

Ecological site R058BY150WY Sandy (Sy) 10-14" PZ

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General information

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

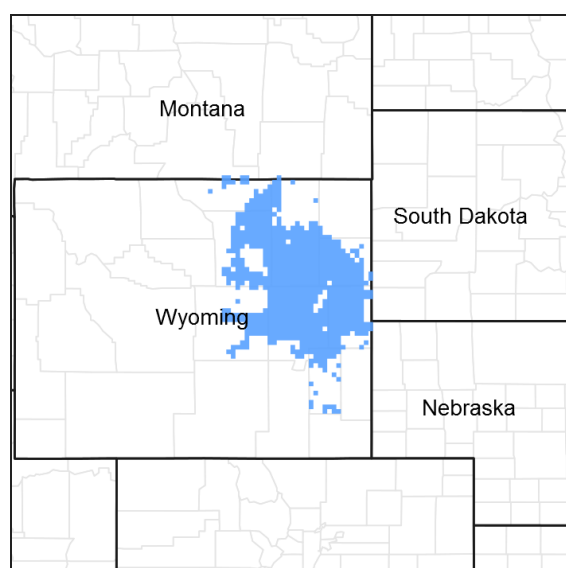


Figure 1. Mapped extent

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): 058B–Northern Rolling High Plains, Southern Part

MLRA 58B is located in northeastern Wyoming (95 percent) and extreme southeastern Montana (5 percent). It is comprised of sedimentary plains, scoria hills, and river valleys. The major rivers include the Powder, Tongue, Belle Fourche, Cheyenne, and North Platte. Tributaries include the Little Powder River, Little Missouri River, Clear Creek, Crazy Woman Creek, and others. This MLRA is traversed by Interstates 25 and 90, and U.S. Highways 14 and 16. The extent of MLRA 58B covers approximately 12.3 million acres. Major land uses include rangeland (approximately 93 percent), cropland, pasture, and hayland (approximately 2 percent), and forest, urban, and miscellaneous uses (approximately 5 percent). Cities include Buffalo, Casper, Sheridan, and Gillette, WY. Land ownership is mostly private. Federal lands include the Thunder Basin National Grassland (U.S. Forest Service) and lands administered by the Bureau of Land Management. Areas of interest in MLRA 58B in Wyoming include Fort Phil Kearny State Historic Site, Glendo State Park, and Lake DeSmet. The elevations in MLRA 58B increase gradually from north to south and range from approximately 2,900 to 5,900 feet. A few buttes are higher than 6,800 feet. The average annual precipitation in this area ranges from 10 to 17 inches per year. Precipitation occurs mostly during the growing season, often during rapidly developing thunderstorms. Mean annual air temperature is 46 degrees Fahrenheit. Summer temperatures may exceed 100 degrees Fahrenheit. Winter temperatures may drop to below zero. Snowfall averages 45 inches per year, but varies from 25 to over 70 inches in some locales.

Classification relationships

USDA Natural Resources Conservation Service (NRCS):

Land Resource Region—G Western Great Plains Range and Irrigation; Major Land Resource Area (MLRA)—58B Northern Rolling High Plains, Southern Part (USDA, 2006).

Relationship to Other Classifications:

USDA Forest Service (FS) Classification Hierarchy:

Province—331 Great Plains-Palouse Dry Steppe; Section—331G-Powder River Basin; Subsections—331Gb Montana Shale Plains, 331Ge Powder River Basin, 331Gf South Powder River Basin-Scoria Hills (Cleland et al, 1997)

Environmental Protection Agency (EPA) Classification Hierarchy:

Level III Ecoregion—43 Northwestern Great Plains; Level IV Ecoregion—43p Scoria Hills, 43q Mesic-Dissected Plains, 43w Powder River Basin (EPA, 2013)

<https://www.epa.gov/eco-research/ecoregions>

Ecological site concept

The Sandy 10-14" PZ site occurs on nearly level to gentle slopes on sedimentary plains or uplands. It is a cool- and warm-season mixed-grass prairie (mid- and shortgrasses), with a lesser component of forbs and shrubs. Site is Sandy to sandy loam in texture, less than 18 percent clays.

Associated sites

R058BY146WY	Sands (Sa) 10-14" PZ Sands sites are on lower sloping, closer to sandstone parent material and lack soil development.
R058BY122WY	Loamy (Ly) 10-14" PZ Loamy soils are sandy loam to clay loam textures, higher productivity and drought tolerance with slight shifts in plants and production.
R058BY166WY	Shallow Sandy (SwSy) 10-14" PZ Shallow Sandy are shallow to a restrictive layer while Sandy sites are deep highly productive soils.

Similar sites

R058BY250WY	Sandy (Sy) 15-17" PZ Sandy 15-17" PZ has higher production.
R058BY146WY	Sands (Sa) 10-14" PZ Sands 10-14: PZ lower soil development and higher water loss rates creates a lower productivity overall with quicker responses to precipitation responses.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Artemisia cana</i>
Herbaceous	(1) <i>Hesperostipa comata</i> (2) <i>Calamovilfa longifolia</i>

Physiographic features

This site occurs on nearly level to gently sloping fans and ridges, and on footslopes or backslopes of hills, on sedimentary plains or uplands.

Table 2. Representative physiographic features

Landforms	(1) Alluvial fan (2) Fan remnant (3) Ridge (4) Hill
Runoff class	Negligible to medium
Flooding frequency	None
Ponding frequency	None to rare
Elevation	1,036–1,981 m
Slope	0–15%
Water table depth	203 cm
Aspect	Aspect is not a significant factor

Climatic features

The average annual precipitation ranges from 10 to 17 inches per year across MLRA 58B. There are two precipitation zones (PZ). The 10 to 14 inch precipitation zone is predominant across the MLRA, including portions of Sheridan, Johnson, and Natrona Counties; portions of Campbell and Converse Counties; and smaller portions of Weston and Niobrara Counties. The 15 to 17 inch precipitation zone occurs in northern and eastern portions of the MLRA, including portions of Sheridan, Campbell, and western Crook Counties. Wide fluctuations in precipitation may occur from year to year, and occasional periods of extended drought (longer than one year in duration) can be expected. Two-thirds of the annual precipitation occurs during the growing season from May through September. Mean Annual Air Temperature (MAAT) is 46 degrees Fahrenheit. Cold air outbreaks from Canada in winter move rapidly from northwest to southeast and account for extreme minimum temperatures. Chinook winds may also occur in winter and bring rapid rises in temperature. Extreme storms may occur during the winter, but most severely affect ranching operations during late winter and spring. High-intensity afternoon thunderstorms may occur during the summer. Annual wind speeds average about 5 mph. Daytime winds are generally stronger than nighttime winds. Occasional strong storms may bring brief periods of high winds with gusts of more than 75 mph. The average length of the freeze-free period (28 degrees Fahrenheit) is 125 days and generally occurs from May 16 to September 19. The average frost-free period (32 degrees Fahrenheit) is 101 days and generally occurs from June 1 to September 9.

The growth of native cool-season plants begins in late April to early May with peak growth occurring in mid to late June. Native warm-season plants begin growth in late May to early June and continue into August. Regrowth of cool-season plants occurs in September in most years, depending upon moisture.

Note: The climate described here is based on historic climate station data and is averaged to provide an overview of the annual precipitation, temperatures, and growing season. Future climate is beyond the scope of this document. However, research to determine the effects of elevated CO₂ and heating on mixed-grass prairie ecosystems, and how it may relate to future plant communities, is ongoing.

For detailed information, or to find a specific climate station, visit the Western Regional Climate Center (WRCC) website: Western Regional Climate Center, Historical Data, Western U.S. Climate summaries, NOAA Coop Stations, Wyoming (Note: Montana climate stations are also listed under the Wyoming link).
<https://wrcc.dri.edu/summary/Climsmwy.html>

Wind speed averages can be found at the WRCC home page, under the Specialty Climate tab: <https://wrcc.dri.edu/>

The following tables represent area-wide climate data for the 10 to 14 inch precipitation zone:

Table 3. Representative climatic features

Frost-free period (characteristic range)	92-103 days
Freeze-free period (characteristic range)	121-128 days

Precipitation total (characteristic range)	305-330 mm
Frost-free period (actual range)	86-107 days
Freeze-free period (actual range)	116-129 days
Precipitation total (actual range)	254-356 mm
Frost-free period (average)	101 days
Freeze-free period (average)	125 days
Precipitation total (average)	330 mm

Climate stations used

- (1) BUFFALO [USC00481165], Buffalo, WY
- (2) DULL CTR 1SE [USC00482725], Douglas, WY
- (3) GLENROCK 5 ESE [USC00483950], Glenrock, WY
- (4) KAYCEE [USC00485055], Kaycee, WY
- (5) MIDWEST [USC00486195], Midwest, WY
- (6) SHERIDAN CO AP [USW00024029], Sheridan, WY
- (7) WESTON 1 E [USC00489580], Weston, WY
- (8) WRIGHT 12W [USC00489805], Gillette, WY
- (9) CASPER NATRONA CO AP [USW00024089], Casper, WY

Influencing water features

This upland ecological site is not influenced by a water table or run in from adjacent sites. Due to the semi-arid climate in which it occurs, the water budget is normally contained within the soil pedon. Soil moisture is recharged by spring rains, but it rarely exceeds field capacity in the upper 40 inches before being depleted by evapotranspiration. During intense precipitation events, precipitation rates frequently exceed infiltration rates and the site delivers moisture to downslope sites through surface runoff. Moisture loss through evapotranspiration exceeds precipitation for a majority of the growing season. Soil moisture is the primary limiting factor for vegetative production on this ecological site.

Wetland description

N/A

Soil features

The soils on this site are typically deep to very deep, but includes moderately deep, well drained soils that formed from eolian deposits or alluvium; moderately deep soils formed from residuum derived from sandstone. They typically are in a moderate to rapid permeability class. The available water capacity is low to moderate. The surface layer of the soils in this site are typically fine sandy loam or sandy loam but may include loamy sand and loamy fine sand. The surface layer ranges from a depth of 2 to 10 inches thick. The subsoil is typically fine sandy loam, sandy loam, or sandy clay loam, but may include loamy sand and loamy very fine sand. The subsoil typically contains less than 5 percent rock fragments, but this may range up to 14 percent in some soils. Soils in this site are typically leached of carbonates 10 to 40 inches or more; some soils may have carbonates at the surface. These soils are susceptible to erosion by wind if not covered. The potential for water erosion accelerates with increasing slope. The soil moisture regime is typically ustic aridic. The soil temperature regime is mesic.

Major soil series correlated to this ecological site include: Bowbac, Decolney, Hiland, Julesburg, Keeline, Terro, Turnercrest, Vonalee.

The attributes listed below represent 0-40 inches in depth or to the first restrictive layer.

Table 4. Representative soil features

Parent material	(1) Alluvium (2) Eolian deposits (3) Residuum
Surface texture	(1) Fine sandy loam (2) Sandy loam (3) Loamy sand (4) Loamy fine sand
Drainage class	Well drained to excessively drained
Permeability class	Moderate to rapid
Soil depth	51–203 cm
Surface fragment cover <=3"	0–5%
Available water capacity (Depth not specified)	7.11–15.24 cm
Calcium carbonate equivalent (Depth not specified)	0–10%
Electrical conductivity (Depth not specified)	0–4 mmhos/cm
Sodium adsorption ratio (Depth not specified)	0–5
Soil reaction (1:1 water) (Depth not specified)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–14%

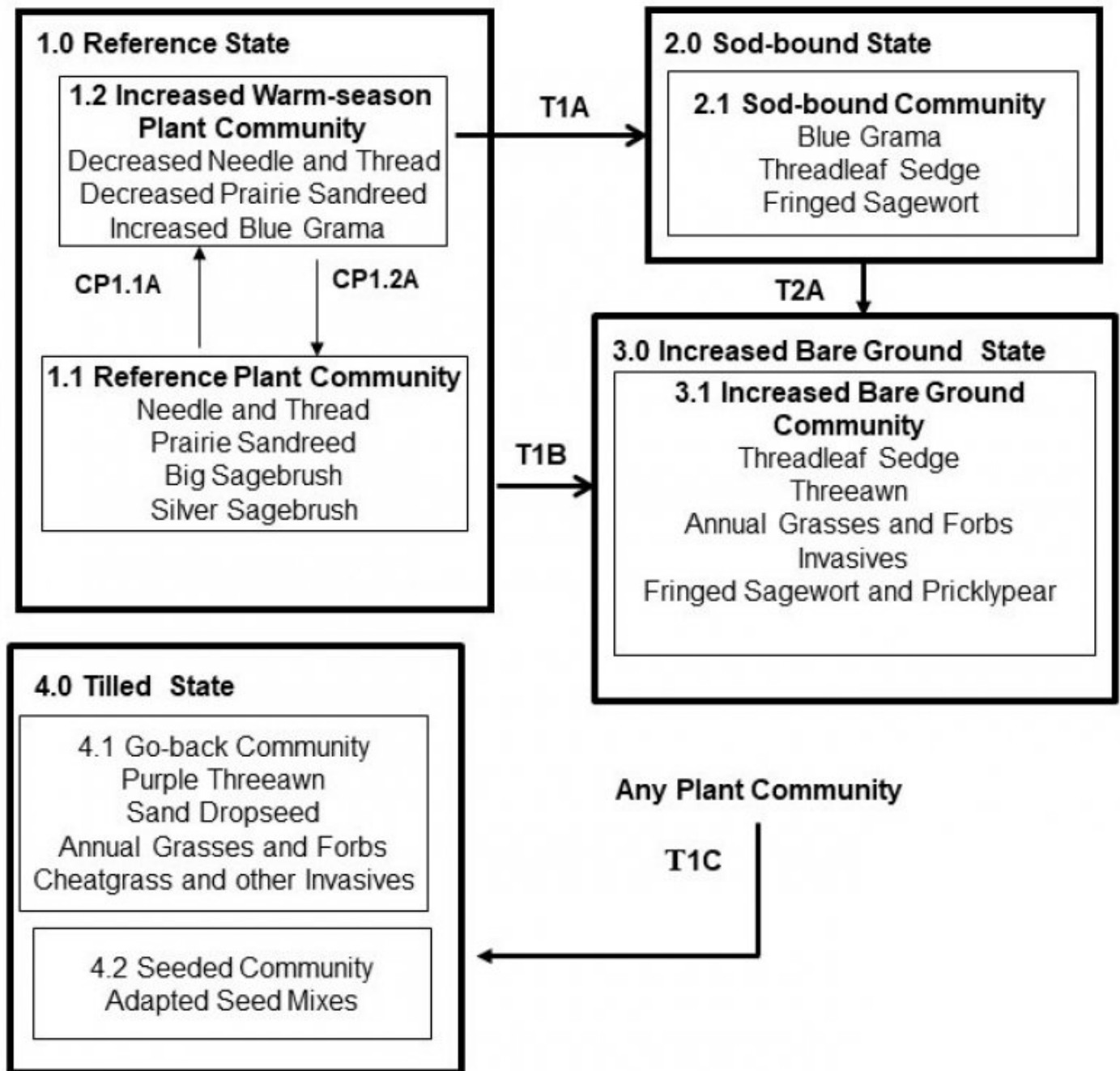
Ecological dynamics

The Reference State is the plant community in which interpretations are primarily based and is used as a reference in order to understand the original potential of the site. The Reference State evolved under the combined influences of climatic conditions, periodic fire activity, grazing by large herbivores, and impacts from small mammals and insects. Changes may occur to the Reference State due to management actions such as continuous season-long or year-long grazing, increased stocking rates, climatic conditions such as drought, and natural events such as multiple fires in close succession. The reference plant community for this ecological site is dominated by cool-season bunch midgrass, and warm-season rhizomatous midgrass. Secondary grasses are cool-season rhizomatous midgrasses, and warm-season shortgrass. A lesser component of forbs and shrubs are also present. The Reference Plant Community is not necessarily the management goal, as other vegetative states may be considered desired plant communities as long as critical resource concerns are met.

In addition to the Reference State, other plant communities can occur on this site and are usually the result of historic management practices. As this site begins to shift from a combination of frequent and severe defoliation during the growing season, bunchgrasses such as needle and thread will decrease in both frequency and production. Grasses such as blue grama, threadleaf sedge, and sixweeks fescue will increase. Under continued frequent and severe defoliation with no rest periods, rhizomatous wheatgrasses will also begin to decrease. Forbs and shrubs such as curlycup gumweed, western ragweed, hairy false goldenaster, pricklypear, and broom snakeweed also will increase. If continued, the plant community will become sod-bound, and all midgrasses may eventually be removed from the plant community. Over the long-term, this continuous use in combination with high stocking rates will result in a broken sod, with areas of bare ground developing and species such as broom snakeweed, prickly pear, and annual forbs increasing, and non-native species invading. There are various transitional stages which may occur on this ecological site. The information presented is representative of a dynamic set of plant communities that illustrate the complex interaction of several ecological processes.

State and transition model

Sandy 10-14" PZ, R058BY150WY



CP- Community Pathway

T- Transition

CP1.1A- Continuous seasonal-use grazing, drought, fire

CP1.2A- Prescribed grazing, normal precipitation, no fire

T1A- Continuous grazing without adequate recovery, frequent and severe defoliation

T1B- Heavy continuous grazing, frequent and severe defoliation

T2A- Long-term continuous grazing without adequate recovery, heavy continuous grazing, frequent and severe defoliation

T1C- Tillage

State 1
Reference State

The Reference State is characterized by two distinct plant community phases: Reference and Increased Warm-Season Plant Communities. The plant communities, and various successional stages between them, represent the natural range of variability within the Reference State.

Community 1.1
Artemisia cana/*Calamovilfa longifolia*-*Hesperostipa comata* (silver sagebrush/prairie sandreed-needle and thread)

The Reference Plant Community is the interpretive plant community for an ecological site. This community developed with grazing by large herbivores and is suited to grazing by domestic livestock. Historically, fires likely occurred infrequently, and were randomly distributed. This plant community can be found on areas where grazed plants receive adequate periods of recovery during the growing season. The potential vegetation is about 75 percent grasses and grass-likes, 10 to 15 percent forbs and 10 to 15 percent woody plants, on a pounds per acre (lbs./acre) air-dry basis. The Reference Plant Community consists predominantly of needle and thread and prairie sandreed. Secondary grasses are Indian ricegrass, western wheatgrass, and blue grama. Minor grasses and grass-likes that may occur include thickspike wheatgrass, prairie Junegrass, threadleaf sedge, and sand dropseed. A variety of forbs such as scarlet globemallow, slimflower scurfpea, Indian breadroot, textile onion, and biscuitroot; half-shrubs such as silver sagebrush; and shrubs such green rabbitbrush and Wyoming big sagebrush also occur. Plant diversity is high. In the 10 to 14" Precipitation Zone (PZ), the total annual production (air-dry weight) is about 1,300 pounds per acre during an average year, but it can range from about 750 pounds per acre in unfavorable years to about 1,600 pounds per acre in above-average years. Defoliation levels should be determined as part of a grazing management plan based on objectives. Nutrient and water cycles and energy flow are functioning properly. Infiltration rates are moderate and soil erosion is low. Litter is properly distributed where vegetative cover is continuous. Decadence and natural plant mortality are low. This community is resistant to many disturbances except excessive grazing, tillage, or development into urban or other uses.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	1052	1648	2242
Shrub/Vine	170	265	359
Forb	127	198	269
Total	1349	2111	2870

Figure 9. Plant community growth curve (percent production by month).
WY5803, Northern Rolling High Plains, Southern Part, cool-season/warm-season co-dominant. Cool-season/warm-season co-dominant.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		3	10	20	28	21	10	5	3		

Community 1.2
Artemisia cana-*Artemisia frigida*/*Calamovilfa longifolia*-*Carex inops* (silver sagebrush-prairie sawewort/prairie sandreed-sun sedge)

This plant community developed with frequent and severe defoliation without adequate recovery opportunity during the growing season, or with fire. The plant community has a reduced component of midgrasses with an understory of short sod-forming grasses. Dominant grasses include needle and thread, blue grama, and prairie sandreed. A cool-season/warm-season shift may occur depending upon the pre-dominant season of use. Recurrent excessive grazing in the spring, over time, will eventually reduce the cool-season grasses such as needle and thread and the rhizomatous wheatgrasses. Likewise, recurrent excessive grazing in the summer will reduce the warm-season midgrasses such as prairie sandreed. The significant forbs include dotted blazing star (also known as dotted

gayfeather), scarlet globemallow, cudweed sagewort, spiderworts, and upright prairie coneflower. Shrubs in this community include Arkansas rose, fringed sagewort, silver sagebrush, and broom snakeweed. Compared to the Reference Plant Community, blue grama and threadleaf sedge have increased. All the midgrass species are present but in lesser amounts, especially the bunchgrasses. Plant diversity is moderate. The risk of losing key midgrasses and important forbs and shrubs is a major concern. Prescribed grazing with adequate recovery periods between grazing events will maintain the vegetation or move it toward the Reference Plant Community. Natural disturbances such as fire and drought can contribute to this shift. In the 10 to 14" PZ, the total annual production (air-dry weight) is about 800 pounds per acre during an average year, but it can range from about 600 pounds per acre in unfavorable years to about 1,000 pounds per acre in above-average years. Total aboveground biomass has been reduced. Reduction of rhizomatous wheatgrasses, nitrogen-fixing forbs, and increased warm-season shortgrasses have begun to alter the biotic integrity of this community. Water and nutrient cycles may be impaired. Nearly all plant species typically found in the Reference Plant Community are present and will respond to changes in grazing management.

Figure 10. Plant community growth curve (percent production by month).
WY5803, Northern Rolling High Plains, Southern Part, cool-season/warm-
season co-dominant. Cool-season/warm-season co-dominant.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		3	10	20	28	21	10	5	3		

Pathway CP1.1A

Community 1.1 to 1.2

Excessive grazing without adequate recovery between grazing events, recurring seasonal-use grazing, or frequent and severe defoliation, can shift this plant community toward the Increased Warm-season Plant Community. Over a period of years, plant species less tolerant to frequent and severe defoliation will begin to decrease, and those more tolerant will begin to increase. Other natural disturbance such as drought, or fire may contribute to this shift. Biotic integrity and water and nutrient cycles may become impaired because of this community pathway.

Pathway CP1.2A

Community 1.2 to 1.1

Grazing that allows for adequate recovery between grazing events, along with proper stocking rates, lack of fire, and/or a return to normal precipitation, will shift the Increased Warm-Season Plant Community back toward the Reference Plant Community.

State 2

Sod-Bound State

This state is characterized by the Sod-bound Plant Community. An ecological threshold has been crossed and a significant amount of production and diversity has been lost when compared to the Reference State. Significant biotic and soil changes have negatively impacted energy flow, and the nutrient and hydrologic cycles. This is a very stable state, resistant to change due to the high tolerance of blue grama and threadleaf sedge to grazing, the development of a shallow root system or "root pan", and subsequent changes in hydrology and nutrient cycling. Loss of other functional/structural groups such as cool-season bunch- and rhizomatous grasses, forbs, and shrubs reduces the biodiversity productivity of this site.

Community 2.1

Artemisia frigida-Opuntia polyacantha/Carex inops-Bouteloua gracilis/Heterotheca villosa-Ambrosia psilostachya (prairie sagewort-plains pricklypear/sun sedge-blue grama/hairy false goldenaster-Cuman ragweed)

The Sod-bound Plant Community develops under long-term frequent and severe defoliation. This typically occurs when the community has been excessively grazed with heavy stocking rates, throughout the growing season over a period of many years. Initially, this plant community is dominated by sod-forming grasses and grass-likes, such as blue grama and threadleaf sedge, with remnants of mid-grasses such as prairie sandreed and some rhizomatous wheatgrasses. Forbs include Cuman ragweed (western ragweed), lemon scurfpea, hairy false goldenaster,

cudweed sagewort, and skeletonplant. Shrubs such as fringed sagewort, broom snakeweed, and pricklypear continue to increase. Under long-term frequent and severe defoliation, blue grama and threadleaf sedge have become sod-bound in localized colonies and exhibit a mosaic appearance. Other minor grasses are sand dropseed, Fendler's threeawn, and annuals. The midgrasses and palatable forbs have been eliminated. Plant diversity is very low. Energy flow and the water and mineral cycles have been negatively affected. Litter levels are very low and unevenly distributed. In the 10 to 14" PZ, the total annual production (air-dry weight) is about 500 pounds per acre during an average year, but it can range from about 350 pounds per acre in unfavorable years to about 650 pounds per acre in above-average years. The Sod-bound Plant Community is extremely resistant to change. Many plant species are missing and a seed source is not readily available. Also, sod-forming grasses tend to maintain themselves due to their resistance to any further overgrazing.

Figure 11. Plant community growth curve (percent production by month).
 WY6403, Pine Ridge/Badlands, cool-season/warm-season codominant.
 Hartville Uplift - Cool-season/warm-season codominant.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		2	5	18	30	25	10	8	2		

State 3 Increased Bare Ground State

The Increased *Bare Ground* State develops with heavy, excessive grazing with overstocking, or frequent and severe defoliation. An ecological threshold has been crossed. Erosion and loss of organic matter and carbon reserves are concerns.

Community 3.1 Artemisia frigida-Opuntia polyacantha/Bromus tectorum/Heterotheca villosa- Ambrosia psilostachya (prairie sagewort-plains pricklypear/cheatgrass/hairy false goldenaster-Cuman ragweed)

The Increased *Bare Ground* Plant Community occurs where the rangeland is grazed year-round at high stock densities. Physical impacts such as trampling, soil compaction, and trailing typically contribute to this transition. The plant composition is comprised of annuals with a few species of perennial forbs and grasses that are very tolerant to frequent and severe defoliation. The dominant grasses include blue grama, threadleaf sedge, and Fendler's threeawn. Annual grasses and forbs such as cheatgrass, sixweeks fescue, Russian thistle, and kochia have increased or invaded. The dominant forbs include curlycup gumweed, Cuman (western) ragweed, and hairy false goldenaster. Broom snakeweed, fringed sagewort, and pricklypear will increase. In the 10 to 14" PZ, the total annual production (air-dry weight) is about 500 pounds per acre during an average year, but it can range from about 350 pounds per acre in unfavorable years to about 650 pounds per acre in above-average years. The hazard of soil erosion has increased due to the increase of bare ground. Runoff is typically high and infiltration is low. All ecological functions are impaired. Desertification is advanced.

Figure 12. Plant community growth curve (percent production by month).
 WY1104, 12-14SP upland sites w/ warm. 12-14" Precipitation Zone, Southern Plains (SP) with warm-season (grass) species.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	20	35	30	5	5	0	0	0

State 4 Tilled State

The Tilled State is the result of mechanical farming operations on the site. An ecological threshold has been crossed due to complete removal of vegetation and years of soil tillage. Physical, chemical, and biological soil properties have been dramatically altered. There is no restorative pathway known at this time. This state includes Go-back and Seeded Communities.

Community 4.1

Abandoned Cropland

Go-back land is created when the soil is tilled or farmed (sodbusted) and abandoned. Native plants are destroyed, soil organic matter is reduced, soil structure is changed, and a plowpan or compacted layer is formed. Residual synthetic chemicals often remain from past farming operations, and erosion processes may be active. Go-back land evolves through several plant communities beginning with an early annual plant community, which initiates the revegetation process. Plants such as Russian thistle, kochia, sixweeks fescue, cheatgrass, and other annuals begin to establish. These plants give some protection from erosion and start to build minor levels of soil organic matter. Purple threeawn, sand dropseed, and several other early perennials can dominate the plant community for five to eight years or more. Non-native perennial grasses such as crested wheatgrass may invade the site. Eventually western wheatgrass, needle and thread, and other natives become reestablished. Blue grama and threadleaf sedge are absent. Forbs can include annual sunflower, bractless blazingstar, and Rocky Mountain beeplant. Where go-back land has eroded to parent material, the slow process of soil development and re-establishment of vegetation will start. This is a very slow process (100 years or more). A new ecological site may evolve depending upon the severity of soil and parent material erosion, and parent material.

Community 4.2 Seeded Community

The Seeded Plant Community can vary considerably depending upon the degree of soil erosion, the species seeded, stand establishment, and the age and management of the stand. This plant community is represented by applying the conservation practice of Rangeland Seeding on go-back land or recently cropped land for converting it to permanent vegetative cover. Plant species indigenous to the site are used throughout the MLRA due to their suitability to the semi-arid climate. Indigenous species are most adapted to site conditions and therefore can be sustained in the MLRA. Improved cultivars (named varieties) of plant species are typically used to enhance seedling establishment and meet specific reclamation resource objectives.

Transition T1A State 1 to 2

Excessive grazing without adequate recovery between grazing events or frequent and severe defoliation, if continued, will shift this plant community across an ecological threshold toward the Sod-bound State. Biotic integrity and hydrologic function will be impaired because of this transition.

Transition T1B State 1 to 3

Heavy, excessive grazing with overstocking or frequent and severe defoliation, will shift this plant community across an ecological threshold toward the Increased *Bare Ground* State. Erosion and loss of organic matter and carbon reserves are concerns. Non-native plants are likely to invade.

Transition T1C State 1 to 4

Mechanical tillage of this ecological site will cause an immediate transition across an ecological threshold to the Tilled State. This transition can occur from any plant community and is irreversible.

Transition T2A State 2 to 3

Long-term heavy excessive grazing without adequate recovery periods, or heavy, excessive grazing with overstocking, or frequent and severe defoliation, if continued, will cause a shift across an ecological threshold to the Increased *Bare Ground* State. Erosion and loss of organic matter are concerns. Annual plants such as sixweeks fescue and/or cheatgrass, are likely to increase or invade because of this transition.

Transition T2B State 2 to 4

Mechanical tillage of this ecological site will cause an immediate transition across an ecological threshold to the Tilled State. This transition can occur from any state or plant community and is irreversible.

Transition T3A State 3 to 4

Mechanical tillage of this ecological site will cause an immediate transition across an ecological threshold to the Tilled State. This transition can occur from any state or plant community and is irreversible.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	Cool-season mid-rhizomatous			84–146	
	western wheatgrass	PASM	<i>Pascopyrum smithii</i>	84–179	1–10
	thickspike wheatgrass	ELLAL	<i>Elymus lanceolatus</i> ssp. <i>lanceolatus</i>	84–179	1–10
2	Cool-season mid-bunch			506–1076	
	needle and thread	HECO26	<i>Hesperostipa comata</i>	211–448	10–25
	Indian ricegrass	ACHY	<i>Achnatherum hymenoides</i>	127–269	5–15
	Cusick's bluegrass	POCU3	<i>Poa cusickii</i>	84–179	1–10
	threadleaf sedge	CAFI	<i>Carex filifolia</i>	84–179	1–10
3	Warm-season mid-bunch			168–359	
	little bluestem	SCSC	<i>Schizachyrium scoparium</i>	84–179	1–10
4	Warm-season rhizomatous			168–359	
	prairie sandreed	CALO	<i>Calamovilfa longifolia</i>	168–359	10–20
5	Miscellaneous			211–448	
	prairie Junegrass	KOMA	<i>Koeleria macrantha</i>	43–90	1–5
	needleleaf sedge	CADU6	<i>Carex duriuscula</i>	43–90	1–5
	sun sedge	CAINH2	<i>Carex inops</i> ssp. <i>heliophila</i>	43–90	1–5
	blue grama	BOGR2	<i>Bouteloua gracilis</i>	43–90	1–5
	hairy grama	BOHI2	<i>Bouteloua hirsuta</i>	43–90	1–5
	Sandberg bluegrass	POSE	<i>Poa secunda</i>	43–90	1–5
	Grass, perennial	2GP	<i>Grass, perennial</i>	43–90	1–5
Forb					
6	Forb			127–448	
	American vetch	VIAM	<i>Vicia americana</i>	43–90	1–5
	upright prairie coneflower	RACO3	<i>Ratibida columnifera</i>	43–90	1–5
	aster	ASTER	<i>Aster</i>	43–90	1–5
	desertparsley	LOMAT	<i>Lomatium</i>	43–90	1–5
	large Indian breadroot	PEES	<i>Pedimelum esculentum</i>	43–90	1–5
	common yarrow	ACMI2	<i>Achillea millefolium</i>	43–90	1–5
	rosy pussytoes	ANRO2	<i>Antennaria rosea</i>	43–90	1–5
	milkvetch	ASTRA	<i>Astragalus</i>	43–90	1–5
	sulohur-flower	ERUM	<i>Eriogonum umbellatum</i>	43–90	1–5

	buckwheat				
	stemless mock goldenweed	STAC	<i>Stenotus acaulis</i>	43–90	1–5
	scarlet beeblossom	OESU3	<i>Oenothera suffrutescens</i>	43–90	1–5
	purple prairie clover	DAPU5	<i>Dalea purpurea</i>	43–90	1–5
	white prairie clover	DACA7	<i>Dalea candida</i>	43–90	1–5
	bluebells	MERTE	<i>Mertensia</i>	43–90	1–5
	textile onion	ALTE	<i>Allium textile</i>	43–90	1–5
	tapertip hawksbeard	CRAC2	<i>Crepis acuminata</i>	43–90	1–5
	scarlet globemallow	SPCO	<i>Sphaeralcea coccinea</i>	43–90	1–5
	Forb, perennial	2FP	<i>Forb, perennial</i>	43–90	1–5
	scarlet beeblossom	GACO5	<i>Gaura coccinea</i>	43–90	1–5
Shrub/Vine					
7	Shrub			127–269	
	Subshrub (<.5m)	2SUBS	<i>Subshrub (<.5m)</i>	43–90	1–5
	Wyoming big sagebrush	ARTRW8	<i>Artemisia tridentata ssp. wyomingensis</i>	43–90	1–5
	silver sagebrush	ARCA13	<i>Artemisia cana</i>	43–90	1–5
	western snowberry	SYOC	<i>Symphoricarpos occidentalis</i>	43–90	1–5
	winterfat	KRLA2	<i>Krascheninnikovia lanata</i>	43–90	1–5
	prairie sagewort	ARFR4	<i>Artemisia frigida</i>	43–90	1–5
	soapweed yucca	YUGL	<i>Yucca glauca</i>	43–90	1–5
	Shrub (>.5m)	2SHRUB	<i>Shrub (>.5m)</i>	43–90	1–5
	yellow rabbitbrush	CHVI8	<i>Chrysothamnus viscidiflorus</i>	43–90	1–5

Animal community

Wildlife Interpretations (from 2001 ESD; will be revised in future updates)

Needleandthread/ Prairie sandreed (Reference): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. When found adjacent to sagebrush- dominated states, this plant community may provide brood-rearing and foraging areas for sage grouse, as well as lek sites. Other birds that would frequent this plant community include western meadowlarks, horned larks, and golden eagles. Many grassland-obligate small mammals would occur here.

Needleandthread/Threadleaf sedge/Fringed sagewort: These communities provide foraging for antelope and other grazers. They may be used as a foraging site by sage grouse if proximal to woody cover.

Threadleaf sedge/Fringed sagewort/Cactus: These communities provide limited grazing for antelope and other herbivores due to low production. They may be used as a foraging site by sage grouse if proximal to woody cover.

Grazing Interpretations (updated in 2019 Provisional revision)

Plant Community (PC) Production (lbs.ac), and Stocking Rate (AUM/Acre)

The table below is a guide to stocking rates for the plant communities described in the Sandy 10 to 14 inch Precipitation Zone ecological site. These are conservative estimates for initial planning. On-site conditions will vary, and stocking rates should be adjusted based on range inventories, animal kind and class, forage availability (adjusted for slope, distance to water), and the type of grazing system (number of pastures, planned moves, etc.), all of which is determined in the conservation planning process.

The following stocking rates are based on the total annual forage production in a normal year multiplied by 25 percent harvest efficiency of preferred and desirable forage species, divided by 912 pounds of ingested air-dry vegetation for an animal unit per month (Natl. Range and Pasture Handbook, 1997). An animal unit month is defined as the amount of forage required by one livestock animal, with or without one calf, for one month, and is shortened to AUM.

Plant Community (PC) Production (total lbs./acre in a normal year) and Stocking Rate (AUM/acre) are listed below:

Example:

1,300 lbs. per acre X 25% Harvest Efficiency = 325 lbs. forage demand for one month. 325 lbs. per acre/912 demand per AUM = 0.36

Plant Community (PC) Production (lbs.ac), and Stocking Rate (AUM/Acre)

Reference Plant Community 750-1600 .4

Threadleaf sedge/Needleandthread/Fringed sagewort 600-1000 .33

Threadleaf sedge/Fringed sagewort/Cactus 500-900 .2

Increased *Bare Ground* PC (*) (*)

Go-back PC (*) (*)

Seeded PC (*) (*)

* Highly variable stocking rates must be determined on-site.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangelands in this area provide year-long forage under prescribed grazing for cattle, sheep, horses, and other herbivores. During the dormant period, livestock may need supplementation based on reliable forage analysis.

Hydrological functions

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

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals typically non-existent, but steeper areas (greater than 10% slope) may have limited pedestalling of bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Cryptogamic crusts are present, but only cover 1-2 percent of the soil surface.

Recreational uses

This site provides hunting opportunities for upland game species. The wide variety of plants which bloom from spring until fall have an esthetic value that appeals to visitors.

Wood products

No appreciable wood products are present on the site.

Other products

None noted.

Other information

Site Development & Testing Plan

General Data (MLRA and Revision Notes, Hierarchical Classification, Ecological Site Concept, Physiographic, Climate, and Water Features, and Soils Data):

Updated all "Required" items complete to Provisional level.

Community Phase Data (Ecological Dynamics, STM, Transition & Recovery Pathways, Reference Plant Community, Species Composition List, Annual Production Table, and Growth Curve):

Updated all "Required" items complete to Provisional level.

Annual Production Table is from the "Previously Approved" ESD (2001).

The Annual Production Table and Species Composition List will be reviewed for future updates at the Approved level.

Each Alternative State/Community:

Complete to Provisional level.

Supporting Information (Site Interpretations, Assoc. & Similar Sites, Inventory Data References, Agency/State Correlation, References):

Updated all "Required" items complete to Provisional level.

Wildlife Interpretations: Narrative is from "Previously Approved" ESD (2001). Wildlife species will be updated at the next Approved level.

Livestock Interpretations: Plant community names and stocking rates updated.

Hydrology, Recreational Uses, Wood Products, and Other Products carried over from previously "Approved" ESD (2001).

Existing NRI Inventory Data References updated.

Reference Sheet:

Rangeland Health Reference Sheet carried over from previously "Approved" ESD (2005). It will be updated at the next "Approved" level.

"Future work, as described in a project plan, to validate the information in this provisional ecological site description is needed. This will include field activities to collect low and medium intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document." (NI 430_306 ESI and ESD, April 2015)

Inventory data references

Inventory data has been collected on private and federal lands by the following methods:

- Double Sampling (Determining Vegetation Production and Stocking Rates, WY-ECS-1)
- Rangeland Health (Interpreting Indicators of Rangeland Health, Version 4, 2005)
- Soil Stability (Interpreting Indicators of Rangeland Health, Version 4, 2005)
- Line Point Intercept (Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems, Volume II, 2005)

- Soil Pedon Descriptions (Field Book for Describing and Sampling Soils, Version 3, 2012)
- SCS-RANGE-417 (Production & Composition Record for Native Grazing Lands)

National Resources Inventory (NRI)

Number of Records: 78

Sample Period: 2004-2017

State: WY

Counties: Campbell, Converse, Johnson, Natrona, Niobrara, Weston

Additional data collection includes ESI data collection in conjunction with Soil Surveys conducted within MLRA 58B; ocular estimates; rangeland vegetative clipping for NRCS program support; field observations from experienced rangeland personnel

Data collection for this ecological site was done in conjunction with the progressive soil surveys within MLRA 58B Northern Rolling High Plains (Southern Part)

Note: Revisions to soil surveys are on-going. For the most recent updates, visit the Web Soil Survey, the official site for soils information: <http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>

Other references

Anderson, R.C. 2006. Evolution and origin of the central grassland of North America: Climate, fire, and mammalian grazers. *Journal of the Torrey Botanical Society* 133:626–647.

Bragg, T.B. 1995. The physical environment of the Great Plains grasslands. In: A. Joern and K.H. Keeler (eds) *The changing prairie*. Oxford University Press, Oxford, UK, pages 49–81.

Branson, D.H. and G.A. Sword. 2010. An experimental analysis of grasshopper community responses to fire and livestock grazing in a northern mixed-grass prairie. *Environmental Entomology* 39:1441–1446.

Brinson, M.M. 1993. A hydrogeomorphic classification for wetlands. Technical Report WRP–DE–4. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Cleland, D., P. Avers, W.H. McNab, M. Jensen, R. Bailey, T. King, and W. Russell. 1997. National hierarchical framework of ecological units. In: *Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources*, Yale University Press.

Coupland, R.T. 1958. The effects of fluctuations in weather upon the grasslands of the Great Plains. *Botanical Review* 24:273–317.

Davis, S.K., R.J. Fisher, S.L. Skinner, T.L. Shaffer, and R.M. Brigham. 2013. Songbird abundance in native and planted grassland varies with type and amount of grassland in the surrounding landscape. *Journal of Wildlife Management* 77:908–919.

DeLuca, T.H. and P. Lesica. 1996. Long-term harmful effects of crested wheatgrass on Great Plains grassland ecosystems. *Journal of Soil and Water Conservation* 51:408–409.

Derner, J.D. and R.H. Hart. 2007. Grazing-induced modifications to peak standing crop in northern mixed-grass prairie. *Rangeland Ecology and Management* 60:270–276.

Derner, J.D. and A.J. Whitman. 2009. Plant interspaces resulting from contrasting grazing management in northern mixed-grass prairie: Implications for ecosystem function. *Rangeland Ecology and Management* 62:83–88.

Derner, J.D., W.K. Lauenroth, P. Stapp, and D.J. Augustine. 2009. Livestock as ecosystem engineers for grassland bird habitat in the western Great Plains of North America. *Rangeland Ecology and Management* 62:111–118.

Dillehay, T.D. 1974. Late Quaternary bison population changes on the southern Plains. *Plains Anthropologist* 19:180–196.

- Dormaar, J.F., and S. Smoliak. 1985. Recovery of vegetative cover and soil organic matter during revegetation of abandoned farmland in a semiarid climate. *Journal of Range Management* 38:487–491.
- Guyette, Richard P., M.C. Stambaugh, D.C. Dey, and R.M. Muzika. (2012). Predicting fire frequency with chemistry and climate. *Ecosystems*, 15: 322-335.
- Harmony, K.R. 2007. Grazing and burning Japanese brome (*Bromus japonicus*) on mixed grass rangelands. *Rangeland Ecology and Management* 60:479–486.
- Heitschmidt, R.K. and L.T. Vermeire. 2005. An ecological and economic risk avoidance drought management decision support system. In: J.A. Milne (ed.) *Pastoral systems in marginal environments*, 20th International Grasslands Congress, July, 2005. Page 178.
- Knopf, F.L. 1996. Prairie legacies—Birds. In: F.B. Samson and F.L. Knopf (eds.) *Prairie conservation: Preserving North America's most endangered ecosystem*. Island Press, Washington, DC. Pages 135–148.
- Knopf, F.L., and F.B. Samson. 1997. Conservation of grassland vertebrates. In: F.B. Samson and F.L. Knopf (eds.) *Ecology and conservation of Great Plains vertebrates: Ecological Studies* 125. Springer-Verlag, New York, NY. Pages 273–289.
- Lauenroth, W.K., O.E. Sala, D.P. Coffin, and T.B. Kirchner. 1994. The importance of soil water in recruitment of *Bouteloua gracilis* in the shortgrass steppe. *Ecological Applications* 4:741–749.
- Laycock, W.A. 1988. History of grassland plowing and grass planting on the Great Plains. In: J.E. Mitchell (ed.) *Impacts of the Conservation Reserve Program in the Great Plains—symposium proceedings*, September 16–18, 1987. U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.
- Malloch, D.W., K.A. Pirozynski, and P.H. Raven. 1980. Ecological and evolutionary significance of mycorrhizal symbioses in vascular plants (a review). *Proceedings of the National Academy of Sciences* 77:2113–2118.
- Ogle, S.M., W.A. Reiners, and K.G. Gerow. 2003. Impacts of exotic annual brome grasses (*Bromus* spp.) on ecosystem properties of the northern mixed grass prairie. *American Midland Naturalist* 149:46–58.
- Roath, L.R. 1988. Implications of land conversions and management for the future. In: J.E. Mitchell (ed.) *Impacts of the Conservation Reserve Program in the Great Plains—symposium proceedings*, September 16–18, 1987. U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.
- Smoliak, S. and J.F. Dormaar. 1985. Productivity of Russian wildrye and crested wheatgrass and their effect on prairie soils. *Journal of Range Management* 38:403–405.
- Smoliak, S., J.F. Dormaar, and A. Johnston. 1972. Long-term grazing effects on *Stipa-Bouteloua* prairie soils. *Journal of Range Management* 25:246–250.
- Soil Survey Division Staff. 2017. Soil survey manual. U.S. Dept. of Agriculture Handbook 18.
- Soil Survey Staff. Official Soil Series Descriptions. U.S. Dept. of Agriculture, Natural Resources Conservation Service. Available online. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053587 Accessed 15 November, 2017.
- Soil Survey Staff. Soil Survey Geographic (SSURGO) database. U.S. Dept. of Agriculture, Natural Resources Conservation Service.
- Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th edition. U.S. Dept. of Agriculture, Natural Resources Conservation Service.

- Soil Survey Staff. 2018. Web Soil Survey. U.S. Dept. of Agriculture, Natural Resources Conservation Service. Available online. <https://websoilsurvey.nrcs.usda.gov/app/>. Accessed 15 February, 2018.
- Soller, D.R. 2001. Map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains. U.S. Geological Survey Miscellaneous Investigations Series I-1970-E, scale 1:3,500,000.
- Stewart, Omer C. 2002. *Forgotten Fires*. Univ. of Oklahoma Press, Norman, OK.
- United States Department of Agriculture, Natural Resources Conservation Service. Glossary of landform and geologic terms. National Soil Survey Handbook, Title 430-VI, Part 629.02c. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054242 (Accessed 16 January, 2018).
- United States Army Corps of Engineers. 1987. Corps of Engineers wetlands delineation manual. Wetlands Research Program Technical Report Y-87-1. Available online. <http://www.lrh.usace.army.mil/Portals/38/docs/USACE%2087%20Wetland%20Delineation%20Manual.pdf>. Waterways Experiment Station, Vicksburg, MS.
- United States Environmental Protection Agency, National Health and Environmental Effects Research Laboratory. 2013. Level III ecoregions of the continental United States. Available online. <https://www.epa.gov/eo-research/ecoregions> Accessed 30 January, 2019.
- United States Department of Agriculture, Natural Resources Conservation Service. 2010a. Field indicators of hydric soils in the United States, version 7.0.
- United States Department of Agriculture, Natural Resources Conservation Service. 2013a. Climate data. National Water and Climate Center. Available online. <http://www.wcc.nrcs.usda.gov/climate>. Accessed 13 October, 2017.
- United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. Agriculture Handbook 296.
- United States Department of Agriculture, Natural Resources Conservation Service. 2013b. National Soil Information System. Available online. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?Cid=nrcs142p2_053552. Accessed 30 October, 2017.
- United States Department of the Interior, Geological Survey. 2008. LANDFIRE 1.1.0 Vegetation Dynamics Models. <http://landfire.cr.usgs.gov/viewer/>.
- United States Department of the Interior, Geological Survey. 2011. LANDFIRE 1.1.0 Existing Vegetation Types. <http://landfire.cr.usgs.gov/viewer/>.
- Willeke, G.E. 1994. The national drought atlas [CD ROM]. U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources Report 94-NDS-4.
- Wilson, S.D., and J.M. Shay. 1990. Competition, fire, and nutrients in a mixed-grass prairie. *Ecology* 71:1959–1967.
- With, K.A. 2010. McCown's longspur (*Rhynchophanes mccownii*). In: A. Poole (ed.) *The birds of North America* [online]. Cornell Lab of Ornithology, Ithaca, NY. Available online. <https://birdsna.org/Species-Account/bna/home>.
- Augustine, D.J., J. Derner, D. Milchunas, D. Blumenthal, and L. Porensky. 2017. Grazing moderates increases in C3 grass abundance over seven decades across a soil texture gradient in shortgrass steppe. In: *Journal of Vegetation Science*, DOI:10.1111/jvs.12508.
- Clark, J., E. Grimm, J. Donovan, S. Fritz, D. Engrstrom, and J. Almendinger. 2002. Drought cycles and landscape responses to past aridity on prairies of the Northern Great Plains, USA. *Ecology*, 83(3), Pages 595-601.
- Connell, L. C., J. D. Scasta, and L. M. Porensky. 2018. Prairie dogs and wildfires shape vegetation structure in a

sagebrush grassland more than does rest from ungulate grazing. *Ecosphere* 9(8):e02390. 10.1002/ecs2.2390

Collins, S. and S. Barber. (1985). Effects of disturbance on diversity in mixed-grass prairie. In: *Vegetatio*, 64, pages 87-94.

Egan, Timothy. 2006. *The Worst Hard Time*. Houghton Mifflin Harcourt Publishing Company, New York, NY.

Guyette, R.P., M.C. Stambaugh, D.C. Dey, and R.M. Muzika. 2012. Predicting fire frequency with chemistry and climate. In: *Ecosystems*, 15: pages 322-335.

Hart, R. and J. Hart. 1997. Rangelands of the Great Plains before European settlement. In: *Rangelands*, 19(1), pages 4-11.

Hart, R. 2001. Plant biodiversity on shortgrass steppe after 55 years of zero, light, moderate, or heavy cattle grazing. In: *Plant Ecology*, 155, pages 111-118.

Pellant, M., P. Shaver, D.A. Pyke, and J.E. Herrick. 2005. Interpreting indicators of rangeland health, Version 4. United States Department of the Interior, Bureau of Land Management.

Porensky, L.M. and D.M. Blumenthal. 2016. Historical wildfires do not promote cheatgrass invasion in a western Great Plains steppe. In: *Biological Invasions* 18:3333-3349: DOI 10.1007/s10530-16-1225-z

Porensky, L.M., J.D. Derner, and D.W. Pellatz. 2018. Plant community responses to historical wildfire in a shrubland-grassland ecotone reveal hybrid disturbance response. In: *Ecosphere*. DOI: 9(8):e02363. 10.1002/ecs2.2363.

Mack, Richard N., and J.N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. In: *The American Naturalist*. 119, No. 6, pages 757-773.

Reyes-Fox, M., H. Stelzer, M.J. Trlica, G.S. McMaster, A. A. Andales, D.R. LeCain, and J.A. Morgan. 2014. Elevated CO₂ further lengthens growing season under warming conditions. In: *Nature*, April 23, 2014. Available online. <http://www.nature.com/nature/journal/v510/n7504/full/nature13207.html>. Accessed 1 March, 2017.

Schoeneberger, P.J., D.A. Wysockie, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, Version 3.0. U.S. Dept. of Agriculture, Natural Resources Conservation Service.

Stahl, David W., E.R. Cook, M.K. Cleaveland, M.D. Therrell, D.M. Meko, H.D. Grissino-Mayer, E. Watson, and B.H. Luckman. Tree-ring data document 16th century megadrought over North America. 2000. In: *Eos*, 81(12), pages 121-125.

Stewart, Omer C. 2002. *Forgotten Fires*. University of Oklahoma Press, Norman, OK.

Stubbendieck, James, S.L. Hatch, and L.M. Landholt. 2003. *North American wildland plants*. Univ. of Nebraska Press, Lincoln and London.

Zelikova, T.J., D.M. Blumenthal, D.G. Williams, L. Souza, D.R. LeCain, and J. Morgan. 2014. Long-term exposure to elevated CO₂ enhances plant community stability by suppressing dominant plant species in a mixed-grass prairie. In: *Ecology*, 2014. Available online. <https://www.pnas.org/content/111/43/15456>.

United States Department of Agriculture, Natural Resources Conservation Service. National Ecological Site Handbook, Title 190, Part 630, 1st Edition. Available online. <https://directives.sc.egov.usda.gov/>. Accessed 15 September, 2017.

United States Department of Agriculture, Natural Resources Conservation Service. 2009. Part 630, Hydrology, National Engineering Handbook.

United States Department of Agriculture, Natural Resources Conservation Service. 1972-2012. National Engineering Handbook Hydrology Chapters. Available online.

<http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?&cid=stelprdb1043063>. Accessed August, 2015.

United States Department of Agriculture, Natural Resources Conservation Service. 1997, revised 2003. National Range and Pasture Handbook. Available online. <http://www.glti.nrcs.usda.gov/technical/publications/nrph.html> Accessed 26 February, 2018.

United States Department of Agriculture, Natural Resources Conservation Service. National Soil Survey Handbook title 430-VI. Available online. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054242.

United States Department of Agriculture, Natural Resources Conservation Service. Web Soil Survey. Available online. <http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>. Accessed 15 November, 2017.

United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). Cooperative climatological data summaries. NOAA Western Regional Climate Center, Reno, NV. Available online. <http://www.wrcc.dri.edu/climatedata/climsum>. Accessed 16 November, 2017.

Contributors

Everett Bainter
Glenn Mitchell

Approval

Kirt Walstad, 10/05/2023

Acknowledgments

Project Staff:

Kimberly Diller, Ecological Site Inventory Specialist, NRCS MLRA SSO, Pueblo CO
Mike Leno, Project Leader, NRCS MLRA SSO, Buffalo, WY

Partners/Contributors:

Joe Dyer, Soil Scientist, NRCS MLRA SSO, Buffalo, WY
Arnie Irwin, Soil Scientist, BLM, Buffalo, WY
Blaine Horn, Rangeland Extension Educator, UW Extension, Buffalo, WY
Isabelle Giuliani, Resource Soil Scientist, NRCS, Douglas, WY
Mary Jo Kimble, Project Leader, NRCS MLRA SSO, Miles City, MT
Ryan Murray, Rangeland Management Specialist, NRCS, Buffalo, WY
Lauren Porensky, Ph.D. Ecologist, ARS, Fort Collins, CO
Chadley Prosser, Rangeland Program Manager, USFS, Bismarck, ND
Bryan Christensen, Ecological Site Inventory Specialist, NRCS-MLRA SSO, Pinedale, WY
Marji Patz, Ecological Site Inventory Specialist, NRCS-MLRA SSO, Powell, WY
Rick Peterson, Ecological Site Inventory Specialist, NRCS-MLRA SSO, Rapid City, SD

Program Support:

John Hartung, WY State Rangeland Management Specialist-QC, NRCS, Casper, WY
David Kraft, NRCS MLRA Ecological Site Inventory Specialist-QA, Emporia, KS
Carla Green Adams, Editor, NRCS-SSR5, Denver, CO
Chad Remley, Regional Director, Northern Great Plains Soil Survey, Salina, KS

Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	04/01/2005
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rills should not be present.

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

3. **Number and height of erosional pedestals or terracettes:** Essentially non-existent.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground is 20-30% occurring in small areas throughout site.

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

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

7. **Amount of litter movement (describe size and distance expected to travel):** Little to no plant litter movement. Plant litter remains in place and is not moved by erosional forces.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Plant cover and litter is at 70% or greater of soil surface and maintains soil surface integrity. Soil Stability class is anticipated to be 4 or greater.

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

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Grass canopy and basal cover should reduce raindrop impact and slow overland flow providing increased time for infiltration to occur. Healthy deep-rooted native grasses enhance infiltration

and reduce runoff. Infiltration is Moderately Rapid to Rapid.

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 or soil surface crusting should be present.
-

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

Dominant: Mid stature Cool Season Grasses = Mid-stature Warm-season Grasses

Short-stature Grasses/Grasslike Shrubs Forbs

Sub-dominant:

Other:

Additional:

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

14. **Average percent litter cover (%) and depth (in):** Average litter cover is 25-35% with depths of 0.25 to 1.0 inches
-

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 1300 lbs./ac
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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:** Threadleaf sedge, Fringed sagewort, Prickly Pear, Broom Snakeweed, Yucca, and Species found on Noxious Weed List.
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17. **Perennial plant reproductive capability:** All species are capable of reproducing.
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