. The morphology of the seed allows for easy dispersal and longevity, creating a widespread and long-term seed bank. Seeds can persist for long periods of time until growing conditions are optimal, allowing growth before most native species. The ability of the plant to grow quickly, utilizing available resources and producing large quantities of seed rapidly, and to reproduce in poor conditions are what drives cheatgrass above the natives and many improved varieties of grass; as well as creates a management challenge that has not been successfully met at this time. Once this species has a niche on a landscape it is resistant and resilient to change. The absence of sagebrush in this community restricts the potential for native herbaceous species, but some will persist in small scattered populations or sparsely under the canopy of cheatgrass. When climatic conditions are optimal, these resilient native species will respond to the available resources (typically mid-spring moisture). They are not able to out-compete invasive species long-term, so are restricted to a minor composition in the community. The ability for cheatgrass to emerge, bolt, produce seed, and mature two to three times within a year utilizes all available soil nutrients and moisture resources. Chemical control is difficult to attain and maintain success without lasting effects on the native grasses in the area. Chlorosis of wheatgrasses, stunted plants, and loss of certain forbs are a few of the residual chemical effects from binding to the mineralogy of the soil, inhibiting the uptake of nutrients by the roots. The risk, frequency and intensity of wildfires increase with the increasing fine fuels (biomass load) created by cheatgrass. The fire frequency interval has been noted to shift to a possible five-year cycle, preventing sagebrush and other woody species from establishing on the site. The grazing potential is limited due to the unpalatable and harsh environment that the mature seeds create with their long awns and chaff. If grazed in early spring or late fall some of this can be avoided, but general use through the middle of the growing season is difficult and negates the purpose of intensively grazing the location. In smaller invaded sites or under certain conditions, grazing can be used as a tool within the integrated pest management toolbox, but it is not effective alone.

Resilience management. This plant community is resistant to change. Plant diversity is poor. The plant vigor is diminished, and replacement capabilities are non-existent due to the loss of cool-season grasses. Plant litter is noticeably more when compared to Reference communities in response to the dense duff layer created by cheatgrass. Soil erosion generally is reduced in response to the litter accumulation. Infiltration and runoff are variable due to the loss of perennial vegetation, but with the potential increase in root density. Overall biotic integrity is lost in this community.

Dominant plant species

- cheatgrass (*Bromus tectorum*), grass

Dominant resource concerns

- Aggregate instability

- Plant productivity and health
- Plant structure and composition
- Plant pest pressure
- Wildfire hazard from biomass accumulation
- Terrestrial habitat for wildlife and invertebrates
- Feed and forage imbalance
- Inadequate livestock shelter
- Inadequate livestock water quantity, quality, and distribution

Pathway CP4.1-4.2
Community 4.1 to 4.2

Frequent or severe grazing, wildfire, and drought— Wildfire is plausibe with the increasing cover by invasive species (cheatgrass). Drought or other climatic factors will continue to hinder the native species, reducing their ability to maintain their footprint in the plant community. Continued stress of frequent or severe grazing pressure from wildlife and livestock can reduce the native composition to an unsustainable population and allow the invasive species to dominate.

Pathway CP4.1-4.3
Community 4.1 to 4.3

Extended periods of frequent or severe grazing and/or drought, or wildfire—A major disturbance that removes sagebrush as well as other native herbaceous species leaves the community vulnerable to monoculture stand of invasive species. With the increase in fine fuels created by cheatgrass and other invasive species, the wildfire risk rises. Fire will trigger a shift to an invader-dominated community. Continued stress of drought or frequent and severe grazing can also further degrade this community, allowing for a complete invasion.

Context dependence. The transition from a sagebrush and native grasses driven state to a invader driven state may occur over a period of time, but generally this transition is related to a catastrophic type event. These events may include a wildfire, mechanical treatment failure, or construction type activities.

Pathway CP4.2-4.1
Community 4.2 to 4.1

Integrated pest management and weed control and long-term prescribed grazing—Control of invasive species and managing grazing to allow use of the invasive species with minimal impact to the native population, will allow the community to regain or maintain potential. Wildlife and livestock will utilize cheatgrass and other invasive species but tends to be during initial spring green-up while natives are still dormant or in the fall after the natives have dried down and invasive species have a secondary flush of growth. This is more typical in species such as knapweeds, whitetop, and specifically cheatgrass (downy brome). But currently, it is not possible to eradicate the invasive species, and sustained control requires intensive inputs over the course of several years. To maintain the system with no further degradation requires a dual approach with both long-term prescribed grazing and intensive weed management (integrated pest management). No one single practice can sustain this phase, as it requires intensive management to prevent the transition to Community Phase 4.3 – Invaders (Annuals), and to encourage the recovery of native species.

Context dependence. Extent of control and ability of the community to recover (native grasses primarily) is dependent on climatic conditions and the invasive species that established in the community.

Conservation practices

Brush Management
Critical Area Planting
Prescribed Grazing
Grazing Land Mechanical Treatment
Heavy Use Area Protection

Integrated Pest Management (IPM)
Upland Wildlife Habitat Management

Pathway CP4.3-4.3
Community 4.2 to 4.3

Catastrophic events, extreme grazing, drought events, or wildfire—The transition to Community Phase 4.3 can occur with continued extensive use and drought. However, the complete loss of sagebrush generally occurs under a major disturbance (fire, mechanical alteration, chemical means). The establishment of invasive species will become a near-monoculture. The loss of sagebrush, the increased litter biomass that inhibits infiltration will increase the risk of fire and inhibit recruitment of native species.

State 5
Altered

The arid nature of this region has played a major role in the development and transitions in land use over time. Early settlers worked to farm any land that was accessible by water (canal systems) and equipment. Many of these small areas were later abandoned and left to return to rangeland. Other landscapes were treated with a variety of prescriptions to manage or eradicate sagebrush. Tillage of the soil, changes in hydrology caused by the loss of vegetative structure, constant natural climatic fluctuations, and advancements in seed sources has led to the creation of a site description for the Altered State. The Altered state could be drafted as a alternative land use within the State-and-Transition Model diagram. No matter how a location is classified, once the site has experienced an event that has altered the soil properties (erosional, depositional, hydrological, or chemical), the site potential is altered. The Shallow to Gravel ecological site, once mined or tilled, potentially will lose the top soil or gain chemistry that could potentially change the ecological site the soil would key to. In some cases (site by site consideration), recorrelation of a location may be needed. In many cases, however, the soils have not been altered out of the current site characteristics, but the potential has shifted enough that it is no longer truly comparable to the Reference State (State 1).

Characteristics and indicators. Mechanical, cultural, or natural disturbance to soils resulting in an alteration of structure, hydrologic function, and possibly stability prevent a site from supporting the native vegetation or responding to management in the same way as an undisturbed site. Reclamation or restoration of an area will not replace the original function and factors that made the original location respond as it did. Therefore, these "altered" lands may, after significant inputs and time, resemble the Reference Communities (1.1 or 1.2), but they will not respond or function as the Reference Community.

Resilience management. The species selection, extent or occurrence of tillage, and the resulting loss of structure, moisture, biotic degradation, changes in infiltration and water-holding capacity, and change in permeability are all factors that affect a planted site. The time required and feasibility for the redevelopment of soil, as well as variability in plant establishment and climatic conditions determine the successional path after a disturbance event. Kochia, Russian thistle, and mustards are the typical primary successional species in this LRU. Although they provide organic material, nutrient flow and erosional protection, they lack the structure and root system to fully stabilize the site. With time, the site may become similar in composition to Reference, but the integrity of the soil is altered, changing community potential. To capture the dynamics of this process, an Altered State was added to document these communities.

Community 5.1
Altered/Degraded

Disturbed or degraded lands are characterized by alteration of the soils to a degree that the functionality (erosional, depositional, hydrological, or chemical) and potential of the soils has been impacted. The method and severity of alternation, as well as the spatial extent of the disturbance will determine vegetation response and management needs. Linear disturbances such as pipelien corridors, trails, and roads will hold a different risk than patchwork or polygonal disturbances such as well-pads or parking areas. Small-scale or isolated disturbances (spot fires, prairie dog town) can be just as significant of a risk as a large-scale disturbance (mine lands). Site-specific evaluations need to be completed to determine the level of effect. Variability of the plant composition within this community

prohibits the selection of one specific growth curve. Growth curves for seeded locations will vary, especially with the use of non-native or cultivated species. In the case of an early successional community or naturally recovering system, the growth curve may resemble the pre-disturbed community. For a more accurate growth curve, a site-specific species inventory and documentation of the climatic tendencies should be collected.

Resilience management. The plant community is variable as a factor of the age of the stand and the stage of successional tendencies of the location. The specific community composition will determine the stablity (resilient/resistant) of the community. Plant diversity of these successional communities generally is strong but is usually lacking in the structural groups that are desired on the site. In areas of new or frequent disturbance, annual weedy species or early successional plants will be the dominant cover, providing strong diversity, but limited structure and cover for some wildlife. As the site matures or as the period between disturbances is lengthened, perennial or taller-statured, stronger-rooted species will increase providing protection, improves hydrologic processes, and allows establishment of grasses, forbs, and shrubs. This flexibility within the community creates a variable level of biotic integrity. Soil erosion is dependent upon the disturbance regime and the biotic integrity of the community. The variability of the community also affects water flow, infiltration, and runoff, which in turn effects the potential risk for erosion and pedestalling. Other factors that are more prevalent or influential for these sites are surface roughness and brokenness (tire tracks, hoof action, smoothed, denuded surfaces, trails that may focus the water).

Dominant resource concerns

- Sheet and rill erosion
- Wind erosion
- Ephemeral gully erosion
- Classic gully erosion
- Compaction
- Aggregate instability
- Sediment transported to surface water
- Plant productivity and health
- Plant structure and composition
- Plant pest pressure
- Terrestrial habitat for wildlife and invertebrates
- Feed and forage imbalance
- Inadequate livestock shelter
- Inadequate livestock water quantity, quality, and distribution

Transition T1-2
State 1 to 2

Frequent and severe grazing (year-long) or drought with the absence of brush management or wildfire—The conversion to a Wyoming Big Sagebrush/*Bare Ground* plant community is a response to extended periods of stress, both climate- and human-induced. Frequent or high-intensity herbivory with minimal to no recovery period weakens the ability for the grasses to persist, especially during prolonged drought. With the weakened herbaceous cover, the composition will shift to predominantly Wyoming big sagebrush. Over time sagebrush composition will increase inhibiting the recovery. With added climatic stress, species diversity and productivity are lost, and the community crosses into the Sagebrush/*Bare Ground* State. An illusion of crossing the threshold to State 2 is created in extended periods of significant fluctuation in precipitation patterns affecting production of prominent plants within this system. The loss of species diversity and increased bare ground over a period of years, along with lack of litter are the indicators that a true transition has occurred. It is important to recognize that woody cover is a factor of the number of plants as well as canopy cover. In some instances, the number of actual sagebrush plants may not increase to cause this shift, but the change in composition or vigor of the wood canopy, as well as the loss of herbaceous canopy, creates the perception of an increased number of plants when it is the ratio, size, and age that is more likely to shift.

Constraints to recovery. Having sufficient key species and cooperation of precipitation and rest from use to allow the native bunchgrasses to re-establish within the interspaces of sagebrush is the main constraint to recovery. Being able to thin while maintaining some woody cover may also be challenging for the recovery process.

Transition T1-3
State 1 to 3

Frequent grazing (year-long), brush management, or fire with drought—Severe and frequent grazing reduces vigor and presence of key species, mainly needle and thread and Indian ricegrass, and short-statured grasses become dominant. Animal disturbance (hoof impact) and continuous use reduces the bunchgrass component by allowing repeated defoliation of the desirable species and damage to the structure of the plant. These impacts reduce recovery potential and ground cover for insulation and snow catch; weakening and, over time, removing select species. The open canopy and hoof impact encourage species that are tolerant to trampling and short bursts of spring and summer precipitation. These species generally are tillering, mat- or sod-forming species such as blue grama and threadleaf sedge. Prolonged drought stresses the plants and opens the canopy, allowing sod-formers to fill in the interspaces. The shallow, dense root mats will continue to spread over time. The added removal of sagebrush with animal impacts or with fire or brush management may open the canopy more and aid in establishment. Season of use and intensity of grazing (time and timing) are triggers that can reduce the risk of transitioning, or, if done improperly, can force the transition to occur rapidly. The increase in blue grama adds an element of midsummer growth that extends the “green” grazing window. However, adequate amounts and timing of moisture must occur to allow sufficient growth to prevent overuse of the cool-season species.

Constraints to recovery. The ability to weaken or break up the sod-forming species and the lack of remaining native (key) bunchgrasses are the main constraints to recovery for this community.

Context dependence. The time lapse for the occurrence of this state is varied. It is a transition that takes or may take a significant time frame (over ten years) to occur. Recovery may be able to be achieved; but at this time no proof of recovery, without mechanical interference, has been achieved/documented within a management time frame (25 years).

Restoration pathway R2-1
State 2 to 1

Prescribed grazing with brush management or wildfire—Thinning or patch treatments for sagebrush allow native herbaceous cover to respond to improved moisture and sunlight followed by prescribed grazing to prevent will help this community recover. Treatment will vary depending upon the existing composition of grasses remaining and the potential threats to the location. Removal or thinning of the sagebrush within this community will help to reduce competition, encouraging grasses and forb recovery if the disturbance or overuse (recreational or grazing pressure) is reduced. Drought may prolong the time required for recovery. Mowing or mulching sagebrush trials have shown a strong response by grasses with little to no recovery time post-treatment. The resulting community with these treatments is driven by the dominant species within the community pre-treatment or climatic and treatment conditions during and following may sway the community. It is crucial to investigate the immediate and surrounding area around treatment sites to ensure no invasive species (cheatgrass) are present before treatment type is decided and then applied. The arid climate and lack of fine fuels limits the feasibility of fire as a brush management tool in this system.

Transition T2-3
State 2 to 3

Drought, Disease or Insect Damage, Over-use, or Fire - Sod-forming species such as blue grama and threadleaf sedge can tolerate high levels of use and will maintain as other native species decline. Hoof action or compaction inhibits more desirable native species, allowing the sod-formers to become dominant on the landscape. This decline creates a sagebrush/sod community that is resistant to change with management. Impacts to sagebrush by disease or insect damage, as well as drought or herbivory, will shift this to the secondary community phase with cactus as a subdominant cover with blue grama.

Constraints to recovery. The hydrologic shift caused by blue grama and the tolerance and resiliency of this species limits the ability to weaken/reduce its foothold in the community enough to encourage the mid-stature bunchgrasses key to this site.

Transition T2-4

State 2 to 4

Fire (wild), Frequent or Severe Grazing, Drought with Insect Damage/Brush Management – Throughout most of this LRU there is a seed source present for cheatgrass, knapweed, and other invasive species. Stress to the native community from fire, drought, disease/insect damage to sagebrush, or ground/soil disturbance including impacts by grazing large herbivores or recreational uses; opens the canopy and exposes the soil, creating a niche for undesirable and invasive species to establish. Early detection and rapid response provides a chance to prevent a full-scale invasion, but if left untreated, infestations can establish rapidly and spread with one growing season. The population soon grows exponentially as further stress or disturbance occurs. In some cases, once the invasive species are established, they can create their own habitat; this reduces the competitive ability of native species. The open canopy of the Sagebrush/*Bare Ground* State is vulnerable to invasive species without further influence. With continued over-use, drought, or insect damage/disease, the invasive species will establish and quickly dominate a location. The threshold species in this system is Wyoming big sagebrush, which protects the remnants of the perennial native grasses, allowing them to persist on the landscape.

Constraints to recovery. The lack of sufficient key native species and the inability to eradicate or sufficiently control invasive species are the main constraints to recovery for this state.

Context dependence. Extent of the transition for the sagebrush/bare ground state to the invaded state will determine the severity of the recovery constraints. The loss of sagebrush from this state will further limit/remove any ability of this state to recover back to any previous state.

Transition T3-4
State 3 to 4

Frequent and severe grazing, drought, or disturbance with a seed source present—Increased interspatial gaps in these communities leaves exposed soil that is vulnerable to invasion by undesirable species. Increased pressure from overuse and drought work to weaken the sod or mat-like community, exposing soil further to annuals and other invaders, such as cheatgrass and knapweeds. The aggressive nature and altered hydrology of these sites do restrict weed invasion. But if a seed source is available, ground disturbance by herbivores or man-induced, allows invasive species to find a way into the community. Once established in the community, it may not be feasible to completely remove eradicate the invasive species. Once the invasive species have become prevalent on the landscape (less than 5 percent composition), the community crosses the threshold into the Invaded/Sagebrush State (State 4).

Constraints to recovery. The lack of ability to eradicate or remove invasive species from the community at this time is the constraint to any recover from the invader driven state.

Context dependence. Substantial evidence that a blue grama dominated community has shifted to a invade/sagebrush or invaded community has not been gathered. It has been documented where a significant population of invasive species (ex: cheatgrass) has established within the inter-spaces of the blue grama sod.

Restoration pathway R4-5
State 4 to 5

Integrated pest management with seeding—Integrated pest management with intense weed control pre- and post-seeding is necessary to overcome a severe weed infestation. Thorough seedbed preparation and use of improved varieties (native and introduced species) suited for the intended land use improves the success potential. Seed mixes are generally designed to be similar to the Reference Community Phase (1.1). The limited success of seedings, lack of seed sources for all native species, the mechanical preparation of the seedbed alters soil stability and hydrologic functions, which in turn inhibits the restoration for this site. The alteration of the soils, the change in the plant community, and the risk of reinvasion of the site inhibits its ability to react the same to management and environmental changes as a non-disturbed native community will. Once significant soil disturbance occurs, the community will remain in an Altered State.

Context dependence. Species of concern (invasion) will be the determining factor to what processes will need to occur to allow an invaded community to be restored/reclaimed.

Conservation practices

Critical Area Planting
Prescribed Grazing
Grazing Land Mechanical Treatment
Range Planting
Heavy Use Area Protection
Upland Wildlife Habitat Management

Transition T5-4
State 5 to 4

No use, fire (wild or prescribed), frequent or severe grazing, drought with seed source present—Lack of management to prevent further disturbance or lack of use following reclamation allows the community to revert or transition to an invaded state. Wildfire, prescribed burning, drought, or frequent and severe use by large herbivores can be disturbances that either opens the canopy or introduces the species to the location. Extended periods of non-use create a decadent community with a large proportion of dead growth persisting around the crown of the plants, reducing vigor and production. Loss of vigor and increased bare ground makes the community vulnerable to weed invasions. Frequent or severe grazing, drought, or fire will also open the canopy and assist with the incorporation of seed sources encouraging an invasion and transition to the Invaded State.

Constraints to recovery. The species of invasion is the major constraint to recovery. Eradication has been unsuccessful for most of the major species affecting these communities on a large scale.

Additional community tables

Table 13. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Mid-stature, Cool-season Bunchgrass**			56–168	
	needle and thread	HECO26	*Hesperostipa comata*	22–112	10–20
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	22–56	5–20
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–22	0–5
2	**Rhizomatous, Cool-season Grasses**			6–56	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	0–56	0–10
	western wheatgrass	PASM	*Pascopyrum smithii*	0–56	0–10
3	**Short-stature, Cool-season Bunchgrass**			0–56	
	squirreltail	ELEL5	*Elymus elymoides*	0–22	0–5
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–22	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	0–22	0–5
4	**miscellaneous grass and grass-likes**			0–28	
	blue grama	BOGR2	*Bouteloua gracilis*	0–22	0–5
	Grass, perennial	2GP	*Grass, perennial*	0–22	0–5
Forb					
5	**Perennial Forbs**			0–56	
	milkvetch	ASTRA	*Astragalus*	0–22	0–5
	fleabane	ERIGE2	*Erigeron*	0–22	0–5
	desertparsley	LOMAT	*Lomatium*	0–22	0–5
	spiny phlox	PHHO	*Phlox hoodii*	0–22	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–22	0–5
	Forb, perennial	2FP	*Forb, perennial*	0–22	0–5
Shrub/Vine					
6	**Dominant Shrubs**			28–112	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	28–112	5–15
7	**Miscellaneous Shrubs**			0–56	
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–28	0–5

Animal community

Animal Community – Wildlife Interpretations:

1.1 – Bluebunch Wheatgrass/NeedleandThread (Reference Community): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. When found adjacent to sagebrush-dominated states (1.2 or 3.1), this plant community provides brood-rearing and foraging areas for sage grouse, as well as lek sites. The mosaic pattern of varying density of sagebrush in a smaller scale provides cover and line-of-sight to forage. Other birds that would frequent this plant community include western meadowlarks, horned larks, and golden eagles. Many grassland-obligate small mammals would occur here.

1.2 - Perennial Native Grasses/Wyoming Big Sagebrush (At-Risk Community): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could

provide some escape cover. This plant community provides brood rearing and foraging areas for sage grouse, as well as lek sites. The mosaic pattern of varying density of sagebrush in a smaller scale provides cover and line of sight to forage. Other birds that would frequent this plant community include western meadowlarks, horned larks, and golden eagles. Many grassland-obligate small mammals would occur here.

2.1 - Sagebrush/*Bare Ground* Plant Community: This plant community can provide important winter foraging for elk, mule deer, and antelope, as sagebrush can approach 15 percent protein and 40-60 percent digestibility during that time. This community provides excellent escape and thermal cover for large ungulates, as well as nesting habitat for sage grouse.

3.2 - Sod-formers/Sagebrush Plant Community: This community provides limited foraging for antelope and other grazers. They may be used as a foraging site by sage grouse where Reference State Community Phases are limited. Generally, these are not target plant communities for wildlife habitat management.

State 4 - Invaded: Initial invasion may have similarities to Community Phase 1.2 (Perennial Native Grasses/Wyoming Big Sagebrush) are to some extent enhanced for some species with the added forage provided by the invasive species. However, as the invasive species increase, decreasing the desirable species, the wildlife species benefits are decreased as well. Limited nesting and cover is provided by the existing overstory cover of the Wyoming big sagebrush and other shrubs. Early spring and fall green-up of cheatgrass provides foraging opportunities for many of our grazers and mixed feeders. Removal of sagebrush and other shrubs further decreases the value for many wildlife species.

5.1 - Disturbed/Altered Lands Plant Community: The variability of this site prevents a detailed review of wildlife benefits. However, many of the introduced grasses, forbs, and shrubs can provide adequate cover, food, and nesting sites for those wildlife species that would have selected the site prior to disturbance. Limitations and enhancements should be considered by specific locations.

Animal Community – Grazing Interpretations:

The following table lists suggested stocking rates for cattle under continuous season-long grazing with normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. If distribution problems occur, stocking rates must be reduced to maintain plant health and vigor.

Plant Community Production Carrying Capacity*

The carrying capacity is calculated as the production (normal year) X .25 efficiency factor / 912.5 # / AUM (Animal Unit Month: the amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for one month) to calculate the AUMs/Acre.

Plant Community Description/Title	Lbs./Acre	AUM's/Acre*	Acres/AUM
	Below Ave.	Normal	Above Ave.
1.1 Bluebunch Wheatgrass/NeedleandThread	150	300	400	0.08	12.2
1.2 Perennial Native Grasses/Wyoming Big Sagebrush	150	250	450	0.07	14.6
2.1 Mixed Shrubs/*Bare Ground*	**	**	**	**	**
3.1 Sod-formers/Mixed Shrubs	**	**	**	**	**
4.1 Invaded	**	**	**	**	**
5.1 Disturbed/Degraded	**	**	**	**	**

* - Carrying capacity is figured for continuous, season-long grazing by cattle under average growing conditions.
** - Sufficient data for most sites, especially for the invaded and reclaimed communities, has not be collected or evaluated, at this time, so no projection of a stocking rate recommendation or production range will be established at this time.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide year-long forage for cattle, sheep, or horses. During the dormant period, the forage for livestock use needs to be supplemented with protein because the quality does not meet minimum livestock requirements.

Distance to water, shrub density, and slope can affect carrying capacity (grazing capacity) within a management unit. Adjustments should be made for the area that is considered necessary for reduction of animal numbers. For example, 30 percent of a management unit may have 25 percent slopes and distances of greater than one mile from water; therefore, the adjustment is only calculated for 30 percent of the unit (i.e. 50 percent reduction on 30 percent of the management unit).

Fencing, slope length, management, access, terrain, kind and class of livestock, and breeds are all factors that can increase or decrease the percent of graze-able acres within a management unit. Adjustments should be made that incorporate these factors when calculating stocking rates.

Hydrological functions

Water (time and timing of precipitation) is the principal factor limiting forage production on this site. The Sandy ecological site is dominated by soils in hydrologic group B, with localized areas in hydrologic group C. Infiltration potential for this site varies from moderately rapid to rapid depending upon soil hydrologic group and ground cover. Runoff varies from low to moderate. In many cases, areas with greater than 75 percent ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50 percent have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non- existent. Cryptogrammic crusts are present, but only cover 1-2 percent of the soil surface.

Recreational uses

This site provides hunting opportunities for upland game species. The wide varieties of plants which bloom from spring until fall have an aesthetic value that appeals to visitors. Outside of plants, the extent offers a variety of cultural resources to view on the landscape based on the location of many of these sites on higher ground on the benches and fans which also provides a rich source of geology for exploration. The Shallow to Gravel ecological site has minimal limitations when associated with roadways and trails, and provides a sound base for travel in relation to erosion potential and functionality. Surface fragments may limit comfort for tent camping.

Wood products

No appreciable wood products are present on the site.

Other products

Herbs: The forb species of the Sandy ecological site have medicinal characteristics and have been used by the Native Americans in this area and more recently by the naturopathic profession.

Ornamental Species: The forbs commonly found as well as the shrub component of these communities have been used in landscaping and xeriscaping.

Inventory data references

Information presented in this description was derived from NRCS inventory data. Field observations from range-trained personnel also were used. Those involved in the development of the new concept for the Sandy ecological site include Tricia Hatle, Range Management Specialist, US Department of the Interior-Bureau of Land Management (USDI-BLM); Karen Hepp, Range Management Specialist, USDI-BLM; and Marji Patz, Ecological Site Specialist, NRCS. Other sources used as references include USDA NRCS Water and Climate Center, USDA NRCS

National Range and Pasture Handbook, USDI and USDA Interpreting Indicators of Rangeland Health Version IV, and USDA NRCS Soil Surveys from various counties.

Quality control and quality assurance completed by NRCS: Dan Mattke, Area Resource Soil Scientist; Daniel Wood, MLRA Soil Survey Leader; John Hartung, Wyoming State Rangeland Management Specialist; James Bauchert, Wyoming State Soil Scientist; and Scott Woodall, Regional Quality Assurance Ecological Site Specialist.

For specific data inquiries, contact the Powell, Wyoming Soil Survey Office (USDA-NRCS).

Inventory Data References:
Ocular field estimations observed by trained personnel were completed at each site. Then sites were selected where a 100-feet tape was stretched, and the following sample procedures were completed by inventory staff. For full sampling protocol and guidelines with forms please refer to the Wyoming ESI Operating Procedures, compiled in 2012 for the Powell and Rock Springs Soil Survey Office, USDA-NRCS.
• Double Sampling Production Data (9.6 hoop used to estimate 10 points, clipped a minimum of three of these estimated points, with two 21-foot X 21-foot square extended shrub plots).
• Line Point Intercept (overstory and understory captured with soil cover). Height of herbaceous and woody cover is collected every three feet along established transect.)
• Continuous Line Intercept (Woody Canopy Cover, with minimum gap of 0.2 foot for all woody species and succulents. Intercept height collected at each measurement.),
• Gap Intercept (Basal Gap measured with a minimum gap requirement of 0.7 foot.),
• Sample Point (Ten 1-meter square point photographs taken at set distances on transect. Read using the sample point computer program established by the High Plains Agricultural Research Center, WY).
• Soil Stability (Slake Test – surface and subsurface samples collected and processed according to the soil stability guidelines provided by the Jornada Research Center, NM.)

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Approval

Scott Woodall, 9/16/2020

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.

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Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rare to nonexistent. Where present, short and widely spaced.

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

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

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground can range from 25-35%.

5. **Number of gullies and erosion associated with gullies:** Active gullies should not be present.

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

7. **Amount of litter movement (describe size and distance expected to travel):** Herbaceous litter expected to move only in small amounts (to leeward side of shrubs). Large woody debris from sagebrush will show no movement.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Stability Index ratings range from 1 (interspaces) to 6 (under plant canopy), but average values should be 5.0 or greater.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Refer to soil series description and map unit information for specific information. Described A-horizons vary from 1-4 inches (3-10 cm) with OM of 1 to 2%.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Evenly distributed plant canopy (35-50%) and litter plus moderate to moderately rapid infiltration rates result in minimal runoff. Basal cover is typically less than 10% for this site and does very little to effect runoff on this site. Canopy cover is sufficient to reduce raindrop impact.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** No compaction of soil surface crusting should be present.

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: Cool-season, mid-stature grasses >>

    Sub-dominant: Sub-dominant: perennial shrubs >

Other: Short stature grasses/grass-likes > Forbs

Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal decadence, typically associated with shrub component of the canopy cover.

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14. **Average percent litter cover (%) and depth (in):** Litter ranges from 10-25% of total canopy measurement with total litter (including beneath the plant canopy) from 25-50% expected. Herbaceous litter depth typically ranges from 3-7 mm. Woody litter can be up to 2 inches (2-5 cm).

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** Estimated annual production for ranges from 150 - 400 lbs./ac (168-448 kg/ha), with an average of 300 lbs./ac (336 kg/ha).

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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:** The increase of bare ground above 50% is an indicator that a threshold is being crossed. Corresponding increase will be noted in one or more of the following species is common: blue grama, Sandberg bluegrass, pricklypear cactus, Wyoming big sagebrush, and broom snakeweed. Annual weeds such as kochia, mustards, lambsquarter, Russian thistle, and pepperweed are common invasive species in disturbed sites. Common noxious weeds that invade are: cheatgrass (downy brome), knapweed, whitetop and others found on the Noxious Weed List for Wyoming and specific counties (Big Horn, Hot Springs, Park, and Hot springs, Wyoming; and Carbon County, Montana).

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17. **Perennial plant reproductive capability:** All species are capable of reproducing, except in drought years.
