USDA Natural Resources Conservation Service

Ecological site DX034A02X126
Loamy Calcareous Pinedale Plateau (LyCa PP)

Last updated: 9/28/2023
Accessed: 05/18/2024

General information

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

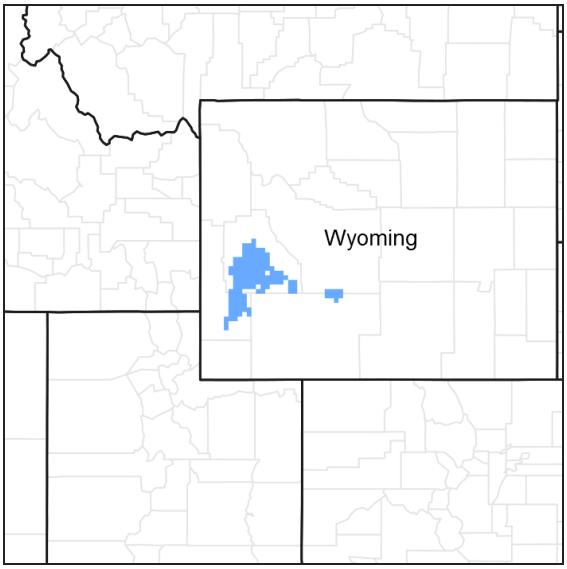


Figure 1. Mapped extent

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

Site Name: Loamy Calcareous Pinedale Plateau

Site Type: Rangeland

Site ID: R034AC126WY

Precipitation or Climate Zone: 9-12” P.Z.

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

Land Resource Unit (LRU) C (Pinedale Plateau):
• Moisture Regime: aridic ustic
• Temperature Regime: frigid, cool
• Dominant Cover: rangeland

• Representative Value (RV) Effective Precipitation: 9-12 inches
• RV Frost-Free Days: 30-60 days

Classification relationships

Site Name: Loamy Calcareous Pinedale Plateau
Site Type: Rangeland
Site ID: R034AC126WY
Precipitation or Climate Zone: 9-12” P.Z.
Relationship to Other Established Classification Systems
National Vegetation Classification System (NVC):
3 Semi-Desert
3.B.1 Cool Semi-Desert Scrub & Grassland
D040 Western North American Cool Semi-Desert Scrub & Grassland
M169 Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe Group
CEGL001011 *Artemisia tridentata*/*Achnatherum lettermanii* 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 additional water.
• Soils are:
o non-saline, non-sodic, and non-saline-sodic.
o Moderately deep, deep, or very deep
o slight to no effervescence in surface mineral 6” (14 cm)
o have a CCE of 0-5% within top 10” and >15% CCE below
o surface textures most commonly gravelly loam, but range from fine sandy loam to a light clay loam
o site has a “strong” diagnostic calcic horizon within 10-20 inches of the surface mineral
• Slope is 0-15%
• Clay content is <32% in surface mineral 6”
• Site does not exceed 35% clay in the argillic horizon
• The concept of this site is based on having a very strong diagnostic calcic horizon (an illuvial horizon in which secondary carbonate or other carbonates have accumulated to a significant extent and also the presence (>20%) of nodules or concretions that are strongly cemented or greater), but does not have the presence of secondary or possibly primary carbonates at the surface (non-effervescent in the upper 5 inches of the profile). A similar site is the Limy site, which is strongly to violently effervescence to the soil surface and does not have the presence of a well-developed diagnostic calcic horizon. The reference state is a Wyoming Big Sagebrush/Bunchgrass plant community and with mismanagement or corrected management responds differently than the Loamy site in its potential plant community dynamics and productivity.

Associated sites

DX034A02X122	**Loamy Pinedale Plateau (Ly PP)**
DX034A02X124	**Loamy Argillic Pinedale Plateau (LyA PP)**
DX034A02X150	**Sandy Pinedale Plateau (Sy PP)**

Similar sites

DX034A02X122	**Loamy Pinedale Plateau (Ly PP)** Is higher in production and lacks the calcic horizon in the top 10-20 inches of the soil profile
DX034A01X126	**Loamy Calcareous Green River Basin (LyCa GRB)** Has similar soil characteristics, but is drier and slightly warmer

R034AY162WY	**Shallow Loamy Green River and Great Divide Basins (SwLy)** Is similar in production and was previously correlated to these soils, but the soil description was to general (acting shallow or skeletal) and the climate information was too dry and slightly warmer

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata subsp. wyomingensis*
Herbaceous	(1) *Achnatherum hymenoides* (2) *Achnatherum lettermanii*

Legacy ID

R034AC126WY

Physiographic features

The Loamy Calcareous Pinedale Plateau (LyC PP) ecological site (R034AC126WY) is located MLRA “34.” This ecological site occurs in intermontane basin landscapes on hill, draw, pediment, and fan remnant landforms (see definitions below). The slope ranges from level to 15%. This site occurs on all aspects.
fan remnant – A general term for landforms that are the remaining parts of older fan-landforms, such as alluvial fans, fan aprons, inset fans, and fan skirts, that either have been dissected (erosional fan-remnants) or partially buried (nonburied fan-remnants). An erosional fan remnant must have a relatively flat summit that is a relict fan-surface.
intermontane basin – A generic term for wide structural depressions between mountain ranges that are partly filled with alluvium and called "valleys" in the vernacular.
hills – A landscape dominated by hills and associated valleys. The landform term is singular (hill).

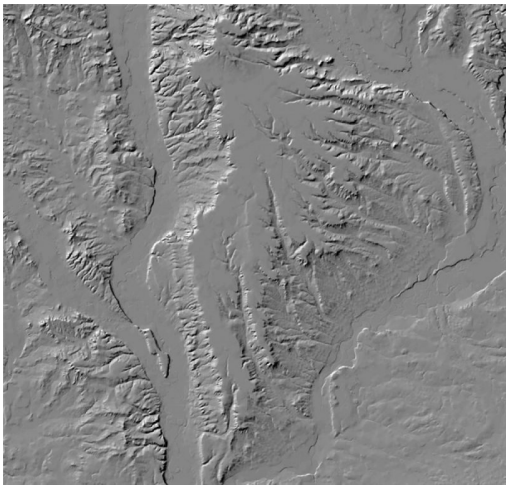


Figure 2. Hill, Fan Remnant

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Fan remnant
Flooding frequency	None
Ponding frequency	None
Elevation	1,981–2,286 m
Slope	0–15%
Water table depth	152 cm
Aspect	Aspect is not a significant factor

Climatic features

Annual precipitation ranges from 9-12 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 (1.69 inches). The growing season is short (<60 day) and cool (critical growth period): 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)	36 days
Freeze-free period (average)	64 days
Precipitation total (average)	279 mm

Climate stations used

- (1) BOULDER REARING STN [USC00480951], Boulder, WY
- (2) PINEDALE [USC00487260], Pinedale, 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 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.

Major Soil Series correlated to this site includes: Jemdilon, Forelle, and Fonce series.

Other Soil Series correlated to this site in MLRA 34A include: Maysprings, Cushool, Voldseth, Bluerim, Fluetsch, and Ferbal series.
Typical taxonomy: Fine-loamy Calcic Haplustalf

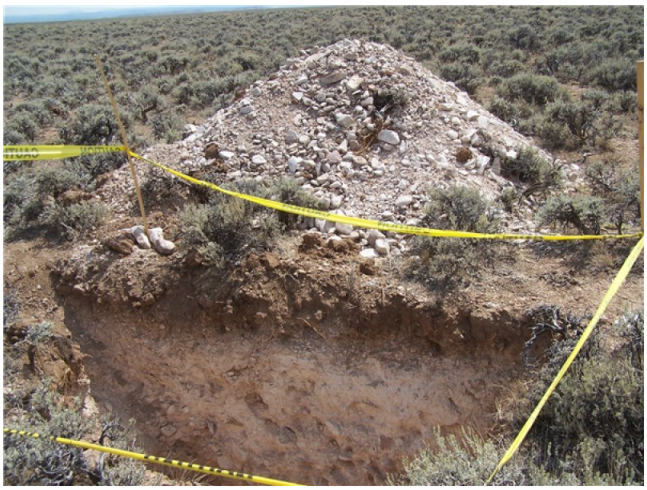


Figure 7. Soil Pit

Table 4. Representative soil features

Parent material	(1) Residuum–sandstone and shale (2) Slope alluvium–calcareous siltstone
Surface texture	(1) Gravelly loam (2) Sandy clay loam (3) Clay loam
Family particle size	(1) Loamy
Drainage class	Moderately well drained to well drained
Permeability class	Moderate to moderately rapid
Soil depth	152 cm
Surface fragment cover <=3"	0–20%
Surface fragment cover >3"	0–35%
Available water capacity (0-101.6cm)	15.24–18.29 cm
Calcium carbonate equivalent (0-101.6cm)	15–50%
Electrical conductivity (0-101.6cm)	0–4 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–5
Soil reaction (1:1 water) (0-101.6cm)	7.4–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–30%
Subsurface fragment volume >3" (Depth not specified)	0–50%

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), *Bare Ground* State (3), Disturbed State (4), and Highly Disturbed State (5).

The Reference State is a collection of 3 distinct Plant Communities that exist on a continuum relative to disturbances, primarily grazing, pests, drought, and fire 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 Letterman's needlegrass (*Achnatherum lettermanii*) Indian Ricegrass (*Achnatherum hymenoides*) and Needleandthread (*Hesperostipa comata*) with bluebunch wheatgrass (*Pseudoroegneria spicata*), bottlebrush squirreltail (*Elymus elymoides*), mutton bluegrass (*Poa fendleriana*), and rhizomatous grasses like thickspike wheatgrass (*Elymus lanceolatus* ssp. lanceolatus) as a subdominant. Minor components include short-statured bunchgrasses such as Sandberg bluegrass perennial forbs, and shrubs, including green rabbitbrush (Chrysothamnus viscidiflorus).

After a sagebrush killing disturbance, the 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 to be fairly infrequent on this site.
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. Low stature bunchgrasses and rhizomatous grasses tolerate higher grazing pressure and grow on less fertile soils (Natural Resouces Conservation Service, 2007) than mid stature bunchgrasses. They often fill in the vegetation gaps created when mid stature bunchgrasses decline, hence, collectively referred to as increaser species.
Big sagebrush, is the dominant shrub on this site. Most often Wyoming big sagebrush is the sub-species present, but this transitions to mountain big sagebrush (*Artemisia tridentata* ssp. vaseyana) at the upper end of the precipitation range for this site (12+ inches). Snow catchment is a significant hydrologic component of this site, and the hydrology changes when shrubs are removed from this site.

Chemical treatment of shrubs have replaced natural sagebrush killing events on many sites in the area. However, chemical treatments impact non-target species, particularly broad-leafed species (forbs and shrubs) differently than natural events such as drought, herbivory, disease, or fire. Where fire tends to result in a short-term increase in forbs, some chemical treatments result in a short-term (or medium-term) reduction in forb density and diversity. Some chemical treatments without grazing management pre- or post-treatment have resulted in transition to alternate States, such as the Disturbed State.

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 cattle. In fact, early grazers established a "Deadline" from Fontenelle Creek across the desert to the Big Sandy River and sheep grazing was not allowed north of this line. Sheep crossing the line often died of plant poisoning from plants that were left lying along the boundary line by cattlemen (Sommers, 1994).

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

The most prevalent noxious weed in the Pinedale Plateau LRU is Canada thistle (*Cirsium arvense*). It can be found in all ecological sites but is mostly associated with riparian areas and disturbances. Canada thistle invades Federal, State and private lands. Developments and disturbance of the soil usually will result in a new infestation of Canada thistle. Canada thistle is from Eurasia, it was introduced via Canada as a seed contaminate in the 18th Century. It is prevalent though out the United States as seeds are transported via wind and its aggressive rhizomatous root system sustains very dense patches. The second most prevalent noxious weed in riparian areas is perennial pepperweed (*Lepidium latifolium*). This mustard is usually found in riparian areas, but more recently has been found invading other plant communities too. The Green River and many of its tributaries have significant perennial pepperweed infestations. It is said to be introduced to the Sublette County Area as a hay contaminant, when ranches had to bring in hay from Utah, Idaho and other areas in the state during a drought in the 70's.

Another noxious mustard of concern is whitetop or hoary cress (*Cardaria draba*). This species is also found in many vegetation types within the Pinedale Plateau. It is found in irrigated hay meadows, roadsides, rangelands, but most significantly invades rangelands or fields that have had a disturbance event. This disturbance can be from over utilization of forage or native plant thinning due to drought. This deep rooted perennial mustard completes its life cycle in early summer. There are several varieties of *Cardaria draba* in the area, which are difficult to distinguish but all seem to have the same effect but bloom at different times of the summer

Plant Communities and Transitional Pathways
Thorough descriptions of each state, transition, plant community, and pathway are found after the model 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 for the Reference State. The biological processes on this site are complex; therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are used in this ESD. Foliar cover drives the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight remains an important descriptor of the herbaceous community and of site productivity as a whole. Woody species are included in species composition by weight for the site. Calculating similarity index requires use of species composition by dry weight.

Although there is considerable qualitative experience supporting the pathways and transitions within the State and Transition Model (STM), 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, et al., 2003), (Bestelmeyer, Herrick, Brown, Trujillo, & Havstad, 2004), (Bestelmeyer & Brown, State-and-transition models 101: a fresh look at vegetation change, 2005), (Stringham, Kreuger, & Shaver, 2003)

State and transition model

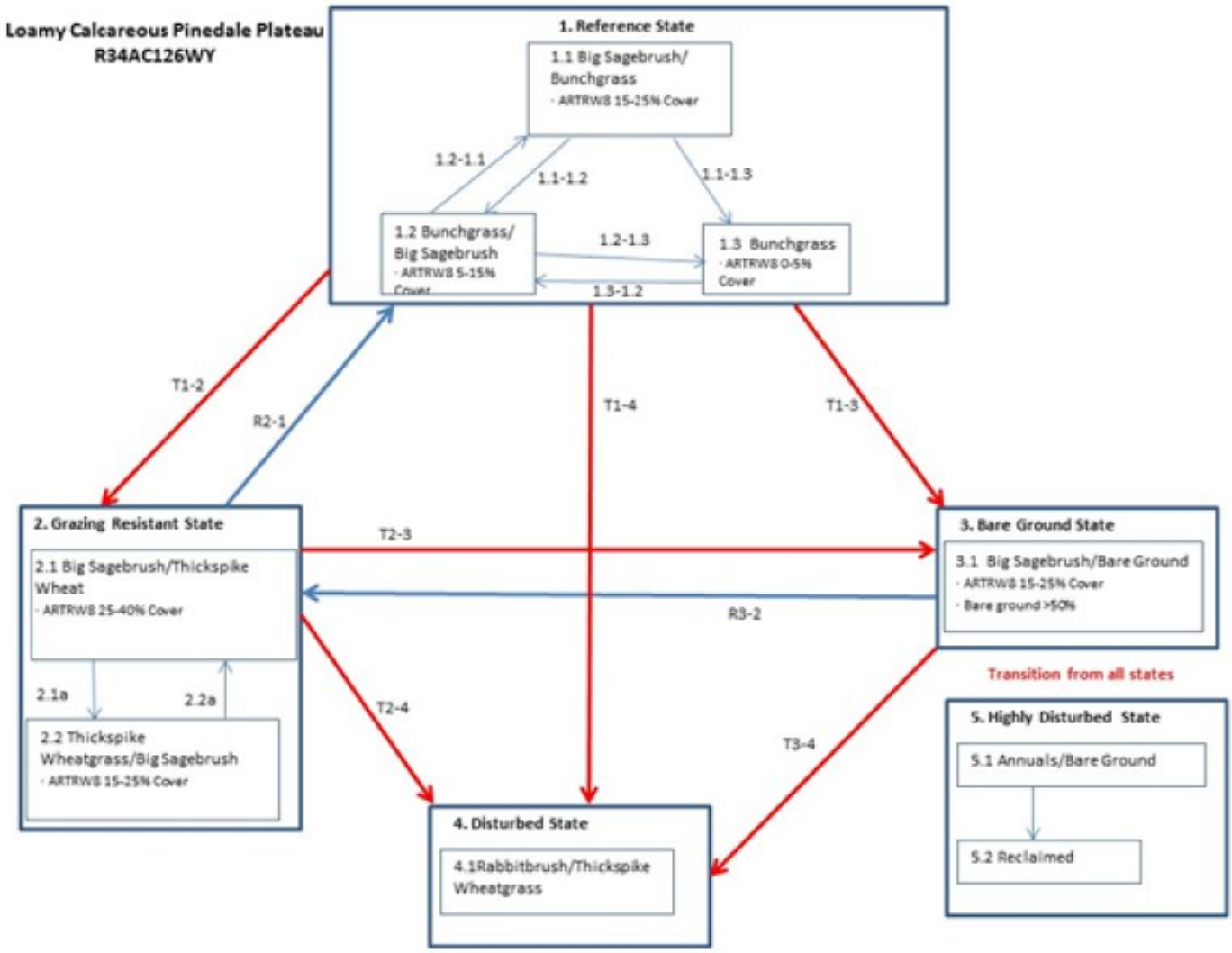

Loamy Calcareous Pinedale Plateau
R34AC126WY
1. Reference State
1.1 Big Sagebrush/ Bunchgrass
· ARTRW8 15-25% Cover
1.2-1.1
1.1-1.2
1.1-1.3
1.2 Bunchgrass/ Big Sagebrush
· ARTRW8 5-15% Cover
1.2-1.3
1.3-1.2
1.3 Bunchgrass
· ARTRW8 0-5% Cover
T1-2
R2-1
T1-4
T1-3
2. Grazing Resistant State
2.1 Big Sagebrush/Thickspike Wheat
· ARTRW8 25-40% Cover
T2-3
3. Bare Ground State
3.1 Big Sagebrush/Bare Ground
· ARTRW8 15-25% Cover
· Bare ground >50%
R3-2
Transition from all states
2.1a
2.2a
2.2 Thickspike Wheatgrass/Big Sagebrush
· ARTRW8 15-25% Cover
T2-4
T3-4
5. Highly Disturbed State
5.1 Annuals/Bare Ground
5.2 Reclaimed
4. Disturbed State
4.1Rabbitbrush/Thickspike Wheatgrass

Figure 8. STM

Figure 9. Legend

State 1
Reference

The Loamy Calcareous site potential is slightly less than the Loamy site in this LRU, due to the restrictive nature of the shallow calcic horizon that occurs in it. The Big Sagebrush/Bunchgrass Plant Community is well adapted to Cool Central Desertic Basins and Plateaus climatic conditions. The diversity in plant species allows for drought tolerance, and natural plant mortality is very low. These plants have strong, healthy root systems that allow production to increase significantly with favorable moisture conditions. Plant litter is available for soil building and moisture retention. Plant litter is properly distributed with very little movement off-site. This plant community provides for soil stability and a properly functioning hydrologic cycle. The soils associated with this site are fertile and hold moderately large amounts of soil moisture, providing a very favorable soil-water-plant relationship until reaching the limiting calcic layer. The plant community phases can occur homogeneously across a landscape, but more often in the reference state occurred in a mosaic pattern as a result of many small disturbances (Bukowski & Baker, 2013).

Community 1.1
Big Sagebrush/Bunchgrass

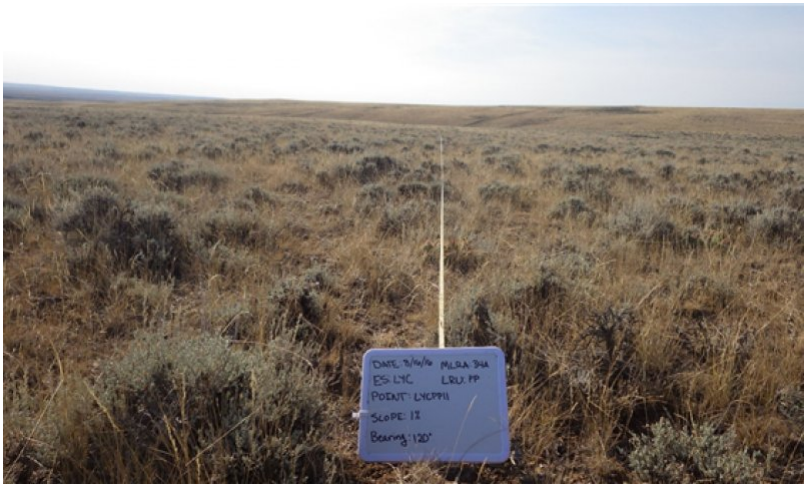


Figure 10. 1.1

Big sagebrush is dominant in the Big Sagebrush/Bunchgrass Community (1.1) with sagebrush foliar cover ranging from 15% to 25%. At this sagebrush canopy level in this precipitation zone, there is competition between the shrub overstory and the herbaceous understory (Winward, 2007). A Big Sagebrush/Bunchgrass Community with a degraded understory is an “at-risk” community, particularly when occurring homogenously across the landscape. This community can occur over long time periods without disturbances, but can be accelerated with added herbaceous grazing pressure. In the Big Sagebrush/Bunchgrass Community (1.1), there are generally few canopy gaps, and most basal gaps are moderate (3-6 feet). Rock cover on the soil surface can be as high as 5%. Most plant interspaces have canopy or litter cover. Production of grasses is much lower than in the Bunchgrass Community (1.3) and slightly lower than in the Bunchgrass/Big Sagebrush Community (1.2).

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	168	336	448
Grass/Grasslike	135	269	359
Forb	34	67	90
Total	**337**	**672**	**897**

Figure 12. Plant community growth curve (percent production by month). WY0301, 34AC, Upland Sites. All Upland Sites.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			5	40	50			5			

Community 1.2
Bunchgrass/Big Sagebrush

Figure 13. 1.2

Mid-stature bunchgrasses dominate in the Bunchgrass/Big Sagebrush Community (1.2) with sagebrush sub-dominant with cover ranging from 5% to 15%. At this sagebrush canopy level in this precipitation zone, there is little if any competition between the shrub overstory and the herbaceous understory. In fact, there is evidence to suggest that the understory receives more benefit from the sage overstory than negative effects. (Winward, 2007) In the Bunchgrass/Big Sagebrush Community (1.2), there are generally few canopy gaps, and most basal gaps are generally in the 1-2 foot category. Rock cover on the soil surface is essentially nonexistent. Many plant interspaces have canopy or litter cover. Production of grasses is slightly lower than in the Bunchgrass Community (1.3), but shrub production is higher.

Table 6. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	185	370	493
Shrub/Vine	118	235	314
Forb	34	67	90
Total	**337**	**672**	**897**

Figure 15. Plant community growth curve (percent production by month). WY0301, 34AC, Upland Sites. All Upland Sites.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			5	40	50			5			

Community 1.3
Bunchgrass

Figure 16. 1.3

The Bunchgrass Community (1.3) is dominated by mid-stature cool-season bunchgrasses mixed with a minor component of forbs and shrubs. Big sagebrush is present as a part of the community, but is minor with 0 to 5% foliar cover. The Bunchgrass Community (1.3) generally occurs immediately following a stand replacing sagebrush killing event such as moderate drought, insects, winter browse, or fire. Chemical, mechanical, and biological control can be effective tools to achieve this plant community when used in conjunction with a grazing system that alters the timing and intensity of grazing and provides periodic rest/deferment during the critical growth period.

Table 7. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	219	437	583
Shrub/Vine	84	168	224
Forb	34	67	90
Total	**337**	**672**	**897**

Figure 18. Plant community growth curve (percent production by month). WY0301, 34AC, Upland Sites. All Upland Sites.

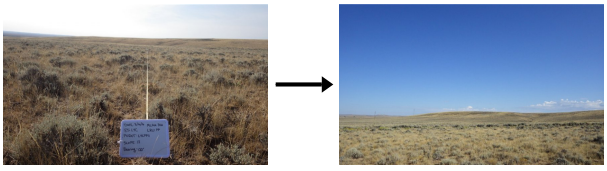
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			5	40	50			5			

Pathway 1.1-1.2
Community 1.1 to 1.2

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

The driver for community shift 1.1-1.2 is the increase in relative density and proportion of mid-stature bunchgrasses to the point that they dominate species composition by weight. The trigger for this is a sagebrush killing event, such as fire, chemical, mechanical or biological control of sagebrush that favors the existing herbaceous vegetation.

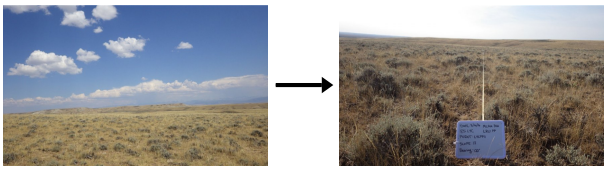
Pathway 1.1-1.3
Community 1.1 to 1.3



Big Sagebrush/Bunchgrass **Bunchgrass**

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 fire, severe drought, insect outbreak, disease, chemical, mechanical or biological control of sagebrush 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.

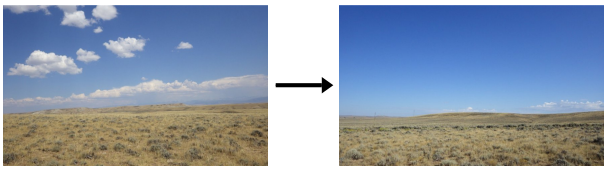
Pathway 1.2-1.1
Community 1.2 to 1.1



Bunchgrass/Big Sagebrush Big Sagebrush/Bunchgrass

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

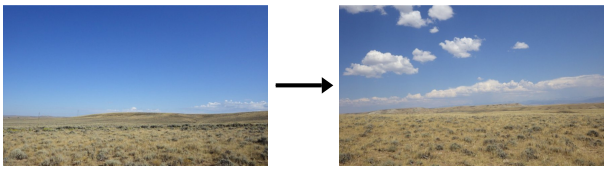
Pathway 1.2-1.3
Community 1.2 to 1.3



Bunchgrass/Big Sagebrush Bunchgrass

The driver for community shift 1.2-1.3 is the increase in density and vigor of mid-stature bunchgrasses to the point that they dominate species composition by weight. The trigger for this is a sagebrush killing event, such as fire, chemical, mechanical or biological control of sagebrush that favors the existing herbaceous vegetation.

Pathway 1.3-1.2
Community 1.3 to 1.2



Bunchgrass Bunchgrass/Big Sagebrush

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

State 2
Grazing Resistant

The Grazing Resistant State is characterized by an herbaceous component dominated by thickspike wheatgrass and Sandberg bluegrass, with limited mid-stature bunchgrasses. Once mid stature bunchgrasses become scarce, it is unlikely there will be sufficient reproductive capability (seed source, tillering, or resprouting) to recover dominance in a reasonable time frame without extra energy being added to the system (Cagney, et al., 2010). The plant community is highly resistant to changes in composition, due to the dominance and competition of established grazing resistant species. However, the community can be restored to the Reference State over time with sagebrush treatments (chemical, mechanical, or biological brush management) and grazing deferment followed by a grazing system that allows periodic rest during the critical growth period. Seeding maybe needed in some instances to achieve desired results.

Community 2.1

Big Sagebrush/Thickspike Wheatgrass

Figure 19. 2.1

Wyoming big sagebrush dominates with cover as high as 25% or higher. The dominant shrub is Wyoming big sagebrush. Areas that catch and retain snow are more likely to have higher shrub cover. Production is lower than in Reference State (1), and is highly variable, fluctuating drastically in response to drought and wet cycles. Lower soil organic matter content leads to lower soil stability than in the Reference State. Ground cover is still high. Infiltration is lower than in the Reference State and the water cycle has reduced function due to decreased soil organic matter.

Table 8. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	112	224	336
Grass/Grasslike	90	224	269
Forb	22	45	67
Total	**224**	**493**	**672**

Figure 21. Plant community growth curve (percent production by month). WY0301, 34AC, Upland Sites. All Upland Sites.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			5	40	50			5			

Community 2.2
Thickspike Wheatgrass/Big Sagebrush

Figure 22. 2.2

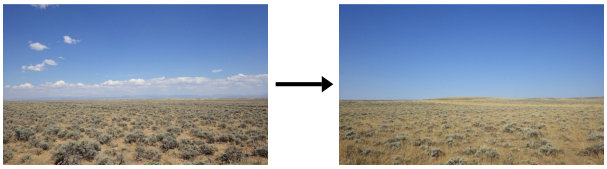
Thickspike wheatgrass (*Elymus lanceolatus* ssp. lanceolatus) dominates, and Wyoming big sagebrush foliar cover

is typically 5% to 15%. This plant community phase occurs if there is a sagebrush killing event after the herbaceous component has already been degraded. 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. Hydrologic function is impaired due to decreased infiltration.

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

Pathway 2.1-2.2
Community 2.1 to 2.2

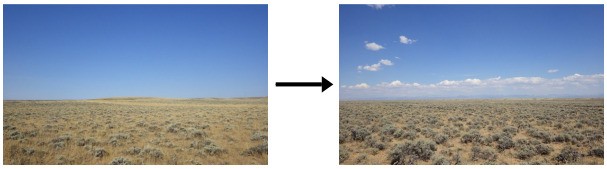


Big Sagebrush/Thickspike Wheatgrass

Thickspike Wheatgrass/Big Sagebrush

The trigger for a community shift from the Big Sagebrush/Thickspike Wheatgrass Community (2.1) to the Thickspike Wheatgrass/Big Sagebrush Community (2.2) is a sagebrush killing event such as drought, insects, and disease, chemical, mechanical or biological control of sagebrush that favors the existing herbaceous vegetation and removes sagebrush canopy along with 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 2.2-2.1
Community 2.2 to 2.1



Thickspike Wheatgrass/Big Sagebrush

Big Sagebrush/Thickspike Wheatgrass

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

State 3
Bare Ground

This state contains one community, the Big Sagebrush/*Bare Ground* Community (3.1). It is characterized by sparse herbaceous plant cover dominated by big sagebrush and bare ground. Communities in the *Bare Ground* State (3) have crossed a threshold because of soil erosion, loss of soil fertility, and/or degradation of soil properties. Soil erosion affects the hydrology, soil chemistry, soil microorganisms, and soil physics to the point where intensive restoration is required to restore the site to another state or community. Simply changing grazing management may not create sufficient change to restore the site within a reasonable period. It will require a considerable input of energy to move the site back to the Reference State (1). The *Bare Ground* State (3) is at risk of weed invasion due to the high percentage of bare ground, but climatic conditions contribute to higher resistance to invasion. This State is at risk of transitioning to the Disturbed State (4) if mechanical treatments are applied without consideration for seeding or grazing management.

Community 3.1

Big Sagebrush/Bare Ground

Figure 24. 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 grass species (e.g., Indian ricegrass, needleandthread, and Letterman's needlegrass) may exist only in patches and are typically low in vigor. This community tends to be dominated by big sagebrush (>25% cover) and bare ground often exceeds 40% in large patches in the interspaces of the shrub canopy (>6 foot canopy gap common). 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 do not exist. Therefore, fire is no longer a driver of ecological dynamics unless conditions exist (high wind, low relative humidity) to carry a fire in the sagebrush canopy. Sparse vegetation creates low levels of foliar and basal cover. This, in turn, leads to low litter production, which is combined with reduced ability to retain litter on site. Soil is exposed to wind and water erosion in the plant interspaces. These factors combine to create a decrease in soil organic matter. Reduced litter cover, combined with reduced herbaceous cover, results in higher soil temperature, poor water infiltration rates, and high evaporation, thus favoring species which are more adapted to drier conditions. Soil fertility is reduced, soil compaction is increased, and resistance to soil surface erosion has declined compared to the other states. This community has lost most, if not all, of the attributes of a functioning, healthy rangeland, including good infiltration, minimal erosion and runoff, nutrient cycling, and energy flow.

Figure 25. 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 pasture corners, gravel pits and areas repeatedly treated to kill sagebrush.

Community 4.1
Rabbitbrush/Thickspike Wheatgrass

The plant community is in a perpetual state of disturbance when maintained by frequent management activities such a livestock congregation areas, periodic mowing, dragging, or other mechanical operations. 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 catastrophic fire. 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 due to irreversible changes to soil dynamic properties (structure, organic matter, infiltration, bulk density, and/or water holding capacity) unless disturbance ceases.

Figure 26. 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 5
Highly Disturbed

All sites may transition to this state following a severe soil disturbance such as oil and gas development or surface mining extraction.

Community 5.1
Annuals/Bare Ground

The Annuals/*Bare Ground* Community (5.1) occurs after severe disturbance, most often physical soil disturbance that removes all topsoil, but it can also occur as a transition from the *Bare Ground* State (3) after severe drought, flooding, pests, 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 go through this plant community as part of the restoration process, but the time in this plant community phase is largely dependent on the use of restoration Best Management Practices (BPMs) and climate cycles. Biological soil crusts are non-existent, further exposing the soil surface to erosional forces as well as impairing carbon, nutrient, and water cycles.

Community 5.2
Reclaimed

The Reclaimed Community (5.2) 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. The most common scenario is a reclaimed oil and gas well pad planted to crested wheatgrass (*Agropyron cristatum*) 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.

Pathway 5.1-5.2
Community 5.1 to 5.2

The trigger for a community shift from the Annuals/*Bare Ground* Community (5.1) to the Reclaimed Community (5.2) 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/). Under optimal conditions reclamation can be achieved in 8-10 years, but it is not currently known if restoration to the Reference State is possible.

Transition 1-2
State 1 to 2

The drivers for transition from the Reference State to the Grazing Resistant State are continuous low intensity spring grazing and/or severe drought. Continuous spring grazing and/or drought can lead to a decline in palatable mid-stature bunchgrasses. Indian ricegrass, a short-lived perennial that requires more frequent seed production to provide an adequate seedbank, and bluebunch wheatgrass, a long-lived perennial that has elevated growth points, are typically the first species to decline (Natural Resouces Conservation Service, 2007). Needleandthread as well as Letterman’s needlegrass are 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, the pattern of bare ground will shift to larger gaps in the canopy and fewer herbaceous plants between shrubs. Many of the remaining desirable bunchgrasses will be only found in the understory of the sagebrush canopy. Once mid-stature bunchgrasses species become scarce, it is unlikely that they have sufficient reproductive capability (seed source, tillering, or resprouting) to recover dominance in a reasonable time frame without management changes and extra energy being added to the system (Cagney, et al., 2010). 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 shrub cover, but rather 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 the dry vs. wet years.

Transition 1-3
State 1 to 3

The driver for transition from the Reference State to the *Bare Ground* State is continuous high intensity/long duration grazing. Drought can accelerate this transition. Indicators of this transition include significant declines in herbaceous cover or total annual aboveground biomass production falls below 300 pounds per acre. The trigger for this transition is the loss of understory, which creates open spots with bare soil between the sagebrush canopy (>6 foot gap size). Soil erosion is accompanied by decreased soil fertility driving the transitions to the *Bare Ground* State. Several other key factors signal the approach of a threshold: an increase in soil physical crusting, a decrease in soil surface aggregate stability, and/or evidence of erosion, including water flow patterns, development of plant pedestals, and litter movement.

Transition 1-4
State 1 to 4

The driver for transition from Reference State to the Disturbed State is an increase in the disturbance cycle (i.e. grazing, drought, fire, mechanical, chemical or biological treatments) often in combination with grazing management that does not provide periodic deferment during the critical growth period. The Reference State (1) may transition to the Disturbed State (4) if multiple soil disturbing activities occur over a relative short time period, effectively decreasing the disturbance return interval. Indicators include an increase in rabbitbrush to dominant levels 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). To prevent this transition, the site will require proper reclamation using the most current science and technology available to restore native vegetation. In some instances, it may not be possible to prevent this transition. In cases where total topsoil loss occurs, it may be impossible to prevent this transition. Long-term stressors on native species (e.g., improper grazing management, and drought) will alter plant community composition and production over time and may hasten a transition to the Disturbed State (4), but the main trigger is ground disturbance. The resulting lower biomass production, reduced litter, and increased bare ground in this community can promote invasion of undesirable species, but climate and soil chemistry contribute to the resistance of this site to invasives. The site transitions to the Disturbed State when populations of invasive species reach critical levels.

Transition 1-5
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 2-1
State 2 to 1

The drivers for this restoration pathway are restoration of native herbaceous species by mechanical or chemical treatment of sagebrush (from community phase 2.1), and grazing rest or deferment followed by changing the season of use from spring to fall. If some mid- stature bunchgrasses remain under the sage canopy, proper grazing

management can move the site back to the Reference State (1) when combined with a well-planned mechanical or chemical sagebrush treatment. This could take multiple generations of management or could be accelerated with rest or deferment combined with successive wet springs conducive to seed germination and seedling establishment. (Derner, Schuman, Follett, & Vance, 2014).

Transition 2-3
State 2 to 3

The driver for transition from the Grazing Resistant State to the *Bare Ground* State (T2-3) is continuous high intensity grazing from the Big Sagebrush/Thickspike 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 large (>6 foot canopy gaps comprising >30% of transect) and comprise the majority of the interspaces between sagebrush plants.

Transition 2-4
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. drought, mechanical, chemical, biological treatments) and/or continuous high intensity grazing. Examples include pasture corners near gates, 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 results in an increase in the disturbance cycle. A non-grazing influenced example would be a gravel pit. 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, particularly green rabbitbrush (*Chrysothamnus viscidiflorus*).

Transition 2-5
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 3-2
State 3 to 2

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

Transition 3-4
State 3 to 4

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

Transition 3-5
State 3 to 5

The driver for transition from the Eroded State to the Highly Disturbed State (T3-5) is a topsoil removing event with mechanical equipment. Examples include construction sites, oil and gas activity, and borrow areas.

Transition 4-5
State 4 to 5

The driver for transition from the Disturbed State to the Highly Disturbed State (T4-5) is a topsoil removing event with mechanical equipment. Examples include construction sites, oil and gas activity, and borrow areas.

Restoration pathway 5-2
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 5-3
State 5 to 3

The Highly Disturbed State (5) can transition the *Bare Ground* 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.

Restoration pathway 5-4
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 shrubs such as rabbitbrush or shadscale. 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 9. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Perrenial Mid-Stature Cool Season Grasses**			74–135	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	67–135	10–20
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	34–101	5–15
	Letterman's needlegrass	ACLE9	*Achnatherum lettermanii*	34–101	5–15
	squirreltail	ELEL5	*Elymus elymoides*	34–67	5–10
	needle and thread	HECO26	*Hesperostipa comata*	7–67	1–10
	muttongrass	POFE	*Poa fendleriana*	7–67	1–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–67	0–10
2	**Rhizomatous Grasses**			34–67	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	34–67	5–10

	western wheatgrass	PASM	*Pascopyrum smithii*	34–67	5–10
3	**Misc. Grasses/Grasslikes**			34–67	
	needleleaf sedge	CADU6	*Carex duriuscula*	0–34	0–5
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–34	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	7–34	1–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–34	0–5
	Grass, perennial	2GP	*Grass, perennial*	0–34	0–5
Forb					
4	**Perennial Forbs**			34–61	
	buckwheat	ERIOG	*Eriogonum*	7–34	1–5
	spiny phlox	PHHO	*Phlox hoodii*	7–34	1–5
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–20	0–3
	evening primrose	OENOT	*Oenothera*	0–20	0–3
	fleabane	ERIGE2	*Erigeron*	0–20	0–3
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–20	0–3
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–20	0–3
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–3
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–20	0–3
	Townsend daisy	TOWNS	*Townsendia*	0–20	0–3
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–20	0–3
	sandwort	ARENA	*Arenaria*	0–20	0–3
	lesser rushy milkvetch	ASCO12	*Astragalus convallarius*	0–20	0–3
	milkvetch	ASTRA	*Astragalus*	0–20	0–3
	sego lily	CANU3	*Calochortus nuttallii*	0–7	0–1
	Indian paintbrush	CASTI2	*Castilleja*	0–7	0–1
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–7	0–1
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–7	0–1
	larkspur	DELPH	*Delphinium*	0–7	0–1
	pussytoes	ANTEN	*Antennaria*	0–7	0–1
	rockcress	ARABI2	*Arabis*	0–7	0–1
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	0–7	0–1
	deathcamas	ZIGAD	*Zigadenus*	0–7	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–7	0–1
	rayless tansyaster	MAGR2	*Machaeranthera grindelioides*	0–7	0–1
	desertparsley	LOMAT	*Lomatium*	0–7	0–1
	lupine	LUPIN	*Lupinus*	0–7	0–1
	beardtongue	PENST	*Penstemon*	0–7	0–1
	sagebrush buttercup	RAGL	*Ranunculus glaberrimus*	0–7	0–1
5	**Annual Forbs**			0–7	
	rockjasmine	ANDRO3	*Androsace*	0–7	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–7	0–1
	Forb, annual	2FA	*Forb, annual*	0–7	0–1

Shrub/Vine					
6	**Shrubs**			161–303	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	161–303	20–25
7	**Misc Shrubs**			13–34	
	little sagebrush	ARARL	*Artemisia arbuscula ssp. longiloba*	0–34	0–5
	black sagebrush	ARNO4	*Artemisia nova*	0–34	0–5
	shadscale saltbush	ATCO	*Atriplex confertifolia*	0–34	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	7–34	1–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	7–34	1–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–34	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–7	0–1
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–7	0–1
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–7	0–1
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–7	0–1
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–7	0–1
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–7	0–1
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–7	0–1

Table 10. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Perennial Mid-Stature Cool Season Grasses**			94–202	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	67–135	10–20
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	34–101	5–15
	Letterman's needlegrass	ACLE9	*Achnatherum lettermanii*	34–101	5–15
	squirreltail	ELEL5	*Elymus elymoides*	34–67	5–10
	needle and thread	HECO26	*Hesperostipa comata*	7–67	1–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–67	0–10
	muttongrass	POFE	*Poa fendleriana*	7–67	1–10
2	**Rhizomatous Grasses**			34–67	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	34–67	5–10
	western wheatgrass	PASM	*Pascopyrum smithii*	34–67	5–10
3	**Misc. Grasses/Grasslikes**			47–101	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–34	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	0–34	0–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–34	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	7–34	1–5
	Grass, perennial	2GP	*Grass, perennial*	0–34	0–5
Forb					
4	**Perennial Forbs**			34–61	
	buckwheat	ERIOG	*Eriogonum*	7–34	1–5
	spiny phlox	PHHO	*Phlox hoodii*	7–34	1–5

	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–20	0–3
	evening primrose	OENOT	*Oenothera*	0–20	0–3
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–20	0–3
	sandwort	ARENA	*Arenaria*	0–20	0–3
	lesser rushy milkvetch	ASCO12	*Astragalus convallarius*	0–20	0–3
	milkvetch	ASTRA	*Astragalus*	0–20	0–3
	fleabane	ERIGE2	*Erigeron*	0–20	0–3
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–20	0–3
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–20	0–3
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–3
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–20	0–3
	Townsend daisy	TOWNS	*Townsendia*	0–20	0–3
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	0–7	0–1
	deathcamas	ZIGAD	*Zigadenus*	0–7	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–7	0–1
	rayless tansyaster	MAGR2	*Machaeranthera grindelioides*	0–7	0–1
	desertparsley	LOMAT	*Lomatium*	0–7	0–1
	lupine	LUPIN	*Lupinus*	0–7	0–1
	Indian paintbrush	CASTI2	*Castilleja*	0–7	0–1
	sego lily	CANU3	*Calochortus nuttallii*	0–7	0–1
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–7	0–1
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–7	0–1
	larkspur	DELPH	*Delphinium*	0–7	0–1
	pussytoes	ANTEN	*Antennaria*	0–7	0–1
	rockcress	ARABI2	*Arabis*	0–7	0–1
	beardtongue	PENST	*Penstemon*	0–7	0–1
	sagebrush buttercup	RAGL	*Ranunculus glaberrimus*	0–7	0–1
5	**Annual Forbs**			0–7	
	rockjasmine	ANDRO3	*Androsace*	0–7	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–7	0–1
	Forb, annual	2FA	*Forb, annual*	0–7	0–1
Shrub/Vine					
6	**Shrubs**			81–168	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	84–168	15–25
7	**Misc Shrubs**			34	
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–34	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	7–34	1–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	7–34	1–5
	little sagebrush	ARARL	*Artemisia arbuscula ssp. longiloba*	0–34	0–5
	black sagebrush	ARNO4	*Artemisia nova*	0–34	0–5
	shadscale saltbush	ATCO	*Atriplex confertifolia*	0–34	0–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–7	0–1

	granite prickly phlox	LIPU11	*Linanthus pungens*	0–7	0–1
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–7	0–1
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–7	0–1
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–7	0–1
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–7	0–1
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–7	0–1

Table 11. Community 1.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Perennial Mid-Stature Cool Season Grasses**			128–269	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	135–269	20–40
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	67–135	10–20
	Letterman's needlegrass	ACLE9	*Achnatherum lettermanii*	67–135	10–20
	squirreltail	ELEL5	*Elymus elymoides*	34–67	5–10
	needle and thread	HECO26	*Hesperostipa comata*	7–67	1–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–67	0–10
	muttongrass	POFE	*Poa fendleriana*	7–67	1–10
2	**Rhizomatous Grasses**			34–67	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	34–67	5–10
	western wheatgrass	PASM	*Pascopyrum smithii*	34–67	5–10
3	**Misc Grasses/Grasslikes**			47–101	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–34	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	0–34	0–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–34	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	7–34	1–5
	Grass, perennial	2GP	*Grass, perennial*	0–34	0–5
Forb					
4	**Perennial Forbs**			34–61	
	buckwheat	ERIOG	*Eriogonum*	7–34	1–5
	spiny phlox	PHHO	*Phlox hoodii*	7–34	1–5
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–20	0–3
	bladderpod	LESQU	*Lesquerella*	0–20	0–3
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–20	0–3
	evening primrose	OENOT	*Oenothera*	0–20	0–3
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–20	0–3
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–3
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–20	0–3
	Townsend daisy	TOWNS	*Townsendia*	0–20	0–3
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–20	0–3
	fleabane	ERIGE2	*Erigeron*	0–20	0–3

	sandwort	ARENA	*Arenaria*	0–20	0–3
	lesser rushy milkvetch	ASCO12	*Astragalus convallarius*	0–20	0–3
	milkvetch	ASTRA	*Astragalus*	0–20	0–3
	sego lily	CANU3	*Calochortus nuttallii*	0–7	0–1
	Indian paintbrush	CASTI2	*Castilleja*	0–7	0–1
	pale bastard toadflax	COUMP	*Comandra umbellata ssp. pallida*	0–7	0–1
	tapertip hawksbeard	CRAC2	*Crepis acuminata*	0–7	0–1
	larkspur	DELPH	*Delphinium*	0–7	0–1
	pussytoes	ANTEN	*Antennaria*	0–7	0–1
	rockcress	ARABI2	*Arabis*	0–7	0–1
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	0–7	0–1
	deathcamas	ZIGAD	*Zigadenus*	0–7	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–7	0–1
	beardtongue	PENST	*Penstemon*	0–7	0–1
	rayless tansyaster	MAGR2	*Machaeranthera grindelioides*	0–7	0–1
	desertparsley	LOMAT	*Lomatium*	0–7	0–1
	lupine	LUPIN	*Lupinus*	0–7	0–1
	sagebrush buttercup	RAGL	*Ranunculus glaberrimus*	0–7	0–1
5	**Annual Forb**			0–7	
	rockjasmine	ANDRO3	*Androsace*	0–7	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–7	0–1
	Forb, annual	2FA	*Forb, annual*	0–7	0–1
Shrub/Vine					
6	**Shrubs**			47–101	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	47–101	5–15
7	**Misc Shrubs**			34–67	
	black sagebrush	ARNO4	*Artemisia nova*	0–34	0–5
	shadscale saltbush	ATCO	*Atriplex confertifolia*	0–34	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	7–34	1–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	7–34	1–5
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–34	0–5
	little sagebrush	ARARL	*Artemisia arbuscula ssp. longiloba*	0–34	0–5
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–7	0–1
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–7	0–1
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–7	0–1
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–7	0–1
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–7	0–1
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–7	0–1
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–7	0–1

Table 12. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					

1	**Perennial Mid-Stature Cool Season Grasses**			22–45	
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	22–45	5–10
	Letterman's needlegrass	ACLE9	*Achnatherum lettermanii*	4–45	1–10
	squirreltail	ELEL5	*Elymus elymoides*	4–45	1–10
	needle and thread	HECO26	*Hesperostipa comata*	4–45	1–10
	muttongrass	POFE	*Poa fendleriana*	4–45	1–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–45	0–10
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	4–45	1–10
2	**Rhizomatous Grasses**			40–67	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	45–67	10–15
	western wheatgrass	PASM	*Pascopyrum smithii*	22–45	5–10
3	**Misc Grasses/Grasslikes**			40–67	
	Sandberg bluegrass	POSE	*Poa secunda*	22–67	5–15
	Grass, perennial	2GP	*Grass, perennial*	0–22	0–5
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–22	0–5
	needleleaf sedge	CADU6	*Carex duriuscula*	0–22	0–5
	threadleaf sedge	CAFI	*Carex filifolia*	0–22	0–5
Forb					
4	**Perennial Forbs**			22–40	
	buckwheat	ERIOG	*Eriogonum*	4–22	1–5
	spiny phlox	PHHO	*Phlox hoodii*	4–22	1–5
	longleaf phlox	PHLOL2	*Phlox longifolia ssp. longifolia*	0–13	0–3
	evening primrose	OENOT	*Oenothera*	0–13	0–3
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–13	0–3
	fleabane	ERIGE2	*Erigeron*	0–13	0–3
	hoary tansyaster	MACA2	*Machaeranthera canescens*	0–13	0–3
	flaxleaf plainsmustard	SCLI	*Schoenocrambe linifolia*	0–13	0–3
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–13	0–3
	stemless mock goldenweed	STAC	*Stenotus acaulis*	0–13	0–3
	Townsend daisy	TOWNS	*Townsendia*	0–13	0–3
	sandwort	ARENA	*Arenaria*	0–13	0–3
	lesser rushy milkvetch	ASCO12	*Astragalus convallarius*	0–13	0–3
	milkvetch	ASTRA	*Astragalus*	0–13	0–3
	pond water-starwort	CAST	*Callitriche stagnalis*	0–4	0–1
	sego lily	CANU3	*Calochortus nuttallii*	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
	hollyleaf clover	TRGY	*Trifolium gymnocarpon*	0–4	0–1
	deathcamas	ZIGAD	*Zigadenus*	0–4	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–4	0–1
	rayless tansyaster	MAGR2	*Machaeranthera grindelioides*	0–4	0–1

	desertparsley	LOMAT	*Lomatium*	0–4	0–1
	lupine	LUPIN	*Lupinus*	0–4	0–1
	pussytoes	ANTEN	*Antennaria*	0–4	0–1
	rockcress	ARABI2	*Arabis*	0–4	0–1
	beardtongue	PENST	*Penstemon*	0–4	0–1
	sagebrush buttercup	RAGL	*Ranunculus glaberrimus*	0–4	0–1
5	**Annual Forbs**			0–4	
	rockjasmine	ANDRO3	*Androsace*	0–4	0–1
	bushy bird's beak	CORA5	*Cordylanthus ramosus*	0–4	0–1
	Forb, perennial	2FP	*Forb, perennial*	0–4	0–1
Shrub/Vine					
6	**Shrubs**			112–202	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	112–202	20–30
7	**Misc Shrubs**			9–22	
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–22	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	4–22	1–5
	winterfat	KRLA2	*Krascheninnikovia lanata*	4–22	1–5
	little sagebrush	ARARL	*Artemisia arbuscula ssp. longiloba*	0–22	0–5
	black sagebrush	ARNO4	*Artemisia nova*	0–22	0–5
	shadscale saltbush	ATCO	*Atriplex confertifolia*	0–22	0–5
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–4	0–1
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–4	0–1
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–4	0–1
	bud sagebrush	PIDE4	*Picrothamnus desertorum*	0–4	0–1
	spineless horsebrush	TECA2	*Tetradymia canescens*	0–4	0–1
	shortspine horsebrush	TESP2	*Tetradymia spinosa*	0–4	0–1
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–4	0–1

Animal community

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

Plant Community Production Carrying Capacity*
(lb./ac) Low-RV-High (AUM/AC) (AC/AUM)
Big Sagebrush/Bunchgrass (Reference) 300-600-800 0.07 15
Bunchgrass/Big Sagebrush 300-600-800 0.08 13
Bunchgrass 300-600-800 0.11 9
Big Sagebrush/Rhizomatous Wheatgrass 200-400-600 0.04 25
Rhizomatous Wheatgrass/Big Sagebrush 200-400-600 0.06 17

Big Sagebrush/*Bare Ground* 150-250-400 0.01 100
Rabbitbrush/Rhizomatous Wheatgrass 150-250-400 0.06 17
Annuals/*Bare Ground* 100-200-300 0.02 50
Reclaimed 300-500-800 0.15 7

* - Continuous, season-long grazing by cattle under average growing conditions.

**Calculation for these stocking rates are as follows: using RV values for production, take only forage palatable to cattle and multiply by 0.25 harvest efficiency and divide by 913 (pounds of air dried weight forage per Animal Unit Month on intake rate of 2.6%) 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, protein supplement is recommended 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 Calcareous ecological site in the Pinedale Plateau provides suitable and valuable habitat for a variety of wildlife species. In most cases, the greater the density and diversity of native forbs, grass and shrub species within the site, the greater the diversity of wildlife the site can support including insects which many wildlife species depend on for their dietary requirements. Mid-sized cool season bunchgrasses provide forage and cover for big game species, small mammals, birds and reptiles. Wildlife such as pronghorn, elk, cottontails, and jackrabbits depend largely on grass for forage. Birds nest among the bunchgrasses and utilize grass as screening cover from predatory wildlife. Mule deer, pronghorn, greater sage grouse, and songbirds utilize the taller grass amongst the shrubs as hiding cover for their young. Sagebrush provides important winter forage for greater sage grouse, mule deer, and pronghorn. Year-round habitat is provided for sagebrush obligate species such as greater sage grouse, cottontails, pygmy rabbit, sagebrush vole, short-horned lizard, and pronghorn. Seasonal habitat needs are provided for migrants such as sage sparrow, Brewer’s sparrow, Vesper’s sparrow, sage thrasher, and other sagebrush obligate songbirds. Other birds that frequent this plant community include horned larks and golden eagles. Although not a dominant part of this community, forbs are an important component of this habitat type, providing an early food source for sage grouse chicks both nutritionally and via the insects that forbs attract. Forbs provide necessary moisture to wildlife in arid landscapes. Pronghorn depend on abundant forbs to aid in the production of milk to nurse fawns and as forage for fawn development and health.
Reference State:
1.1 Big Sagebrush/Bunchgrass Plant Community
This plant community provides optimal winter habitat for greater sage grouse, mule deer, pronghorn, and other species that depend on shrubs that stand up through the snow for forage. These areas also provide high quality bird nesting habitat where sagebrush canopy and residual bunchgrasses hide nests and young from predators. Forbs, although sparse, are necessary in the understory of this plant community to attract insects that are a highly nutritious spring food source for greater sage grouse chicks and other sagebrush obligate bird species. Winter use by mule deer and pronghorn may be significant and some shrubs may become hedged over time with excessive browsing.
1.2 Bunchgrass/Big Sagebrush Plant Community
This vegetation community tends to have higher herbaceous plant density that may attract more diverse wildlife use. The state provides suitable forage and cover for sagebrush obligate species. The more open canopy promotes higher diversity and quantity of forbs that are important for early greater sage grouse brood rearing habitat. A reduced sagebrush canopy may result in a slightly lower nesting frequency by greater sage grouse and songbirds. Winter use by mule deer and pronghorn may be significant and some shrubs may become hedged over time with excessive browsing.
1.3 Bunchgrass Plant Community

This plant community provides foraging habitat for greater sage grouse when in proximity to areas with denser sagebrush cover. Due to the higher production of perennial cool-season grasses, this vegetation type provides high forage value for wintering elk. Mule deer and pronghorn transition through these habitats during annual migrations between summer and winter ranges. It also provides suitable habitat for burrowing animals.
Grazing Resistant State:
This State is variable in its value to wildlife. The value of the sagebrush community is similar to the reference state but the value of the grass community decreases. In periods of high plant vigor, the grass plants can provide cover for nesting birds and small mammals. In periods of drought and low plant vigor and diversity, especially low forb availability, grass plants are too short and not dense enough to provide adequate cover and the wildlife value of these areas declines. Mat-forming forbs often occupy the space and nutrients needed for more desirable forbs such as globemallow, penstemon, milk vetches and composites.
Bare Ground State:
This State provides suitable winter habitat for foraging big game and greater sage grouse when sagebrush is in a healthy state and stands above winter snow. The lack of herbaceous species limits the value of this state for birds and small mammals due to the lack of cover in the interspaces of the sagebrush plants. The lack of plant diversity limits the diversity of insects used by wildlife species. Bare ground provides essentially no habitat value for wildlife. In addition, bare ground may be more susceptible to invasion of non-native species, further degrading the value for wildlife.
Disturbed State:
This State is capable of producing a high number of insects which are important for pollination and bird forage at times of the year. Depending on the subspecies, rabbitbrush can be used heavily by wintering mule deer and pronghorn, especially when other preferred winter forages are unavailable or in poor vigor due to over-use or drought. The lack of an herbaceous community limits the value as bird and small mammal hiding cover and forage for grazing animals. Annual plants have little nutritive value and are typically too short to provide hiding cover for wildlife.
Highly Disturbed Site:
As described in the *Bare Ground* State, annuals and bare ground hold little value for wildlife due to the lack of suitable forage and cover. This State is vulnerable to an increase in weedy species that can migrate into adjacent areas, degrading the adjacent areas' value for wildlife. Suitable habitat for wildlife species which require tall, dense sagebrush (greater sage grouse, pronghorn, mule deer, and sagebrush obligate songbirds) will likely not benefit from reclamation efforts for a decade or longer, providing shrub species were planted and/or seeded from shrubs adjacent to the area and have established onsite.

Hydrological functions

Water is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group B (infiltration rate of 0.15-0.3 in/hr), with localized areas in hydrologic groups A (infiltration rate of 0.3 in/hr) and C (infiltration rate of 0.05-0.15 in/hr). Infiltration ranges from rapid to moderate. Runoff potential for this site varies from low to moderate depending on soil hydrologic group and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. Areas where ground cover is less than 50% have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

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

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, un-fragmented landscapes.

Wood products

NONE

Other products

NONE

Other information

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

References

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

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

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

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

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

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

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

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

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

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

Derner, J.D., G.E. Schuman, R.F. Follett, and G.F. Vance. 2013. Plant and Soil Consequences of Shrub

Management in a Big Sagebrush-Dominated Rangeland Ecosystem.

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

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

Sommers, J. 1994. Green River Drift- A History of the Upper Green River Cattle Association.

Stiver, S., E. Rinkes, and D. Naugle. 2010. Sage-Grouse Habitat Assessment Framework. 6p.

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

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

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

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Rangeland health reference sheet

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

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Date	06/27/2017
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 for this site. When present, rills are short and widely spaced 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.

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3. **Number and height of erosional pedestals or terracettes:** Existing pedestals are blunt and not active, less than 2 inches (5cm) and typically found at the drip line of the shrub canopy. It is typical to find biological soil crusts at margins. Terracettes are not present.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground is typically <20%, but can be dependent on plant community phase within the reference state. Higher bare ground is expected directly following a sagebrush killing disturbance, but returns to <20% within 2 years post-disturbance. Canopy gaps comprise up to 30% of the ground surface, and are primarily in the 1-2 foot categories (>60%). Canopy gaps >6 ft are rare.

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5. **Number of gullies and erosion associated with gullies:** Active gullies should not be present on this site, but sometimes there is erosion or deposition associated with adjacent steeper sites.

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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.

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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%.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Stability Index ratings can be variable. Values of 6 are typical when sample includes soil biological crusts, but often average 4-5 in plant interspaces. Overall, the biotic component provide stability for this site.

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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 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 with strong, sub-angular blocky structure as evidenced by excessive pedestalling 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 40-80% grasses, 5-10% forbs, and 10-50% shrubs composition by dry weight. The sagebrush canopy is evenly distributed with foliar 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 resulting in moderate runoff potential. 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):** None. A dry subsurface 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: perennial shrubs>Mid-size, cool season bunchgrasses>>cool season rhizomatous grasses >short, cool season bunchgrasses=sprouting shrubs>>perennial forbs

    Sub-dominant:

    Other:

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal decadence can be observed and is typically associated with shrub component. It is common to find dead matter accumulated in bunchgrasses, but live plant matter quantity should exceed standing dead except for in times of severe drought. Sagebrush canopy will often have occasional dead branches, but it should not exceed 30% and shouldn't be found on most plants.

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14. **Average percent litter cover (%) and depth (in):** Litter ranges from 5-35% of total canopy measurement with total litter (including beneath the plant canopy) 35-65% expected. Herbaceous litter depth is typically very shallow, approximately 1-2mm. Woody litter can be up to a couple inches in diameter (4-6cm), but is sporadically distributed.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** English: 300-800 lb/ac (550 lb/ac average); Metric: 336-897 kg/ha (617 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 40% is the most common indicator of a threshold being crossed. Annual weeds such as kochia, lambsquarter, flixweed, and Russian thistle are common weedy species in disturbed sites. When dominant, rabbitbrush, which is native and typically found in small quantities on this site, indicates a change in disturbance regime and a threshold being crossed.

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