USDA Natural Resources
Conservation Service

Ecological site DX034A01X122
Loamy Green River Basin (Ly GRB)

Last updated: 2/19/2025
Accessed: 09/10/2025

General information

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

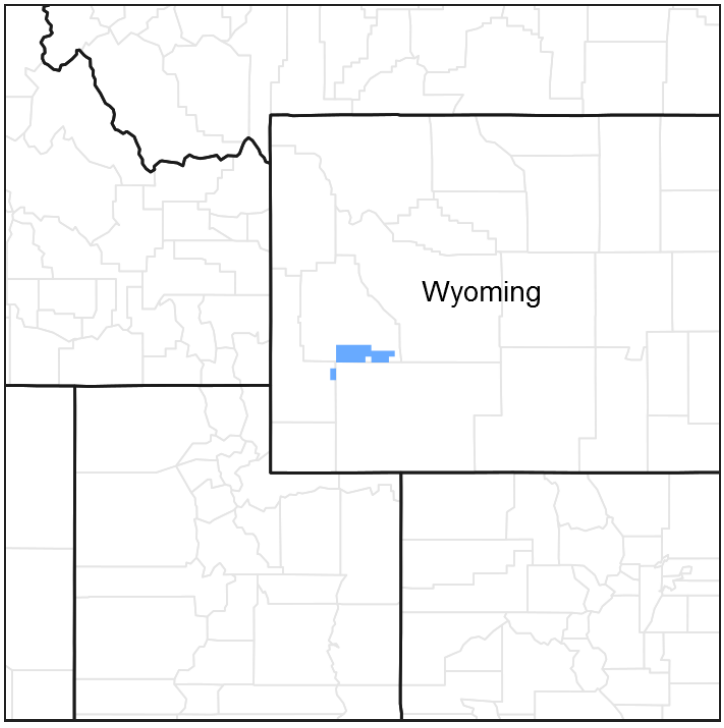


Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

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

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) 34A-B:
Moisture Regime: ustic aridic
Temperature Regime: frigid
Dominant Cover: rangeland
Representative Value (RV) Effective Precipitation: 7-9 inches
RV Frost-Free Days: 50-90 days

Classification relationships

Site Name: Loamy Green River Basin

Site Type: Rangeland

Site ID: R034AB122WY

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:

not saline or saline-sodic.
moderately deep, deep, with < 3% stone (10-25”) and boulder (>25”) cover.
not skeletal within 20” of soil surface.
not strongly or violently effervescent in surface mineral 10”.
textures usually range from very fine sandy loam to clay loam in surface mineral 4”.
Slope is < 15%.
Clay content is = <32% in surface mineral 4”.
Site does not have an argillic horizon with > 35% clay.

Associated sites

R034AY104WY	**Clayey Green River and Great Divide Basins (Cy)** The Clayey 7-9 Green River Basin site is similar in climate and soil depth, slopes, and rock fragments, but it differs in soil surface texture. The Loamy ranges from very fine sandy loam to light clay loam surface textures while the Clayey site ranges from clay loam to clay soil surface textures.
R034AY150WY	**Sandy Green River and Great Divide Basins (Sy)** The Sandy 7-9 Green River Basin site is similar in climate and soil depth, slopes, and rock fragments, but it differs in soil surface texture. The Loamy ranges from very fine sandy loam to light clay loam surface textures while the Sandy site ranges from loamy sand to fine sandy loam soil surface textures. Often the Loamy site will have a sandy loam cap <3 inches in depth, but if this cap exceeds 3 inches, it will likely result in a Sandy site.

Similar sites

R034AY122WY	**Loamy Green River and Great Divide Basins (Ly)** Loamy 7-9 Green River and Great Divide Basins is essentially the same site description, but was written to encompass a broader geographic range with more variability in climatic condition. Therefore, there is a wider range in production potential and broader ranges of species composition to cover a wider range of variability to the site. The Loamy 7-9 Green River and Great Divide Basin ecological site was published in 2003 and based upon the range site concept of Loamy 7-9"ppt Green River and Great Divide Basins originally described in the 1970s and revised in 1988.
DX034A02X122	**Loamy Pinedale Plateau (Ly PP)** Loamy Pinedale Plateau is very similar to Loamy Green River Basin, but geographically occurs further north in the Upper Green River Basin. Soils are similar, but climate cooler with more effective precipitation. Desert salt shrubs are more prominent in the Green River Basin LRU.

Table 1. Dominant plant species

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

Herbaceous	(1) *Elymus elymoides ssp. elymoides* (2) *Achnatherum hymenoides*

Legacy ID

R034AB122WY

Physiographic features

The Loamy Green River Basin (Ly) ecological site (R034AB122WY) is located within LRU “B” in 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).

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 more than 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 (50-90 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 usually occurs in September with adequate fall moisture.

Table 3. Representative climatic features

Frost-free period (average)	54 days
Freeze-free period (average)	82 days
Precipitation total (average)	8 in

Climate stations used

- (1) GREEN RIVER [USC00484065], Green River, WY
- (2) BIG PINEY MARBLETON AP [USW00024164], Big Piney, WY
- (3) FONTENELLE DAM [USC00483396], Green River, WY

Influencing water features

None

Soil features

The soils of this site are deep to moderately deep (greater than 20" to bedrock), and well-drained. Textures range from loams to very fine sandy loam on the coarse end to light clay loam (<30% clay content) on the heavy end. The most common textures include loam, fine sandy loam, and sandy clay loam. A highly common scenario is to have a 1 to 3” cap of sandy loam over a sandy clay loam due to young soil development of weathered sandstone and shale parent materials.
Representative Soil Taxonomy (particle size & taxonomic subgroup): fine-loamy Ustic Haplargids, Ustic Calciargids, or Ustic Haplocambids

Table 4. Representative soil features

Parent material	(1) Alluvium–sandstone and shale

Surface texture	(1) Loam (2) Fine sandy loam (3) Sandy clay loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderately slow to moderate
Soil depth	20–60 in
Surface fragment cover <=3"	0–3%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	1–6 in
Calcium carbonate equivalent (0-40in)	0–15%
Clay content (Depth not specified)	Not specified
Electrical conductivity (0-40in)	0–8 mmhos/cm
Sodium adsorption ratio (0-40in)	0–5
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (0-20in)	0–35%
Subsurface fragment volume >3" (0-20in)	0–5%

Ecological dynamics

This ecological site is dominated (species composition by dry weight) by big sagebrush and perennial grasses with forbs as a minor component. The site consists of five states: the Reference State (1), Grazing Resistant State (2), Eroded 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* var. wyomingensis) and cool-season

perennial bunchgrass species, primarily bottlebrush squirreltail (*Elymus elymoides* ssp. elymoides), Indian Ricegrass (*Achnatherum hymenoides*), and Needleandthread (*Hesperostipa comata*),and rhizomatous grasses like thickspike wheatgrass (*Elymus lanceolatus* ssp. lanceolatus) as subdominant. Minor components include short-statured bunchgrasses such as Sandberg bluegrass, perennial forbs, and other 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 often it is 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 (NRCS) 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.

Wyoming big sagebrush is the dominant shrub on this site. 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 most 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 resulted in the formation of the Rock Springs Grazing Association to restrict 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 (Wyoming Dept. of State Parks and Cultural Resources, 2014). The southern portions of the Green River Basin had some trails (i.e. Cherokee Trail) used by stage coaches, and locals (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*), cheatgrass (*Bromus tectorum*), lambsquarter (*Chenopodium album*), Russian thistle (*Salsola kali*), flixweed (*Descurainia sophia*), and kochia (*Bassia scoparia*). Soil disturbance can be caused by vehicles, equipment, 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 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 annual grass from the Mediterranean region, has been increasing in recent years on sites that have been disturbed. There are many challenges in controlling this invasive grass and its impacts on plant communities, livestock grazing, and wildlife habitat.

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

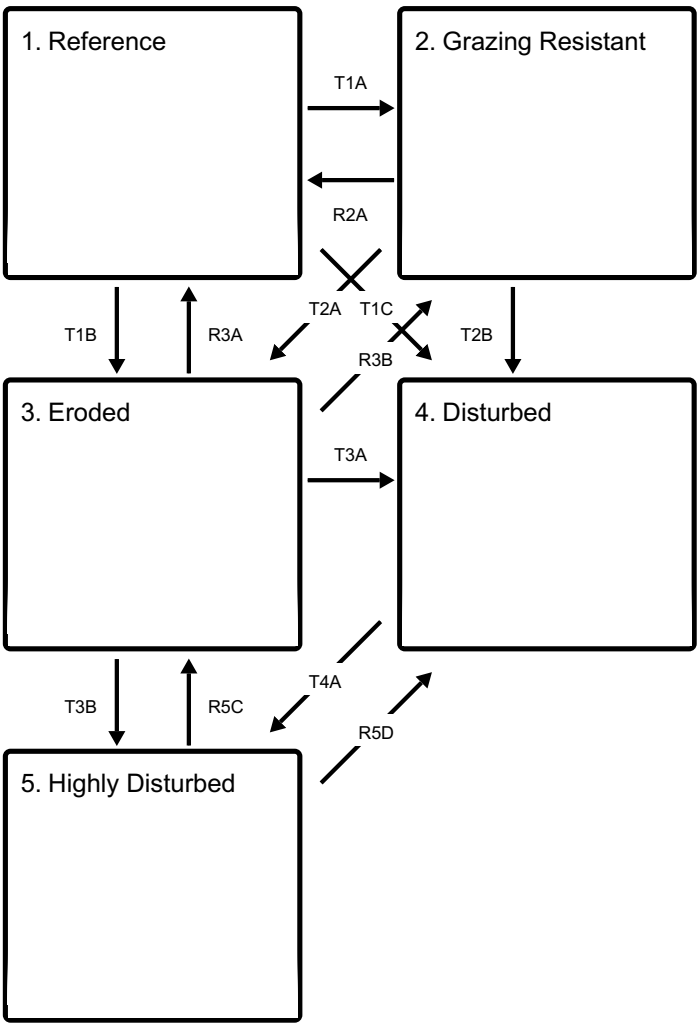
the reference community as the management goal. Other plant communities may be desired to meet land management objectives. This is valid as long as the Rangeland Health attributes assessment departures are slight to moderate or none to slight from the Reference State. The biological processes on this 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 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 is used to define Plant Community Phases, and it 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. The percent foliar cover column in the plant tables is actually species composition by dry weight. Woody species are included in species composition by weight for the site and foliar cover is only discussed in the STM and narratives. Calculating similarity index requires use of species composition by dry weight.

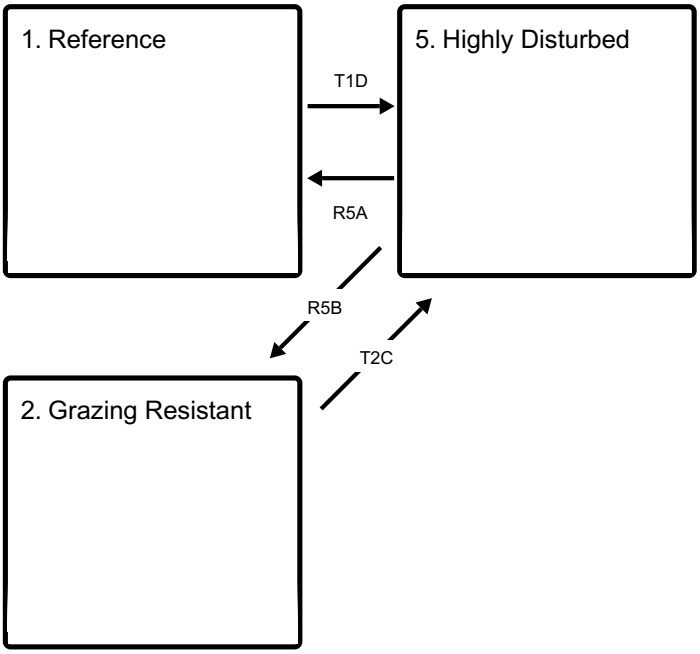
Although there is considerable qualitative experience supporting the pathways and transitions within the State and Transition Model (STM), no quantitative information exists that specifically identifies threshold parameters between reference states and degraded states in this ecological site. For information 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

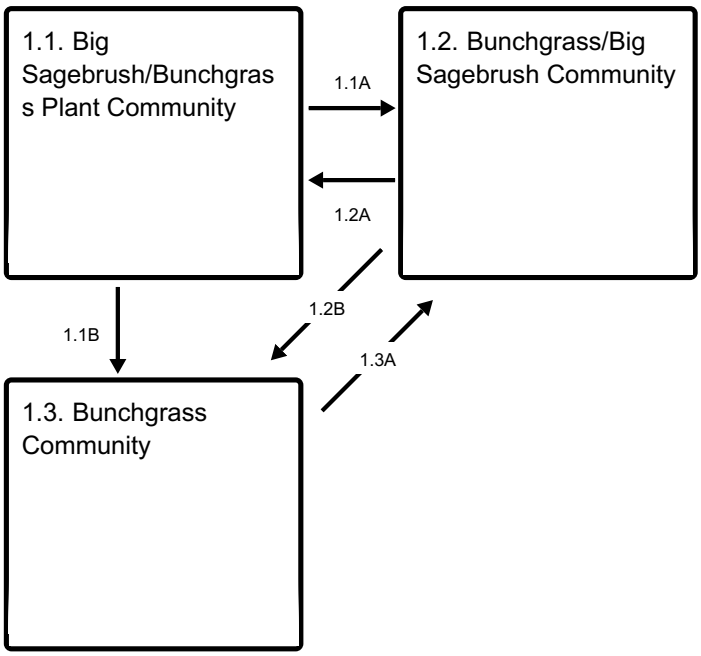
Ecosystem states



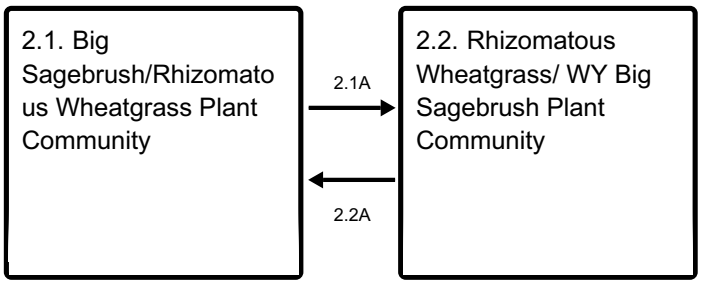
States 1, 5 and 2 (additional transitions)



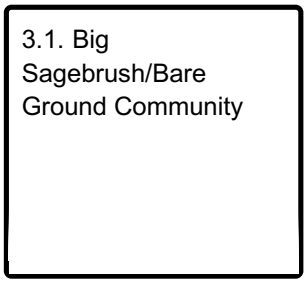
State 1 submodel, plant communities



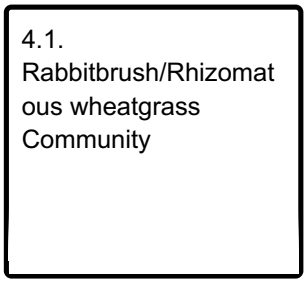
State 2 submodel, plant communities



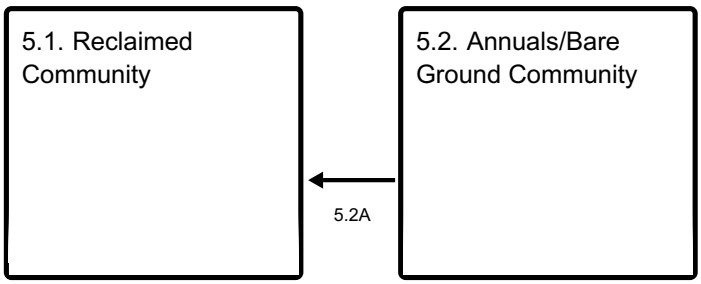
State 3 submodel, plant communities



State 4 submodel, plant communities



State 5 submodel, plant communities



State 1
Reference

The Reference Plant Community (big sage/bunchgrass) of this site is dominated by Wyoming big sagebrush (*Artemisia tridentata* var. wyomingensis) and cool-season perennial bunchgrass species, primarily bottlebrush squirreltail (*Elymus elymoides* ssp. elymoides), Indian Ricegrass (*Achnatherum hymenoides*), and Needleandthread (*Hesperostipa comata*),and rhizomatous grasses like thickspike wheatgrass (*Elymus lanceolatus* ssp. lanceolatus) as 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 often it is 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 (NRCS, n.d.) 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. Wyoming big sagebrush is the dominant shrub on this site. 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*).

Community 1.1
Big Sagebrush/Bunchgrass Plant Community

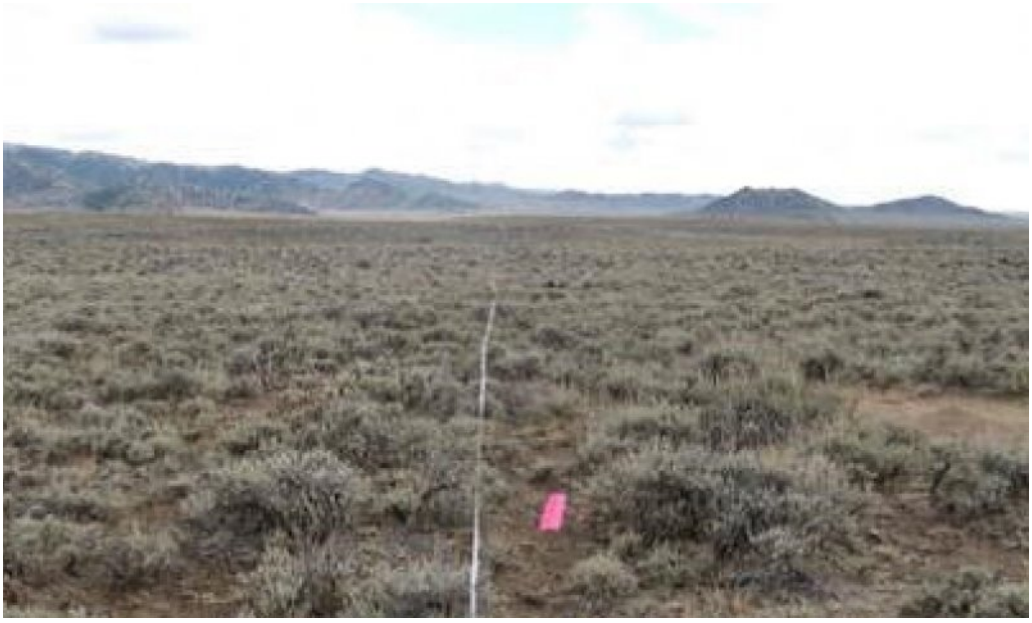


Figure 6. 1.1

The Big Sagebrush/Bunchgrass Community (1.1) is well adapted to Cool Central Desertic Basins and Plateaus climatic conditions. The diversity in plant species allows for drought tolerance, and plant mortality is 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. Biological soil crusts play an important role in protecting the soil surface as well as carbon, nutrient, and water cycles, particularly moss and lichen under the sagebrush canopy and cyanobacteria in the interspaces (NRCS, 1997). They are a source of carbon to soils, and not only do they convert atmospheric nitrogen into bio-available nitrogen, but they also secrete compounds that increase the bio-availability of phosphorus (Rosentrater, 2007). 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. Plant community phases can occur in large contiguous blocks or in a small to large mosaic pattern, but typically this plant community is maintained within a larger mosaic at the landscape level with the other plant communities phases identified in the Reference State. This community can occur over time without disturbance (i.e. “natural succession”), or it can be accelerated with moderate herbaceous grazing pressure. Wyoming big sagebrush is dominant with sagebrush foliar cover ranging from 15% to 25%. At this level of sagebrush cover in this precipitation zone, there is competition between the shrub over-story and the herbaceous understory (Winward, 2007). A Big Sagebrush/Bunchgrass Community with a degraded understory is an “at-risk” community. There are generally few canopy gaps, and most gaps are small(1-2 feet). Rock cover on the soil surface is low. Most plant interspaces have canopy or litter cover. Production of grasses is relatively lower than in the Bunchgrass Community (1.3) and slightly lower than in the Bunchgrass/Big Sagebrush Community (1.2).

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	135	225	315
Shrub/Vine	135	225	315
Forb	30	50	70
Total	**300**	**500**	**700**

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	30-50%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	20-30%

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	1-5%	20-55%	2-15%
>0.5 <= 1	–	5-10%	20-55%	2-5%
>1 <= 2	–	10-15%	–	–
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 8. Plant community growth curve (percent production by month).

WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	10	35	40	10	0	5	0	0	0

Community 1.2
Bunchgrass/Big Sagebrush Community

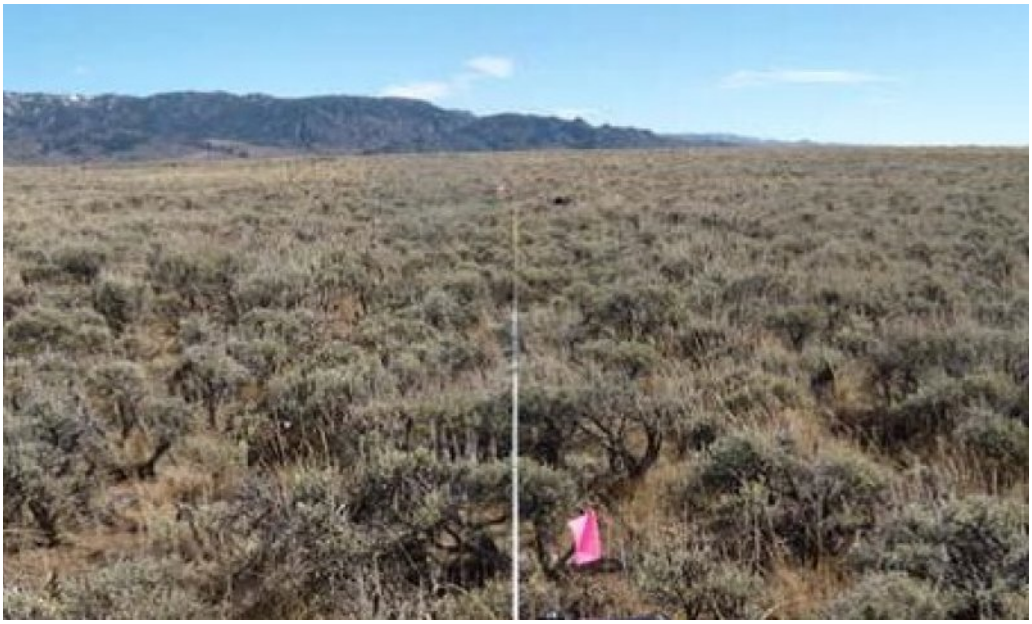


Figure 9. 1.2

The Bunchgrass/Big Sagebrush Community (1.2) is well adapted to Cool Central Desertic Basins and Plateaus climatic conditions. The diversity in plant species allows for drought tolerance, and plant mortality is 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. Biological soil crusts play an important role in protecting the soil surface as well as carbon, nutrient, and water cycles, particularly moss and lichen under the sagebrush canopy and cyanobacteria in the interspaces. (NRCS, 1997)(Rosentrater et.al.,2007) 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. Plant community phases can occur in large contiguous blocks or in a small to large mosaic pattern, but typically this plant community is maintained within a larger mosaic at the landscape level with the other plant communities phases identified in the Reference State. This community can occur after a sagebrush thinning event, such as drought, insects, or disease, or it can take longer to occur after a stand replacing event. Mid-stature bunchgrasses co-dominate with Wyoming big sagebrush, with sagebrush 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 over-story than negative effects. (Winward, 2007) There are generally few canopy gaps, and most gaps are small(1-2 feet). Rock cover on the soil surface is low to

moderate. Many plant interspaces have canopy or litter cover. Production of grasses is slightly less than in the Bunchgrass Community (1.3), but shrub production is higher. Mechanical and chemical treatment of shrubs have replaced natural sagebrush killing events in many cases. However, chemical treatments impact non-target species, particularly broad-leafed species (forbs and shrubs) differently than natural events such as drought or fire. Fire tends to result in a short-term increase in forbs, but chemical treatments with 2,4-D can result in a short-term or long-term reduction in forb density and diversity. Chemical treatment of sagebrush with tebuthiuron can have impacts the understory, depending on application rate. (WWC, 2009)

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	150	250	350
Shrub/Vine	120	200	280
Forb	30	50	70
Total	**300**	**500**	**700**

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	30-50%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	15-25%

Table 10. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	5-10%	20-55%	2-15%
>0.5 <= 1	–	5-15%	20-55%	2-5%
>1 <= 2	–	5-10%	–	–
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

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

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	10	35	40	10	0	5	0	0	0

Community 1.3
Bunchgrass Community

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. Wyoming big sagebrush and desert salt shrubs are present as a part of the community, but they are a minor component with 0 to 5% foliar cover. Sprouting shrubs such as green rabbitbrush (*Chrysothamnus viscidiflorus*) may appear more visible and dominant with reduced sagebrush cover, but

they are not dominant compared to the herbaceous component. Biological soil crusts are temporarily decreased due to disturbance, but soil protection is provided by high amounts of litter from the herbaceous component. The Bunchgrass Community (1.3) generally occurs immediately following a stand replacing sagebrush killing event such as moderate drought, insects, browse, or fire. Chemical, mechanical, and biological control can be effective tools to achieve this plant community, when used in conjuction with a grazing system that alters the timing and intensity of grazing and provides periodic rest/deferment durning the critical growth period.

Table 11. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	180	300	420
Shrub/Vine	90	150	210
Forb	30	50	70
Total	**300**	**500**	**700**

Table 12. 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	30-50%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	10-20%

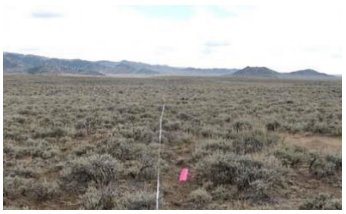
Table 13. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	25-60%	2-15%
>0.5 <= 1	–	0-5%	25-60%	2-5%
>1 <= 2	–	–	–	–
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

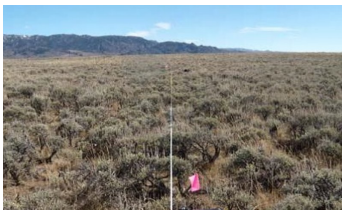
Figure 14. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	10	35	40	10	0	5	0	0	0

Pathway 1.1A
Community 1.1 to 1.2



Big Sagebrush/Bunchgrass Plant Community



Bunchgrass/Big Sagebrush Community

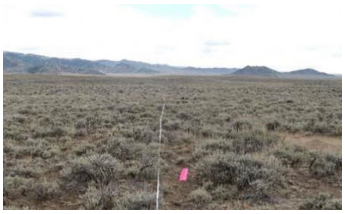
The trigger for a community shift from the Big Sagebrush/Bunchgrass Community (1.1) to the Bunchgrass/Big Sagebrush Community (1.2) is a sagebrush thinning event, such as drought, insects, disease, chemical, mechanical or biological control of sagebrush that favors the existing herbaceous vegetation while only removing a portion of the sagebrush canopy so that 5-15% sagebrush cover remains. Indicators include the increase in density and vigor of mid-stature bunchgrasses to the point that they co-dominate species composition by weight with Wyoming big sagebrush.

Conservation practices

Brush Management

Pathway 1.1B

Community 1.1 to 1.3

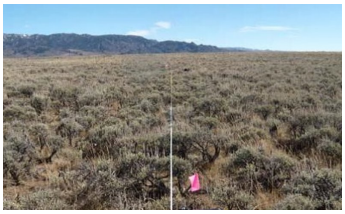


Big Sagebrush/Bunchgrass Plant Community

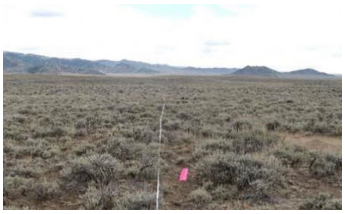
Bunchgrass Community

The trigger for a community shift from the Big Sagebrush/Bunchgrass Community (1.1) to the Bunchgrass Community (1.3) is a stand replacing sagebrush killing event, such as drought, insects, disease, extended saturated soils, or severe drought that favors the existing herbaceous vegetation and removes sagebrush canopy to <5%. Indicators include the increase in density and vigor of mid-stature bunchgrasses to the point that they dominate species composition by weight. Fire is not common on this site due to low amounts of fine fuels, but when it does occur it is stand replacing.

Pathway 1.2A
Community 1.2 to 1.1



Bunchgrass/Big Sagebrush Community



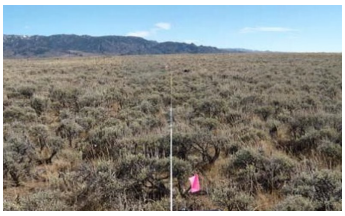
Big Sagebrush/Bunchgrass Plant Community

The trigger for a community shift from the Bunchgrass/Big Sagebrush Community (1.2) to the Big Sagebrush/Bunchgrass Community (1.1) is natural succession, or lack of disturbance over time. Indicators include an increase in shrub cover and proportional decline in overall under-story.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

Pathway 1.2B
Community 1.2 to 1.3



Bunchgrass/Big Sagebrush Community

Bunchgrass Community

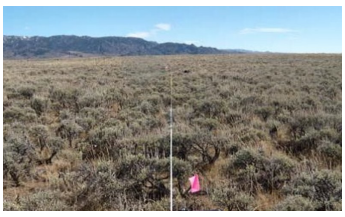
The trigger for a community shift from the Bunchgrass/Big Sagebrush Community (1.2) to the Bunchgrass Community (1.3) is a sagebrush killing event, such as fire, drought, chemical, mechanical or biological control of sagebrush that favors the existing herbaceous vegetation. Indicators include an increase in density and vigor of mid-stature bunchgrasses to the point that they dominate species composition by weight.

Conservation practices

Brush Management

Pathway 1.3A
Community 1.3 to 1.2

Bunchgrass Community



Bunchgrass/Big Sagebrush Community

The trigger for a community shift from the Bunchgrass Community (1.3) to the Bunchgrass/Big Sagebrush Community (1.2) is natural succession, or lack of disturbance over time. Indicators include an increase in shrub cover and proportional decline in overall under-story. Natural succession results in sagebrush cover increasing in response to annual climatic differences and a certain amount of herbivory. Succession 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.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

State 2
Grazing Resistant

The Grazing Resistant State is characterized by the dominance of grazing tolerant species such as sagebrush, cool season rhizomatous grasses, short-statured, cool season bunchgrasses, and persistent, mat-forming perennial forbs. The lack of mid-size, cool season bunchgrasses has a negative effect on overall litter amount, soil organic matter (SOM), and hydrologic function of the site is decreased from the reference state. Total annual production is reduced and species composition is altered, affecting biotic integrity. The state is stable, with moderate resistance and low resilience to disturbance. Returning to the reference state with grazing management (or removal) alone is not possible in a reasonable timeframe.

Community 2.1
Big Sagebrush/Rhizomatous Wheatgrass Plant Community

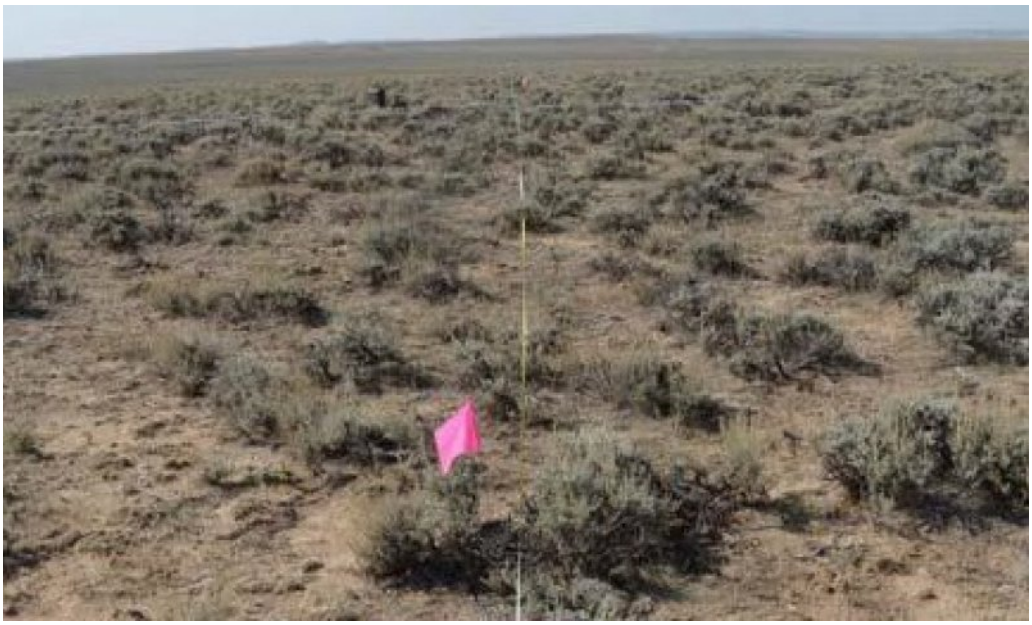


Figure 15. 2.1

The Big Sagebrush/Rhizomatous Wheatgrass Community (2.1) is characterized by high sagebrush cover and an herbaceous component dominated by Sandberg bluegrass, rhizomatous wheatgrasses and/or mat-forming forbs, with limited mid-stature bunchgrasses. Once these key species becomes scarce, it is 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 resistant to changes in composition, due to the dominance and competition of grazing resistant species, such as; Sandberg bluegrass, rhizomatous wheatgrass, and/or persistent mat-forming forbs such as phlox and buckwheat. However, the community can be restored back to the Reference State (1) with sagebrush treatment (chemical, mechanical, or biological) and grazing deferment followed by a grazing system that allows periodic rest during the critical growth period. Wyoming big sagebrush dominates with cover as high as 25% or greater. Areas that catch and retain snow are more likely to have higher shrub cover. Biological soil crusts have diminished in the plant interspaces, affecting soil and site stability, but are still present under the sagebrush canopy and play an important role in protecting the soil surface as well as 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 content and therefore lower soil stability than in the Reference State. Ground cover is highly variable and fluctuates with climatic cycles, but infiltration is lower than in the Reference State and the hydrologic function is impaired due to decreased soil organic matter.

Table 14. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	110	220	330
Grass/Grasslike	70	140	210
Forb	20	40	60
Total	**200**	**400**	**600**

Table 15. 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	45-65%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	20-40%

Table 16. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	20-40%	2-10%
>0.5 <= 1	–	0-5%	20-40%	2-5%
>1 <= 2	–	15-30%	–	–
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 17. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	10	35	40	10	0	5	0	0	0

Community 2.2
Rhizomatous Wheatgrass/ WY Big Sagebrush Plant Community

Figure 18. 2.2

The Rhizomatous Wheatgrass/Big Sagebrush Community (2.2) is characterized by an herbaceous component dominated by Sandberg bluegrass, rhizomatous wheatgrasses and/or mat-forminf forbs, with limited mid-stature bunchgrasses. Once these key mid-stature species becomes scarce, it is 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 established bluegrass, rhizomatous wheatgrass, and/or mat-forming forbs. It is unknown if restoration is possible from this community phase. Thickspike wheatgrass (*Elymus lanceolatus* ssp. lanceolatus) dominates, and Wyoming big sagebrush foliar cover is typically less than 15%. 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 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.

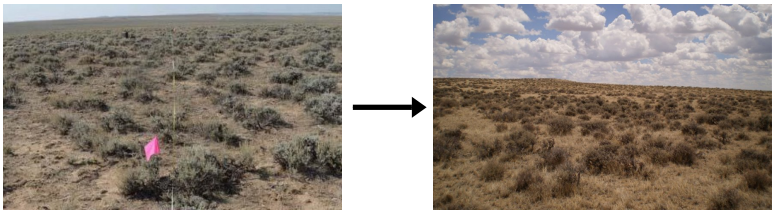
Table 17. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	120	240	360
Shrub/Vine	70	140	210
Forb	10	20	30
Total	**200**	**400**	**600**

Figure 20. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	10	35	40	10	0	5	0	0	0

Pathway 2.1A
Community 2.1 to 2.2



Big Sagebrush/Rhizomatous Wheatgrass Plant Community

Rhizomatous Wheatgrass/ WY Big Sagebrush Plant Community

The trigger for a community shift from the Big Sagebrush/Rhizomatous Wheatgrass Community (2.1) to the Rhizomatous Wheatgrass/Big Sagebrush Community (2.2) is a sagebrush killing event such as drought, insects, disease, chemical, mechanical or biological control of sagebrush that favors the existing herbaceous vegetation and removes sagebrush canopy and continuous spring grazing during the critical growth

period. Without a change in grazing regime, the existing understory will respond, but mid-stature bunchgrasses will not increase. Fire is not typically a driver in this State due to reduced fine fuels.

Pathway 2.2A
Community 2.2 to 2.1

Rhizomatous Wheatgrass/ WY Big Sagebrush Plant Community

Big Sagebrush/Rhizomatous Wheatgrass Plant Community

The trigger for a community shift from the Rhizomatous Wheatgrass/Big Sagebrush Community (2.2) to the Big Sagebrush/Rhizomatous Wheatgrass 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
Eroded

This state is characterized by very old sagebrush stands with very little understory between the sagebrush canopy. Bare ground patch sizes are very large and comprise the majority of the interspaces between sagebrush plants. Communities in the Eroded State (3) have crossed a threshold due to degradation of dynamic soil properties such as soil organic matter, fertility, and infiltration caused by soil erosion. Soil erosion affects the hydrology, soil chemistry, soil microorganisms, and soil physics to the point where intensive restoration is required to return the site to another state. Simply changing grazing management will not create sufficient change to restore the site within a reasonable time period. It will require a considerable input of energy to move the site back to the Reference State (1). The Eroded State (3) 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 Community

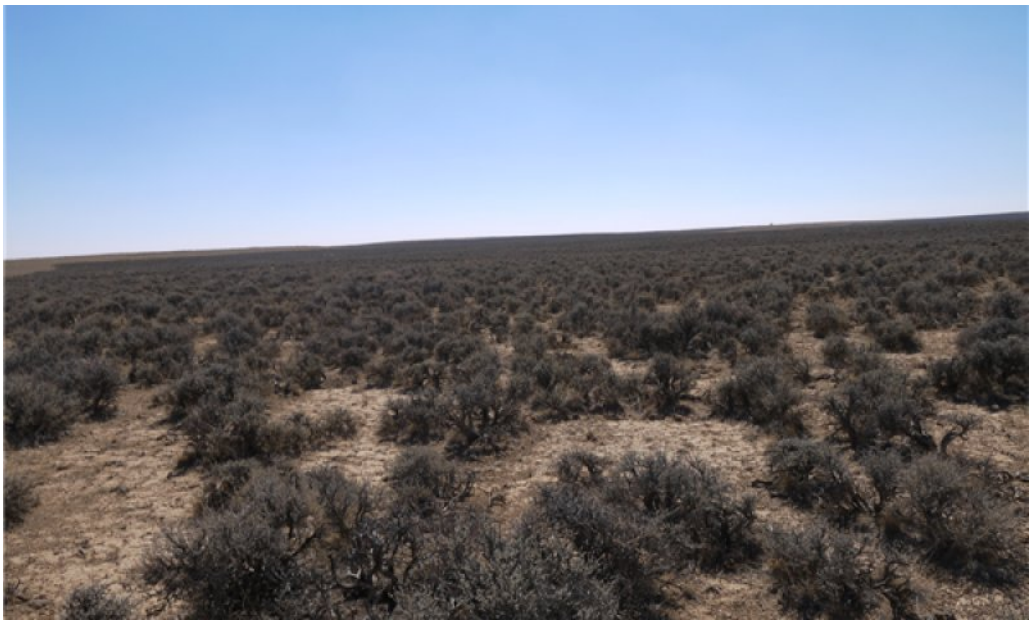


Figure 21. 3.1

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 bunchgrasses (e.g., Indian ricegrass, bottlebrush squirreltail, and needleandthread) exist only in low densities and protected under the sagebrush canopy. This community tends to be dominated by Wyoming big sagebrush (>25% cover) and bare ground in large connected patches in the interspaces of the shrub canopy (>10 foot gap size between all perennial plants). The majority of annual production is from big sagebrush so this site provides very little value for grazing. Sufficient quantity of fine fuels necessary to carry a fire. Therefore, fire is no longer a driver of ecological dynamics. 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 exhibits a moderate or great departure from the reference state for the attributes of a functioning, healthy rangeland, including soil and site stability, hydrologic function, and biotic integrity. Infiltration decreased, erosion and runoff incease, and nutrient cycling and energy flow are impaired. Biological soil crusts have greatly diminished, further exposing the soil surface to erosional forces as well as impairing carbon, nutrient, and water cycles.

Table 18. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	70	210	280
Grass/Grasslike	20	60	80
Forb	10	30	40
Total	**100**	**300**	**400**

Figure 23. Plant community growth curve (percent production by month). WY0401, 7-9GR, UPLAND SITES. ALL UPLAND SITES.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	10	35	40	10	0	5	0	0	0

State 4
Disturbed

This state contains one plant community, the Rabbitbrush/Rhizomatous wheatgrass plant community. It is characterized by rabbitbrush dominance and a perpetual state of disturbance as evidenced in gated pasture corners, gravel pits, and areas repeatedly treated to kill sagebrush. The disturbance cycle has been sped up to preclude non-sprouting shrubs such as Wyoming big sagebrush and favor sprouting shrubs such as green rabbitbrush (*Chrysothamnus viscidiflorus*). Significant changes are expected in soil structure, compaction, soil organic matter, infiltration, bulk density, and/or water holding capacity. Biological soil crusts have been removed, further exposing the soil surface to erosional forces as well as impairing carbon, nutrient, and water cycles. Soil and site stability has been impaired from the reference state.

Community 4.1
Rabbitbrush/Rhizomatous wheatgrass Community

Figure 24. 4.1

The Rabbitbrush/Rhizomatous Wheatgrass Community (4.1) is often in a perpetual state of disturbance. 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/or consecutive fires. Seeding may be used to restore functional structural groups, but rabbitbrush is likely to continue as a dominant shrub into the foreseeable future with no restoration pathway identified at this time without first transitioning to the Highly Disturbed State (5).

State 5
Highly Disturbed

All sites transition to this state following severe soil disturbance that removes the plant community. Extreme changes in soil and site stability have occurred, and primary emphasis for restoration should be to stabilize the site. Hydrologic function is often impaired through reduced litter and changes to soil surface such as compaction, and can be mitigated through proper soil handling and storage as well as erosion control measures on sites with >6% slope. Biotic integrity restoration can be achieved through proper seeding mixtures to restore site diversity and functional/structural vegetative components of the reference state.

Community 5.1
Reclaimed Community

The Reclaimed Community (5.1) is highly variable based on weather conditions during restoration activities, the management practices used to implement the restoration, the seed mix, and timing/method of stockpiling topsoil during the disturbance. A common historical scenario is a reclaimed oil and gas well pad planted to crested wheatgrass (Agropyron cristata) without appropriate topsoil stockpiling. If topsoil is stockpiled, it may have been stored for too long and/or stored too deep resulting in fewer soil

microorganisms. Over time, Wyoming big sagebrush will spread into the reclaimed area, but the understory will be dominated by introduced species. Biological soil crusts are minimal, further exposing the soil surface to erosional forces as well as impairing carbon, nutrient, and water cycles. Modern reclamation techniques include proper soil stockpiling, reshaping and recontouring, deep ripping, and diverse native seed mixtures with varying degrees of successful reclamation. An intermediate timeframe for success (site stability) is 5-7 years while meeting long-term goals may take 8-10 years or longer to achieve (diversity). It is unknown if reference conditions can be achieved for all range health attributes.

Community 5.2
Annuals/Bare Ground Community

The Annuals/*Bare Ground* Community (5.2) occurs after severe disturbance, most often physical soil disturbance that removes all topsoil, but it can also occur as a transition from the Eroded State (3) after severe drought, extended periods of saturated soils, insects, or disease kills sagebrush, leaving the site with no perennial vegetation. Populations of annual and/or invasive weeds reach critical levels and impact the ecological processes on the site until restoration of the site occurs. As part of succession, all sites that are severely disturbed will go through this plant community as part of the restoration process. Biological soil crusts are non-existant, further exposing the soil surface to erosional forces as well as impairing carbon, nutrient, and water cycles. Under optimal conditions this community phase will be limited to 1-3 years of the restoration process.

Pathway 5.2A
Community 5.2 to 5.1

The trigger for a community shift from the Annuals/*Bare Ground* Community (5.2) to the Reclaimed Community (5.1) is a variety of reclamation and restoration techniques that include seedbed preparation, seeding, and often post-planting weed control. 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/).

Transition T1A
State 1 to 2

The driver for transition from the Reference State to the Grazing Resistant State (T1A) is continuous spring grazing and/or long-term severe drought. Continuous spring grazing and/or extended 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, and bluebunch wheatgrass, a long-lived perennial that has elevated growth points, are typically the first species to decline (NRCS). Bottlebrush squirreltail will also decline with grazing pressure and lack of disturbances that kill sagebrush. 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 towards less productive, shorter species. While bare ground may not change significantly, 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 re-sprouting) 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, and will dramatically fluctuate in dry vs. wet years.

Transition T1B
State 1 to 3

The driver for transition from the Reference State to the Eroded State (T1-3) is continuous high intensity/long duration grazing typically in the spring. Drought can accelerate this transition. Indicators of this transition include significant decline in plant canopy cover or total annual aboveground biomass production below 200 pounds per acre. The primary indicator of this transition is the loss of understory, which creates open spots of with bare soil between the sagebrush canopy (>6 foot gap size). Soil erosion causes decreased soil fertility and infiltration, triggering the transition to the Eroded State. Several other key factors signal the approach of a threshhold: an increase in soil physical crusting, a decrease in soil surface aggregate stability, and/or evidence of erosion, including water flow patterns, development of pedestals, and litter movement.

Transition T1C
State 1 to 4

The driver for transition from the Reference State to the Disturbed State (T1-4) 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 transition can occur if multiple soil disturbing activities occur over a relatively short time period. This could be high intensity/high frequency grazing, machinery, and/or multiple sagebrush treatments. Indicators include an increase in rabbitbrush to dominant levels in the plant community due to ground disturbance 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 introduced to the site, invasive species, such as cheatgrass, may be present. To prevent this transition, the site will require proper reclamation after disturbance using the most current science and technology available to restore native vegetation and prevent invasive dominance. In cases where 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 the transition. The resulting lower biomass production, reduced litter, and increased bare ground in this community can promote invasion of undesirable species.

Transition T1D
State 1 to 5

The driver for transition from the Reference State to the Highly Disturbed State (T1-5) is a topsoil removing event with mechanical equipment. Examples include construction sites, oil and gas activity, and borrow areas.

Restoration pathway R2A
State 2 to 1

The drivers for this restoration pathway are reduction 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, light to moderate stocking with periodic critical growth period rest every 2 or 3 years can move the site back to the Reference State (1) combined with a mechanical or chemical sagebrush treatment. Most probable restoration pathway is from Big Sagebrush/Rhizomatous Wheatgrass Community (2.1) to the Bunchgrass Community (1.3). 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). Seeding may be needed to acheive desired results, if seedbank has been depleted.

Conservation practices

Brush Management
Prescribed Grazing

Transition T2A
State 2 to 3

The driver for transition from the Grazing Resistant State to the Eroded State (T2-3) is continuous high intensity early season grazing from the Big Sagebrush/Rhizomatous Wheatgrass Community (2-1). Examples include calving pastures and small acreage

horse pastures where rotational grazing is not employed, and stocking densities are high. Extended drought periods accelerate this transition. Indicators include very old sagebrush stands with very little understory between the sagebrush canopy. Bare ground patch sizes are very large (>6 foot gap size between all perennial plants comprising >30% of the transect) and comprise the majority of the interspaces between sagebrush plants.

Transition T2B
State 2 to 4

The driver for transition from the Grazing Resistant State to the Disturbed State (T2-4) is an increase in the disturbance cycle (i.e. grazing, drought, fire, mechanical, chemical, biological treatments) combined with continuous high intensity grazing. Examples include calving pastures and small acreage horse pastures where rotational grazing is not employed combined with sagebrush treatment (mechanical, chemical, or biological). High stocking densities are soil disturbing, and adding sagebrush treatment(s) to this regime result in a an increase in the disturbance cycle. 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, soil erosion, soil crusting, and decrease of soil surface aggregate stability. Indicators of the Disturbed state are a shift in shrub dominance away from sagebrush and toward sprouting shrubs such as green rabbitbrush (*Chrysothamnus viscidiflorus*).

Transition T2C
State 2 to 5

The driver for transition from the Grazing Resistant to the Highly Disturbed State (T2-5) is a topsoil removing event with mechanical equipment. Examples include construction sites, oil and gas activity, and borrow areas.

Restoration pathway R3A
State 3 to 1

The Eroded State (3) has lost soil or vegetation attributes to the point that recovery to the Reference State (1) will require a combination of grazing management (changing season of use to allow frequent rest or deferment during the critical growth period) and chemical, biological or mechanical treatments, and reseeding. Seeding may be cost prohibitive as a restoration practice used alone. With reduced organic matter and loss of soil, soil amendments and/or mulch may be needed for restoration success. Restoration has occurred by mowing without re-seeding, but the grazing regime in this instance is low stocking density and winter only use.

Conservation practices

Brush Management

Range Planting
Prescribed Grazing

Restoration pathway R3B
State 3 to 2

Restoration from the Eroded State (3) to the Grazing Resistant State (2) is possible with mechanical, biological and chemical treatments and 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, and may require successive wet years. This restoration pathway is often unintentionally achieved when the goal is the Reference State (1) because post-treatment management is not sustained in a manner that allows frequent critical growth period rest and/or use levels and recovery periods are not adequate to sustain mid-stature bunchgrasses.

Conservation practices

Brush Management
Prescribed Grazing

Transition T3A
State 3 to 4

The driver for transition to the Disturbed State (4)is a sagebrush killing event with continuous high intensity early season grazing. The event could be severe drought, flooding, insects, disease, or a sagebrush treatment such as mechanical (including heavy equipment/construction or a mowing/chaining/harrow type sage treatment), chemical (including 2,4-D or tebuthiron), 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 (3) is characterized by monotypic decadent sagebrush stands because they are fireproof.

Transition T3B
State 3 to 5

The driver for transition to the Highly Disturbed State (5) is a topsoil removing event with mechanical equipment, but it can also occur after severe drought, extended periods of saturated soils, insects, or disease kills sagebrush, leaving the site with no perennial vegetation. Examples include construction sites, oil and gas activity, and borrow areas. Evidence of climate as a cause for this transition has been captured after the 2002 and 2012 drought (Clause & Randall, 2015).

Transition T4A
State 4 to 5

The driver for transition to Highly Disturbed State (5) includes chemical and/or mechanical disturbance that removes existing vegetation.

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. 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 and are abandoned 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 19. 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**			50–100	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	25–75	5–15
	squirreltail	ELEL5	*Elymus elymoides*	25–75	5–15
	needle and thread	HECO26	*Hesperostipa comata*	0–25	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	0–25	0–5
2	**Rhizomatous Grasses**			40–75	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	40–75	5–15
3	**Misc. Grasses/Grasslikes**			25–50	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–25	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	0–25	0–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–25	0–5
	Montana wheatgrass	ELAL7	*Elymus albicans*	0–25	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	5–25	1–5
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–25	0–5
	Grass, perennial	2GP	*Grass, perennial*	0–25	0–5
Forb					
4	**Perennial Forbs**			25–45	
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–25	0–5

	pussytoes	ANTEN	*Antennaria*	0–25	0–5
	milkvetch	ASTRA	*Astragalus*	0–25	0–5
	buckwheat	ERIOG	*Eriogonum*	5–25	1–5
	beardtongue	PENST	*Penstemon*	0–25	0–5
	spiny phlox	PHHO	*Phlox hoodii*	5–25	1–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–25	0–5
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–25	0–5
	aster	SYMPH4	*Symphyotrichum*	0–25	0–5
	clover	TRIFO	*Trifolium*	0–25	0–5
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	0–15	0–3
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–15	0–3
	cryptantha	CRYPT	*Cryptantha*	0–15	0–3
	fleabane	ERIGE2	*Erigeron*	0–15	0–3
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–15	0–3
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	5–15	1–3
	desertparsley	LOMAT	*Lomatium*	0–15	0–3
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–15	0–3
	rayless tansyaster	MAGR2	*Machaeranthera grindelioides*	0–15	0–3
	Indian paintbrush	CASTI2	*Castilleja*	0–15	0–3
	sandwort	ARENA	*Arenaria*	0–15	0–3
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–5	0–1
	sagebrush buttercup	RAGL	*Ranunculus glaberrimus*	0–5	0–1
	rockcress	ARABI2	*Arabis*	0–5	0–1
	larkspur	DELPH	*Delphinium*	0–5	0–1
	deathcamas	ZIGAD	*Zigadenus*	0–5	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–5	0–1
5	**Annual Forbs**			0–5	
	Forb, annual	2FA	*Forb, annual*	0–5	0–1

	rockjasmine	ANDRO3	*Androsace*	0–5	0–1
	goosefoot	CHENO	*Chenopodium*	0–5	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–5	0–1
	western tansymustard	DEPI	*Descurainia pinnata*	0–5	0–1
Shrub/Vine					
6	**Shrubs**			90–175	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	90–175	20–25
7	**Misc Shrub**			25–50	
	spiny hopsage	GRSP	*Grayia spinosa*	0–25	0–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–25	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–25	0–5
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–25	0–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–25	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	5–25	1–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–25	0–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–25	0–5
	shadscale saltbush	ATCO	*Atriplex confertifolia*	0–25	0–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–25	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	5–25	1–5
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–5	0–1

Table 20. 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**			65–125	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	50–100	10–20
	squirreltail	ELEL5	*Elymus elymoides*	50–100	10–20
	needle and thread	HECO26	*Hesperostipa comata*	0–25	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	0–25	0–5

2	**Rhizomatous Grasses**			40–75	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	25–75	5–15
3	**Misc Grasses/Grasslikes**			25–50	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–25	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	0–25	0–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–25	0–5
	Montana wheatgrass	ELAL7	*Elymus albicans*	0–25	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	5–25	1–5
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–25	0–5
	Grass, perennial	2GP	*Grass, perennial*	0–25	0–5
Forb					
4	**Perennial Forbs**			25–45	
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–25	0–5
	milkvetch	ASTRA	*Astragalus*	0–25	0–5
	buckwheat	ERIOG	*Eriogonum*	5–25	1–5
	clover	TRIFO	*Trifolium*	0–25	0–5
	spiny phlox	PHHO	*Phlox hoodii*	5–25	1–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–25	0–5
	aster	SYMPH4	*Symphyotrichum*	0–25	0–5
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	5–15	1–3
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–15	0–3
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–15	0–3
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	5–15	1–3
	desertparsley	LOMAT	*Lomatium*	0–15	0–3
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–15	0–3
	rayless tansyaster	MAGR2	*Machaeranthera grindelioides*	0–15	0–3
	beardtongue	PENST	*Penstemon*	0–15	0–3

	beardtongue	PENST	*Penstemon*	0–15	0–3
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–15	0–3
	cryptantha	CRYPT	*Cryptantha*	0–15	0–3
	sandwort	ARENA	*Arenaria*	0–15	0–3
	fleabane	ERIGE2	*Erigeron*	0–15	0–3
	Indian paintbrush	CASTI2	*Castilleja*	0–15	0–3
	pussytoes	ANTEN	*Antennaria*	0–15	0–3
	rockcress	ARABI2	*Arabis*	0–5	0–1
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–5	0–1
	larkspur	DELPH	*Delphinium*	0–5	0–1
	deathcamas	ZIGAD	*Zigadenus*	0–5	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–5	0–1
	sagebrush buttercup	RAGL	*Ranunculus glaberrimus*	0–5	0–1
5	**Annual Forbs**			0–5	
	Forb, annual	2FA	*Forb, annual*	0–5	0–1
	rockjasmine	ANDRO3	*Androsace*	0–5	0–1
	goosefoot	CHENO	*Chenopodium*	0–5	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–5	0–1
	western tansymustard	DEPI	*Descurainia pinnata*	0–5	0–1
Shrub/Vine					
6	**Shrubs**			65–125	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	65–125	15–20
7	**Misc Shrubs**			35–75	
	shadscale saltbush	ATCO	*Atriplex confertifolia*	5–25	1–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–25	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	5–25	1–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–25	0–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–25	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–25	0–5
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–25	0–5
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–25	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	5–25	1–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–25	0–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–5	0–1
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–5	0–1

Table 21. 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**			90–175	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	75–150	15–30
	squirreltail	ELEL5	*Elymus elymoides*	75–150	15–30
	needle and thread	HECO26	*Hesperostipa comata*	5–75	1–15
	Sandberg bluegrass	POSE	*Poa secunda*	0–25	0–5
2	**Rhizomatous Grasses**			25–50	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	25–50	5–10
3	**Misc Grasses/Grasslikes**			40–75	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–25	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	0–25	0–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–25	0–5
	Montana wheatgrass	ELAL7	*Elymus albicans*	0–25	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	5–25	1–5
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–25	0–5
	Grass, perennial	2GP	*Grass, perennial*	0–25	0–5
Forb					
4	**Perennial Forbs**			25–45	
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–25	0–5
	pussytoes	ANTEN	*Antennaria*	0–25	0–5

	clover	TRIFO	*Trifolium*	0–25	0–5
	milkvetch	ASTRA	*Astragalus*	0–25	0–5
	Forb, perennial	2FP	*Forb, perennial*	0–25	0–5
	buckwheat	ERIOG	*Eriogonum*	5–25	1–5
	beardtongue	PENST	*Penstemon*	0–25	0–5
	spiny phlox	PHHO	*Phlox hoodii*	5–25	1–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–25	0–5
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–25	0–5
	aster	SYMPH4	*Symphyotrichum*	0–25	0–5
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	5–15	1–3
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–15	0–3
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	5–15	1–3
	desertparsley	LOMAT	*Lomatium*	0–15	0–3
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–15	0–3
	rayless tansyaster	MAGR2	*Machaeranthera grindelioides*	0–15	0–3
	Indian paintbrush	CASTI2	*Castilleja*	0–15	0–3
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–15	0–3
	cryptantha	CRYPT	*Cryptantha*	0–15	0–3
	fleabane	ERIGE2	*Erigeron*	0–15	0–3
	rockcress	ARABI2	*Arabis*	0–15	0–3
	sandwort	ARENA	*Arenaria*	0–5	0–1
	larkspur	DELPH	*Delphinium*	0–5	0–1
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–5	0–1
	deathcamas	ZIGAD	*Zigadenus*	0–5	0–1
	sagebrush buttercup	RAGL	*Ranunculus glaberrimus*	0–5	0–1
5	**Annual Forbs**			0–5	
	Forb, annual	2FA	*Forb, annual*	0–5	0–1
	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
Shrub/Vine					
6	**Shrubs**			35–75	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	35–75	1–15
7	**Misc Shrubs**			40–75	
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–25	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	5–25	1–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–25	0–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–25	0–5
	shadscale saltbush	ATCO	*Atriplex confertifolia*	5–25	1–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–25	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	5–25	1–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–25	0–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–25	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–25	0–5
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–25	0–5
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–5	0–1

Table 22. 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**			12–20	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–20	0–5
	squirreltail	ELEL5	*Elymus elymoides*	4–20	1–5
	needle and thread	HECO26	*Hesperostipa comata*	4–20	1–5
	Sandberg bluegrass	POSE	*Poa secunda*	0–20	0–5
2	**Rhizomatous Grasses**			52–80	

	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	52–80	10–20
3	**Misc Grasses/Grasslikes**			24–40	
	Sandberg bluegrass	POSE	*Poa secunda*	20–40	5–10
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	4–20	1–5
	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
	Montana wheatgrass	ELAL7	*Elymus albicans*	4–20	1–5
	muttongrass	POFE	*Poa fendleriana*	4–20	1–5
Forb					
4	**Forbs**			20–36	
	pussytoes	ANTEN	*Antennaria*	0–20	0–5
	rockcress	ARABI2	*Arabis*	0–20	0–5
	buckwheat	ERIOG	*Eriogonum*	4–20	1–5
	spiny phlox	PHHO	*Phlox hoodii*	4–20	1–5
	aster	SYMPH4	*Symphyotrichum*	0–20	0–5
	Forb, perennial	2FP	*Forb, perennial*	0–20	0–5
	clover	TRIFO	*Trifolium*	0–20	0–5
	fleabane	ERIGE2	*Erigeron*	0–12	0–3
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–12	0–3
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–12	0–3
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–12	0–3
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–12	0–3
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–12	0–3
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–12	0–3
	sandwort	ARENA	*Arenaria*	0–12	0–3

	lesser rushy milkvetch	ASCO12	*Astragalus convallarius*	0–12	0–3
	milkvetch	ASTRA	*Astragalus*	0–12	0–3
	Indian paintbrush	CASTI2	*Castilleja*	0–4	0–1
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–4	0–1
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–4	0–1
	larkspur	DELPH	*Delphinium*	0–4	0–1
	desertparsley	LOMAT	*Lomatium*	0–4	0–1
	rayless tansyaster	MAGR2	*Machaeranthera grindelioides*	0–4	0–1
	beardtongue	PENST	*Penstemon*	0–4	0–1
	sagebrush buttercup	RAGL	*Ranunculus glaberrimus*	0–4	0–1
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	0–4	0–1
	deathcamas	ZIGAD	*Zigadenus*	0–4	0–1
5	**Annual Forbs**			0–4	
	Forb, annual	2FA	*Forb, annual*	0–4	0–1
	rockjasmine	ANDRO3	*Androsace*	0–4	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–4	0–1
	goosefoot	CHENO	*Chenopodium*	0–4	0–1
	western tansymustard	DEPI	*Descurainia pinnata*	0–4	0–1
Shrub/Vine					
6	**Shrubs**			116–180	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	116–180	20–30
7	**Misc Shrbs**			28–40	
	shadscale saltbush	ATCO	*Atriplex confertifolia*	0–20	0–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–20	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–20	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–20	0–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–20	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–20	0–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–20	0–5

	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–20	0–5
	Nuttall's horsebrush	TENU2	*Tetradymia nuttallii*	0–20	0–5
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–4	0–1
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–4	0–1
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–4	0–1
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–4	0–1

Animal community

LIvestock:
The following table lists suggested 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*
(lb./ac) (AUM/AC) (AC/AUM)
Big Sagebrush/Bunchgrass (Reference) 300-500-700 (.06) (16)
Bunchgrass/Big Sagebrush 300-500-700 (.07) (14)
Bunchgrass 300-500-700 (.08) (13)
Big Sagebrush/Rhizomatous Wheatgrass 200-400-600 (.03) (33)
Rhizomatous Wheatgrass/Big Sagebrush 200-400-600 (.06) (17)
Big Sagebrush/*Bare Ground* 100-300-400 (.01) (100)
Rabbitbrush/Rhizomatous Wheatgrass 200-400-600 (.04) (25)
Annuals/*Bare Ground* (.01) (100)
Reclaimed (.08) (13)
* - 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 Loamy (Ly) ecological site in the Green River Basin, LRU B, in MLRA 34A, Cool Central Desertic Basins and Plateaus provides suitable and valuable habitat to an array of wildlife species. including, but not limited to, suitable food, thermal, and escape cover for mule deer, elk, and pronghorn antelope. Sagebrush, which can approach 15% protein and 40-60% digestibility, provides important winter forage for the greater sage-grouse, mule deer, and antelope. Year-round habitat is provided for sage grouse and many other sagebrush obligate species such as the sage sparrow, Brewer’s sparrow, sage thrasher, pygmy rabbit, sagebrush vole, horned lizard, and pronghorn antelope. Other birds that would frequent this plant community include horned larks and golden eagles. (Stiver, Rinkes, & Naugle, 2010)
Reference State:
1.1 Big Sagebrush/Bunchgrass: This community phase provides optimal winter habitat for sage-grouse, mule deer, pronghorn, and other species that depend on shrubs that stand up through the snow for forage. A diverse suite of herbaceous species also provide important micro-nutrient requirements for big game species throughout the year. These areas also provide high quality bird nesting habitat where sagebrush canopy and residual bunchgrasses hide nests and young from predators.
1.2 Bunchgrass/WY Big Sagebrush: This community phase tends to have higher herbaceous plant diversity that may attract more diverse wildlife use. The plant community 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 sage-grouse broodrearing habitat. It also provides high quality habitat for mule deer and pronghorn as they transition between winter and summer ranges.
1.3 Bunchgrass: This community phase provides foraging habitat for sagegrouse 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. Forb diversity is beneficial to mule deer and pronghorn during transition between winter

and summer ranges. It also provides suitable habitat for burrowing animals.
Grazing Resistant State:
2.1 Big Sagebrush/Rhizomatous Wheatgrass: This community phase 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 herbaceous understory provides cover for nesting birds and small mammals. In periods of drought and low plant vigor, the herbaceous understory is short and not dense enough to provide adequate cover and habitat value declines. Diversity is low, and mat-forming forbs often occupy the space and nutrients needed for more desirable forbs such as globemallow, milkvetch, and penstemons.
2.2 Rhizomatous Wheatgrass: This community phase is variable in its value to wildlife. Value is low for species dependent on sagebrush unless in close proximity to areas with sagebrush cover. In periods of high plant vigor, herbaceous species provide cover for some birds and small mammals. In periods of drought and low plant vigor, the herbaceous community is often too short and not dense enough to provide adequate cover and habitat. Plant and animal diversity is low.
Eroded State:
3.1 Big Sagebrush/*Bare Ground*: This community phase provides suitable winter habitat for foraging big game and sagegrouse when sagebrush is in a healthy state and stands above winter snows. The lack of herbaceous species limits the value of the site 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.
Disturbed State:
4.1 Rabbitbrush/Rhizomatous wheatgrass: This community phase is capable of producing a high number of insects which are important for pollination and bird forage. Rabbitbrush, depending on the sub-species present, can be used heavily by wintering and transitional big game, especially when other preferred winter forages are unavailable or in poor vigor due to over-use or drought. This state is vulnerable to repeated disturbance which can result in a complete loss of value for wildlife. In addition, sites in this state are more susceptible to invasion of non-native species, further degrading the value for wildlife.
Highly Disturbed State:
5.1 Annuals/*Bare Ground*: This community phase is dominated by annuals and bare ground which hold little value for wildlife due to the lack of suitable forage and cover. Furthermore, weedy species can migrate into adjacent areas, degrading wildlife habitat in adjacent areas.
5.2 Reclaimed: This community phase is highly variable in its value to wildlife. Reclamation success, size and configuration of the reclaimed area, the species planted, and the time it takes for plants to establish will determine the value of the site for wildlife. A fully reclaimed site containing a diversity of herbaceous and woody native plants can eventually provide the same wildlife habitat benefits as the reference state. In most cases, grasses and forbs establish early in the reclamation process, whereas shrubs take significantly longer to establish. Wildlife species dependent on herbaceous plant communities for forage (elk, prairie dogs, and fox) will benefit from reclamation sooner than those species dependent on a mixed shrub/grass community. Suitable habitat for wildlife species that require tall, dense sagebrush (wintering sage-grouse, pronghorn,

mule deer, and sagebrush obligate songbirds) is likely possible within a decade, providing appropriate shrub species were planted. It is possible to achieve successful, diverse reclamation on linear disturbances (i.e. pipelines) without seeding shrubs, but it will take longer than a decade for seed from shrubs adjacent to the area to established on-site.

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 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, with only slight movement to leeward side of shrubs. Chemical crusts do not exist. Soil biological crusts are common.

Recreational uses

This site provides some limited 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, unfragmented landscapes.

Wood products

None

Other products

None

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Contributors

Karen J. Clause
Bryan Christensen

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)	Wyoming NRCS Wyoming BLM Wyoming State Lands Sublette County Conservation District Wyoming Game and Fish Department Karen Clause, WY NRCS Dan Perkins, NRCS Dan Mattke, WY NRCS Bob Price, BLM Lacey Andersen, WY BLM Mike Henn, WY State Lands Stacie Thompson, WY State Lands Loren Racich, SCCD Jill Randall, WYG&F
Contact for lead author	Bryan Christensen MLRA 34A SSO 1652 Pine Street Pinedale, WY 82941 307-367-2257 bryan.christensen@wy.usda.gov
Date	09/30/2015
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Not common, but can be present, particularly at the upper end of the slope range or after heavy thunderstorms. When present, rills are short (<3 ft), shallow (<1 inch), and widely spaced (>20 ft) relative to slope distance.

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2. **Presence of water flow patterns:** Water patterns can be present, but are very small and not connected beyond 2 gaps in the plant canopy.

3. **Number and height of erosional pedestals or terracettes:** Existing pedastals are blunt and not active, less than 2 inches (5cm) and typically found at the drip line of the shrub canopy or bases of bunchgrasses on upper end of the slope range. It is typical to find biological soil crusts, lichens, and mosses at margins of perennial plants. 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%. 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 on this site.

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 are typical when sample include soil biological crusts, but are oten 1 when a sandy loam cap exists on the site. When consistent values of 6 are encountered, it is important to consider if the soil surface has degraded to the argillic subsurface layer (higher clay content will result in higher soil stability). 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 3-12 inches (7-30 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.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The reference state consists of 45-60% grasses, 5-10% forbs, and 5-45% shrubs composition by dry weight. The sagebrush canopy is evenly distributed with cover ranging from 5-25%. 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 infiltration rates resulting in minimal runoff. Basal cover is typically less than 5% for this site and does very little to effect runoff on this site.

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** No compaction layer should be present. A coarse, dry subsurface (sandy clay loam) will often refuse a probe, causing misidentification of a compaction layer. Most soil profiles must be described by hand dug holes.

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

    Dominant: 1.1) sagebrush
    1.2) mid-size, cool season bunchgrasses=sagebrush
    1.3) mid-size, cool season bunchgrasses

    Sub-dominant: 1.1) mid-size, cool season bunchgrasses
    1.2) rhizomatous grasses=short, cool season bunchgrasses

1.3) sprouting shrubs

Other: 1.1) rhizomatous grasses=short, cool season bunchgrasses>perennial forbssprouting shrubs>>annual forbs
1.2) perennial forbs=sprouting shrubsannual forbs
1.3) rhizomatous grasses=short, cool season bunchgrassessagebrush=perennial forbsannual forbs

Additional: Biologial soils crusts (lichens and mosses) are important to function/structure of this site.
After shrub killing events like insect outbreaks, extended periods of saturated soils, or severe drought (>3 years of below average effective precipitation), sagebrush may be temporarily reduced with a relative increase in sprouting shrubs.

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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 (<10%), except after insect outbreaks, extended periods of saturated soils, or severe drought.

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14. **Average percent litter cover (%) and depth (in):** Litter ranges from 15-35% of total canopy measurement (first hit LPI) with total litter (including beneath the plant canopy) 30-65% expected. Herbaceous litter depth is typically very shallow, approximately 1-2mm. Coarse woody litter can be up to a couple inches in diameter (4-6cm), but is sporadically distributed.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** English: 300-700 lb/ac (500 lb/ac average); Metric: 336-785 kg/ha (560 kg/ha average).

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16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought**

or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site: Bare ground greater than 50% is the most common indicator of a threshold being crossed.
Greasewood commonly invades this site when adjacent to a drainage bottom. Annual invasive species such as cheatgrass and halogeton can occur on disturbed sites. Alyssum, flixweed (tansymustard), kochia, Russian thistle, and lambsquarter are introduced annuals that can become weedy after disturbances.

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17. **Perennial plant reproductive capability:** All species are capable of reproducing, except in drought years. Thickspike wheatgrass will commonly reproduce by underground rhizomes and rarely by seed production.
