USDA Natural Resources Conservation Service

Ecological site DX034A01X150
Sandy Green River Basin (Sy GRB)

Last updated: 2/21/2025
Accessed: 05/10/2025

General information

Approved. An approved ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model, enough information to identify the ecological site, and full documentation for all ecosystem states contained in the state and transition model.

MLRA notes

Major Land Resource Area (MLRA): 034A–Cool Central Desertic Basins and Plateaus

Site Name: Sandy Green River Basin

Site Type: Rangeland

Site ID: R034AB150WY

Precipitation or Climate Zone: 7-9” P.Z.

Major Land Resource Area (MLRA): 34A-Cool Central Desertic Basins and Plateaus
For further information regarding MLRAs, refer to:
http://soils.usda.gov/survey/geography/mlra/index.html

Land Resource Unit (LRU) B (Green River Basin):
• Moisture Regime: ustic aridic
• Temperature Regime: frigid
• Dominant Cover: rangeland
• Representative Value (RV) Effective Precipitation: 7-9 inches
• RV Frost-Free Days: 60-90 days

Classification relationships

Site Name: Sandy Green River Basin
Site Type: Rangeland
Site ID: R034AB150WY
Precipitation or Climate Zone: 7-9” P.Z
National Vegetation Classification System (NVC):
Subclass
3.B Cool Semi-Desert Scrub & Grassland Subclass
Formation
3.B.1 Cool Semi-Desert Scrub & Grassland Formation
Division
3.B.1.Ne Western North American Cool Semi-Desert Scrub & Grassland Division
Macrogroup
3.B.1.Ne Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe Macrogroup
Group
3.B.1.Ne *Artemisia tridentata* ssp. wyomingensis - *Artemisia tridentata* ssp. tridentata Tall Sagebrush Group
Association

3.B.1.Ne *Artemisia tridentata* ssp. wyomingensis / *Achnatherum hymenoides* Shrubland

Ecoregions (EPA):
Level I: 10 North American Deserts
Level II: 10.1 Cold Deserts
Level III: 10.1.4 Wyoming Basin

Ecological site concept

• Site does not receive any additional water.
• Soils are:
o not saline, sodic or saline-sodic in the top 20”(50cm).
o moderately deep to very deep, with < 15% gravel (10-25”) and cobble (>25”) cover.
o not skeletal within 20” (50cm) of soil surface.
o not violently effervescent (>15% CCE) in surface mineral 20”(50cm).
o textures are sandy loam in surface mineral, at least 6”(15cm).
• Slope is < 15%.
• Clay content is = 18% in surface mineral 6”(15cm).
• Site does not have an argillic horizon with > 35% clay in the top 20” (50cm)

Associated sites

DX034A01X122	**Loamy Green River Basin (Ly GRB)**
R034AY144WY	**Saline Upland Green River and Great Divide Basins (SU)**
R034AY166WY	**Shallow Sandy Green River and Great Divide Basins (SwSy)**

Similar sites

DX034A02X150	**Sandy Pinedale Plateau (Sy PP)**
R034AY150WY	**Sandy Green River and Great Divide Basins (Sy)** This is the original site description for this site using ecological zones rather than LRU designations.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata var. wyomingensis*
Herbaceous	(1) *Hesperostipa comata* (2) *Achnatherum hymenoides*

Legacy ID

R034AB150WY

Physiographic features

The Sandy Green River Basin (Sy) ecological site (R034BX150WY) is located within MLRA “34A.” This ecological site occurs in intermontane basin landscapes on hill, draw, pediment, and fan remnant landforms (see definitions below). The slope ranges from level to 15%. This site occurs on all aspects.
fan remnant – A general term for landforms that are the remaining parts of older fan-landforms, such as alluvial fans, fan aprons, inset fans, and fan skirts, that either have been dissected (erosional fan-remnants) or partially buried (nonburied fan-remnants). An erosional fan remnant must have a relatively flat summit that is a relict fan-surface.
intermontane basin – A generic term for wide structural depressions between mountain ranges that are partly filled with alluvium and called "valleys" in the vernacular.
hills – A landscape dominated by hills and associated valleys. The landform term is singular (hill).

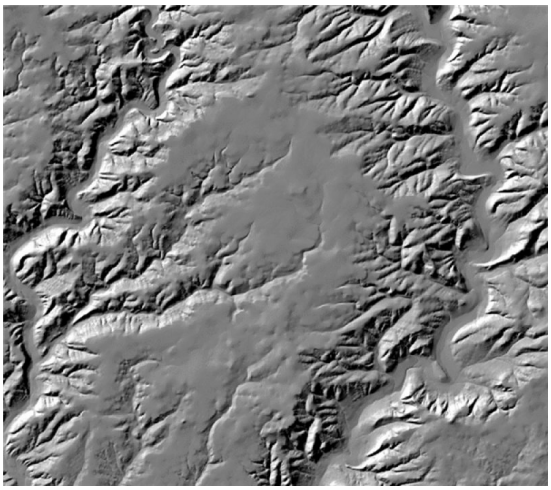


Figure 1. hill, fan remnant

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Fan remnant
Flooding frequency	None
Ponding frequency	None
Elevation	5,800–6,500 ft
Slope	0–15%
Water table depth	60 in
Aspect	Aspect is not a significant factor

Climatic features

Annual precipitation ranges from 7-9 inches per year. Wide fluctuations may occur in yearly precipitation and result in more dry years than those with above normal precipitation. Temperatures show a wide range between summer and winter and between daily maximums and minimums. This is predominantly due to the high elevation and dry air, which permits rapid incoming and outgoing radiation. Cold air outbreaks in winter move rapidly from northwest to southeast and account for extreme minimum temperatures. Much of the precipitation accumulation (45%) comes in the winter in the form of snow (Oct to April). The wettest month is May (1.03 inches). The growing season is short (60-90 day average) and cool: primary growth typically occurs between May and June. The dominant plants (sagebrush and cool season grasses) are well adapted to these conditions. Daytime winds are generally stronger than nighttime and occasional strong storms may bring brief periods of high winds with gusts to more than 50 mph. Growth of native cool season plants begins about mid-April and continues to approximately early-July. Some green up of cool season plants can occur in September upon receiving adequate fall moisture.

Table 3. Representative climatic features

Frost-free period (average)	75 days
Freeze-free period (average)	101 days
Precipitation total (average)	8 in

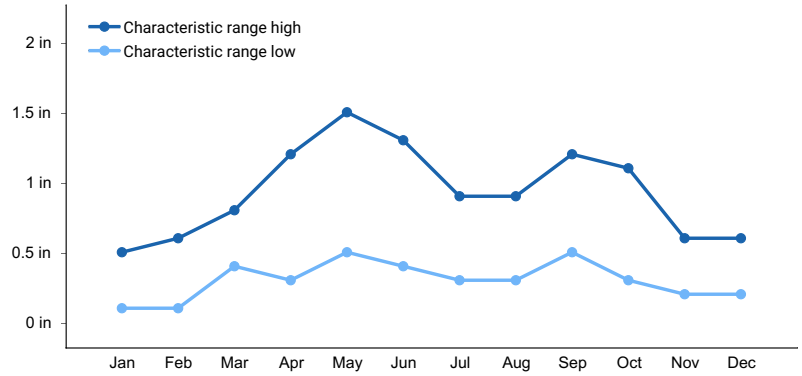


Figure 2. Monthly precipitation range

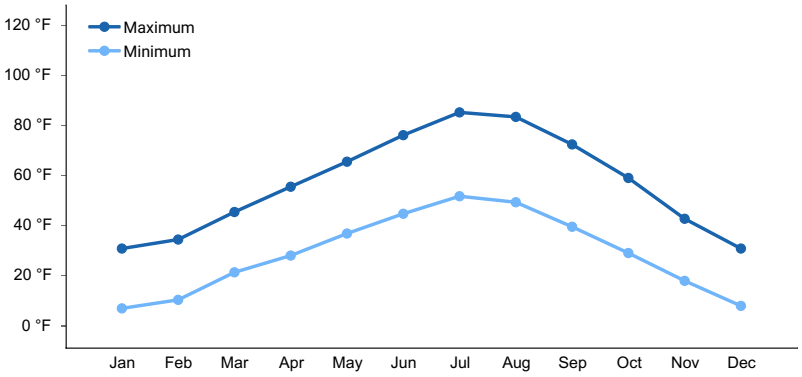


Figure 3. Monthly average minimum and maximum temperature

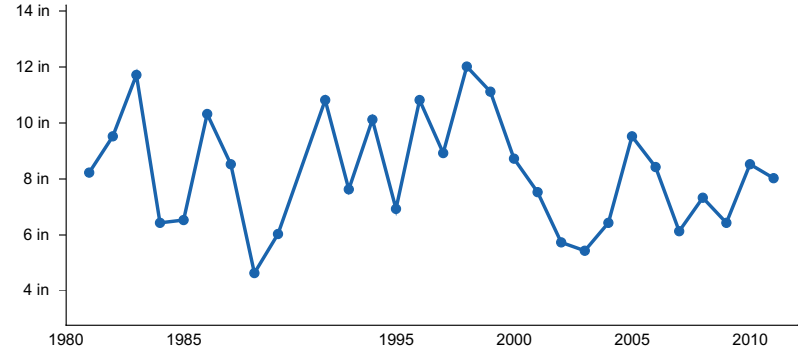


Figure 4. Annual precipitation pattern

Climate stations used

- (1) FONTENELLE DAM [USC00483396], Green River, WY
- (2) GREEN RIVER [USC00484065], Green River, WY
- (3) ROCK SPRINGS AP [USW00024027], Rock Springs, WY

Influencing water features

NONE

Soil features

The soils of this site are moderately deep to very deep (greater than 20" to bedrock), and well-drained throughout the soil profile. Surface textures are sandy loam at least 6 inches thick.

Major Soil Series correlated to this site includes: Pepal, Teagulf, and Sobson series.

Other Soil Series correlated to this site in MLRA 34A include: Leckman, Terada, Diamondville, and Edlin series.

Table 4. Representative soil features

Parent material	(1) Alluvium–sandstone and shale
Surface texture	(1) Gravelly sandy loam (2) Coarse sandy loam (3) Fine sandy loam
Family particle size	(1) Sandy
Drainage class	Moderately well drained to well drained
Permeability class	Moderate to moderately rapid
Soil depth	20–60 in
Surface fragment cover <=3"	0–15%
Surface fragment cover >3"	0–3%
Available water capacity (0-40in)	2.4–7.5 in
Calcium carbonate equivalent (0-40in)	0–15%
Electrical conductivity (0-40in)	0–4 mmhos/cm
Sodium adsorption ratio (0-40in)	0–5
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–35%
Subsurface fragment volume >3" (Depth not specified)	0–5%

Ecological dynamics

This ecological site is dominated (species composition by dry weight) by big sagebrush (*Artemisia tridentata* ssp. Wyomingensis) and perennial cool-season grasses with forbs as a minor component. The site consists of five states: the Reference State (1), Grazing Resistant State (2), *Bare Ground* State (3), Disturbed State (4), and Highly Disturbed State (5). The Reference State is a collection of 3 distinct Plant Communities that exist on a continuum relative to disturbances, primarily grazing, pests, and drought with no disturbance causing successional changes as well over time. These Plant Communities represent the best adapted plant communities to the soils and climate found on the site, and they represent the best estimation of ecological dynamics present on this site at the time of European settlement. The Reference Plant Community (big sage/bunchgrass) of this site is dominated by Wyoming big sagebrush (*Artemisia tridentata* ssp. wyomingensis) and cool-season perennial bunchgrass species, primarily Indian Ricegrass (*Achnatherum hymenoides*) and Needleandthread (*Hesperostipa comata*) with bottlebrush squirreltail (*Elymus elymoides* ssp. elymoides),and rhizomatous grasses like thickspike wheatgrass (*Elymus lanceolatus* ssp. lanceolatus) as a subdominant. Minor components include short-statured bunchgrasses such as Sandberg bluegrass, perennial forbs, and shrubs, including green rabbitbrush (*Chrysothamnus viscidiflorus*).
After a sagebrush killing disturbance (i.e. drought, insect, disease, herbivory, etc.), the Reference Plant Community transitions to the Bunchgrass Plant Community which is dominated by the mid-stature bunchgrasses mentioned above. Sagebrush is a minor component of this Plant Community, and only time without a sagebrush killing disturbance will advance this to the Bunchgrass/Big Sagebrush which is an intermediate Plant Community described because of the time this site spends with this species composition, its value to resource managers, and it can be the most prone to some sagebrush killing disturbances, such as fire, which are thought be fairly infrequent on this site (Bukowski & Baker, 2013).
The Bunchgrass/Big Sagebrush Plant Community, as a mid-seral stage, is often considered to have the most diversity and provide the most ecosystem services (i.e. wildlife habitat, livestock forage, etc.) in a multiple use management system.
Mid-stature bunchgrasses act as decreaser species in the Reference Community because they decrease in

response to grazing pressure. Low stature bunchgrasses and rhizomatous grasses tolerate higher grazing pressure and grow on less fertile soils (USDA/NRCS 2007) than mid stature bunchgrasses. They often fill in the vegetation gaps created when mid stature bunchgrasses decline, hence they are collectively referred to as increaser species. Big sagebrush is the dominant shrub on this site. Wyoming big sagebrush is the sub-species present. Snow catchment is a significant hydrologic component of this site, and the hydrology changes when shrubs are removed from this site. There are often trace amounts of desert salt shrubs present on this site such as shadscale (*Atriplex confertifolia*), grey horsebrush (*Tetradymia canescens*), winterfat (*Krascheninnikovia lanata*), Gardner's saltbush (*Atriplex gardneri*), and spiny hopsage (*Grayia spinosa*).

Prior to the introduction of livestock (cattle and sheep) during the late 1800s, elk, mule deer, and pronghorn grazed this ecological site, primarily as winter and transitional range (early spring, late fall). Significant livestock grazing has occurred on much of this ecological site for more than 100 years. The Trans-Continental Railroad in the 1860s brought the first herds, and homesteaders began settling the area through the turn of the century. Livestock grazing in this region has historically been a mix of cattle and sheep. In the Green River Basin moving south towards Farson and Rock Springs, historical livestock grazing was predominantly sheep grazing with some cattle grazing (USDI BLM allotment files, 2015). Because of limited water availability, especially during the warmer months when snow was absent, grazing was predominantly winter sheep grazing with some winter cattle grazing in areas away from perennial streams and with shallow winter snow depths (USDI BLM allotment files, 2015). This traditional use was reflected in the Rock Springs Grazing Association forming in response to restricting nomadic sheepherders from Colorado and

Utah from using winter sheep range traditionally relied upon by Wyoming sheepherders (Western, S., 2 Feb., 2015). Historical accounts prior to the Taylor Grazing Act indicated grazing was a free-range system where nomadic sheepherders grazed their sheep wherever they could when not restricted by cattlemen and homesteads (Western, S., 2 Feb., 2015). As time progressed and water developments were constructed, the areas historically used by winter sheep slowly converted to more cattle grazing along with sheep grazing (USDI BLM allotment files, 2015). Areas with available water during the summer changed to include cattle grazing during the warm months (USDI BLM allotment files, 2015).

The northern portions of the Green River Basin starting in the South Pass area and the area branching outward toward the south had substantial emigrant trails crossing the region. Accounts estimate that from 1841 to 1869 between 300,000 to 350,000 emigrants followed the trail corridors on their way to Oregon, California, and Utah (USDI Wyoming Dept. of State Parks and Cultural Resources, 2014). The southern portions of the Green River Basin had some trails (Cherokee Trail) used by stage coaches, and locals (USDI Wyoming Dept. of State Parks and Cultural Resources, 2014).

Without ground disturbing activities, this site is relatively free of invasive weeds, but once mechanically or physically disturbed it is prone to weed invasion, primarily by annuals such as Halogeton (*Halogeton glomeratus*), lambsquarter (*Chenopodium album*), Russian thistle (*Salsola kali*), flixweed (*Descurainia sophia*), and kochia (*Bassia scoparia*). Soil disturbance can be caused by vehicles, equipment, high densities of animals (hoof-action), severe over-utilization of the herbaceous vegetation, or large amounts of bare ground created by extended drought conditions combined with over-utilization.

Perennial pepperweed (*Lepidium latifolium*) is a prevalent noxious weed in adjacent riparian areas. This mustard is usually found in riparian areas but has recently been observed invading adjacent upland sites. The Green River and many of its tributaries have significant perennial pepperweed infestations. It is said to be introduced to the area as a hay contaminant when ranches had to bring in hay from Utah, Idaho, and other areas during a drought in the 1970's. Another noxious mustard of concern is whitetop or hoary cress (*Cardaria draba*). This species is also found in all habitat types within the Green River Basin, including irrigated hay meadows, roadsides, and disturbed rangelands. This disturbance can be from over-utilization of forage or plant thinning due to drought. This deep rooted perennial mustard completes its life cycle in early summer. Whitetop can tolerate the often highly alkaline soils of the Green River Basin.

Cheatgrass (*Bromus tectorum*), an invasive winter annual grass from the Mediterranean region, has been increasing in recent years. There are many challenges in controlling with this invasive grass and its impacts on plant communities, livestock grazing, and wildlife habitat. Recent publications have classified this soil temperature and moisture regime as moderately resilient and resistant to invasive species (Chambers et.al, 2016), but localized conditions on this ecological site result in relatively lower resistance compared to adjacent sites.

State-and-Transition Diagram

Thorough descriptions of each state, transition, plant community, and pathway are found after the State and Transition Model (STM) diagram in this document. Experts base this model on available experimental research, field observations, professional consensus, and interpretations. While based on the best available information, the STM will change over time as knowledge of ecological processes increases.

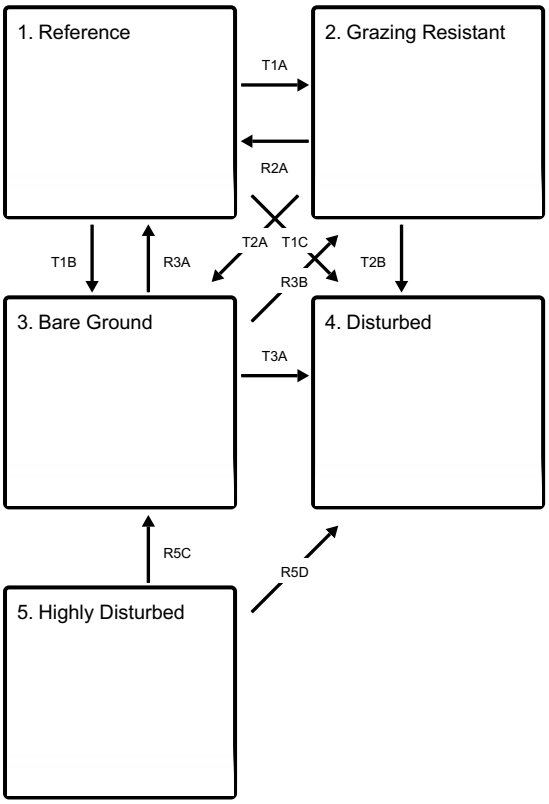
Plant communities within the same ecological site differ across the LRU due to the naturally occurring variability in weather, soils, and aspect. Not all managers will choose the reference plant community as the management goal. Other plant communities may be desired to meet land management objectives. This is valid as long as the Rangeland Health attributes assessment departures are slight to moderate or none to slight for the Reference State. The biological processes on this site are complex; therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are used in this ESD. Most observers find it easier to visualize or estimate percent cover for woody species (trees and shrubs). Foliar cover drives the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight remains an important descriptor of the herbaceous community and of site productivity as a whole. Woody species are included in species composition by weight for the site. Calculating similarity index requires use of species composition by dry weight.

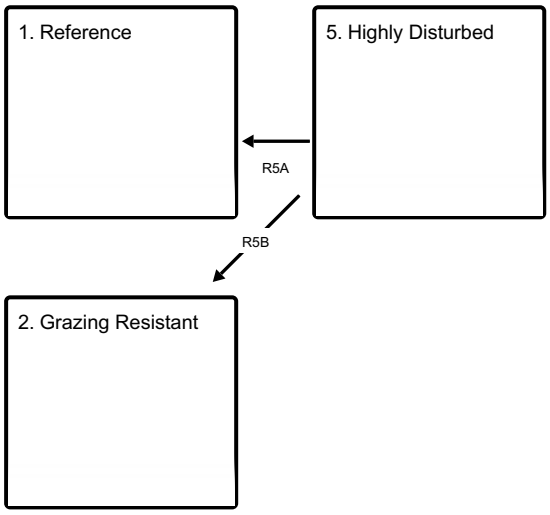
Although there is considerable qualitative experience supporting the pathways and transitions within the State and Transition Model (STM), quantitative information is lacking that specifically identifies threshold parameters between reference states and degraded states in this ecological site. For information on STMs, see the following citations: Bestelmeyer el al. 2003, Bestelmeyer et al. 2004, Bestelmeyer and Brown 2005, Stringham et al. 2003.

State and transition model

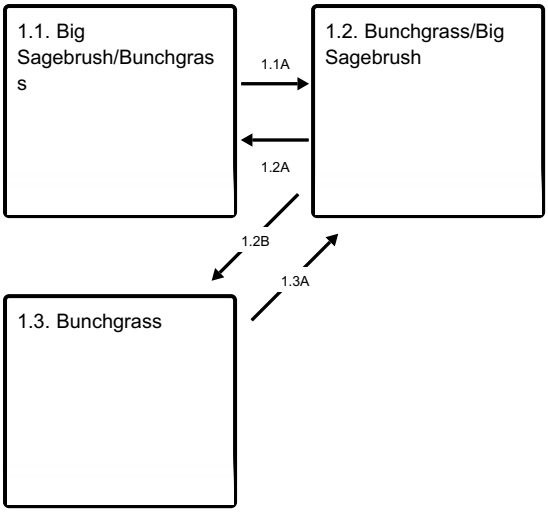
Ecosystem states



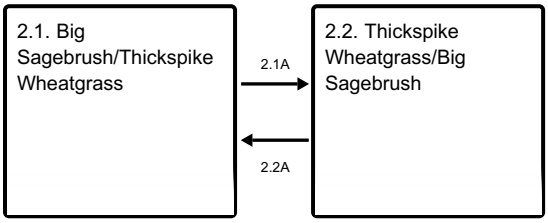
States 1, 5 and 2 (additional transitions)



State 1 submodel, plant communities

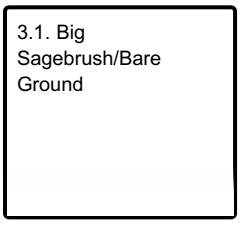


State 2 submodel, plant communities



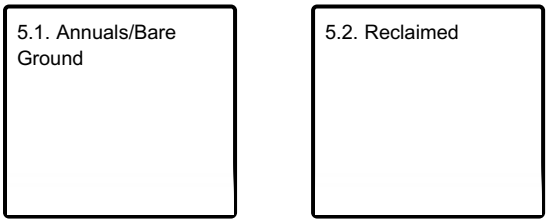
2.1A - Brush Management (mechanical or chemical)

State 3 submodel, plant communities



State 4 submodel, plant communities

State 5 submodel, plant communities



State 1
Reference

The Reference State consists of three Plant Communities: the Big Sagebrush/Bunchgrass Community (1.1) the Bunchgrass/Big sagebrush Plant Community (1.2) and the Bunchgrass Community (1.3). Each community differs in percent composition of bunchgrasses and percent woody canopy cover. Forbs are a minor component on this site.

Woody canopy cover is less than 25 percent. The dominant shrub species is Wyoming Big Sagebrush in the Reference State (1). Two important processes occurring in this state result in plant community changes within Reference State: sagebrush killing disturbances (browse, insects, drought, fire) and time without those disturbances. These processes are generally referred to as “natural succession.” The shift from the Bunchgrass Plant Community (1.3) to the Bunchgrass/Big Sagebrush Plant Community (1.2) and subsequently to the Big Sagebrush/Bunchgrass Plant Community is dependent on an increase of woody cover. Without sagebrush killing disturbance, shrubs will increase on this ecological site even with proper grazing management. Improper grazing management may accelerate the rate of increase for woody species and/or result in higher shrub canopy cover than in the Reference State. The shift from the Big Sagebrush/Bunchgrass or Bunchgrass/Big Sagebrush Plant Communities is dependent on sagebrush killing disturbances such as fire, drought, browse, and insects. Management actions can and are often used to mimic these processes through mechanical and chemical treatments. Prescribed fire is not often used on this site due to current land uses and lack of fuels and adequate burn windows.

Community 1.1
Big Sagebrush/Bunchgrass

Figure 6. 1.1

The Sandy site has the potential to be one of the most productive upland sites in this LRU. The Big Sagebrush/Bunchgrass Plant Community is well adapted to Cool Central Desertic Basins and Plateaus climatic conditions. The diversity in plant species allows for drought tolerance, and natural plant mortality is very low. These plants have strong, healthy root systems that allow production to increase significantly with favorable moisture conditions. Abundant plant litter is available for soil building and moisture retention. Plant litter is properly distributed with very little movement off-site. This plant community provides for soil stability and a properly functioning hydrologic cycle. The soils associated with this site are fertile and hold moderately large amounts of soil moisture, providing a very favorable soil-water-plant relationship. Chemical and mechanical treatment of shrubs has replaced natural sagebrush killing events on many sites in the area. However, chemical treatments can impact non-target species, particularly broad-leafed species (forbs and shrubs) differently than natural events such as drought or fire. Where fire tends to result in a short-term increase in forbs, some chemical treatments result in a short-term (or medium-term) reduction in forb density and diversity. The Big Sagebrush/Bunchgrass Community (1.1) can occur across the entire ecological site or can occur in a mosaic. This community can occur over time without disturbances and accelerated with added herbaceous grazing pressure. Big sagebrush is dominant in the Big Sagebrush/Bunchgrass Community (1.1) with sagebrush canopy cover ranging from 15% to 25%. At this sagebrush canopy level in this precipitation zone, there is competition between the shrub overstory and the herbaceous understory (Alma Winward personal communication, 2004). A Big Sagebrush/Bunchgrass Community with a degraded understory is an “at-risk” community. (Define At Risk) In the Big Sagebrush/Bunchgrass Community (1.1), there are generally few canopy gaps great than 6 feet. Rock cover on the soil surface is less than 15%. Many plant interspaces have canopy or litter cover. Production of grasses is much lower than in the Bunchgrass Community (1.3) and slightly lower than in the Bunchgrass/Big Sagebrush Community (1.2). It is typical for shrubs to increase as the community shifts from the Bunchgrass Community (1.1) to the Bunchgrass/Big Sagebrush Community (1.2). Note: POSE in Group 1 refers to larger varieties such as Canby's and big bluegrass. POSE in Group 3 refers to Sandberg bluegrass.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	200	300	400
Shrub/Vine	180	270	360
Forb	20	30	40
Total	**400**	**600**	**800**

Table 6. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0%
Grass/grasslike foliar cover	0%
Forb foliar cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	15-30%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	20-30%

Table 7. 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%
Litter	25-40%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	20-30%

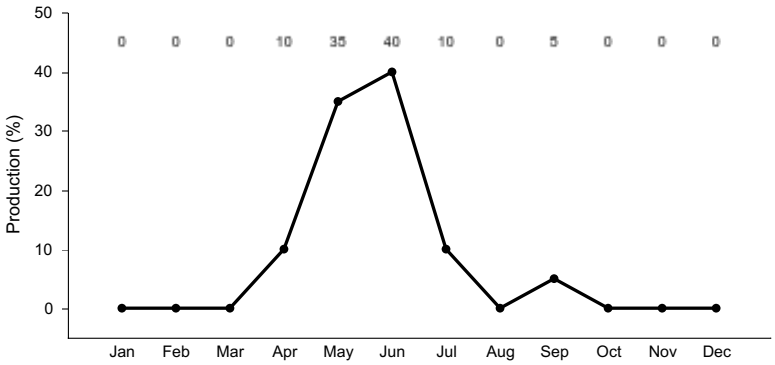


Figure 8. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Community 1.2
Bunchgrass/Big Sagebrush

Figure 9. 1.2

The Bunchgrass/Big Sagebrush Community (1.2) can occur across the entire ecological site on a given landscape but more likely occurs in a mosaic pattern associated with the disturbance cycle at any given location. Mid-stature bunchgrasses dominate in the Bunchgrass/Big Sagebrush Community (1.2) and sagebrush is sub-dominant with cover ranging from 5% to 15%. At this sagebrush canopy level in this precipitation zone, there is little if any competition between the shrub overstory and the herbaceous understory. In fact, there is evidence to suggest that the understory receives more benefit from the sage overstory than negative effects (Winward, 2007) In the Bunchgrass/Big Sagebrush Community (1.2), there are generally few canopy gaps, and most basal gaps are generally (3-6 feet) . Rock cover on the soil surface is less than 15%. Many plant interspaces have canopy or litter cover. Production of grasses is slightly lower and shrub production is higher than in the Bunchgrass Community (1.3). Note: POSE in Group 1 refers to larger varieties such as Canby's and big bluegrass. POSE in Group 3 refers to Sandberg bluegrass.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	240	360	480
Shrub/Vine	120	180	240
Forb	40	60	80
Total	**400**	**600**	**800**

Table 9. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0%
Grass/grasslike foliar cover	0%
Forb foliar cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	15-30%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%

Water	0%
Bare ground	20-30%

Table 10. 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%
Litter	25-40%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	20-30%

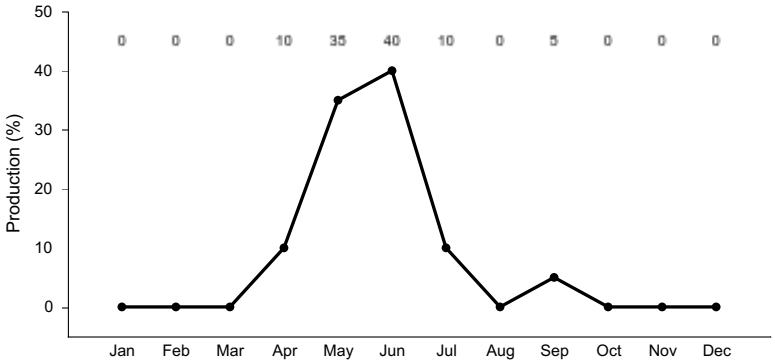


Figure 11. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Community 1.3
Bunchgrass

Figure 12. 1.3

The Bunchgrass Community (1.3) is dominated by mid-stature cool-season bunchgrasses mixed with a minor component of forbs and shrubs. Big sagebrush is present as a part of the community, but is minor with 5 to 15% foliar cover. The Bunchgrass Community (1.3) generally occurs on this site immediately following a sagebrush

killing event such as drought, insects, browse, or fire. Note: POSE in Group 1 refers to larger varieties such as Canby's and big bluegrass. POSE in Group 3 refers to Sandberg bluegrass.

Table 11. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	300	450	600
Shrub/Vine	60	90	120
Forb	40	60	80
Total	**400**	**600**	**800**

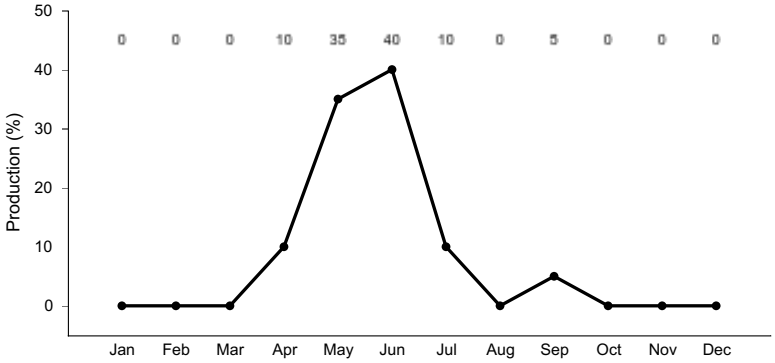
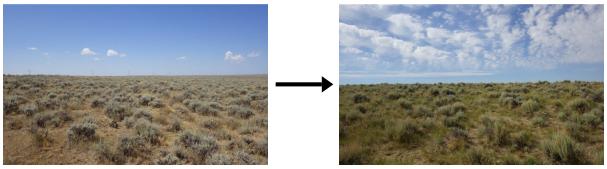


Figure 14. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

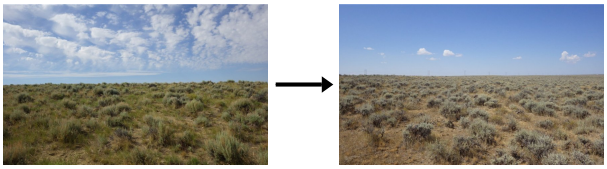
Pathway 1.1A
Community 1.1 to 1.2



Big Sagebrush/Bunchgrass **Bunchgrass/Big Sagebrush**

The driver for community shift 1.1-1.2 is the increase in density and vigor of mid-stature bunchgrasses to the point that they dominate species composition by weight. The trigger for this is a sagebrush killing event, such as drought, insects, and/or disease. In recent history, chemical, mechanical or biological control of sagebrush that favors the existing herbaceous vegetation have been tools to mimic these natural sagebrush killing events. The result of these management actions can have the desired effect of shifting the community from within the Reference State, but they can also accelerate the transition to alternate states depending on current and post-treatment management.

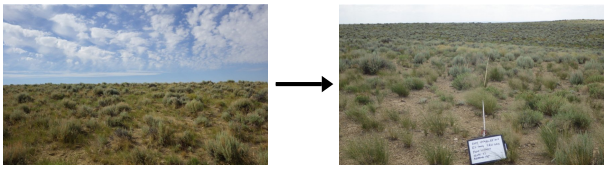
Pathway 1.2A
Community 1.2 to 1.1



Bunchgrass/Big Sagebrush **Big Sagebrush/Bunchgrass**

The driver for community shift 1.2-1.1 is natural succession. The trigger for this shift is an increase in shrub canopy cover and decline in overall bunchgrasses. The transition to the Big Sagebrush/Bunchgrass Community (1.1) can be the result of sagebrush naturally increasing its canopy cover along with yearly climatic differences. This transition can be accelerated with proper herbaceous grazing (properly stocked and a grazing system that varies the time and timing of grazing to provide for periodic deferment during the critical growth period) and natural events such as drought/wet cycles.

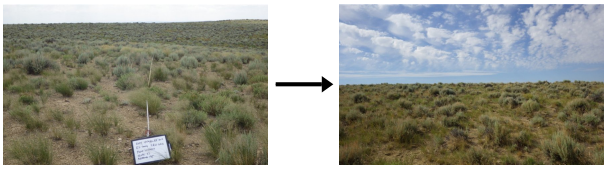
Pathway 1.2B
Community 1.2 to 1.3



Bunchgrass/Big Sagebrush | Bunchgrass

The driver for community shift 1.2-1.3 is the increase in density and vigor of mid-stature bunchgrasses to the point that they dominate species composition by weight. The trigger for this is a sagebrush killing event, such as drought, insects, and/or disease. In recent history, chemical, mechanical or biological control of sagebrush that favors the existing herbaceous vegetation have been tools to mimic these natural sagebrush killing events. The result of these management actions can have the desired effect of shifting the community from within the Reference State, but they can also accelerate the transition to alternate states depending on current and post-treatment management. Mowing treatments in the Reference State have resulted in increased soil nitrogen (N) but no change in soil organic Carbon (C). Conversely, mowing treatments in the Grazing Resistant State have resulted in no changes in soil N or C (Derner, Schuman, Follett, & Vance, 2014)

Pathway 1.3A
Community 1.3 to 1.2



Bunchgrass | Bunchgrass/Big Sagebrush

The driver for community shift 1.3-1.2 is natural succession. The trigger for this shift is an increase in shrub canopy cover and relative decline in bunchgrasses. The transition to the Bunchgrass/Big Sagebrush Community (1.2) is the result of sagebrush naturally increasing in cover along with yearly climatic differences. This transition can be accelerated with proper herbaceous grazing (fully stocked and a system that varies the time and timing of grazing to provide for periodic deferment during the critical growth period) and natural events such as drought/wet cycles.

State 2
Grazing Resistant

The Grazing Resistant State (2) is characterized by an herbaceous layer dominated by short-statured bunchgrasses such as Sandberg bluegrass and, rhizomatous grasses and grass-likes, such as thickspike wheatgrass and needleaf sedge. Mid-stature bunchgrasses such as Indian ricegrass and needleandthread are scarce or absent. There are two community phases in the Grazing Resistant State: the Big Sagebrush/ Thickspike Wheatgrass Plant Community and the Thickspike Wheatgrass/Big Sagebrush Plant Community. (2.1). The site crosses the threshold to the Grazing Resistant State (2) from the Reference State (1) when desirable mid-stature bunchgrasses lose dominance. Once the key species become scarce, it is unlikely that they have sufficient reproductive capability (seed source, tillering, or resprouting) to recover dominance in a reasonable time frame without extra energy being added to the system. The Big Sagebrush/Thickpsike Wheatgrass Plant Community is very resistant to change and therefore is common on this site. In many cases, the transition to the Grazing Resistant State (2) may have occurred many decades ago during an era of higher stocking rates and continuous grazing during the growing season. However, continual grazing during the critical growth period (roughly May-June) at proper stocking rates will facilitate the transition to this state and maintain it in this state. While dominance by rhizomatous grasses makes the return to the Reference State (1) plant community difficult, it also makes the site resistant to further degradation except in cases where overstocked or in the case of prolonged drought with full stocking. The main factor creating resiliency of the Big Sagebrush/Thickspike Wheatgrass Plant Community is that rhizomatous grasses are highly grazing tolerant. Sandberg bluegrass and rhizomatous grasses are low to the ground, so, even under heavy grazing, enough biomass remains for the grasses to maintain plant vigor. Rhizomatous grasses successfully reproduce through underground rhizomes. The rhizomatous grasses can form mats that provide soil protection by protecting the soil from raindrop impact, decreasing the risk of soil erosion.

However, overall soil health is lower than the reference state, primarily due to a reduction in soil organic matter due to a reduction in litter. The decreased infiltration is due increased bare ground patch size and lack of litter that acts as mulch in retaining soil moisture and retarding runoff. Under high intensity grazing, especially in early season pastures and in small acreage pastures, ground cover can decrease to a point that the site will transition to the *Bare Ground* State (3), particularly during drought conditions if stocking is not reduced.

Community 2.1
Big Sagebrush/Thickspike Wheatgrass

The Big Sagebrush/Thickspike Wheatgrass Plant Community (2.1) is shrub-dominated with an herbaceous component dominated by thickspike wheatgrass and other low-growing, grazing tolerant species such as needleleaf sedge. Once the mid-stature bunch grasses becomes scarce, it is unlikely to have sufficient reproductive capability (seed source, tillering, or resprouting) to recover dominance in a reasonable time frame without extra energy being added to the system. The plant community is highly resistant to changes in composition, due to the dominance and competition of established low stature and rhizomatous species. However, the community can be restored back to the Reference State over time with appropriate sagebrush treatment and a grazing regime that includes periodic critical growth period deferment. This community is shrub dominated. Sagebrush canopy is greater than 25 percent. The dominant shrub is Wyoming big sagebrush. The Big Sagebrush/Thickspike Wheatgrass Plant Community occurs if the herbaceous component has been degraded. Areas that catch and retain snow are more likely to have the highest shrub cover. Range Health Indicators: Production is considerably lower than in Reference State (1), leading to lower soil organic matter content and therefore lower soil stability than in the Reference State. Ground cover is still high. Infiltration is lower than in the Reference State and the water cycle has reduced function due to decreased soil organic matter. Note: POSE in Group 1 refers to larger varieties such as Canby's and big bluegrass. POSE in Group 3 refers to Sandberg bluegrass.

Table 12. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	165	220	330
Grass/Grasslike	105	140	210
Forb	30	40	60
Total	**300**	**400**	**600**

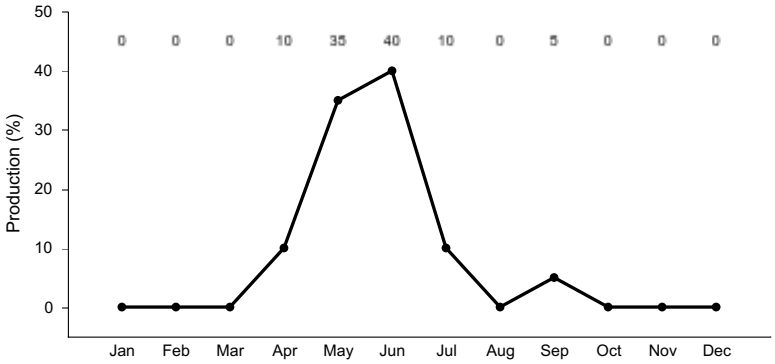


Figure 16. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Community 2.2
Thickspike Wheatgrass/Big Sagebrush

The Thickspike Wheatgrass/Big Sagebrush Community (2.2) is characterized by an herbaceous component dominated by low-stature and rhizomatous species such as thickspike wheatgrass and needleleaf sedge. Once mid-stature bunchgrasses becomes scarce, they are unlikely to have sufficient reproductive capability (seed source, tillering, or re-sprouting) to recover dominance in a reasonable time frame without extra energy being added to the system. The plant community is highly resistant to changes in composition, due to the dominance and competition of grazing tolerant species. However, the community can shift back to the Reference State (1) with grazing deferment followed by a grazing system that allows periodic rest during the critical growth period. Seeding maybe

needed in some instances to achieve desired results. Thickspike wheatgrass (*Elymus lanceolatus* ssp. lanceolatus) dominates, and Wyoming big sagebrush foliar cover is typically 5% to 25%. The Rhizomatous Wheatgrass/Big Sagebrush Community occurs if there is a sagebrush killing event after the herbaceous component has already been degraded. Biological soil crusts have greatly diminished, further exposing the soil surface to erosional forces as well as impairing carbon, nutrient, and water cycles. Productivity is highly variable and fluctuates drastically in response to drought and wet cycles. Production is lower than in Reference State (1), leading to lower soil organic matter and nitrogen content and therefore lower soil stability than in the Reference State. Ground cover is still high, but infiltration is lower than in the Reference State and hydrologic function is impaired due to decreased soil organic matter. Note: POSE in Group 1 refers to larger varieties such as Canby's and big bluegrass. POSE in Group 3 refers to Sandberg bluegrass.

Table 13. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	180	240	360
Shrub/Vine	90	120	180
Forb	30	40	60
Total	**300**	**400**	**600**

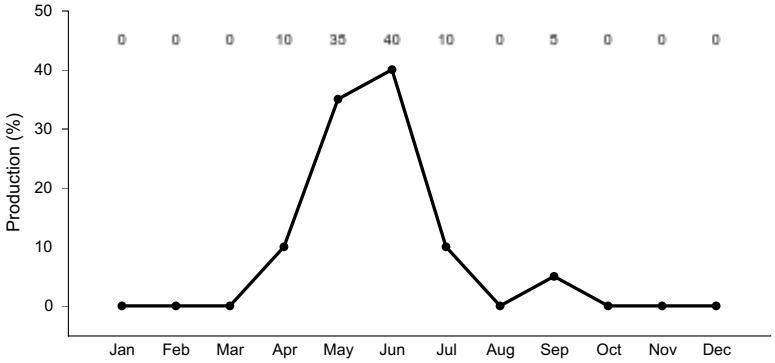


Figure 18. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Pathway 2.1A
Community 2.1 to 2.2

Sagebrush killing event, typically a mechanical or chemical treatment. Due to low fine fuels, fire is seldom a driver in this state.

Pathway 2.2A
Community 2.2 to 2.1

The trigger for a community shift from the Thickspike Wheatgrass/Big Sagebrush Plant Community (2.2) to the Big Sagebrush/Thickspike Wheatgrass Plant Community (2.1) is time without sagebrush killing disturbances. This shift can be accelerated with high utilization levels by grazers, particularly during the critical growth period.

State 3
Bare Ground

This state contains one community, the Big Sagebrush/*Bare Ground* Community (3.1). It is characterized by sparse herbaceous plant cover dominated by big sagebrush and bare ground. Communities in the *Bare Ground* State (3) have crossed a threshold (T1-3 or T2-3) because of soil erosion, loss of soil fertility, and/or degradation of soil properties. Soil erosion affects the hydrology, soil chemistry, soil microorganisms, and soil physics to the point where intensive restoration is required to restore the site to another state or community. Simply changing grazing management may not create sufficient change to restore the site within a reasonable period. It will require a considerable input of energy to move the site back to the Reference State (1). The *Bare Ground* State (3.0) is at high risk of weed invasion due to the high percentage of bare ground. Many invasive species are adapted to low soil

fertility, high soil temperatures and low soil moisture content. This puts the community at risk of transitioning to the Disturbed State (4).

Community 3.1
Big Sagebrush/Bare Ground

Herbaceous canopy cover in the Big Sagebrush/*Bare Ground* Community (3.1) is significantly reduced. Annual production is approximately half of the Bunchgrass Plant Community (1.1). Perennial grasses may exist only in patches and are typically low in vigor. This community tends to be dominated by big sagebrush (>25% cover) and bare ground in large patches in the interspaces of the shrub canopy. The majority of annual production is from big sagebrush so this site provides very little value for livestock grazing. There is some value to wintering big game, but the lack of an herbaceous understory results in poor wildlife values overall. The Big Sagebrush/*Bare Ground* Community (3.1) rarely produces sufficient quantity of fine fuels necessary to carry a fire. Therefore, fire no longer influences community dynamics. The Big Sagebrush/*Bare Ground* Community (3.1) differs from other communities, because it is characterized by sparse plant cover and soil surface erosion. Sparse vegetation creates low levels of foliar and basal cover. This, in turn, leads to low litter production, which is combined with reduced ability to retain litter on site. Soil is exposed to wind and water erosion in the plant interspaces. These factors combine to create a decrease in soil organic matter. Reduced litter cover, combined with reduced herbaceous cover, results in higher soil temperature, poor water infiltration rates, and high evaporation, thus favoring species which are more adapted to drier conditions. Soil fertility is reduced, soil compaction is increased, and resistance to soil surface erosion has declined compared to the other states. This community has lost most, if not all, of the attributes of a functioning, healthy rangeland, including good infiltration, minimal erosion and runoff, nutrient cycling, and energy flow.

State 4
Disturbed

This state is characterized by the amount of rabbitbrush on the site. It also has a component of annual forbs and substantial bare ground. It occurs with multiple sagebrush killing events in rapid succession outside the normal disturbance regime for this site (see Reference State for discussion). It could be mechanical (including heavy equipment/construction or a mowing/chaining/harrow type sage treatment), chemical (including 2,4-D or tebuthiuron), or biological (including browse and/or insects). Fire could be a factor in maintaining this plant community perpetually by stimulating sprouting shrubs (rabbitbrush) and killing sagebrush. This is usually only a concern when annual weeds are prolific on the site during wet cycles that boost their production. Removal of shrubs without proper grazing management can lead to an increase in bare ground and erosion of the upper soil horizon. Consequences of this are decreased soil fertility or even soil erosion, soil crusting, and decrease of soil surface aggregate stability.

Community 4.1
Sprouting Shrub/Thickspike Wheatgrass

The plant community is in a perpetual state of disturbance when maintained long-term on a site. The disturbance regime of the site has been accelerated often with the addition of ground disturbing activities (i.e. gravel pits, pasture corners where livestock are gathered, continual sagebrush removal techniques, and rapid succession fire). Seeding may be used to restore Reference State functional structural groups, but it is unlikely that the Reference soil site stability can be achieved, and so any restoration efforts of this State will result in transition to the Reclaimed Plant Community of the Highly Disturbed State.

State 5
Highly Disturbed

Community 5.1
Annuals/Bare Ground

As part of succession, all sites that are severely disturbed will go through this plant community as part of their restoration. Weather is the largest determining factor in how long a site will be in this plant community phase, but is approximately 2-5 years on sites that use Best Management Practices for site restoration (http://www.uwyo.edu/wrrc/).

Community 5.2
Reclaimed

This plant community is highly variable based on weather conditions during restoration activities, the management practices used to implement the restoration, the seed mix, and how soil was stockpiled during the disturbance.

Transition T1A
State 1 to 2

The driver for Transition T1-2 is continuous spring grazing and/or long-term drought. Continuous spring grazing and/or drought can lead to a decline in palatable mid-stature bunchgrasses. Indian ricegrass, a short-lived perennial that requires more frequent seed production to provide an adequate seedbank, is typically the first species to decline (Natural Resources Conservation Service, 2007). Needleandthread is more grazing tolerant, but will eventually decline in plant density and vigor. As bunchgrasses diminish or die during periods of stress, low- stature bunchgrasses and rhizomatous grasses gain a competitive advantage, creating a shift in species composition toward less productive species. While bare ground may not change, the pattern of bare ground will shift to larger gaps in the canopy and fewer herbaceous plants between shrubs. Many of the remaining desirable bunchgrasses will be only found in the understory of the sagebrush canopy. Once mid-stature bunchgrasses species become scarce, it is unlikely that they have sufficient reproductive capability (seed source, tillering, or resprouting) to recover dominance in a reasonable time frame without extra energy being added to the system. When the understory vegetation has been degraded to this point, the transition to the Grazing Resistant State (2) can occur from either the Bunchgrass/Big Sagebrush Plant Community (1.2) or the Big Sagebrush/Bunchgrass Plant Community (1.1). The transition is not dependent on the increase of woody canopy cover, but rather on the lack of mid-stature bunchgrasses in the canopy interspaces. Management should focus on grazing management strategies that will prevent further degradation. This can be achieved through a grazing management scheme that varies the season of use to provide periodic deferment during the critical growth period (roughly May-June). Forage quantity and/or quality in the Grazing Resistant State (2) may be substantially reduced compared to the Reference State.

Transition T1B
State 1 to 3

The driver for Transition T1-3 is continuous high intensity grazing and/or long-term drought. The Reference State (1) transitions to the Eroded State (3) if plant canopy cover declines significantly or total annual aboveground biomass production falls below 300 pounds per acre. The trigger for this transition is the loss of understory, which creates open spots with bare soil. Soil erosion is accompanied by decreased soil fertility driving the transitions to the *Bare Ground* State. Several other key factors signal the approach of transition T1B: an increase in soil physical crusting, a decrease in soil surface aggregate stability, and/or evidence of erosion, including water flow patterns, development of plant pedestals, and litter movement.

Transition T1C
State 1 to 4

The driver for this transition is an increase in the disturbance cycle (i.e. grazing, drought, fire, mechanical, chemical or biological treatments) often in combination with grazing management that does not provide periodic deferment during the critical growth period. The Reference State (1) may transition to the Disturbed State (4) if a soil disturbing activity has occurred. Sprouting shrubs such as rabbitbrush increase from ground disturbances that could be either natural (i.e. water movement) or manmade (i.e. high density/high frequency stocking, mechanical treatments or heavy equipment operations). If a seed source exists, aggressive invasive species, such as cheatgrass, may be present, but are not expected to dominate the site. However, it is projected that annual invasives may effect site dynamics under future climate change scenarios. To prevent this transition, the site will require proper reclamation using the most current science and technology available to restore native vegetation and prevent invasive dominance. In some instances, it may not be possible to prevent this transition. In cases where total topsoil loss occurs, it may be unavoidable to prevent this transition. Long-term stress conditions for native species (e.g., improper grazing management, drought, and fire) will alter plant community composition and production over time and may hasten a transition to the Disturbed State (4). The resulting lower biomass production, reduced litter, and increased bare ground in this community can promote invasion of undesirable species. The site transitions to the Disturbed State when populations of invasive species reach critical levels.

Restoration pathway R2A
State 2 to 1

The drivers for this restoration pathway are removal of woody species and restoration of native herbaceous species by mechanical or chemical treatment of sagebrush, and grazing rest or deferment. If some mid- stature bunchgrasses remain under the sage canopy, proper grazing management can move the site back to the Reference State (1) combined with a mechanical or chemical sagebrush treatment. This could take multiple generations of management or could be accelerated with rest or deferment combined with successive wet springs conducive to seed germination and seedling establishment. (Derner, Schuman, Follett, & Vance, 2014).

Transition T2A
State 2 to 3

The driver for transition to the *Bare Ground* State is continuous high intensity grazing. Examples include calving pastures and small acreage horse pastures where rotational grazing is not employed. Extended drought period may provide a trigger to accelerate this process. The *Bare Ground* State is typified by old age sagebrush stands with very little herbaceous understory. Bare ground patch size has increased to the majority of the interspaces between sagebrush plants.

Transition T2B
State 2 to 4

The driver for transition to the Disturbed State is an increase in the disturbance cycle (i.e. grazing, drought, fire, mechanical, chemical, biological treatments). Removal of shrubs without proper grazing management can lead to an increase in bare ground and erosion of the upper soil horizon, and the site can degrade to the Disturbed State (4). Consequences of this transition are decreased soil fertility or even soil erosion, soil crusting, and decrease of soil surface aggregate stability.

Restoration pathway R3A
State 3 to 1

This state has lost soil or vegetation attributes to the point that recovery to the Reference State will require a combination of long-term grazing management (changing season of use to allow frequent rest or deferment during the critical growth period) and chemical, biological or mechanical treatments, and often re-seeding. Seeding may become cost prohibiting as a restoration practice used alone. With reduced organic matter and loss of soil, soil amendments may be needed to have a successful seeding. Care must be taken with any re-seeding operation to prevent the introduction of invasive species, such as cheatgrass, to areas where these species are not currently present.

Restoration pathway R3B
State 3 to 2

The drivers for this restoration pathway are mechanical, biological and chemical treatments with only temporary rest or deferment post-treatment. Due to loss of soil fertility, structure, and organic matter, reference community plants are slow to repopulate the site. Success of this restoration is highly dependent upon climatic factors.

Transition T3A
State 3 to 4

The driver for this transition is multiple sagebrush killing events in rapid succession outside the normal disturbance regime for this site (see Reference State for discussion). It could be mechanical (including heavy equipment/construction or a mowing/chaining/harrow type sage treatment), chemical (including 2,4-D or tebuthiuron), or biological (including browse and/or insects). Fire is not usually possible due to lack of understory fuels to carry the fire. In fact, the Eroded State is characterized by monotypic decadent sagebrush stands because they are fireproof.

Restoration pathway R5A
State 5 to 1

The Highly Disturbed State (5) can be restored to the Reference State (1) if appropriate seedbed preparation and seed mixes are used, and weather conditions are conducive to seedling establishment. This most often occurs through achieving the Bunchgrass Plant Community first. Weather is the largest determining factor in determining time and success, but the process can be accelerated with Best Management Practices for site restoration (http://www.uwyo.edu/wrrc/). There is low potential for recovery without significant inputs of energy and resources if topsoil has been removed. Seeding is needed to restore functional structural groups, and proper seedbed preparation is key to restoring ecological processes on the site.

Restoration pathway R5B
State 5 to 2

The Highly Disturbed State (5) is often restored to the Grazing Resistant State (2) unintentionally when inappropriate seed mixes are used and post-seeding grazing does not provide adequate and periodic critical growth period rest. There is low potential for recovery without significant inputs of energy and resources if topsoil has been removed. Seed mixes that mimic an adjacent “reference area” rather than the site potential as described in the Reference State (1) will often result in a plant community resembling the Grazing Resistant State (2) due to pre and post-seeding grazing management of the area.

Restoration pathway R5C
State 5 to 3

The Highly Disturbed State (5) can transition the Eroded State (3) if disturbed areas result in total topsoil removal, are abandoned (no re-seeding) and climate is favorable for sagebrush seedling establishment. Wyoming big sagebrush will eventually colonize the site, but because soil conditions are severely altered, little to no under-story can be found. An example of this transition can be found on abandoned oil and gas wells that are 30+ years old where topsoil was not stockpiled and re-spread on the site after proper contouring and ripping, and either no seeding was done or the planting was a failure. If topsoil was not physically removed, and there is a viable seedbank in the soil, recovery is possible without re-seeding as long as adequate rest from herbivory is provided to allow seedling establishment. Rest from herbivory is recommended during dry years to prevent further soil loss as well as in wet years to allow seedling establishment.

Restoration pathway R5D
State 5 to 4

The Highly Disturbed State (5) can transition the Disturbed State (4) if disturbed areas result in only partial topsoil removal, leaving rootstock available for sprouting species such as rabbitbrush. This is common for gravel pits and areas disturbed as stockpile areas where soil is placed on the area for any amount of time, and then removed with equipment that scrapes some of the soil surface during the removal process.

Additional community tables

Table 14. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Perennial Mid-Size Cool Season Grasses**			78–180	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	30–180	5–30
	needle and thread	HECO26	*Hesperostipa comata*	30–180	5–30
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–90	0–15
	Sandberg bluegrass	POSE	*Poa secunda*	0–60	0–10
	Montana wheatgrass	ELAL7	*Elymus albicans*	0–60	0–10
	squirreltail	ELELE	*Elymus elymoides ssp. elymoides*	6–60	1–10

2	**Rhizomatous Grasses**			30–60	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	30–60	5–10
3	**Misc. Grasses/Grasslikes**			30–60	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–30	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	6–30	1–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–30	0–5
	James' galleta	PLJA	*Pleuraphis jamesii*	0–30	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	6–30	1–5
	Grass, perennial	2GP	*Grass, perennial*	0–30	0–5
Forb					
4	**Perennial Forbs**			12–24	
	milkvetch	ASTRA	*Astragalus*	0–30	0–5
	buckwheat	ERIOG	*Eriogonum*	6–30	1–5
	western wallflower	ERAS2	*Erysimum asperum*	0–30	0–5
	draba	DRABA	*Draba*	0–30	0–5
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–30	0–5
	beardtongue	PENST	*Penstemon*	0–30	0–5
	spiny phlox	PHHO	*Phlox hoodii*	6–30	1–5
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	6–30	1–5
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–30	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	6–30	1–5
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–30	0–5
	Townsend daisy	TOWNS	*Townsendia*	0–18	0–3
	twinpod	PHYSA2	*Physaria*	0–18	0–3
	Nuttall's sandwort	MINU4	*Minuartia nuttallii*	0–18	0–3
	evening primrose	OENOT	*Oenothera*	0–18	0–3
	fleabane	ERIGE2	*Erigeron*	0–18	0–3
	bladderpod	LESQU	*Lesquerella*	0–18	0–3
	desertparsley	LOMAT	*Lomatium*	0–18	0–3
	smooth woodyaster	XYGL	*Xylorhiza glabriuscula*	0–18	0–3
	deathcamas	ZIGAD	*Zigadenus*	0–18	0–3
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–18	0–3
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–18	0–3
	springparsley	CYMOP2	*Cymopterus*	0–18	0–3
	onion	ALLIU	*Allium*	0–18	0–3
	pussytoes	ANTEN	*Antennaria*	0–18	0–3
	sandwort	ARENA	*Arenaria*	0–12	0–2
	larkspur	DELPH	*Delphinium*	0–12	0–2
	Indian paintbrush	CASTI2	*Castilleja*	0–12	0–2
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–12	0–2
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	0–12	0–2
	sego lily	CANU3	*Calochortus nuttallii*	0–6	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–6	0–1

5	**Annual Forbs**			0–6	
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–6	0–1
	western tansymustard	DEPI	*Descurainia pinnata*	0–6	0–1
	rockjasmine	ANDRO3	*Androsace*	0–6	0–1
	goosefoot	CHENO	*Chenopodium*	0–6	0–1
	Forb, annual	2FA	*Forb, annual*	–	–
Shrub/Vine					
6	**Shrubs**			102–240	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	102–240	17–40
7	**Misc Shrub**			12–30	
	prairie sagewort	ARFR4	*Artemisia frigida*	0–30	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	6–30	1–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–30	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–30	0–5
	shadscale saltbush	ATCO	*Atriplex confertifolia*	6–30	1–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–30	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–30	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	6–30	1–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–30	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–30	0–5
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–30	0–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–30	0–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–30	0–5
	hairspine pricklypear	OPPOP	*Opuntia polyacantha var. polyacantha*	0–18	0–3
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–6	0–1

Table 15. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Perennial Mid-Size Cool Season Grasses**			120–240	
	needle and thread	HECO26	*Hesperostipa comata*	90–180	15–30
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	90–180	15–30
	Montana wheatgrass	ELAL7	*Elymus albicans*	0–60	0–10
	squirreltail	ELELE	*Elymus elymoides ssp. elymoides*	6–60	1–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–60	0–10
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–60	0–10
2	**Rhizomatous Grasses**			30–60	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	30–60	5–10
3	**Misc. Grasses/Grasslikes**			30–60	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–30	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	6–30	1–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–30	0–5

	James' galleta	PLJA	*Pleuraphis jamesii*	0–30	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	6–30	1–5
	Grass, perennial	2GP	*Grass, perennial*	0–30	0–5
Forb					
4	**Perennial Forbs**			30–54	
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	6–30	1–5
	rosy pussytoes	ANRO2	*Antennaria rosea*	0–30	0–5
	milkvetch	ASTRA	*Astragalus*	0–30	0–5
	deathcamas	ZIGAD	*Zigadenus*	0–30	0–5
	Indian paintbrush	CASTI2	*Castilleja*	0–30	0–5
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–30	0–5
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–30	0–5
	larkspur	DELPH	*Delphinium*	0–30	0–5
	draba	DRABA	*Draba*	0–30	0–5
	fleabane	ERIGE2	*Erigeron*	0–30	0–5
	buckwheat	ERIOG	*Eriogonum*	6–30	1–5
	western wallflower	ERAS2	*Erysimum asperum*	0–30	0–5
	desertparsley	LOMAT	*Lomatium*	0–30	0–5
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–30	0–5
	beardtongue	PENST	*Penstemon*	0–30	0–5
	spiny phlox	PHHO	*Phlox hoodii*	6–30	1–5
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–30	0–5
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–30	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–30	0–5
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–30	0–5
	Townsend daisy	TOWNS	*Townsendia*	0–18	0–3
	twinpod	PHYSA2	*Physaria*	0–18	0–3
	Nuttall's sandwort	MINU4	*Minuartia nuttallii*	0–18	0–3
	evening primrose	OENOT	*Oenothera*	0–18	0–3
	bladderpod	LESQU	*Lesquerella*	0–18	0–3
	springparsley	CYMOP2	*Cymopterus*	0–18	0–3
	smooth woodyaster	XYGL	*Xylorhiza glabriuscula*	0–18	0–3
	onion	ALLIU	*Allium*	0–18	0–3
	sandwort	ARENA	*Arenaria*	0–12	0–2
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–12	0–2
	sego lily	CANU3	*Calochortus nuttallii*	0–6	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–6	0–1
5	**Annual Forbs**			0–6	
	rockjasmine	ANDRO3	*Androsace*	0–6	0–1
	goosefoot	CHENO	*Chenopodium*	0–6	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–6	0–1
	western tansymustard	DEPI	*Descurainia pinnata*	0–6	0–1
	Forb, annual	2FA	*Forb, annual*	0–6	0–1

Shrub/Vine					
6	**Shrubs**			60–120	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	60–120	10–20
7	**Misc. Shrubs**			30–60	
	shadscale saltbush	ATCO	*Atriplex confertifolia*	6–30	1–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–30	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	6–30	1–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–30	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	6–30	1–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–30	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–30	0–5
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–30	0–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–30	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–30	0–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–30	0–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–30	0–5
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–30	0–5
	hairspine pricklypear	OPPOP	*Opuntia polyacantha var. polyacantha*	0–18	0–3

Table 16. Community 1.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Perennial Mid-Size Cool Season Grasses**			162–330	
	needle and thread	HECO26	*Hesperostipa comata*	60–180	10–30
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	60–180	10–30
	Montana wheatgrass	ELAL7	*Elymus albicans*	0–60	0–10
	squirreltail	ELELE	*Elymus elymoides ssp. elymoides*	6–60	1–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–60	0–10
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–60	0–10
2	**Rhizomatous Grasses**			30–60	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	30–60	5–10
3	**Misc. Grasses/Grasslikes**			30–60	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–30	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	0–30	0–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–30	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	6–30	1–5
	Grass, perennial	2GP	*Grass, perennial*	0–30	0–5
Forb					
4	**Perennial Forbs**			30–54	
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	6–30	1–5
	rosy pussytoes	ANRO2	*Antennaria rosea*	0–30	0–5
	milkvetch	ASTRA	*Astragalus*	0–30	0–5

	deathcamas	ZIGAD	*Zigadenus*	0–30	0–5
	Indian paintbrush	CASTI2	*Castilleja*	0–30	0–5
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–30	0–5
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–30	0–5
	larkspur	DELPH	*Delphinium*	0–30	0–5
	draba	DRABA	*Draba*	0–30	0–5
	fleabane	ERIGE2	*Erigeron*	0–30	0–5
	buckwheat	ERIOG	*Eriogonum*	6–30	1–5
	western wallflower	ERAS2	*Erysimum asperum*	0–30	0–5
	desertparsley	LOMAT	*Lomatium*	0–30	0–5
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–30	0–5
	beardtongue	PENST	*Penstemon*	0–30	0–5
	spiny phlox	PHHO	*Phlox hoodii*	6–30	1–5
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–30	0–5
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–30	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–30	0–5
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–30	0–5
	Townsend daisy	TOWNS	*Townsendia*	0–18	0–3
	twinpod	PHYSA2	*Physaria*	0–18	0–3
	Nuttall's sandwort	MINU4	*Minuartia nuttallii*	0–18	0–3
	evening primrose	OENOT	*Oenothera*	0–18	0–3
	bladderpod	LESQU	*Lesquerella*	0–18	0–3
	springparsley	CYMOP2	*Cymopterus*	0–18	0–3
	smooth woodyaster	XYGL	*Xylorhiza glabriuscula*	0–18	0–3
	onion	ALLIU	*Allium*	0–18	0–3
	sandwort	ARENA	*Arenaria*	0–12	0–2
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–12	0–2
	sego lily	CANU3	*Calochortus nuttallii*	0–6	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–6	0–1
5	**Annual Forbs**			0–6	
	rockjasmine	ANDRO3	*Androsace*	0–6	0–1
	goosefoot	CHENO	*Chenopodium*	0–6	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–6	0–1
	western tansymustard	DEPI	*Descurainia pinnata*	0–6	0–1
	Forb, annual	2FA	*Forb, annual*	0–6	0–1
Shrub/Vine					
6	**Shrubs**			12–30	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	12–30	2–5
7	**Misc. Shrubs**			30–60	
	shadscale saltbush	ATCO	*Atriplex confertifolia*	0–30	0–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–30	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–30	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–30	0–5

	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–30	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–30	0–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–30	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–30	0–5
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–30	0–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–30	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–30	0–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–30	0–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–30	0–5
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–30	0–5
	hairspine pricklypear	OPPOP	*Opuntia polyacantha var. polyacantha*	0–18	0–3

Table 17. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Perennial Mid-Size Cool Season Grasses**			8–20	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	20	5
	Montana wheatgrass	ELAL7	*Elymus albicans*	0–20	0–5
	squirreltail	ELELE	*Elymus elymoides ssp. elymoides*	4–20	1–5
	needle and thread	HECO26	*Hesperostipa comata*	20	5
	Sandberg bluegrass	POSE	*Poa secunda*	0–20	0–5
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–20	0–5
2	**Rhizomatous Grasses**			28–60	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	40–60	10–15
3	**Misc. Grasses/Grasslikes**			28–60	
	Sandberg bluegrass	POSE	*Poa secunda*	20–60	5–15
	needleleaf sedge	CADU6	*Carex duriuscula*	0–40	0–10
	threadleaf sedge	CAFI	*Carex filifolia*	0–20	0–5
	Grass, perennial	2GP	*Grass, perennial*	0–20	0–5
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–20	0–5
Forb					
4	**Perennial Forbs**			16–36	
	rosy pussytoes	ANRO2	*Antennaria rosea*	0–20	0–5
	milkvetch	ASTRA	*Astragalus*	0–20	0–5
	milkvetch	ASTRA	*Astragalus*	0–20	0–5
	Indian paintbrush	CASTI2	*Castilleja*	0–20	0–5
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–20	0–5
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–20	0–5
	larkspur	DELPH	*Delphinium*	0–20	0–5
	draba	DRABA	*Draba*	0–20	0–5
	fleabane	ERIGE2	*Erigeron*	0–20	0–5
	buckwheat	ERIOG	*Eriogonum*	4–20	1–5
	western wallflower	ERAS2	*Erysimum asperum*	0–20	0–5

	desertparsley	LOMAT	*Lomatium*	0–20	0–5
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–20	0–5
	beardtongue	PENST	*Penstemon*	0–20	0–5
	spiny phlox	PHHO	*Phlox hoodii*	4–20	1–5
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–20	0–5
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–20	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–5
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–20	0–5
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	4–20	1–5
	deathcamas	ZIGAD	*Zigadenus*	0–20	0–5
	smooth woodyaster	XYGL	*Xylorhiza glabriuscula*	0–12	0–3
	Townsend daisy	TOWNS	*Townsendia*	0–12	0–3
	twinpod	PHYSA2	*Physaria*	0–12	0–3
	Nuttall's sandwort	MINU4	*Minuartia nuttallii*	0–12	0–3
	evening primrose	OENOT	*Oenothera*	0–12	0–3
	bladderpod	LESQU	*Lesquerella*	0–12	0–3
	springparsley	CYMOP2	*Cymopterus*	0–12	0–3
	onion	ALLIU	*Allium*	0–12	0–3
	sandwort	ARENA	*Arenaria*	0–8	0–2
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–8	0–2
	Forb, perennial	2FP	*Forb, perennial*	0–4	0–1
	sego lily	CANU3	*Calochortus nuttallii*	0–4	0–1
5	**Annual Forb**			0–4	
	rockjasmine	ANDRO3	*Androsace*	0–4	0–1
	goosefoot	CHENO	*Chenopodium*	0–4	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–4	0–1
	western tansymustard	DEPI	*Descurainia pinnata*	0–4	0–1
	Forb, annual	2FA	*Forb, annual*	0–4	0–1
Shrub/Vine					
6	**Shrubs**			80–180	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	80–180	20–45
7	**Misc. Shrubs**			20–40	
	shadscale saltbush	ATCO	*Atriplex confertifolia*	4–20	1–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–20	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–20	0–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–20	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–20	0–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–20	0–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–20	0–5
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–20	0–5
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–20	0–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–20	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–20	0–5

	spineless horsebrush	TECA2	*Tetradymia canescens*	0–20	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–20	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	4–20	1–5
	hairspine pricklypear	OPPOP	*Opuntia polyacantha var. polyacantha*	0–12	0–3

Table 18. Community 2.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Perennial Mid-Size Cool Season Grasses**			20–40	
	squirreltail	ELELE	*Elymus elymoides ssp. elymoides*	0–40	0–10
	needle and thread	HECO26	*Hesperostipa comata*	20–40	5–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–20	0–5
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–20	0–5
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–20	0–5
	Montana wheatgrass	ELAL7	*Elymus albicans*	4–20	1–5
2	**Rhizomatous Grasses**			60–100	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	60–100	15–25
3	**Misc Grasses/Grasslikes**			60–100	
	Sandberg bluegrass	POSE	*Poa secunda*	40–80	10–20
	Grass, perennial	2GP	*Grass, perennial*	0–20	0–5
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–20	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	0–20	0–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–20	0–5
Forb					
4	**Perennial Forbs**			20–36	
	rosy pussytoes	ANRO2	*Antennaria rosea*	0–20	0–5
	Indian paintbrush	CASTI2	*Castilleja*	0–20	0–5
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–20	0–5
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–20	0–5
	larkspur	DELPH	*Delphinium*	0–20	0–5
	draba	DRABA	*Draba*	0–20	0–5
	fleabane	ERIGE2	*Erigeron*	0–20	0–5
	buckwheat	ERIOG	*Eriogonum*	4–20	1–5
	western wallflower	ERAS2	*Erysimum asperum*	0–20	0–5
	milkvetch	ASTRA	*Astragalus*	0–20	0–5
	desertparsley	LOMAT	*Lomatium*	0–20	0–5
	beardtongue	PENST	*Penstemon*	0–20	0–5
	spiny phlox	PHHO	*Phlox hoodii*	4–20	1–5
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–20	0–5
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–20	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–5
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–20	0–5
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–20	0–5

	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	4–20	1–5
	deathcamas	ZIGAD	*Zigadenus*	0–20	0–5
	smooth woodyaster	XYGL	*Xylorhiza glabriuscula*	0–12	0–3
	Nuttall's sandwort	MINU4	*Minuartia nuttallii*	0–12	0–3
	evening primrose	OENOT	*Oenothera*	0–12	0–3
	Townsend daisy	TOWNS	*Townsendia*	0–12	0–3
	twinpod	PHYSA2	*Physaria*	0–12	0–3
	bladderpod	LESQU	*Lesquerella*	0–12	0–3
	springparsley	CYMOP2	*Cymopterus*	0–12	0–3
	onion	ALLIU	*Allium*	0–12	0–3
	sandwort	ARENA	*Arenaria*	0–8	0–2
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–8	0–2
	sego lily	CANU3	*Calochortus nuttallii*	0–4	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–4	0–1
5	**Annual Forbs**			0–4	
	rockjasmine	ANDRO3	*Androsace*	0–4	0–1
	goosefoot	CHENO	*Chenopodium*	0–4	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–4	0–1
	Forb, annual	2FA	*Forb, annual*	0–4	0–1
	western tansymustard	DEPI	*Descurainia pinnata*	0–4	0–1
Shrub/Vine					
6	**Shrubs**			48–80	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	48–80	12–20
7	**Misc. Shrubs**			20–40	
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–20	0–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–20	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–20	0–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–20	0–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–20	0–5
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–20	0–5
	shadscale saltbush	ATCO	*Atriplex confertifolia*	4–20	1–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–20	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–20	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–20	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	4–20	1–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–20	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–20	0–5
	hairspine pricklypear	OPPOP	*Opuntia polyacantha var. polyacantha*	0–12	0–3

Animal community

The following table lists suggested initial stocking rates for cattle under continuous season-long grazing under 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 be calculated using field 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, but recovery time for upland sites is much longer than in a low intensity system. If distribution problems occur, stocking rates must be reduced or facilitating conservation practices (i.e. cross-fencing, water development) used to maintain plant health and vigor.

Plant Community	Production Carrying Capacity*		
Low-RV-High	lb./ac	AUM/AC	AC/AUM
Big Sagebrush/Bunchgrass	400-600-800	0.08	13
Bunchgrass/Big Sagebrush	400-600-800	0.1	10
Bunchgrass	400-600-800	0.12	8
Big Sagebrush/Thickspike Wheatgrass	300-400-600	0.04	25
Thickspike Wheatgrass/Big Sagebrush	300-400-600	0.07	14
Big Sagebrush/*Bare Ground*	200-300-400	0.02	50
Sprouting Shrub/Thickspike Wheatgrass	200-300-400	0.03	33
Annuals/*Bare Ground*	100-200-300	0.02	50
Reclaimed	400-600-800	0.12	8

* - Continuous, season-long grazing by cattle under average growing conditions.
**Calculation for stocking rates are as follows: using RV values for production, take forage palatable to grazing cattle multiply by 0.25 harvest efficiency and divide by 912 (air dried weight) to arrive at carrying capacity.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide yearlong 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 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% of a management unit may have 25% slopes and distances of greater than 1 mile from water; therefore the adjustment is only calculated for 30% of the unit (i.e. 50% reduction on 30% 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.

Wildlife
The Sandy ecological site in the Green River Basin provides suitable and valuable habitat for a variety of wildlife species. In most cases, the greater the density and diversity of native forbs, grass and shrub species within the site, the greater the diversity of wildlife the site can support including insects which many wildlife species depend on for their dietary requirements. Mid-sized cool season bunchgrasses provide forage and cover for big game species, small mammals, birds and reptiles. Wildlife such as pronghorn, elk, cottontails, and jackrabbits depend largely on grass for forage. Birds nest among the bunchgrasses and utilize grass as screening cover from predatory wildlife. Mule deer, pronghorn, greater sage grouse, and songbirds utilize the taller grass amongst the shrubs as hiding cover for their young. Sagebrush provides important winter forage for greater sage grouse, mule deer, and pronghorn. Year-round habitat is provided for sagebrush obligate species such as greater sage grouse, cottontails, pygmy rabbit, sagebrush vole, short-horned lizard, and pronghorn. Seasonal habitat needs are provided for migrants such as sage sparrow, Brewer’s sparrow, Vesper’s sparrow, sage thrasher, and other sagebrush obligate songbirds. Other birds that frequent this plant community include horned larks and golden eagles.
Although not a dominant part of this community, forbs are an important component of this habitat type, providing an early food source for sage grouse chicks both nutritionally and via the insects that forbs attract. Forbs provide necessary moisture to wildlife in arid landscapes. Pronghorn depend on abundant forbs to aid in the production of milk to nurse fawns and as forage for fawn development and health. Dietary overlap between wildlife and wild horses in this ecological site can significantly reduce the quantity and quality of habitat for wildlife.
Reference State:

1.1 Big Sagebrush/Bunchgrass Plant Community
This plant community provides optimal winter habitat for greater sage grouse, mule deer, pronghorn, and other species that depend on shrubs that stand up through the snow for forage. These areas also provide high quality bird nesting habitat where sagebrush canopy and residual bunchgrasses hide nests and young from predators. Forbs, although sparse, are necessary in the understory of this plant community to attract insects that are a highly nutritious spring food source for greater sage grouse chicks and other sagebrush obligate bird species. Winter use by mule deer and pronghorn may be significant and some shrubs may become hedged over time with excessive browsing.
1.2 Bunchgrass/Big Sagebrush Plant Community
This vegetation community tends to have higher herbaceous plant density that may attract more diverse wildlife use. The state provides suitable forage and cover for sagebrush obligate species. The more open canopy promotes higher diversity and quantity of forbs that are important for early greater sage grouse brood rearing habitat. A reduced sagebrush canopy may result in a slightly lower nesting frequency by greater sage grouse and songbirds. Winter use by mule deer and pronghorn may be significant and some shrubs may become hedged over time with excessive browsing.
1.3 Bunchgrass Plant Community
This plant community provides foraging habitat for greater sage grouse when in proximity to areas with denser sagebrush cover. Due to the higher production of perennial cool-season grasses, this vegetation type provides high forage value for wintering elk. Mule deer and pronghorn transition through these habitats during annual migrations between summer and winter ranges. It also provides suitable habitat for burrowing animals.
Grazing Resistant State:
This State is variable in its value to wildlife. The value of the sagebrush community is similar to the reference state but the value of the grass community decreases. In periods of high plant vigor, the grass plants can provide cover for nesting birds and small mammals. In periods of drought and low plant vigor and diversity, especially low forb availability, grass plants are too short and not dense enough to provide adequate cover and the wildlife value of these areas declines. Mat-forming forbs often occupy the space and nutrients needed for more desirable forbs such as globemallow, penstemon, milk vetches and composites.
Bare Ground State:
This State provides suitable winter habitat for foraging big game and greater sage grouse when sagebrush is in a healthy state and stands above winter snow. The lack of herbaceous species limits the value of this state for birds and small mammals due to the lack of cover in the interspaces of the sagebrush plants. The lack of plant diversity limits the diversity of insects used by wildlife species. Bare ground provides essentially no habitat value for wildlife. In addition, bare ground may be more susceptible to invasion of non-native species, further degrading the value for wildlife.
Disturbed State:
This State is capable of producing a high number of insects which are important for pollination and bird forage at times of the year. Depending on the subspecies, rabbitbrush can be used heavily by wintering mule deer and pronghorn, especially when other preferred winter forages are unavailable or in poor vigor due to over-use or drought. The lack of an herbaceous community limits the value as bird and small mammal hiding cover and forage for grazing animals. Annual plants have little nutritive value and are typically too short to provide hiding cover for wildlife.
Highly Disturbed Site:
As described in the *Bare Ground* State, annuals and bare ground hold little value for wildlife due to the lack of suitable forage and cover. This State is vulnerable to an increase in weedy species that can migrate into adjacent areas, degrading the adjacent areas' value for wildlife. Suitable habitat for wildlife species which require tall, dense sagebrush (greater sage grouse, pronghorn, mule deer, and sagebrush obligate songbirds) will likely not benefit from reclamation efforts for a decade or longer, providing shrub species were planted and/or seeded from shrubs adjacent to the area and have established onsite.

Hydrological functions

Water is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group B (infiltration rate of 0.15-0.3 in/hr), with localized areas in hydrologic groups A (infiltration rate of 0.3 in/hr) and C (infiltration rate of 0.05-0.15 in/hr). Infiltration ranges from moderately rapid to moderate. Runoff potential for this site varies from low to moderate depending on soil hydrologic group and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. Areas where ground cover is less than 50% 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 and shrubs. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Biological crusts should be present, and play an important role in soil stability.

Recreational uses

This site provides recreational opportunities for hiking, horseback riding, bird watching, and upland game hunting. The forbs have a variety of colors and shapes that appeal to photographers. This site provides valuable open space when located in large, un-fragmented landscapes.

Wood products

None

Other products

None

Other information

Similarity Index is based on species composition by air-dry weight. Calculations of allowable pounds per acre for each species are based on the sum of the maximum end of the production range or actual production (whichever is less) in the plant table for the Desired Plant Community until the maximum allowable is reached for the plant grouping. The sum is then divided by the Representative Value (RV) of total annual production for the Desired Plant Community.

References

. 1997. Introduction to Microbiotic Crusts. Natural Resources Conservation Service.

. 2002. Management considerations for sagebrush (Artemisia) in the western U.S.: A selective summary of cumulative information about the ecology and biology of woody N. American sagebrush taxa. USDI-BLM, Washington, D.C..

Bestelmeyer, B., J.R. Brown, K.M. Havstad, B. Alexander, G. Chavez, and J.E. Herrick. 2003. Development and Use of State and Transition Models for Rangelands. Jornal of Range Management 56:114–126.

Bestelmeyer, B., J.R. Brown, J.E. Herrick, D.A. Trujillo, and K.M. Havstad. 2004. Land Management in the American Southwest: a state-and-transition approach to ecosystem complexity. Environmental Management 34:38–51.

Bestelmeyer, B. and J. Brown. 2005. State-and-Transition Models 101: A Fresh look at vegetation change.

Bukowski, B.E. and W.L. Baker. 2013. Historical fire regimes, reconstructed from land-survey data, led to complexity and fluctuation in sagebrush landscapes. Ecological Applications 23:546–564.

Cagney, J., E. Bainter, B. Budd, T. Christiansen, V. Herren, and M. Holloran. 2010. Grazing Influence, Objective Development, and Management in Wyoming's Greater Sage-Grouse Habitat. 35p.

Chambers, J.C., J.L. Beck, T.J. Christiansen, K.J. Clause, J.B. Dinkins, K.E. Doherty, K.A. Griffin, D.W. Havlina,

K.F. Henke, L.L. Kurth, J.D. Maestas, M. Manning, K.E. Mayer, B.A. Mealor, C. McCarthy, M.A. Perea, and D.A. Pyke. 2016. Using resilience and resistance concepts to manage threats to sagebrush ecosystems, Gunnison sage-grouse, and Greater sage-grouse in their eastern range: A strategic multi-scale approach.. Gen. Tech. Rep. RMRS-GTR-356.. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO. 1–143.

Clause, K. and J. Randall. 2014. Wyoming Sagebrush Die-Off Report. Unpublished.

Derner, J.D., G.E. Schuman, R.F. Follett, and G.F. Vance. 2013. Plant and Soil Consequences of Shrub Management in a Big Sagebrush-Dominated Rangeland Ecosystem.

LLC, . 2009. Greater Sage-Grouse Focused Herbaceous Monitoring of Moxa Arch Sagebrush Vegetation Treatments.

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. “Precipitation-Frequency Atlas of the United States” NOAA Atlas 2, Volume 2 (Wyoming). National Weather Service, Silver Spring, Maryland.

Rosentrater, R., M. Bowker, and J. Belnap. 2007. A Field Guide to Biological Soil Crusts of the Western U.S. Drylands. U.S. Government Printing Office, Denver, Colorado.

Shultz, L.M. 2009. Monograph of Artemisia Subgenus Tridentatae (Asteraceae-Anthemideae). Systematic Botany Monographs 89:1–131.

Stringham, T.K., W.C. Kreuger, and P.L. Shaver. 2003. State and Transition Modeling: an ecological process approach. Journal of Range Management 56:106–113.

Tanner, R.L. 2016 (Date accessed). Leasing the Public Range: The Taylor Grazing Act and the BLM. http://www.wyohistory.org/encyclopedia/leasing-public-range-taylor-grazing-act-and-blm.

U. S. Environmental Protection Agency. 2010. Level III and IV ecoregions of the continental United States. U.S. EPA, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon, U.S..

Winward, A. 2007. Boulder, Squaretop Area Field Notes. Field Notes. Unpublished.

. 2021 (Date accessed). USDA PLANTS Database. http://plants.usda.gov.

. 2021 (Date accessed). USNVC [United States National Vegetation Classification]. 2019. United States National Vegetation Classification Database, V2.03. Federal Geographic Data Committee, Vegetation Subcommittee, Washington DC.. USNVC: http://usnvc.org/.

Other references

USDI, B. o. (2015). Allotment files. Rock Springs, WY: unpublished.

Contributors

Bryan Christensen
Karen J. Clause

Approval

Kirt Walstad, 2/21/2025

Acknowledgments

Jill Randell, Wyoming Game and Fish
Shari Meeks, Sublette County Conservation District
Bailey Terry, BLM

Rangeland health reference sheet

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

Author(s)/participant(s)	Bryan Christensen, Karen Clause
Contact for lead author	Karen Clause USDA-NRCS 1625 W Pine Street Pinedale, WY 82941 307-367-2257
Date	05/08/2017
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Should not occur. If present, will be at the upper end of the slope range for this site and will be short and widely spaced relative to slope distance.

---

2. **Presence of water flow patterns:** Water patterns are rare, but when they occur they are very small and not connected beyond 1 gap in the plant canopy.

---

3. **Number and height of erosional pedestals or terracettes:** Pedastalling is rare, but when they occur they are blunt and not active, less than 1 inch (2.5 cm) and typically found at the drip line of the shrub canopy. It is typical to find biological soil crusts at margins. Terracettes are not present.

---

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground is typically <30%, but can be dependent on plant community phase within the reference state. Higher bare ground is expected directly following a sagebrush killing disturbance, but returns to <30% within 2 years post-disturbance. Canopy gaps comprise <20% of the ground surface, and are primarily in the 1-2 foot category (>70%). No canopy gaps >6 feet should be present.

---

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:** Minimal wind scour or deposition may be present with wind scour found in canopy gaps and deposition found on the leeward side of shrubs. It is only occasional and does not occur as repeating pattern across the landscape, but is localized to exposed topography.

---

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) due to wind. Large woody debris from sagebrush will show no movement except for minimal debris damming after large rain or snowmelt events on slopes >6%.

---

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 are highly variable. Values of 6 can occur when sample includes soil biological crusts, but often average less than 3 in plant interspaces. When consistent values of 6 are encountered, it is important to consider if the soil surface has degraded to an argillic subsurface layer (higher clay content will result in higher soil stability). An indicator of degraded soil surface is the appearance of “desert pavement” with higher rock fragment on a deflated soil surface and sagebrush located on islands of intact soil. Overall, the biotic component (plants and soil biological crusts) provide stability for this site.

---

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil organic matter (SOM) <2% is common. Color and structure are poor indicators of SOM in Aridisols (dry, arid soils with thin surfaces and salt and/or clay close to the surface) because SOM potential is low. Typically soil surface consists of an A-horizon of 3-10 inches (7-25 cm) thick with weak to medium sub-angular blocky or sometimes granular or platy structure that is brown to grayish brown (i.e. 10YR 5/3 or 5/2) in color. Field indicators of departure from the reference condition include exposure of subsoil as evidenced by excessive pedastalling and/or surface disturbance.

---

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The reference state consists of 40-80% grasses, 5-10% forbs, and 5-50% shrubs composition by dry weight. The sagebrush canopy is evenly distributed with cover ranging from 5-35%. When sage canopy is at the high end, herbaceous understory diminishes in the plant interspaces, but desirable bunchgrasses can still be found in the interspaces of sage canopy as well as litter to reduce runoff potential. Infiltration is moderate to moderately rapid resulting in minimal runoff. Basal cover is typically less than 5% for this site and does very little to effect runoff on this site.

---

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None. A coarse, dry subsurface will often refuse a probe, causing misidentification of a compaction layer. Most soil profiles must be described by hand dug holes.

---

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: Mid-size, cool season bunchgrasses=perennial shrubs>> cool season rhizomatous grasses=short, cool season bunchgrasses>>perennial forbs

Sub-dominant:

Other:

Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal decadence can be observed and is typically associated with shrub component. It is common to find dead matter accumulated in bunchgrasses such as Indian ricegrass, but live plant matter quantity should exceed standing dead except for in times of severe drought. Sagebrush canopy will often have occasional dead branches, but it should not exceed 10% or be found on most plants.

---

14. **Average percent litter cover (%) and depth (in):** Litter ranges from 5-35% of total canopy measurement with total litter (including beneath the plant canopy) 30-60% expected. Herbaceous litter depth is typically very shallow, approximately 1-2mm. Woody litter can be up to a couple inches in diameter (4-6cm), but is sporadically distributed.

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** English: 400-800 lb/ac (600 lb/ac average); Metric: 448-897 kg/ha (673 kg/ha average).

---

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:** Bare ground greater than 50% is the most common indicator of a threshold being crossed. Greasewood commonly invades this site when adjacent to a Saline Lowland (drainage bottom). Annual weeds such as cheatgrass, halogeton, kochia, lambsquarter, flixweed, and Russian thistle are common invasive species in disturbed sites. Cheatgrass has the potential to change site dynamics in the future, but under current conditions it does not dominate the site or influence site dynamics except when the site has been severely disturbed.

---

17. **Perennial plant reproductive capability:** All species are capable of reproducing, except in drought years. Thickspike wheatgrass and needleleaf sedge will commonly reproduce by underground rhizomes and not by seed production, especially in drought years.
