United States Department of Agriculture
Natural Resources Conservation Service

Ecological Site Description

Site Stage: Provisional

Provisional: an ecological site description (ESD) at the provisional status represents the lowest tier of documentation that is releasable to the public. It contains a grouping of soil units that respond similarly to ecological processes. The ESD contains 1) enough information to distinguish it from similar and associated ecological sites and 2) a draft state and transition model capturing the ecological processes and vegetative states and community phases as they are currently conceptualized. The provisional ESD has undergone both quality control and quality assurance protocols. It is expected that the provisional ESD will continue refinement towards an approved status.

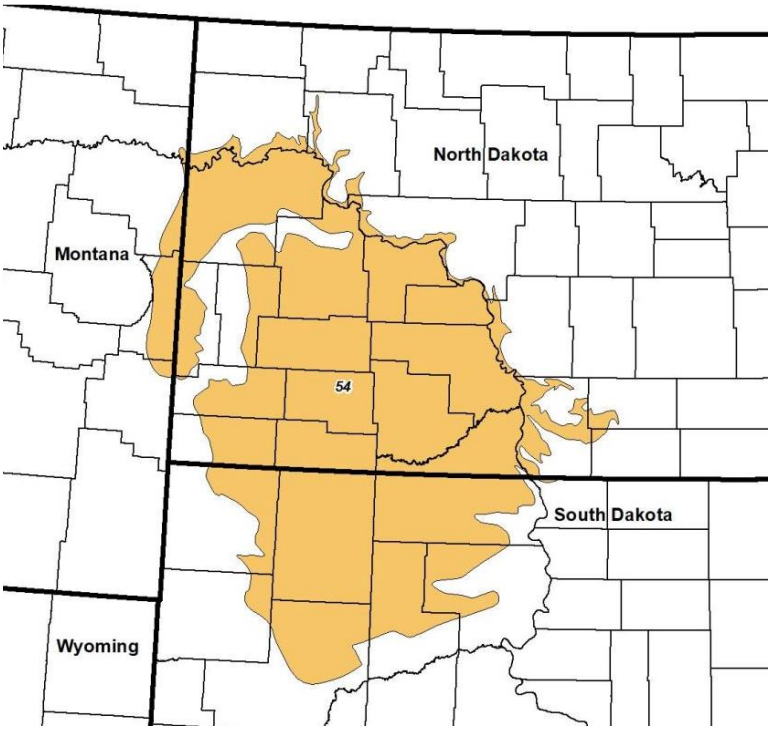
Site Name: Limy Sands

Site Type: Rangeland

Site ID: R054XY045ND

Major Land Resource Area (MLRA): 54-Rolling Soft Shale Plain

For more information on MLRAs, refer to the following web site: https://www.nrcs.usda.gov/resources/data-and-reports/major-land-resource-area-mlra



Location of MLRA 54 - Rolling Soft Shale Plain in North Dakota, South Dakota, and Montana

MLRA 54 covers 29,280 square miles and encompasses approximately 18.7 million acres. MLRA 54 spans three states with 64 percent of it in North Dakota, 33 percent in South Dakota, and 3 percent in Montana. Most of MLRA 54 is underlain by soft, calcareous shale, siltstone, and sandstone of the Tertiary Fort Union Group and the Cretaceous Fox Hills and Hell Creek Formations. Most of the soils in MLRA 54 developed from residuum weathered in place including colluvial and alluvial deposits from residuum. Along the eastern and northern edges of the MLRA where MLRA 54 transitions into the glaciated Missouri plateau, remnants of glacial till parent materials remain on the high areas of the landscape. The MLRA 54 landscape is characterized by moderately dissected rolling plains with areas of local badlands, hills, and isolated buttes. Elevation is 1,650 feet (505 meters) on the eastern side of the MLRA with a gradual rise to 3,600 feet (1,100 meters) on the western side. The Missouri River runs along the north and east side of MLRA 54. Most of the Standing Rock Indian Reservation, the northwest third of the Cheyenne River Indian Reservation, and the Grand River National Grasslands are in the southern part of the MLRA.

Ecological Site Concept

The Limy Sands ecological site is formed in sandy materials weathered from calcareous soft sandstone. These sites are located on pediments, ridges and hillslopes on sedimentary uplands. Slopes range from 0 to 50 percent. The Limy Sands site has a soil surface layer that ranges from 5 to 12 inches thick in native grassland; where cultivated, much (or all) of the naturally formed surface layer may be mixed with the upper part of the subsoil. The soil typically has a loamy fine sand texture above the weathered sandstone; however, textures of loamy sand or fine sandy loam are allowed. Depth to calcium carbonates is 0 to 12 inches. Depth to sandstone (affects root growth), is 20 to 40 inches. On the landscape, the Shallow Sandy ecological site is higher; the Sands and Sandy sites are lower. The Choppy sands site is on nearby dune areas. In a few areas, rock outcrops of hard sandstone may also occur.

Physiographic Features

The Limy Sands sites are located on nearly level to very steep sedimentary uplands. Slope ranges from 0 to 50 percent.

Landform: pediments, ridges, hillslopes

	Minimum	**Maximum**
Elevation (feet):	1650	3600
Slope (percent):	0	50
Water Table Depth (inches):	80	>80
Flooding:		
Frequency:	None	None
Ponding:		
Frequency:	None	None
Runoff Class:	Very low	Medium
Aspect:	No influence on this site	

Climatic Features

MLRA 54 is considered to have a continental climate with cold winters and hot summers, low humidity, light rainfall, and much sunshine. Extremes in temperature are common and characteristic of the MLRA. The continental climate is the result of this MLRA's location in the geographic center of North America. There are few natural barriers on the northern Great Plains, so air masses move unobstructed across the plains and account for rapid changes in temperature.

Annual precipitation ranges from 14 to 18 inches per year. The normal average annual temperature is about 42° F. January is the coldest month with average temperatures ranging from about 13° F (Beach, ND) to about 16° F (Bison, SD). July is the warmest month with temperatures averaging from about 69° F (Beach, ND) to about 72° F (Timber Lake, SD). The range of normal average monthly temperatures between the coldest and warmest months is about 57° F. This large temperature range attests to the continental nature of MLRA 54's climate. Wind speeds average about 11 miles per hour, ranging from about 13 miles per hour during the spring to about 10 miles per hour during the summer. Daytime wind speeds are generally stronger than nighttime wind speeds, and occasional strong storms may bring brief periods of high winds with gusts to more than 50 miles per hour.

Growth of native cool-season plants begins in late March and continues through early to mid-July. Native warm-season plants begin growth in mid-May and continue to the end of August. Greening up of cool-season plants can occur again in September and October when adequate soil moisture is present.

Climate Station(s) 1981 - 2010

Sation	Name	Location	Elevation	Lat	Long
USC00323207	FT YATES 4 SW	Fort Yates	1674.9	46.05	-100.6667
USC00392429	DUPREE	Dupree	2375.0	45.0481	-101.5992
USC00324178	HETTINGER	Hettinger	2680.1	45.9925	-102.6442
USC00329233	WATFORD CITY	Watford City	2169.9	47.8039	-103.2892
USC00325479	MANDAN EXP STN	Mandan	1750.0	46.8128	-100.9097
USC00395048	LUDLOW 3 SSE	Ludlow	2990.2	45.785	-103.3719
USC00324102	HEBRON	Hebron	2167.0	46.9028	-102.0478

Climate Normals

	Representative		Actual		
	High	Low	High	Low	Average
Mean annual precipitation (in):	18	15	18	15	16
Frost free period (days):	111	95	114	91	101
Freeze free period (days):	127	118	129	116	123

Normal Monthly Precipitation (in)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Representative high:	0.4	0.4	1.0	1.7	2.8	3.3	2.7	1.7	1.5	1.4	0.7	0.4
Representative low:	0.3	0.3	0.6	1.0	2.5	3.0	2.2	1.4	1.1	1.2	0.5	0.3
Actual high:	0.5	0.5	1.1	1.9	3.0	3.4	3.1	2.1	1.5	1.5	0.7	0.5
Actual low:	0.2	0.3	0.6	0.9	2.3	2.9	2.1	1.3	1.0	1.1	0.4	0.2

Normal Monthly Minimum Temperature (°F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Representative high:	8.3	12.0	20.5	31.0	42.7	52.3	57.8	55.5	44.9	32.8	20.1	9.3
Representative low:	2.1	7.3	17.1	28.7	40.2	49.7	55.1	52.8	41.8	30.0	18.1	6.2
Actual high:	9.2	12.8	21.3	31.9	43.3	52.7	58.7	56.8	46.3	34.0	21.0	10.3
Actual low:	2.0	6.7	17.0	28.4	39.6	49.7	55.0	52.4	41.6	29.5	17.4	5.8
Average:	4.7	9.1	18.8	29.9	41.3	50.9	56.6	54.4	43.5	31.5	19.0	7.5

Normal Monthly Maximum Temperature (°F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Representative high:	29.1	33.2	43.2	58.3	69.1	78.5	86.6	85.6	73.9	59.8	42.2	30.1
Representative low:	23.5	28.9	39.6	55.1	66.4	75.2	83.2	82.6	71.2	56.6	39.3	26.4
Actual high:	29.8	33.5	43.7	59.1	70.1	79.8	87.3	86.7	75.5	60.6	42.4	30.6
Actual low:	23.1	28.2	39.3	55.0	65.8	74.9	82.8	82.1	70.5	56.4	38.8	25.9
Average:	26.3	30.9	41.4	56.6	67.6	76.6	84.6	84.1	72.5	57.9	40.6	28.3

30 Year Annual Rainfall (inches): D-Dry; N-Normal; W-W

1981 N	1982 W	1983 D	1984 N	1985 D	1986 N	1987 D	1988 D	1989 D	1990 D	1991 N	1992 N	1993 W	1994 N	1995 W
15.1	26.3	12.7	16.1	14	18.9	14.7	10.6	14.8	11.2	15.4	15.3	19.9	17.4	21.5

1996 W	1997 D	1998 W	1999 N	2000 N	2001 N	2002 D	2003 D	2004 D	2005 B	2006 N	2007 N	2008 N	2009 N	2010 W
19.5	14.2	21.5	16.9	17.9	15.9	10.2	14.4	13.8	17.3	11.5	17.1	18.4	16.8	22.5

Influencing Water Features

No significant water features influence this site. It is on a runoff landscape position. A seasonal water table is deeper than 6 feet throughout the growing season. Permeability is moderately rapid or rapid. Water loss is through evapotranspiration and percolation below the root zone.

Representative Soil Features

Soils associated with Limy Sands ES are in the Entisol and Inceptisol orders. The Entisols are classified further as Typic Ustipsamments; the Inceptisols are classified further as Typic Calciustepts. These soils were developed under prairie vegetation. They formed in sandy residuum weathered from the calcareous sandstone. Depth to soft, sedimentary sandstone is 20 to 40 inches; the sandstone affects root growth. The soils are typically somewhat excessively drained. Slope ranges from 0 to 50 percent. Soil texture throughout the profile, typically, is loamy fine sand; however, a few soils with fine sandy loam or loamy sand texture are included in the site. Generally, the surface layer is less than 5 inches thick, but ranges to 12 inches thick. Calcium carbonates are within a depth of 12 inches.

Soil reaction is neutral to moderately alkaline (pH 6.6 to 8.4) in the surface layer. The substratum is slightly alkaline to moderately alkaline (pH 7.4 to 8.4). Calcium carbonate content is 1 to 10 percent in surface layer and ranges from 3 to 20 percent in the subsoil and substratum. Salinity and sodicity are typically none.

These soils are susceptible to wind and water erosion. The hazard of water erosion increases on slopes greater than about 6 percent. Loss of the soil surface layer can result in a shift in species composition and/or production.

The major soil series which characterize the Limy Sands ecological site are Beisigl and Dast.

Access Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx) for specific local soils information.

Parent Material Kind: residuum
Parent Material Origin: calcareous sandstone
Surface Texture: loamy fine sand, loamy sand, fine sandy loam
Surface Texture Modifier: none
Subsurface Texture Group: Sandy
Surface Fragments <3" (% Cover): 0-8
Surface Fragments ≥3" (%Cover): 0-3
Subsurface Fragments <3" (% Volume): 0-14
Subsurface Fragments ≥3" (% Volume): 0-2

	Minimum	Maximum
Drainage Class:	well	somewhat excessively
Permeability Class*:	moderately rapid	rapid
Depth to first restrictive layer (inches):	20	40
Electrical Conductivity (dS/m)*:	0	1
Sodium Absorption Ratio*:	0	0
Soil Reaction (1:1 Water)*:	6.6	8.4
Soil Reaction (0.1M CaCl2):	NA	NA
Available Water Capacity (inches)*:	1.0	3.0
Calcium Carbonate Equivalent (percent)*:	1	20

* These attributes represent from 0 to 40 inches or the first restrictive layer. Electrical Conductivity (E.C.) values are based on Saturated Paste method; the commonly used 1:1 field method will likely have E.C. value of 0.

Plant Communities

Ecological Dynamics of the Site:
This ecological site description is based on nonequilibrium ecology and resilience theory and utilizes a State-and-Transition Model (STM) diagram to organize and communicate information about ecosystem change as a basis for management. The ecological dynamics characterized by the STM diagram reflect how changes in ecological drivers, feedback mechanisms, and controlling variables can maintain or induce changes in plant community composition (phases and/or states). The application of various management actions, combined with weather variables, impact the ecological processes which influence the competitive interactions, thereby maintaining or altering plant community structure.

Prior to European influence, the historical disturbance regime for MLRA 54 included frequent fires, both anthropogenic and natural in origin. Most fires, however, were anthropogenic fires set by Native Americans. Native Americans set fires in all months except perhaps January. These fires occurred in two peak periods, one from March-May with the peak in April and another from July-November with the peak occurring in October. Most of these fires were scattered and of small extent and duration. The grazing history would have involved grazing and browsing by large herbivores (such as American bison, elk, and whitetail deer). Herbivory by small mammals, insects, nematodes, and other invertebrates are also important factors influencing the production and composition of the communities. Grazing and fire interaction, particularly when coupled with drought events, influenced the dynamics discussed and displayed in the following state and transition diagram and descriptions.

A Note on Prairie Dogs: Prairie dogs prefer habitats composed predominantly of shortgrasses and avoid those dominated by tallgrasses. Historically, prairie dogs likely occupied a wide range of soils (at least occasionally) due to variations in environmental factors such as drought severity and length, grazing, etc. Presently, the known occupation of this ecological site in this MLRA by prairie dogs is considered uncommon or rare. As a result, the presence of prairie dog towns for this ecological site in this MLRA is not included in this ecological description. However, prairie dog towns may be encountered on the site. If encountered, impacts would include increased bare ground with decreased production and plant vigor.

Following European influence, this ecological site generally has had a history of grazing by domestic livestock, particularly cattle, which along with other related activities (e.g., fencing, water development, fire suppression) has changed the disturbance regime of the site. Changes will occur in the plant communities due to these and other factors.

Weather fluctuations, coupled with managerial factors, may lead to changes in the plant communities and may, under adverse impacts, result in a slow decline in vegetative vigor and composition. However, under favorable conditions the botanical composition may resemble that prior to European influence.

Five vegetative states have been identified for the site (Reference, Native/Invaded, Invaded, Go-Back, and Conifer Invaded). Within each state, one or more community phases have been identified. These community phases are named based on the more dominant and visually conspicuous species; they have been determined by study of historical documents, relict areas, scientific studies, and ecological aspects of plant species and plant communities. Transitional pathways and thresholds have been determined through similar methods.

State 1: Reference State represents the natural range of variability that dominated the dynamics of this ecological site prior to European influence. Dynamics of the state were largely determined by variations in climate and weather (e.g., drought), as well as that of fire (e.g., timing, frequency) and by grazing by native herbivores (e.g., frequency, intensity, selectivity). Due to those variations, the Reference State is thought to have shifted temporally and spatially between three plant community phases.

Currently the primary disturbances include widespread introduction of exotic species, concentrated livestock grazing, lack of fire, and perhaps long-term non-use and no fire. Because of these changes (particularly the widespread occurrence of exotic species), as well as other environmental changes, the Reference State is considered to no longer exist. Thus, the presence of exotic species on the site precludes it from being placed in the Reference State. It must then be placed in one of the other states, commonly State 2: Native/Invaded State (T1A).

State 2: Native/Invaded State. Colonization of the site by exotic species resulted in a transition from State 1: Reference State to State 2: Native/Invaded State (T1A). This transition was probably inevitable; it often resulted from colonization by exotic cool-season grasses (e.g., Kentucky bluegrass, smooth brome, Canada bluegrass, crested wheatgrass, and/or annual bromes) which have been particularly and consistently invasive under extended periods of no use and no fire. Other exotic plants (e.g., Canada thistle, leafy spurge) are also known to invade the site.

Three community phases have been identified for this state; they are similar to the community phases in the Reference State but have now been invaded by exotic cool-season grasses. These exotic cool-season grasses can be expected to increase. As that increase occurs, plants more desirable to wildlife and livestock may decline. A decline in forb diversity can also be expected. Under non-use or minimal use management, mulch increases and may become a physical barrier to plant growth. This also changes the micro-climate near the soil surface and may alter infiltration, nutrient cycling, and biological activity near the soil surface. As a result, these factors combined with shading cause desirable native plants to have increasing difficulty remaining viable and recruitment declines.

To slow or limit the invasion of these exotic grasses or other exotic plants, it is imperative that managerial techniques (e.g., long-term prescribed grazing and prescribed burning) be carefully constructed, monitored, and evaluated with respect to that objective. If management does not include measures to control or reduce these exotic plants, the transition to State 3: Invaded State should be expected (T2A).

State 3: Invaded State. The threshold for this state is reached when both the exotic cool-season grasses (e.g., Kentucky bluegrass, smooth brome, Canada bluegrass, crested wheatgrass, annual bromes) exceed 30% of the plant community and native grasses represent less than 40% of the community. One community phase has been identified for this state.

The exotic cool-season grasses can be quite invasive and often form monotypic stands. As they increase, both forage quantity and quality of the annual production becomes increasingly restricted to late spring and early summer, even though annual production may increase. Forb diversity often declines. Under non-use or minimal use management, mulch can increase and become a physical barrier to plant growth which alters nutrient cycling, infiltration, and soil biological activity. As such, desirable native plants become increasingly displaced.

Once the state is well established, prescribed burning and prescribed grazing techniques have been largely ineffective in suppressing or eliminating the exotic cool-season grasses, even though some short-term reductions may appear successful. However, assuming there is an adequate component of native grasses to respond to treatments, a restoration pathway to State 2: Native/Invaded State may be accomplished with the implementation of long-term prescribed grazing in conjunction with prescribed burning (R3A).

State 4: Go-Back State. This state often results following cropland abandonment and consists of only one plant community phase. This weedy assemblage may include noxious weeds that need control. Over time, the exotic cool-season grasses (Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes) will likely predominate.

Initially, due to extensive bare ground and a preponderance of shallow-rooted annual plants, the potential for soil erosion is high. Plant species richness may be high, but overall diversity (i.e., equitability) is typically low, with the site dominated by a relatively small assemblage of species. Due to the lack of native perennials and other factors, restoring the site with the associated ecological processes is difficult. However, a successful range planting may result in something approaching State 2: Native/Invaded State (R4A). Following seeding, long-term prescribed grazing and prescribed burning, haying, and the use of herbicides will generally be necessary to achieve the desired result and control weeds, some of which may be noxious weeds. A failed range planting and/or secondary succession will lead to State 4: Invaded State (R4B).

State 5: Conifer Invaded State. Historically small patches of fire-tolerant trees and shrubs occurred when precipitation, fire frequency, and other factors enabled woody species to colonize or encroach on the site. This often resulted in a mosaic of small, scattered patches of woody vegetation interspersed within the grass dominated vegetation.

A marked decrease in fire frequency and increased fire suppression since European influence has enabled this state to expand and become more widespread. This is particularly important to the fire-intolerant juniper species' ability to expand and exploit and dominate grasslands. Where a conifer seed source is available, woody encroachment processes begin to dominate as fire intervals increase or fire is eliminated from the site. As depicted in the following diagram, conifer seeds disperse into an intact grassland State 1.0 or 2.0, beginning the process of woody encroachment. Extended fire intervals allow conifer to establish allowing for a transition to State 5: Conifer Invaded State.

This conifer invaded state often results from extended periods of non-use or very light grazing and no fire (T2B, T3A,). Brush control (e.g., prescribed burning, and/or chemical/mechanical brush management) may lead to State 2: Native/Invaded State (R5A) or perhaps State 3: Invaded State (R5B).

Juniper Invasion - Juniper species may have been present as scattered trees or shrubs prior to European influence. Since that time, decreased fire frequency, increased fire suppression, and dispersal from shelterbelts have been particularly important in enabling junipers to increase and, potentially, dominate a wide range of rangeland and forest land ecological sites in MLRA 54. Extended periods of non-use or very light grazing may also be factors.

Where a conifer seed source is available, woody encroachment begins to expand, exploit, and eventually dominate the sites, threatening the ecological integrity of the sites. Without managerial intervention these sites may transition to a Conifer Invaded State. As depicted in the following diagram, confer seeds disperse into an intact grassland beginning the process of woody encroachment.

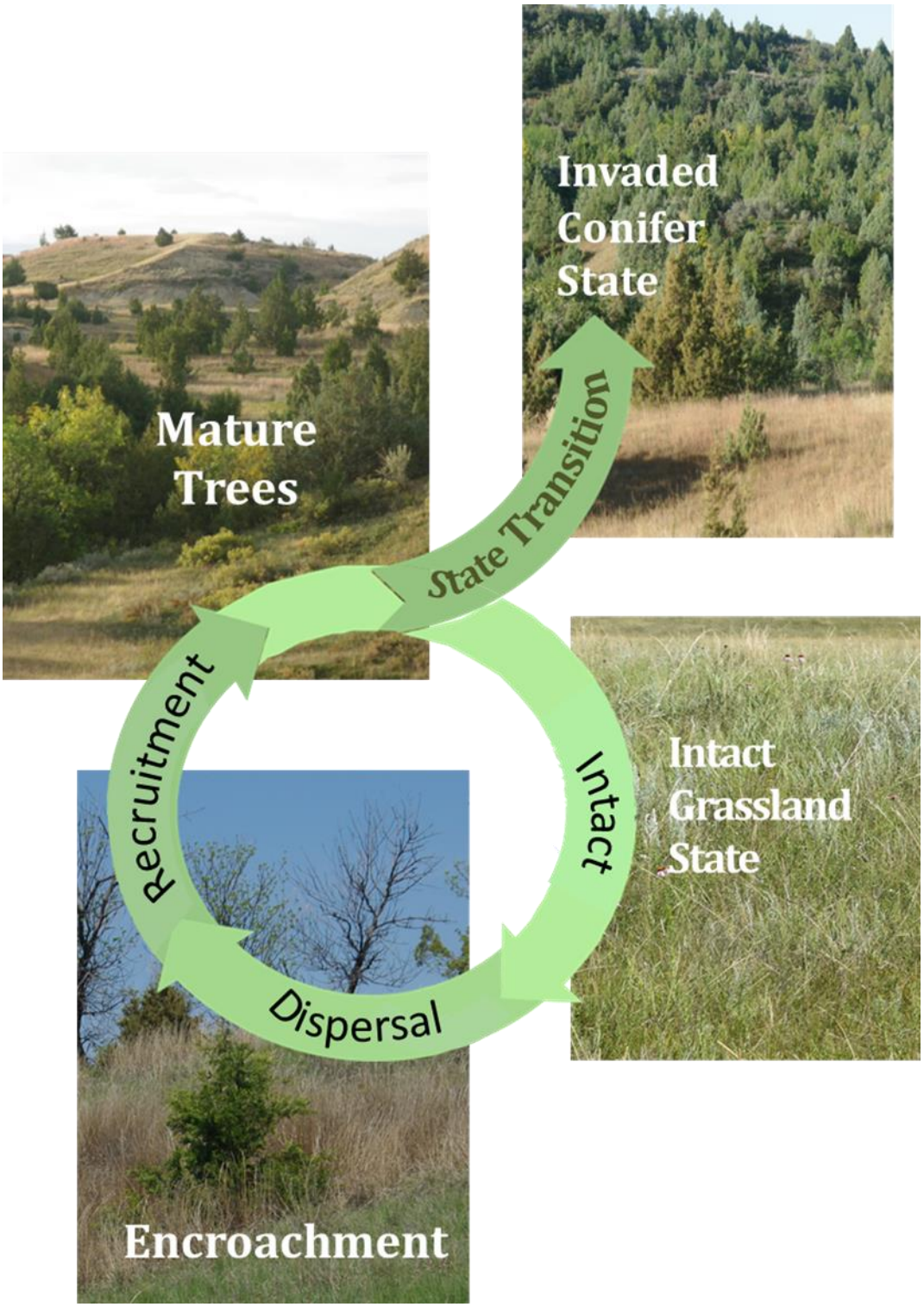


Figure 1. Stages of Woody Encroachment - Adapted from: Reducing Woody Encroachment in Grasslands – A Guide for Understanding Risk and Vulnerability; Oklahoma Cooperative Extension Service

The following state and transition model diagram illustrates the common states, community phases, community pathways, and transition and restoration pathways that can occur on the site. These are the most common plant community phases and states based on current knowledge and experience; changes may be made as

more data are collected. Pathway narratives describing the site's ecological dynamics reference various management practices (e.g., prescribed grazing, prescribed burning, brush management, herbaceous weed treatment) which, if properly designed and implemented, will positively influence plant community competitive interactions. The design of these management practices will be site specific and should be developed by knowledgeable individuals; based upon management goals and a resource inventory; and supported by an ongoing monitoring protocol.

When the management goal is to maintain an existing plant community phase or restore to another phase within the same state, modification of existing management to ensure native species have the competitive advantage may be required. To restore a previous state, the application of two or more management practices in an ongoing manner will be required. Whether using prescribed grazing, prescribed burning, or a combination of both, with or without additional practices (e.g., brush management), the timing and method of application needs to favor the native species over the exotic species. Adjustments to account for variations in annual growing conditions and implementing an ongoing monitoring protocol to track changes and adjust management inputs to ensure desired outcome will be necessary.

The plant community phase composition table(s) has been developed from the best available knowledge including research, historical records, clipping studies, and inventory records. As more data are collected, plant community species composition and production information may be revised.

Plant Communities and Transitional Pathways

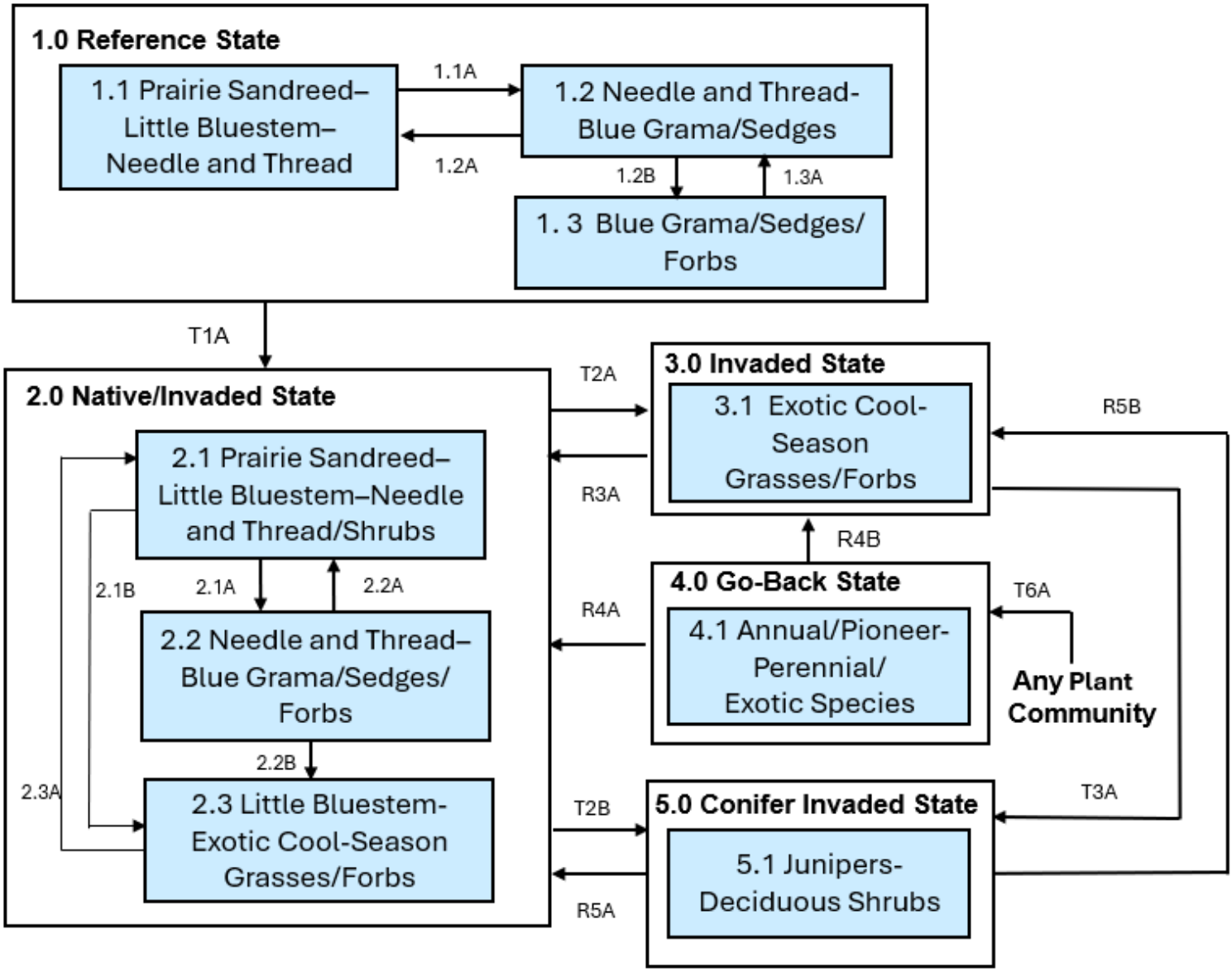


Diagram Legend-MLRA 54 Limy Sands	
T1A	Introduction of exotic cool-season grasses
T2A	Extended periods of non-use or very light grazing, no fire
T2B	Extended periods of non-use or very light grazing, no fire
T3A	Extended periods of non-use or very light grazing, no fire
T5A	Cessation of annual cropping
R3A	Long-term prescribed grazing and prescribed burning
R4A	Successful range planting
R4B	Failed range planting and/or secondary succession
R5A	Prescribed burning and/or chemical/mechanical brush management
R5B	Prescribed burning and/or chemical/mechanical brush management
CP 1.1 - 1.2 (1.1A)	Multiyear drought with/without heavy, long-term grazing
CP 1.2 - 1.1 (1.2A)	Return to average precipitation and reduced grazing
CP 1.2 - 1.3 (1.2B)	Long-term heavy continuous grazing, with drought
Cp1.3 - 1.2 (1.3A)	Return to average precipitation and reduced grazing
CP 2.1 - 2.2 (2.1A)	Heavy continuous grazing with or without drought
CP 2.1 - 2.3 (2.1B)	Extended periods of non-use or very light grazing, no fire
CP 2.2 - 2.1 (2.2A)	Long-term prescribed grazing and prescribed burning and return to average precipitation
CP 2.2 - 2.3 (2.2B)	Extended periods of non-use or very light grazing, no fire
CP 2.3 - 2.1 (2.3A)	Long-term prescribed grazing and prescribed burning and return to average precipitation

State 1: Reference State

This state represents the natural range of variability that dominated the dynamics of this ecological site prior to European influence. The primary disturbance mechanisms for this site in the reference condition included frequent fire and grazing by large herding ungulates. Timing of fires and grazing, coupled with weather events, dictated the dynamics that occurred within the natural range of variability. These factors likely caused the community to shift both spatially and temporally between three community phases.

Characteristics and indicators (i.e., characteristics and indicators that can be used to distinguish this state from others). Because of changes in disturbances and other environmental factors (particularly the widespread occurrence of exotic species), the Reference State is considered to no longer exist.

Resilience management (i.e., management strategies that will sustain a state and prevent a transition). If intact, the reference state should probably be managed with current disturbance regimes which has permitted the site to remain in reference condition as well as maintaining the quality and integrity of associated ecological sites. Maintenance of the reference condition is contingent upon a monitoring protocol to guide management.

Community Phase 1.1: Prairie Sandreed-Little Bluestem-Needle and Thread (*Calamovilfa longifolia-Schizachyrium scoparium-Hesperostipa comata*)

This community phase was historically the most dominant both temporally and spatially. Warm-season grasses dominated this plant community with cool-season grasses and sedges being subdominant. The major grasses and sedges included big bluestem, little bluestem, prairie sandreed, and sideoats grama with associates of needle and thread, porcupinegrass, prairie Junegrass, and upland sedges. Common forb and shrub species included tarragon, blacksamson echinacea, blazing star, purple locoweed, Indian breadroot, prairie sagewort, skunkbush sumac, and shrubby cinquefoil.

Annual production likely varied from about 1100-2500 pounds per acre with grasses and grass-likes, forbs, and shrubs contributing about 85%, 10% and 5%, respectively. Both warm-season and cool-season grasses are well represented in the community; as a result, production is distributed throughout the growing season. This community represents the plant community phase upon which interpretations are primarily based and is described in the “Plant Community Composition and Group Annual Production” portion of this ecological site description.

Plant Community Composition and Group Annual Production

		1.1 Prairie Sandreed-Little Bluestem-Needle and Thread		
COMMON/GROUP NAME	**SYMBOL**	**Group**	**lbs./acre**	**% Comp**
GRASSES & GRASS-LIKES			*1350 - 1530*	*75 - 85*
BLUESTEM		**1**	**180 - 270**	**10 - 15**
sand bluestem	ANHA	1	180 - 270	10 - 15
big bluestem	ANGE	1	0 - 90	0 - 5
OTHER WARM-SEASON GRASSES		**2**	**180 - 540**	**10 - 30**
prairie sandreed	CALO	2	90 - 360	5 - 20
little bluestem	SCSC	2	90 - 360	5 - 20
NEEDLEGRASS		**3**	**90 - 180**	**5 - 10**
needle and thread	HECOC8	3	72 - 144	4 - 8
porcupinegrass	HESP11	3	36 - 144	2 - 8
GRAMA		**4**	**90 - 270**	**5 - 15**
sideoats grama	BOCU	4	90 - 180	5 - 10
blue grama	BOGR2	4	90 - 144	5 - 8
OTHER NATIVE GRASSES		**5**	**90 - 270**	**5 - 15**
Scribner's rosette grass	#N/A	5	18 - 36	1 - 2
western wheatgrass	PASM	5	0 - 54	0 - 3
sand dropseed	SPCR	5	18 - 36	1 - 2
prairie Junegrass	KOMA	5	18 - 36	1 - 2
plains muhly	MUCU3	5	18 - 36	1 - 2
Fendler threeawn	ARPUL	5	18 - 36	1 - 2
other perennial grasses	2GP	5	18 - 36	1 - 2
GRASS-LIKES		**6**	**90 - 270**	**5 - 15**
threadleaf sedge	CAFI	6	108 - 180	6 - 10
sun sedge	CAINH2	6	36 - 54	2 - 3
other grass-likes	2GL	6	0 - 18	0 - 1
FORBS		*7*	*90 - 180*	*5 - 10*
tarragon	ARDR4	7	18 - 36	1 - 2
blacksamson echinacea	ECAN2	7	18 - 36	1 - 2
hairy false goldenaster	HEVIV	7	18 - 36	1 - 2
blazing star	LIATR	7	18 - 36	1 - 2
purple locoweed	OXLA3	7	18 - 36	1 - 2
penstemon	PENST	7	18 - 36	1 - 2
Indian breadroot	PEDIO2	7	18 - 36	1 - 2
American pasqueflower	PUPA5	7	18 - 36	1 - 2
goldenrod	SOLID	7	18 - 36	1 - 2
white heath aster	SYER	7	18 - 36	1 - 2
silky prairie clover	DAVI	7	0 - 36	0 - 2
rush skeletonplant	LYJU	7	0 - 18	0 - 1
scarlet globemallow	SPCO	7	0 - 18	0 - 1
bracted spiderwort	TRBR	7	0 - 18	0 - 1
pussytoes	ANTEN	7	0 - 18	0 - 1
plains milkvetch	ASGI5	7	0 - 18	0 - 1
wavyleaf thistle	CIUN	7	0 - 18	0 - 1
western wallflower	ERCAC	7	0 - 18	0 - 1
eriogonum	ERIOG	7	0 - 18	0 - 1
old man's whiskers	GETR	7	0 - 18	0 - 1
stiff sunflower	HEPA19	7	0 - 18	0 - 1
cutleaf ironplant	MAPI	7	0 - 18	0 - 1
large Indian breadroot	PEES	7	0 - 18	0 - 1
spiny phlox	PHHO	7	0 - 18	0 - 1
upright prairie coneflower	RACO3	7	0 - 18	0 - 1
other perennial forbs	2FP	7	0 - 18	0 - 1
SHRUBS		*8*	*36 - 90*	*2 - 5*
leadplant	AMCA6	8	18 - 36	1 - 2
prairie sagewort	ARFR4	8	18 - 36	1 - 2
rose	ROSA5	8	18 - 36	1 - 2
dwarf false indigo	AMNA	8	0 - 18	0 - 1
silver sagebrush	ARCA13	8	0 - 18	0 - 1
shrubby cinquefoil	DAFL3	8	0 - 18	0 - 1
creeping juniper	JUHO2	8	0 - 18	0 - 1
pricklypear	OPUNT	8	0 - 18	0 - 1
western sandcherry	PRPUB	8	0 - 18	0 - 1
skunkbush sumac	RHTR	8	0 - 18	0 - 1
soapweed yucca	YUGL	8	0 - 18	0 - 1
other shrubs	2SHRUB	8	0 - 18	0 - 1
TREES		*9*	*0 - 18*	*0 - 1*
juniper	JUNIP	9	0 - 18	0 - 1

Annual Production lbs./acre	LOW	RV	HIGH
GRASSES & GRASS-LIKES	980	1593	2200
FORBS	85	135	185
SHRUBS	35	63	95
TREES	0	9	20
TOTAL	1100	1800	2500

This list of plants and their relative proportions are based on near normal years. Fluctuations in species composition and relative production may change from year to year dependent upon precipitation or other climatic factors. RV = Relative Value.

Community Phase Pathway 1.1A
Community Phase Pathway 1.1 to 1.2 occurred during periods of multiyear drought with/without heavy, long-term grazing. This resulted in marked increases of the drought and grazing tolerant graminoids (e.g., blue grama, upland sedges) with corresponding decreases of the less drought and grazing tolerant graminoids (e.g., prairie sandreed, little bluestem).

Community Phase 1.2: Needle and Thread-Blue Grama/Sedges (*Hesperostipa comata-Bouteloua gracilis*/*Carex* spp.)
Community Phase 1.2 occurred during periods of multiyear drought with/without heavy, long-term grazing. Compared to Community Phase 1.1, this community would have resulted in increases in the more drought and grazing tolerant graminoids - such as blue grama and upland sedges (e.g., threadleaf sedge, sun sedge) - with corresponding decreases in the less drought and grazing tolerant grasses (such as prairie sandreed, little bluestem, and porcupinegrass). Forbs and shrubs (such as white heath aster, silverleaf Indian breadroot, prairie sagewort, and pricklypear) would have increased. Annual production would have declined compared to that of Community Phase 1.1.

Community Phase Pathway 1.2A
Community Phase Pathway 1.2 to 1.1 would have occurred with return to average growing conditions and reduced grazing. This would have resulted in increases in prairie sandreed and little bluestem with corresponding decreases in blue grama and sedges.

Community Phase Pathway 1.2B
Community Phase Pathway 1.2 to 1.3 occurred during periods of long-term heavy continuous grazing with drought. This would have resulted in further increases in blue grama, upland sedges, and forbs with corresponding decreases in the more drought and grazing intolerant grasses (e.g., prairie sandreed, porcupinegrass).

Community Phase 1.3: Blue Grama/Sedges/Forbs (*Bouteloua gracilis*/*Carex* spp./Forbs)
Community Phase 1.3 occurred during periods of long-term heavy continuous grazing with drought. It would have been similar to Community Phase 1.2 with further increases in the more drought and grazing tolerant graminoids, such as blue grama and upland sedges. Forbs and shrubs (such as tarragon, prairie sagewort, white heath aster, and scarlet globemallow) would have been conspicuously abundant.

Community Phase Pathway 1.3A
Community Phase Pathway 1.3 to 1.2 occurred with the return to average precipitation and reduced grazing resulting in a marked increase in needle and thread and a decrease in forbs.

Transition T1A
This is the transition from the State 1: Reference State to the State 2: Native/Invaded State due to the introduction and establishment of exotic cool-season grasses (typically Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes). This transition was probably inevitable and corresponded to a decline in native warm-season and cool-season grasses; it may have been exacerbated by chronic season-long or heavy late season grazing. Complete rest from grazing and suppression of fire could also have hastened the transition. The threshold between states was crossed when Kentucky bluegrass, smooth bromegrass, crested wheatgrass, Canada bluegrass, annual bromes, or other exotic species became established on the site.

Constraints to recovery (i.e., variables or processes that preclude recovery of the former state). Current knowledge and technology will not facilitate a successful restoration to Reference State.

State 2: Native/Invaded State

This state is similar to State 1: Reference State but has now been colonized by the exotic cool-season grasses (commonly Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes) which are now present in small amounts. Although the state is still dominated by native grasses, an increase in these exotic cool-season grasses can be expected.

These exotic cool-season grasses can be quite invasive on the site and are particularly well adapted to heavy grazing. They also often form monotypic stands. As these exotic cool-season grasses increase, both forage quantity and quality become increasingly restricted to late spring and early summer due to the monotypic nature of the stand, even though annual production may increase. Native forbs generally decrease in production, abundance, diversity, and richness compared to that of State 1: Reference State.

These exotic cool-season grasses have been particularly and consistently invasive under extended periods of non-use and no fire. To slow or limit the invasion of these exotic grasses, it is imperative that managerial techniques (e.g., prescribed grazing, prescribed burning) be carefully constructed, monitored, and evaluated with respect to that objective. If management does not include measures to control or reduce these exotic cool-season grasses, the transition to State 3: Invaded State should be expected.

Annual production of this state can be quite variable, in large part due to the amount of exotic cool-season grasses.

Characteristics and indicators (i.e., characteristics that can be used to distinguish this state from others). The presence of trace amounts of exotic cool-season grasses indicates a transition from State 1 to State 2. The presence of exotic biennial or perennial leguminous forbs (i.e., sweet clover, black medic) may not, on their own, indicate a transition from State 1 to State 2 but may facilitate that transition.

Resilience management (i.e., management strategies that will sustain a state and prevent a transition). To slow or limit the invasion of these exotic grasses, it is imperative that managerial techniques (e.g., prescribed grazing, prescribed burning) be carefully constructed, monitored, and evaluated with respect to that objective.

Grazing management should be applied that enhances the competitive advantage of native grass and forb species. This may include: (1) early spring grazing when exotic cool-season grasses are actively growing and native cool-season grasses are dormant; (2) applying proper deferment periods allowing native grasses to recover and maintain or improve vigor; (3) adjusting overall grazing intensity to reduce excessive plant litter (above that needed for rangeland health indicator #14 – see Rangeland Health Reference Worksheet); (4) incorporating early heavy spring utilization which focuses grazing on exotic cool-season grasses and reduces plant litter, provided that livestock are moved when grazing selection shifts from exotic cool-season grasses to native grasses.

Prescribed burning should be applied in a manner that maintains or enhances the competitive advantage of native grass and forb species. Prescribed burns should be applied as needed to adequately reduce/remove excessive plant litter and maintain the competitive advantage for native species. Timing of prescribed burns (spring vs. summer vs. fall) should be adjusted to account for differences in annual growing conditions and applied during windows of opportunity to best shift the competitive advantage to the native species.

Community Phase 2.1: Prairie Sandreed-Little Bluestem-Needle and Thread/Shrubs (*Calamovilfa longifolia-Schizachyrium scoparium-Hesperostipa comata*/Shrubs)

This community phase is similar to Community Phase 1.1 but has been colonized by exotic cool-season grasses (often Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual

bromes). However, these exotics are present in smaller amounts with the community still dominated by native grasses. Shrubs often include rose and creeping juniper. Annual production may be comparable to that of Community Phase 1.1 (1100-2500 pounds per acre). However, as the exotic cool-season grasses increase, peak production will shift to earlier in the growing season.

Figure 2. Community Phase 2.1, prairie sandreed, needle and thread, and little bluestem dominate grasses.

Community Phase Pathway 2.1A

Community Phase Pathway 2.1 to 2.2 occurs with heavy continuous grazing with or without drought. This results in marked increases of the drought and grazing tolerant graminoids (e.g., blue grama, upland sedges) with corresponding decreases of the less drought and grazing tolerant graminoids (e.g., prairie sandreed, little bluestem).

Community Phase Pathway 2.1B

Community Phase Pathway 2.1 to 2.3 occurs with extended periods of non-use or very light grazing, and no fire. This leads to marked increases in the exotic cool-season grasses and forbs.

Community Phase 2.2: Needle and Thread-Blue Grama/Forbs/Shrubs (*Hesperostipa comata-Bouteloua gracilis*/Forbs/Shrubs)

This community phase occurs with heavy continuous grazing with or without drought. It is similar to Community Phase 1.2 but has now been colonized by exotic cool-season grasses (often Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes). These exotics, however, are present in smaller amounts with the community still dominated by native grasses. Common forb and shrub species often include Indian breadroot, white heath aster, rose, and creeping juniper.

This community phase is often dispersed throughout a pasture in an overgrazed/undergrazed pattern, typically referred to as patch grazing. Some overgrazed areas will exhibit the impacts of heavy use, while the ungrazed areas will have a build-up of litter and increased plant decadence. This is a typical pattern found in properly stocked pastures grazed season-long. As a result, Kentucky bluegrass tends to increase more in the

undergrazed areas while the more grazing tolerant, short statured species (such as blue grama and sedges) increase in the heavily grazed areas. If present, Kentucky bluegrass may increase under heavy grazing.

Community Phase Pathway 2.2A
Community Phase Pathway 2.2 to 2.1 occurs with the implementation of long-term prescribed grazing and prescribed burning and return to average precipitation. This results in increases in the more grazing intolerant grasses (such as prairie sandreed and little bluestem) with corresponding decreases in blue grama and sedges.

Community Phase Pathway 2.2B
Community Phase Pathway 2.2 to 2.3 occurs with extended periods of non-use or very light grazing, and no fire. It results in increases in little bluestem, exotic cool-season grasses, and forbs.

Community Phase 2.3: Little Bluestem/Exotic Cool-Season Grasses/Forbs (*Schizachyrium scoparium/Exotic Cool-Season Grasses/Forbs*)
This community phase is approaching the threshold leading to a transition to State 3: Invaded State due to increasing amounts of exotic cool-season grasses, even though their presence may not be obvious (e.g., Kentucky bluegrass). As a result, it is an “at risk” community. If management does not include measures to control or reduce the exotic cool-season grasses, the transition to State 3: Invaded State should be expected.

Community Phase Pathway 2.3A
Community Phase Pathway 2.3 to 2.1 occurs with the implementation of long-term prescribed grazing and prescribed burning and return to average precipitation. This results in decreases in the exotic cool-season grasses and increases in the native grasses, including prairie sandreed and needle and thread.

Transition T2A
This transition from the State 2: Native/Invaded State to State 3: Invaded State generally occurs during extended periods of non-use or very light grazing, and no fire. Exotic cool-season grasses (such as Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes) became the dominant graminoids.

Studies indicate that a threshold may exist in this transition when both Kentucky bluegrass exceeds 30% of the plant community and native grasses represent less than 40% of the plant community composition. Similar thresholds may exist for other exotic cool-season grasses. This transition may occur under a wide range of managerial conditions ranging from non-use and no fire to heavy season-long grazing (primarily Kentucky bluegrass).

Constraints to recovery (i.e., variables or processes that preclude recovery of the former state). Variations in growing conditions (e.g., cool, wet spring) will influence effects of various management activities on exotic cool-season grass populations.

Transition T2B
This transition from State 2: Native/Invaded State to State 5: Conifer Invaded State occurs over extended periods of non-use or very light grazing, and no fire. A marked decrease in fire frequency and increased fire suppression since European influence has been particularly important to the fire-intolerant juniper species’ ability to expand and exploit and dominate grasslands.

Constraints to recovery (i.e., variables or processes that preclude recovery of the former state). The extended fire interval may make recovery doubtful due to the abundance of exotic cool-season grasses and lack of native grasses. Fire intensity along with consumption of available fuels may cause incomplete or

patchy burns. Ladder fuel and/or fuel loading are required for successfully controlling ponderosa pine (crown vs. ground fire). Continued recruitment of seeds (juniper and pine) from adjacent sites will hamper site restoration.

Constraints to recovery include reticence to undertake tree removal and the perception that trees may be a desirable vegetation component for wildlife habitat, carbon sequestration, aesthetics, etc. Managing the site for mule deer, livestock, or grassland nesting birds will need to consider the intensive management required to restore and maintain the site in State 2. The disturbance regime necessary to restore this site to State 2: Native/Invaded State is very labor intensive and costly; therefore, addressing woody removal earlier in the encroachment phase is the most cost-effective treatment for woody control.

State 3: Invaded State

This state is the result of invasion and dominance by the exotic cool-season grasses (commonly Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes). Exotic forbs (e.g., leafy spurge) may also invade the site. These exotic cool-season grasses can be quite invasive on the site and are particularly well adapted to heavy grazing. They also often form monotypic stands. As these exotic cool-season grasses increase, both forage quantity and quality become increasingly restricted to late spring and early summer due to the monotypic nature of the stand, even though annual production may increase. Native forbs generally decrease in production, abundance, diversity, and richness compared to that of State 1: Reference State. Common forbs often include white heath aster, goldenrod, common yarrow, and white sagebrush. Shrubs (such as western snowberry and rose) may show marked increases. Once the state is well established, prescribed burning and grazing techniques have been largely ineffective in suppressing or eliminating these species, even though some short-term reductions may appear successful.

Annual production of this state may vary widely, in part due to variations in the extent of invasion by exotic cool-season grasses.

Characteristics and indicators (i.e., characteristics that can be used to distinguish this state from others). This site is characterized by exotic cool-season grasses constituting greater than 30 percent of the annual production and native grasses constituting less than 40 percent of the annual production.

Resilience management (i.e., management strategies that will sustain a state and prevent a transition). Light or moderately stocked continuous, season-long grazing or a prescribed grazing system which incorporates adequate deferment periods between grazing events and proper stocking rate levels will maintain this State. Application of herbaceous weed treatment, occasional prescribed burning, and/or brush management may be needed to manage noxious weeds and increasing shrub (e.g., western snowberry) populations.

Community Phase 3.1 – Exotic Cool-Season Grasses/Forbs

This community phase is dominated by exotic cool-season grasses (commonly Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes), often with a much-reduced forb and shrub component. Excessive accumulation of mulch may also be present, particularly when dominated by Kentucky bluegrass. Common forb and shrub species often include silverleaf Indian breadroot, white heath aster, hairy false goldenaster, and goldenrod. The exotic forb leafy spurge may also invade the site.

Annual production of this state can be quite variable, in part due to the amount of exotic cool-season grasses. The longer this community phase exists, the more resilient it becomes. Natural or management disturbances that reduce the cover of Kentucky bluegrass or smooth brome are typically short-lived.

Restoration R3A

This restoration pathway from State 3: Invaded State to State 2: Native/Invaded State may be accomplished with the implementation of long-term prescribed grazing and prescribed burning, assuming there is an adequate component of native grasses to respond to the treatments.

Both prescribed grazing and prescribed burning are likely necessary to successfully initiate this restoration pathway, the success of which depends upon the presence of a remnant population of native grasses in Community Phase 3.1. That remnant population, however, may not be readily apparent without close inspection. The application of several prescribed burns may be needed at relatively short intervals in the early phases of this restoration process, in part because many of the shrubs (e.g., western snowberry) sprout profusely following one burn. Early season prescribed burns have been successful; however, fall burning may also be an effective technique.

The prescribed grazing should include adequate recovery periods following each grazing event and stocking levels which match the available resources. If properly implemented, this will shift the competitive advantage from the exotic cool-season grasses to the native cool-season grasses.

Context dependence (i.e., factors that cause variations in plant community shifts, restoration likelihood, and contribute to uncertainty). Grazing management should be applied in a manner that enhances/maximizes the competitive advantage of native grass and forb species over the exotic species. This may include the use of prescribed grazing to reduce excessive plant litter accumulations above that needed for rangeland health indicator #14 (see Rangeland Health Reference Worksheet). Increasing livestock densities may facilitate the reduction in plant litter provided length and timing of grazing periods are adjusted to favor native species.

Grazing prescriptions designed to address exotic grass invasion and favor native species may involve earlier, short, intense grazing periods with proper deferment to improve native species health and vigor. Fall (e.g., September, October) prescribed burning followed by an intensive, early spring graze period with adequate deferment for native grass recovery may shift the competitive advantage to the native species, facilitating the restoration to State 2: Native/Invaded.

Prescribed burning should be applied in a manner that enhances the competitive advantage of native grass and forb species over the exotic species. Prescribed burns should be applied at a frequency which mimics the natural disturbance regime, or more frequently as is ecologically (e.g., available fuel load) and economically feasible. Burn prescriptions may need adjustment to: (1) account for change in fine fuel orientation (e.g., “flopped” Kentucky bluegrass); (2) fire intensity and duration by adjusting ignition pattern (e.g., backing fires vs head fires); (3) account for plant phenological stages to maximize stress on exotic species while favoring native species (both cool- and warm-season grasses).

Transition T3A

This transition from State 3: Invaded State to State 5: Conifer Invaded State occurs over extended periods of non-use or very light grazing, and no fire. A marked decrease in fire frequency and increased fire suppression since European influence has been particularly important to the fire-intolerant juniper species’ ability to expand and exploit and dominate grasslands.

Constraints to recovery (i.e., variables or processes that preclude recovery of the former state). Lack of fine fuels in the tree understory limits fire intensity causing incomplete or patchy burns. Ladder fuels and/or fuel loading are required, but are limited, for successfully controlling ponderosa pine (crown vs. ground fire). Cost of mechanical and/or chemical treatment may be prohibitive. Continued recruitment of seeds (juniper and pine) from adjacent sites and sprouting nature of deciduous trees and shrubs will hamper site restoration. Existing herbaceous vegetation (native grasses and cool-season exotics) may be lacking allowing for invasive species (e.g., Canada thistle, leafy spurge) to dominate after a prescribed fire.

Constraints to recovery include reticence to undertake tree removal and the perception that trees may be a desirable vegetation component for wildlife habitat, carbon sequestration, aesthetics, etc. Managing the site for mule deer, livestock, or grassland nesting birds will need to consider the intensive management required to restore and maintain the site in State 2. The disturbance regime necessary to restore this site to State 2: Native/Invaded State is very labor intensive and costly; therefore, addressing woody removal earlier in the encroachment phase is the most cost-effective treatment for woody control.

State 4: Go-Back State

This state is highly variable depending on the level and duration of disturbance related to the T6A transitional pathway. In this MLRA, the most probable origin of this state is plant succession following cropland abandonment. This plant community will initially include a variety of annual forbs and grasses, some of which may be noxious weeds and need control. Over time, the exotic cool-season grasses (Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes) will likely predominate.

Characteristics and indicators (i.e., characteristics that can be used to distinguish this state from others). Tillage has destroyed the native plant community, altered soil structure and biology, reduced soil organic matter, and resulted in the formation of a tillage induced compacted layer which is restrictive to root growth. Removal of perennial grasses and forbs results in decreased infiltration and increased runoff.

Resilience management (i.e., management strategies that will sustain a state and prevent a transition). Continued tillage will maintain the state. Control of noxious weeds will be required.

Community Phase 4.1: Annual/Pioneer Perennial /Exotics

This community phase is highly variable depending on the level and duration of disturbance related to the T6A transitional pathway. In this MLRA, the most probable origin of this phase is secondary succession following cropland abandonment. This plant community will initially include a variety of annual forbs and grasses, including noxious weeds (e.g., Canada thistle) which may need control. Over time, the exotic cool-season grasses (e.g., Kentucky bluegrass, smooth brome, crested wheatgrass, Canada bluegrass, and/or annual bromes) will likely predominate.

Restoration R4A

This Restoration Pathway from State 4: Go-Back State to the State 2: Native/Invaded State can be accomplished with a successful range planting. Following seeding, long-term prescribed grazing and prescribed burning, haying, or use of herbicides will generally be necessary to achieve the desired result and control any noxious weeds.

It may be possible using selected plant materials and agronomic practices to approach something very near the functioning of State 2: Native/Invaded State. Application of chemical herbicides and the use of mechanical seeding methods using adapted varieties of the dominant native grasses are possible and can be successful. After establishment of the native plant species, prescribed grazing should include adequate recovery periods following each grazing event and stocking levels which match the available resources; management objectives must include the maintenance of those species, the associated reference state functions, and continued treatment of exotic grasses.

Context dependence (i.e., factors that cause variations in plant community shifts, restoration likelihood, and contribute to uncertainty). A successful range planting will include proper seedbed preparation, weed control (both prior to and after the planting), selection of adapted native species representing functional/structural groups inherent to the State 1, and proper seeding technique. Management (e.g., prescribed grazing, prescribed burning) during and after establishment must be applied in a manner that maintains the competitive

advantage for the seeded native species. Adding non-native species can impact the above and below ground biota. Elevated soil nitrogen levels have been shown to benefit smooth brome and Kentucky bluegrass more than some native grasses. As a result, fertilization, exotic legumes in the seeding mix, and other techniques that increase soil nitrogen may promote smooth brome and Kentucky bluegrass invasion.

The method or methods of herbaceous weed treatment will be site specific to each situation; but generally, the goal would be to apply the pesticide, mechanical control, or biological control (either singularly or in combination) in a manner that shifts the competitive advantage from the targeted species to the native grasses and forbs. The control method(s) should be as specific to the targeted species as possible to minimize impacts to non-target species.

Restoration R4B

A failed range planting and/or secondary succession will lead to State 3: Invaded State.

Context dependence (i.e., factors that cause variations in plant community shifts, restoration likelihood, and contribute to uncertainty). Failed range plantings can result from many causes (both singularly and in combination) including drought, poor seedbed preparation, improper seeding methods, seeded species not adapted to the site, insufficient weed control, herbicide carryover, poor seed quality (purity & germination), and/or improper management.

State 5: Conifer Invaded State

Historically, small patches of fire-tolerant trees and shrubs existed when precipitation, fire frequency, and other factors enabled woody species to colonize or encroach on the site. This often resulted in a mosaic of small, scattered patches of woody vegetation interspersed within the grass dominated vegetation. A marked decrease in fire frequency and increased fire suppression since European influence has enabled this state to expand and become more widespread. This is particularly important to the fire-intolerant juniper species' ability to expand and dominate grasslands.

One community phase has been identified and often results from extended periods non-use or very light grazing, and no fire (T2B, T3A). Prescribed burning and/or chemical/mechanical brush management may lead to State 2: Native/Invaded State (R5A) or State 3: Invaded State (R5B).

Characteristics and indicators (i.e., characteristics and indicators that can be used to distinguish this state from others). The dominance of woody species (by cover and production) distinguishes this state from other herbaceously dominated states.

Resilience management (i.e., management strategies that will sustain a state and prevent a transition). This state is resistant to change in the long-term absence of fire. Restoration efforts would require the use of prescribed fire, mechanical treatment, and prescribed grazing. Considerable time and effort will be required to restore to other States.

Community Phase 5.1: Junipers/Deciduous shrubs (*Juniperus* spp./Deciduous Shrubs)

This community phase results from extended periods of non-use or very light grazing, and no fire. It typically consists of stands of juniper (e.g., common juniper, Rocky Mountain juniper, creeping juniper) with associates of shrubs (such as silver sagebrush, prairie rose, western snowberry, and silver buffaloberry). Native deciduous trees including green ash, boxelder, Plains cottonwood, and the exotic Siberian elm may also be present. Associated grasses can be quite variable depending on variations in shading and other factors, but often includes exotic cool-season grasses (e.g., crested wheatgrass, Kentucky bluegrass, Canada bluegrass, smooth brome, and/or annual bromes). The forb component can also be quite variable, but may include white sagebrush, white heath aster, common yarrow, and bluebell bellflower.

Restoration R5A

This restoration pathway from State 5: Conifer Invaded State to State 2: Native/Invaded State can occur with prescribed burning and/or chemical/mechanical brush management, assuming exotic cool-season grasses do not dominate the understory. If exotic cool-season grasses dominate the understory, brush management will lead to State 3: Invaded State (via R5B).

Context dependence (i.e., factors that cause variations in plant community shifts, restoration likelihood, and contribute to uncertainty). Fire intensity along with consumption of available fuels may cause incomplete or patchy burns. Ladder fuel and/or fuel loading are required for successfully controlling ponderosa pine (crown vs. ground fire). Continued recruitment of seeds (juniper and pine) from adjacent sites will hamper site restoration. Intensive management is required to restore and maintain the site in State 2: Native/Invaded State.

Restoration R5B

This restoration pathway from State 5: Conifer Invaded State to State 3: Invaded State can occur with prescribed burning and/or chemical/mechanical brush management, assuming exotic cool-season grasses dominate the understory. If native grasses dominate the understory, brush management will lead to State 2: Native/Invaded State (via R5A).

Context dependence (i.e., factors that cause variations in plant community shifts, restoration likelihood, and contribute to uncertainty). Fire intensity along with consumption of available fuels may cause incomplete or patchy burns. Ladder fuel and/or fuel loading are required for successfully controlling ponderosa pine (crown vs. ground fire). Continued recruitment of seeds (juniper and pine) from adjacent sites will hamper site restoration. Intensive management is required to restore and maintain the site in State 3: Invaded State.

Transition T6A

This transition is from any plant community to State 4: Go-Back State. It is most commonly associated with the cessation of cropping without the benefit of range planting, resulting in a “go-back” situation. Soil conditions can be quite variable on the site, in part due to variations in the management/cropping history (e.g., development of a tillage induced compacted layer (plow pan), erosion, fertility, and/or herbicide/pesticide carryover). Thus, soil conditions should be assessed when considering restoration techniques.

Ecological Site Interpretations

Animal Community – Wildlife Interpretations

Landscape

The MLRA 54 landscape is characterized by moderately dissected rolling plains with areas of local badlands, buttes, and isolated hills. MLRA 54 is considered to have a continental climate with cold winters and hot summers, low humidity, light rainfall, and much sunshine. Extremes in temperature are common and characteristic of the MLRA. This area supports natural mixed-grass prairie vegetation with prairie rose, leadplant, and patches of western snowberry interspersed throughout the area. Green ash, chokecherry, and buffaloberry occur in draws and narrow valleys creating woody riparian corridors. Complex intermingled ecological sites create diverse grass/shrub land habitats interspersed with varying densities linear, slope, depressional, and in-stream wetlands associated with headwater streams and tributaries to the Missouri River. These habitats provide critical life-cycle components for many wildlife species.

Historic Communities/Conditions within MLRA:

The northern mixed-grass prairie was a disturbance-driven ecosystem with fire, herbivory, and climate functioning as the primary ecological drivers (either singly or often in combination). Many species of grassland birds, small mammals, insects, reptiles, amphibians, and large herds of roaming American bison, elk, and pronghorn were historically among the inhabitants adapted to this semi-arid region. Roaming herbivores, as well as several small mammal and insect species, were the primary consumers linking the grassland resources to large predators (such as the wolf, mountain lion, and grizzly bear) and smaller carnivores (such as the coyote, bobcat, red fox, and raptors). The black-tailed prairie dog was once abundant and provided ecological services by manipulating the soil and plant community, thus providing habitat for the black-footed ferret, burrowing owl, ferruginous hawk, mountain plover, swift fox, small mammals, and amphibians and reptiles. Extirpated species include free-ranging American bison, grizzly bear, gray wolf, black-footed ferret, mountain plover, and peregrine falcon (breeding). Extinct from the region is the Rocky Mountain locust.

Present Communities/Conditions within MLRA:

Following European influence, domestic livestock grazing, elimination of fire, energy development, and other anthropogenic factors influenced plant community composition and abundance. Agriculture, transportation corridors, and energy development are the main factors contributing to habitat fragmentation, reducing habitat quality for area-sensitive species. These influences fragmented the landscape; reduced or eliminated ecological drivers (fire); and introduced exotic species including smooth brome, crested wheatgrass, Kentucky bluegrass, and leafy spurge. This further impacted plant and animal communities. The loss of the bison, black-tailed prairie dogs, and fire as primary ecological drivers greatly influenced the character of the remaining native plant communities and the associated wildlife, moving towards a less diverse and more homogeneous landscape.

Included in this MLRA are the isolated Killdeer Mountains (limestone capped residual butte) containing bur oak, quaking aspen, green ash, paper birch, and American elm. Except for floodplain forests within the MLRA, the Killdeer Mountains contain the largest deciduous forest in southwestern North Dakota.

Some wildlife species in this area are mule deer, white-tailed deer, elk, pronghorn, moose, coyote, red fox, bobcat, prairie rattlesnake, American badger, raccoon, North American porcupine, beaver, striped skunk, American mink, white-tailed jackrabbit, black-tailed prairie dog, Eastern and Merriam's turkey, golden eagle, ferruginous hawks, sharp-tailed grouse, black-billed magpie, and numerous species of grassland-nesting birds and pollinating insects.

Presence of wildlife species is often determined by ecological site characteristics including grass and forb species, hydrology, aspect, and other associated ecological sites. The home ranges of a majority species are larger than one ecological site or are dependent on more than one ecological site for annual life requisites. Ecological sites offer different habitat elements as the annual life requisites change. Habitat improvement and creation must be conducted within the mobility limits of a known population for the species.

Insects play an important role providing ecological services for plant community development. Insects that are scavengers or aid in decomposition provide the food chain baseline sustaining the carnivorous insects feeding upon them. Many insects provide the ecological services necessary for

pollination, keeping plant communities healthy and productive. Insects provide a protein food source for numerous species including grassland-nesting birds and their young.

Species unique to MLRA:

Bald eagle: Bald Eagles prefer large rivers, lakes, reservoirs, or wetlands that are bordered by mature stands of trees or a single large tree. Bald eagles use the Missouri River system, including Lakes Sakakawea and Oahe, and associated tributaries. Mature trees, including cottonwoods, provide nesting sites adjacent to aquatic and upland foraging sites.

Dakota skipper: The extreme northern portion of this MLRA provides limited Dakota skipper habitat. Dakota skipper habitat within MLRA 54 is considered Type B habitat. Type B habitat is described as rolling native-prairie terrain over gravelly glacial moraine deposits dominated by bluestems and needlegrasses with the likely presence of bluebell bellflower, wood lily, blacksamson echinacea, upright prairie coneflower, and blanketflower. The United States Fish and Wildlife Service lists two critical habitat units within the MLRA in McKenzie County, North Dakota.

Golden eagle: The Lake Sakakawea breaks, bluffs, and rock outcroppings within the northwest portion of the MLRA are key areas for golden eagle nesting. Grasslands, shrublands, and black-tailed prairie dog towns are used for foraging.

Black-footed ferret: Black-footed ferrets have been reintroduced as an experimental population in the southern portion of the MLRA located on the Cheyenne Sioux Indian Reservation. Since reintroduction between 1991 and 1996, black-footed ferrets have been documented on the Standing Rock Sioux Indian Reservation approximately 20 miles north of the reintroduction site. Black-footed ferrets rely exclusively on prairie dog towns for shelter, breeding, and food sources (prairie dogs and other species within the town).

Least tern (Interior): Least terns are found on the Missouri River system in MLRA 54. Sparsely vegetated sandbars within the free-flowing portions of the Missouri River or shorelines of Lake Oahe and Sakakawea are used for nesting and foraging.

Species of Concern within the MLRA:

The following is a list of species considered “species of conservation priority” in the North Dakota State Wildlife Action Plan (2015); “species of greatest conservation need” in the Montana State Wildlife Action Plan (2015) and the South Dakota State Wildlife Action Plan (2014); and “species listed as threatened, endangered, or petitioned” under the Endangered Species Act within MLRA 54 at the time this section was developed:

Invertebrates: Dakota skipper, little white tiger beetle, monarch butterfly, Ottoe skipper, regal fritillary, yellow-banded bumble bee, and western bumble bee.

Birds: American Kestrel, Baird’s sparrow, bald eagle, black-billed cuckoo, black tern, bobolink, Brewer’s sparrow, burrowing owl, chestnut-collared longspur, ferruginous hawk, golden eagle, grasshopper sparrow, greater sage-grouse, lark bunting, loggerhead shrike, least tern, long-billed curlew, marbled godwit, McCown’s longspur, mountain plover, northern goshawk, northern harrier, northern pintail, peregrine falcon (migration), piping plover, prairie falcon, red knot (migration), red-headed woodpecker, sharp-tailed grouse, short-eared owl, Sprague’s pipit, Swainson’s hawk, trumpeter swan, upland sandpiper, western meadowlark, willet, Wilson’s phalarope, and whooping crane (migration).

Mammals: Big and little brown bats, long-eared bat, long-legged bat, northern long-eared bat, Townsend's big-eared bat, western small-footed bat, black-footed ferret, black-tailed prairie dog, dwarf shrew, gray wolf, hispid pocket mouse, Merriam's shrew, northwestern moose, sagebrush vole, silver-haired bat, and swift fox.

Amphibians/Reptiles: Common snapping turtle, Great Plains toad, false map turtle, greater short-horned lizard, milk snake, northern leopard frog, plains hognose snake, plains spadefoot, smooth green snake, and smooth softshell and spiny softshell turtle.

Fish and Mussels: Blue sucker, burbot, flathead chub, fragile papershell, northern redbelly dace, paddlefish, pallid sturgeon, pearl dace, pink papershell, shortnose gar, sickle-fin chub, sturgeon chub, and sauger.

Grassland Management for Wildlife in the MLRA

Management activities within the community phase pathways impact wildlife. Community phase, transitional, and restoration pathways are keys to long-term management within each state and between states. Significant inputs must occur to cross the threshold between states (e.g., State 3.0 to 2.0) requiring substantial economic inputs and management (mechanical, reseeding, prescribed burning, woody vegetation removal, grazing intensity, etc.). Timing, intensity, and frequency of these inputs can have dramatic positive or negative effects on local wildlife species. Ranchers and other land managers must always consider the long-term beneficial effects of management on the habitat in comparison to potential short-term negative effects to individuals.

Ecological sites occur as intermingled complexes on the landscape with gradual or sometimes abrupt transitions. Rarely do ecological sites exist in large enough acreage to manage independently. Ecological sites that support a dominance of herbaceous vegetation (Loamy/Clayey) can be located adjacent to ecological sites that support medium to tall shrubs (Loamy Overflow). Conversely, ecological sites that are dominated by short- to mid-statured grasses (Claypan) can be adjacent to sites with bare soil only supporting minor amounts of short grasses and forbs (Thin Claypan).

Management of these complex ecological sites can provide a heterogeneous or a homogenous landscape. Grassland bird use declines as the plant community transitions to a homogenous state. Managers should recognize ecological sites and the complexes they occur in to properly manage the landscape. A management regime for one ecological site may negatively impact an adjacent site; for example, alteration of a grazing regime within a Loamy Overflow ecological site to encourage understory growth may encourage exotic cool-season grasses to increase or dominate an adjacent ecological site.

Life requisites and habitat deficiencies are determined for targeted species. Deficiencies must be addressed along community phase, transitional, and restoration pathways as presented in specific state-and-transition models. Ecological sites should be managed and restored within the site's capabilities to provide sustainable habitat. Managers also should consider habitat provided by adjacent/intermingled ecological sites for species with home ranges or life requisites that cannot be provided by one ecological site.

With populations of many grassland-nesting birds in decline, it is important to maintain these ecological sites in a 1.0 Reference State (rarely found intact) or the 2.0 Native/Invaded. Plant communities optimal for a guild of grassland species serve as a population source where the birth

rate exceeds mortality. Species may use marginal plant communities; however, these sites may function as a population sink where mortality exceeds the birth rate.

Understanding preferred vegetative stature and sensitivity to woody encroachment is necessary to manage for the specific grassland species. Various grass heights may be used for breeding, nesting, foraging, or winter habitat. While most species use varying heights, many have a preferred vegetative stature height. The following chart provides preferred vegetative stature heights and sensitivity to woody vegetation encroachment.

Grassland-nesting Bird Species	Preferred Vegetative Stature			Avoids woody vegetation*
	Short < 6 inches	Medium 6 - 12 inches	Tall >12 inches	
Baird's sparrow	x	x		x
Bobolink		x	x	x
Brewer's sparrow	x	x		
Burrowing owl	x			x
Chestnut-collared longspur	x	x		x
Common yellowthroat			x	
Dickcissel		x	x	
Ferruginous hawk	x	x		
Grasshopper sparrow	x	x		x
Horned lark	x			x
Killdeer	x			x
Lark bunting	x	x		
Lark sparrow	x			
Le Conte's sparrow			x	x
Long-bill curlew	x			x
Marbled godwit	x	x		x
McCown's longspur	x	x		x
Mountain plover	x			x
Nelson's sparrow			x	x
Nesting waterfowl		x	x	
Northern harrier		x	x	x
Savannah sparrow		x	x	x
Short-eared owl		x	x	x
Sprague's pipit	x	x		x
Upland sandpiper	x	x		x
Western meadowlark	x	x		
Willet	x	x		x

*Many of the listed species avoid nesting in grassland areas with large amounts of woody vegetation within a grassland or avoid nesting near woody vegetation in adjacent habitats. Although these species avoid areas with woody vegetation, most can tolerate a small amount of woody vegetation within areas dominated by grassland habitat, including short-statured shrubs (e.g., sagebrush, western snowberry) in this MLRA.

Limy Sands Wildlife Habitat Interpretation:

Limy Sands ecological sites are droughty sites identified by the presence of sandy materials with calcium carbonates within 12 inches of the surface. Limy Sands sites support diverse stands of tall and short warm-season grasses, along with a diverse stand of cool-season grass and numerous forb species. Associated ecological sites include Sands, Sandy, Choppy Sands, Shallow Sandy, and Steep-Sided Wooded Draw. This complex of ecological sites provides habitat for many edge-sensitive grassland bird species.

Limy Sands habitat features and components commonly support grassland-nesting birds. Slope ranges may be too steep to support sharp-tailed grouse lekking sites but should provide nesting and brood cover, dependent upon its state and plant community phase. Insects rely on associated forbs and grasses for survival and serve as food sources for birds and their young, and as forage for small and large herbivores. Ecological services, historically provided by bison, are mirrored by domestic livestock.

Limy Sands ecological sites may be found in four plant community states (1.0 Reference State, 2.0 Native/Invaded State, 3.0 Invaded State, and 4.0 Go-Back State) within a local landscape. Multiple plant community phases exist within States 1.0 and 2.0. Today, these states occur primarily in response to grazing and drought. Secondary influences include anthropogenic disturbances and fire.

Because there is no known restoration pathway from State 2.0 to State 1.0, it is important to intensively manage using tools in State 1.0 and State 2.0 Community Phase Pathways to prevent further plant community degradation along either the T1A transitional pathway to Native/Invaded State 2.0 or the T2A transitional pathway to Invaded State 3.0. Native wildlife generally benefits from a heterogeneous grassland found in States 1.0 and 2.0 that include diverse grass and forb species with varying stature and density. As plant communities degrade within State 2.0, short warm-season grasses increase while native forbs are reduced. This transition results in reduced stature and increased plant community homogeneity. When adjacent/intermingled ecological sites undergo the same transition, the result can be an expansive, homogenous landscape.

State 3.0 has a dramatic increase in exotic cool-season grasses with a further reduction in native forbs. Reduced forb diversity limits insect populations, negatively affecting foraging opportunities for grassland-nesting birds. A homogenous grassland landscape does not provide quality escape or winter cover. As a result, many species are not able to meet life requisites within the Limy Sands ecological site. Further degradation within State 3.0 occurs when cool-season exotic crested wheatgrass begins to dominate the site. Successful restoration along the R3A pathway can be accomplished with the implementation of prescribed burning coupled with prescribed grazing.

Management along community phase, transition, or restoration pathways should focus upon attainable changes. Short- and long-term monetary costs must be evaluated against short- and long-

term ecological services in creating and maintaining habitat of sufficient quality to support a sustainable population density.

1.0 Reference State

Community Phase 1.1 Prairie Sandreed-Little Bluestem-Needle and Thread: This plant community offers quality wildlife habitat; every effort should be made to maintain this ecological site within this community phase. This phase retains high functionality through continued maintenance, including prescribed grazing with adequate recovery period as well as prescribed burning. Predominance of grass species in this community favors grazers and mixed feeders (animals selecting grasses as well as forbs and shrubs). The structural diversity provides habitat for a wide array of migratory and resident birds.

Invertebrates: Insects play a role in maintaining the forb community and provide a forage base for grassland birds, reptiles, and rodents. These services include putting plant material and dung in contact with mineral soil to be used by low trophic level consumers (such as invertebrate shredders, predators, herbivores, dung beetles, and fungal feeders).

Dakota skippers may use this site due to presence of host plants, such as little bluestem and prairie dropseed. Regal fritillary habitat is limited due to the rarity of Nuttall's violet and prairie violets. Monarch butterfly may use flowering forbs on this site; however, few milkweed species are found on this site to support breeding. Bumblebees and other native bees utilize forbs as a nectar source and bare ground for nesting sites in bunchgrasses. Prescribed grazing with adequate recovery periods, as well as prescribed burning, to maintain the 1.1 phase has little effect on nests of ground-dwelling insects.

Birds: This plant community provides quality nesting, foraging, and escape habitats favored by mid- to tallgrass-nesting birds. Several species of grassland birds that prefer mid- to tallgrass stature will use this site. In years with reduced precipitation or drought, nesting recruitment may be compromised. This plant community provides suitable areas for sharp-tailed grouse nesting and brood-rearing habitat. Diverse prey populations provide good hunting opportunities for grassland raptors.

Mammals: The diversity of grasses and forbs provide high nutrition levels for small and large herbivores including voles, mice, rodents, jackrabbits, pronghorn, and deer (white-tailed and mule). Short to moderate stature provides suitable food, thermal, protective, and escape cover for small herbivores. The composition of mid- to tallgrasses may limit use by the hispid pocket mouse.

Amphibians/Reptiles: The Limy Sands ecological site and associated plant communities provide habitat for smooth green snakes. This ecological site can provide habitat for the plains hog-nosed snake and plains spadefoot. Northern leopard frog and Great Plains toad may be present if freshwater habitats (such as stock water ponds) are located in or adjacent to the site. Plains spadefoot prefer sandy soils found on this site and plant community and may utilize this site if small ephemeral ponds are available for breeding. Sandy soils provide burrowing sites for short-horned lizards; however, vegetation within this plant community may be too tall and dense for the short-horned lizard.

Fish and Mussels: This ecological site is not directly associated with streams, rivers, or water bodies. Permeability is rapid with limited runoff to associated ecological sites (such as Sands, Sandy, or Choppy Sands). Management on these interconnected sites will have limited, secondary effects on aquatic species.

Community Phase 1.2 Needle and Thread–Blue Grama/Sedges: Long-term drought, with or without heavy long-term grazing, increases the percentage of sedges in this plant community. The loss of tall warm-

season grasses changes the stature of the plant community from mid- to tallgrass, to mid- to short-grass species.

Invertebrates: This phase provides similar life requisites as Community Phase 1.1. However, heavy, long-term-grazing may negatively impact ground-nesting sites for bumblebees, other native bees, and other ground-nesting insects due to reduction of forbs, timing of forb flowering, or increased soil compaction.

Birds: This plant community provides nesting, foraging, and escape habitats favored by short- to midgrass-nesting birds. A shift to a shorter herbaceous plant structure, along Community Phase Pathway 1.1A begins to benefit McCown's longspur, chestnut collared longspur, horned lark, and burrowing owl. Species that prefer a midgrass stature will be generally successful with normal to above-normal precipitation and a change in management along the 1.2A Community Phase Pathway. In years with reduced precipitation or heavy grazing, nesting recruitment may be compromised for midgrass-nesting species. This plant community provides areas suitable for sharp-tailed grouse leks. Limited cover and diverse prey populations provide good hunting opportunities for grassland raptors.

Mammals: Provides similar life requisites as Community Phase 1.1; however, the loss of the tall warm-season grass component my reduce thermal and escape covers.

Amphibians/Reptiles: Provides similar life requisites as Community Phase 1.1.

Fish and Mussels: Provides similar life requisites as Community Phase 1.1.

Community Phase 1.3 Blue Grama/Sedges/Forbs: Short-statured grasses will dominate with continued long-term heavy continuous grazing and drought.

Invertebrates: Reduction in forbs (stature and abundance) will reduce nectar availability for foraging insect populations. Continued heavy grazing may negatively impact ground-nesting sites for bumblebees, other native bees, and other ground-nesting insects due to reduction of forbs, timing of forb flowering, or increased soil compaction.

Birds: This plant community provides quality nesting, foraging, and escape habitats favored by shortgrass-nesting birds. A shift to a shorter plant structure (along Community Phase Pathway 1.2B) benefits McCown's longspur, chestnut collared longspur, horned lark, and burrowing owl. Species that prefer a midgrass stature may be successful with normal to above-normal precipitation and a change in management along the 1.3A Community Phase Pathway. In years with reduced precipitation or heavy grazing, nesting recruitment will be compromised for midgrass-nesting species. Limited cover and diverse prey populations provide good hunting opportunities for grassland raptors.

Mammals: This short-statured plant community limits use by most mammals. Richardson's and thirteen-lined ground squirrels may increase.

Amphibians/Reptiles: Provides similar life requisites as Community Phase 1.1.

Fish and Mussels: Provides similar life requisites as Community Phase 1.1.

2.0 Native/Invaded State

Community Phase 2.1 Prairie Sandreed-Little Bluestem-Needle and Thread/Shrubs: This plant community develops through Transition Pathway T1A, due to changes in management (chronic season-long or heavy late season grazing or complete rest) and the presence of exotic, cool-season grasses. The threshold

between States 1.0 and 2.0 is crossed when Kentucky bluegrass, crested wheatgrass, smooth brome grass, or other exotic species become established. This plant community phase has a very similar appearance and function to the Reference State of Community 1.1, except that it has a minor amount of cool-season exotic grasses and forbs. This phase functions at a high level for native wildlife; therefore, managers should consider the 2.0 Community Phase Pathways to avoid transitioning to State 3.0.

Invertebrates: Provides similar life requisites as Community Phase 1.1.

Birds: Provides similar life requisites as Community Phase 1.1.

Mammals: Provides similar life requisites as Community Phase 1.1.

Amphibians/Reptiles: Provides similar life requisites as Community Phase 1.1.

Fish and Mussels: Provides similar life requisites as Community Phase 1.1.

Community Phase 2.2 Needle and Thread-Blue Grama/Forbs/Shrubs: Heavy, continuous grazing along Community Phase Pathway 2.1A leads to shorter-statured plant species, such as blue grama and sedges. Dominated by shorter-statured grasses and a loss of nitrogen-fixing or leguminous native forbs, the diversity of this plant community is reduced. Both tap- and fibrous-rooted perennial forbs increase in this phase but remain a minor component. Prescribed grazing with adequate recovery periods along Community Phase Pathway 2.2A is an efficient, effective method to regain the cool-season grass and forb diversity components in Community Phase 2.1.

Invertebrates: The loss of native forbs and increase in sod-forming grasses limit foraging and nesting sites for all pollinators. Continuous, heavy grazing may reduce ground-nesting site availability. Homogeneity of forb species may limit season-long nectar availability.

Birds: Heavy, continuous grazing will reduce nesting sites, forage (invertebrates), and cover. A reduced forb component may limit foraging opportunities. The stature is generally short, serving both mid- and shortgrass-nesting birds. Species that prefer a midgrass stature will be generally successful with normal to above-normal precipitation and a change in management along the 2.2A Community Phase Pathway. In years with reduced precipitation or heavy grazing during the nesting season, nesting recruitment may be compromised for midgrass-nesting species. This plant community provides areas suitable for sharp-tailed grouse lek site development. Limited stature and diverse prey populations provide good hunting opportunities for grassland raptors.

Mammals: Suitable food, thermal, protective, and escape cover for most mammals becomes limited. The loss of diversity of grasses and forbs reduces nutrition levels for small and large herbivores including voles, mice, rodents, jack rabbits, pronghorn, and deer.

Amphibians/Reptiles: Provides similar life requisites as Community Phase 1.1.

Fish and Mussels: Provides similar life requisites as Community Phase 1.1.

Community Phase 2.3 Little Bluestem/Exotic Cool-Season Grasses/Forbs: Community Phase Pathway 2.2B is characterized by complete rest or light utilization (less than 20 percent) grazing and elimination of fire when exotic cool-season grasses are present (as in Community Phase 2.2). Plant community diversity is reduced with a decline of deeper-rooted native species, replaced by shallow-rooted exotic cool-season grasses. This plant community is “at risk” of crossing the threshold to the 3.0 Invaded State. Prescribed grazing with adequate recovery periods between grazing will shift the competitive edge to

native species along Community Phase Pathway 2.3A; this is the most effective method to regain diverse cool-season grass and forb components in Community Phase 2.1. Every effort should be used to manage within Community Phase Pathway 2.3A to avoid crossing the threshold into State 3.0. Restoration Pathway R3A requires intensive management and economic inputs to successfully cross back to State 2.0.

Insects: Provides similar life requisites as Community Phase 2.2. However, the reduction of native forbs and increase in sod-forming grasses limit foraging and nesting sites for all pollinators. Homogeneity of forb species may limit season-long nectar availability. Litter build-up, resulting from complete rest or light utilization, may reduce ground-nesting site availability.

Birds: An increase in exotic cool-season grasses moves this plant community towards homogeneity. Native grasses are still present in the plant community; however, the increase in cool-season exotic grasses reduces plant structure. With reduced amounts of native grasses and forbs, reduced plant stature, and increased litter, bird species shift from mid- to short-grass species. Sharp-tailed grouse may still use this plant community for lek sites and brood-rearing; however, winter cover must be provided by adjacent ecological sites or plant communities. Management for bird species that prefer mid- to tall-statured grasses should follow Community Phase Pathway 2.3A.

Mammals: Provides similar life requisites as Community Phase 2.2.

Amphibians/Reptiles: Provides similar life requisites as Community Phase 1.1.

Fish and Mussels: Provides similar life requisites as Community Phase 1.1.

3.0 Invaded State

Community Phase 3.1 Exotic Cool-Season Grasses/Forbs: Community Phase Pathway T2A is characterized by extend periods of non-use or very light grazing and elimination of fire when exotic cool-season grasses are present (as in Community Phase 2.0). This plant community phase is characterized by a dominance (more than 30 percent) to a complete dominance of exotic cool-season grasses (such as Kentucky bluegrass, crested wheatgrass, and smooth brome). Western snowberry becomes a dominant shrub and tends to increase in density and cover. Restoration Pathway R3A requires remnant amounts of native warm- and cool-season grasses and forbs. These remnant populations can only be expressed through frequent prescribed burns and high levels of prescribed grazing management targeting the exotic cool-season grasses. Intensified management along the R3A pathway will have significant short-term negative impacts on wildlife habitat; however, this is necessary to restore long-term native habitat functions.

Invertebrates: Non-use or light grazing limits use by beneficial insects provided State 2.0 by increasing litter. Lack of grazing leads to limited contact between plant material and mineral soil; this results in a cooler micro-climate, which is unfavorable to most insects. Lack of bare soil limits ground nesting sites for native bees and other ground-nesting insects. The lack of nectar-producing plants limits forage opportunities for bumblebees, regal fritillary, monarch butterfly, and other pollinating species.

Birds: This homogeneous community phase, dominated by exotic plant species, provides limited habitat and life requisites for most obligate grassland-nesting birds. Lack of stature and plant diversity, along with increased litter and the tendency of Kentucky bluegrass and smooth brome to lay down, limits use by many grassland-nesting birds. Litter accumulations reduce use by chestnut-collared and McCown's longspurs. Western snowberry reduces use of this site by species that avoid areas with woody vegetation. Sharp-tailed grouse may use these sites for brood-rearing and lek sites; however, the

reduction in forbs and exotic cool-season grasses may limit winter cover and foraging opportunities for chicks.

Mammals: This plant community phase provides limited foraging habitat for large ungulates and desired plant structure for Richardson's and thirteen-lined ground squirrels. Litter accumulation favors thermal, protective, and escape cover for small rodents. Reduced availability of native grass seed may reduce food availability for species such as the hispid pocket mouse.

Amphibians/Reptiles: Provides similar life requisites as Community Phase 1.1. However, increased litter and cooler soil temperature may reduce use by sagebrush lizard, plains spadefoot, and short-horned lizard.

Fish and Mussels: Provides similar life requisites as Community Phase 1.1.

4.0 Go-Back State

Community Phase 4.1 Annual/Pioneer Perennial/Exotics: These plant communities are the result of severe soil disturbance (such as cropping, recreational activity, or concentrated livestock activity for a prolonged period). Following cessation of disturbances, the resulting plant community is dominated by early pioneer annual and perennial plant species. Plant species composition and production are highly variable. Weedy plants can provide pollinator habitat along with spring and summer cover for many mammals and birds, and their young. Dense weed cover can keep soils moist, increasing insect presence. Tall stature provided by some weeds, such as marsh elder and ragweed, offer thermal cover and seeds throughout winter.

Successful restoration of native species along Transition Pathway R4A results in a native grass and forb community in State 2.0. Failed restoration to native species through Restoration Pathway R4B results in Invaded State 3.0. Wildlife species response will be dependent upon plant community composition, vegetative structure, patch size, and management activities (such as prescribed grazing, burning, interseeding, haying, or noxious weed control).

Animal Community – Grazing Interpretations

This site is well adapted to managed grazing by domestic livestock. The predominance of herbaceous plants across all plant community phases best lends these sites to grazing by cattle, but other domestic grazers with differing diet preferences may also be a consideration depending upon management objectives. Often, the current plant community does not match any particular plant community (as described in the ecological site description). Because of this, a resource inventory is necessary to document plant composition and production. Proper interpretation of this inventory data will permit the establishment of a safe, initial stocking rate for the type and class of animals and level of grazing management. More accurate stocking rate estimates should eventually be calculated using actual stocking rate information and monitoring data.

NRCS defines prescribed grazing as "managing the harvest of vegetation with grazing and/or browsing animals with the intent to achieve specific ecological, economic, and management objectives". As used in this site description, the term 'prescribed grazing' is intended to include multiple grazing management systems (e.g., rotational grazing, twice-over grazing, conservation grazing, targeted grazing, etc.) provided that, whatever management system is implemented, it meets the intent of prescribed grazing definition.

The basic grazing prescription addresses balancing forage demand (quality and quantity) with available forage, varying grazing and deferment periods from year-to-year, matching recovery/deferment periods to growing conditions when pastures are grazed more than once in a growing season, implementation of a contingency

(e.g., drought) plan, and a monitoring plan. When the management goal is to facilitate change from one plant community phase or state to another, then the prescription needs to be designed to shift the competitive advantage to favor the native grass and forb species.

Grazing levels are noted within the plant community narratives and pathways in reference to grazing management. "Degree of utilization" is defined as the proportion of the current years forage production that is consumed and/or destroyed by grazing animals (may refer to a single plant species or a portion or all the vegetation). "Grazing utilization" is classified as slight, moderate, full, close, and severe (see the following table for description of each grazing use category). The following utilization levels are also described in the Ranchers Guide to Grassland Management IV. Utilization levels are determined by using the landscape appearance method as outlined in the Interagency Technical Reference "Utilization Studies and Residual Measurements" 1734-3.

Utilization Level	%	Use Description
Slight (Light)	0-20	Appears practically undisturbed when viewed obliquely. Only choice areas and forage utilized.
Moderate	20-40	Almost all of accessable range shows grazing. Little or no use of poor forage. Little evidence of trailing to grazing.
Full	40-60	All fully accessable areas are grazed. The major sites have key forage species properly utilized (about half taken, half left). Points of concentration with overuse limited to 5 to 10 percent of accessible area.
Close (Heavy)	60-80	All accessible range plainly shows use and major sections closely cropped. Livestock forced to use less desirable forage, considering seasonal preference.
Severe	> 80	Key forage species completely used. Low-value forages are dominant.

Hydrology Functions

Water is the principal factor limiting herbage production on this site. The site is dominated by soils in hydrologic group A with a few soils in group B included. Infiltration rate is rapid or moderately rapid; runoff potential for this site varies from very low to medium depending upon hydrologic group, slope and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. An exception would be where short grasses form a dense sod and dominate the site. Areas where ground cover is less than 50% have the greatest potential to have reduced infiltration and higher runoff (refer to Section 4, NRCS National Engineering Handbook for runoff quantities and hydrologic curves).

Recreational Uses

The largest acreage of public land available for recreation in the MLRA is owned and managed by the United States Forest Service (USFS) within the Little Missouri, Grand River, and Cedar River National Grasslands in South Dakota and the Little Missouri National Grasslands in North Dakota (687,398 acres). These areas are available for hunting, fishing, hiking, camping, horse and bike riding, nature viewing, etc. In addition, the Bureau of Land Management (BLM) manages (40,264 acres) in North and South Dakota with the same recreational opportunities as the USFS lands.

The United States Army Corps of Engineers (USAE) owns 496,162 acres of land and water located on and adjacent to Lake Sakakawea and Lake Oahe. The North Dakota and South Dakota Game and Fish Departments manage the fisheries resources. These two Missouri River reservoirs provide excellent fishing and water recreation opportunities. In addition, the United States Fish and Wildlife Service (USFWS) manages a national fish hatchery below Garrison Dam.

The USFWS manages 36,858 acres in the National Wildlife Refuge system while the North Dakota and South Dakota wildlife management agencies manage 72,218 acres as wildlife or game management areas. The North Dakota, South Dakota, and Montana Department of Trust Lands manage 486,482 acres. These areas provide hunting, bird watching, hiking, and other outdoor recreation opportunities. North Dakota Wildlife Management Areas along the shoreline of Lake Sakakawea and the Missouri River account for 60,000 acres of the approximately 72,218 acres of land managed by the states for wildlife habitat in MLRA 54. Located in the northern portion of the MLRA, the Killdeer Mountain WMA is the largest tract of state-owned land managed for wildlife habitat at approximately 7,000 acres.

The largest refuge managed by the United States Fish and Wildlife service is Lake Ilo National Wildlife Refuge totaling approximately 4,000 acres. United States Bureau of Reclamation manages approximately 11,000 acres at Lake Tschida and 8,460 acres at Bowman-Haley Lake for fish and wildlife habitat. The National Park Service manages the Knife River Indian Village National Historic Site; the North Dakota Historical Society manages the Double Ditch Indian Village site.

Bird watching: Public and private grasslands within MLRA 54 provide essential habitat for prairie-dependent bird species such as Sprague's pipits, western meadowlark, and Baird's sparrow along with some of the larger, showy members of the upland prairie include marbled godwits, upland sandpipers, willets, and sharp-tailed grouse. Publicly owned lands provide excellent birding opportunities. MLRA 54 is in the Central Flyway.

Hunting/Fishing: MLRA 54 is a fall destination for thousands of pheasant and upland game bird hunters. This MLRA also provides excellent deer (white-tailed and mule), pronghorn, and coyote hunting opportunities. Lake Sakakawea, Lake Oahe, Lake Tschida, and the Missouri River provide excellent year-round fishing opportunities. The North Dakota Game and Fish Department and South Dakota Game, Fish and Parks manage approximately 40 fishing lakes within the MLRA. Available species include yellow perch, walleye, northern pike, muskellunge, crappie, bluegill, rainbow trout, and smallmouth bass. Chinook salmon are stocked in Lake Sakakawea.

Camping: Numerous state operated campgrounds are located along the shores of Lake Sakakawea, Lake Oahe, Missouri River, and Shadehill Reservoir. Primitive camping is allowed on Grand River and Cedar River National Grasslands in South Dakota and the Little Missouri National Grasslands in North Dakota. Other numerous camping (primitive and improved) sites are available in numerous city and county parks.

Hiking/Biking/Horseback Riding: Hiking is permitted on most state and federally owned lands. Developed hiking and biking trails can be found on Harmon Lake (13.1 miles), Roughrider Trail (Morton County, 16.5

miles), Missouri River State Natural Area (5 miles), Ft. Abraham Lincoln State Park (8 miles), Cross Ranch State Park (14 miles), Grand River National Grasslands (7 miles), Lake Sakakawea State Park (5 miles), and Lewis & Clark State Park (5 miles). In addition, extensive biking and walking trails are found in local county and city parks. Ft. Abraham Lincoln State Park has 6 miles of horseback trails.

Wood Products

No appreciable wood products are present on the site.

Other Products

Seed harvest of native plant species can provide additional income on this site.

Site Development and Testing Plan

This ESD is the best available knowledge. The site concept and species composition table have been used in the field and tested for more than five years. It is expected that as additional information becomes available revisions may be required.

Supporting Information

Associated Sites

Ecological Site Name	Site ID	Narrative
Sands	R054XY025ND	This site is on backslopes and footslopes lower on the landscape than the Limy Sands ecological site. The soils are >40 inches to sandstone. If carbonates are present in the soil profile, effervescence is very slight or slight to a depth greater than 12 inches. The soil will not form a ribbon, but it may form a ball when squeezed. The Sands site has more production than the Limy Sands ecological site.
Sandy	R054XY026ND	These are coarse loamy, somewhat excessively to well drained soils down-slope from Limy Sands sites. The Sandy ecological sites have less sand and carbonates occur lower in the soil profile than the Limy Sands site. The soils will form a weak ribbon less than 1 inch long. The Sandy site has more production than the Limy Sands ecological site.
Choppy Sands	R054XY034ND	This ecological site occurs on dunes associated with hillslopes and may have blown-out areas associated with this site. The soils typically have a thin surface layer (<5 inches thick) and carbonates may be present lower in the soil profile (>36 inches). The soils on this site are excessively drained. The soil will not form a ribbon, but it may form a ball when squeezed.
Shallow Sandy	R054XY043ND	This ecological site is on hillslopes; it is up-slope from the Limy Sands ecological site. The soils have coarse or moderately coarse or coarse textures 10 to 20 inches thick over soft sandstone (affects root growth). They are somewhat excessively drained. If the soil forms a ribbon, it is less than 1 inch long. The Shallow Sandy ecological site has less production than the Limy Sands ecological site.

Similar Sites

Ecological Site Name	Site ID	Narrative

Sands	R054XY025ND	This site is on backslopes and footslopes lower on the landscape than the Limy Sands ecological site. The soils are >40 inches to sandstone. If carbonates are present in the soil profile, effervescence is very slight or slight to a depth greater than 12 inches. The soil will not form a ribbon, but it may form a ball when squeezed. The Sands site has more production than the Limy Sands ecological site.
Shallow Sandy	R054XY043ND	This ecological site is on hillslopes; it is up-slope from the Limy Sands ecological site. The soils have coarse or moderately coarse or coarse textures 10 to 20 inches thick over soft sandstone (affects root growth). They are somewhat excessively drained. If the soil forms a ribbon, it is less than 1 inch long. The Shallow Sandy ecological site has less production than the Limy Sands ecological site.

Acknowledgements

NRCS would like to acknowledge the United State Forest Service (USFS) and National Park Service (NPS) for access to USFS properties and technical assistance in ESD development. USFS: Jack Dahl, Nickole Dahl, and Chad Prosser.

Developers

ND NRCS: David Dewald, Jonathan Fettig, Jody Forman, Mike Gerbig, Alan Gulsvig, Mark Hayek, Jeanne Heilig, John Kempenich, Chuck Lura, Jeff Printz, Steve Sieler, and Hal Weiser.

Inventory Data References

Information presented here has been derived from NRCS clipping and other inventory data. Also, field knowledge of range-trained personnel was used. All descriptions were peer reviewed and/or field tested by various private, state and federal agency specialists.

State Correlation

This site has been correlated with North Dakota, Montana, and South Dakota.

Relationship to Other Established Classifications

Level IV Ecoregions of the Conterminous United States: 43a – Missouri Plateau; 43c – River Breaks; 43j – Moreau Prairie.

Other References

Bakker, K.K. 2003. The effect of woody vegetation on grassland nesting birds: an annotated bibliography. The Proceedings of the South Dakota Academy of Science 82:119-141.

Barker, W.T. and W. C. Whitman. 1988. Vegetation of the Northern Great Plains. Rangelands 10(6): 266-272.

Bjugstad, A.J. 1965. Vegetation measurements in relation to range condition classification on the principal range sites of southwestern North Dakota. PhD Thesis. N D State University.

Bluemle, J.P. 2017. North Dakota Notes No. 13, North Dakota's mountainous areas: the Killdeer Mountains and the Turtle Mountains. Accessed on web, April 10, 2017, at https://www.dmr.nd.gov/ndgs/ndnotes/ndn15-h.htm.

Bluemle. J.P. 2016. North Dakota's geologic legacy. North Dakota State University Press. 382 pages.

Brand, M. D. and H. Goetz. 1986. Vegetation of exclosures in southwestern North Dakota. Journal of Range Management 39: 434-437.

Briske, D.D. (editor). 2017. Rangeland systems – processes, management, and challenges. Springer Series on Environmental Management. 661 pages.

DeKeyser, E.S., G. Clambey, K. Krabbenhoft, and J. Ostendorf. 2009. Are changes in species composition on central North Dakota rangelands due to non-use management? Rangelands 31:16-19

Dodd, J.L. 1970. Distribution and community site relations of bluebunch wheatgrass in North Dakota. PhD Thesis. N D State University. Fargo, North Dakota.

Dornbusch, M.J., R.F. Limb, and C.K. Gasch. 2018. Facilitation of an exotic grass through nitrogen enrichment by an exotic legume. Rangeland Ecology & Management 71:691-694.

Dyke, S.R., S.K. Johnson, and P.T. Isakson. 2015. North Dakota state wildlife action plan. North Dakota Game and Fish Department, Bismarck, ND. 468 pages.

Ehrenfeld, Joan G. 2002. Effects of exotic plant invasions on soil nutrient cycling processes. Ecosystems 6:503-523.

Ereth, C., J. Hendrickson, D. Kirby, E. DeKeyser, K. Sedevic, and M. West. Controlling Kentucky bluegrass with herbicide and burning is influenced by invasion level. Invasive Plant Science and Management 10: 80-89.

Flesland, J.R. 1964. Composition and structure of the salt-desert shrub type in the badlands of western North Dakota. M.S. Thesis. ND State University.

Franzen, David. 2007. Managing saline soils in North Dakota. SF-1087. NDSU Extension Service. North Dakota State University.

Gilgert, W. and S. Zack. 2010. Integrating multiple ecosystem services into ecological site descriptions. *Rangelands*: 32:49-54.

Grant, T.A. and R.K. Murphy. 2005. Changes on woodland cover on prairie refuges in North Dakota, USA. Natural Areas Journal 25:359-368.

Hanson, H.C and W. Whitman. 1938. Characteristics of major grassland types in western North Dakota. Ecological Monographs. Vol. 8:57-114.

Heitschmidt, R. K., K. D. Klement, and M. R. Haferkamp. 2005. Interactive effects of drought and grazing on Northern Great Plains rangelands. Rangeland Ecology and Management 58:11-19.

Hendrickson, J.R., P. S. Johnson, M. A. Liebig, K. K. Sedivec, and G. A. Halvorson. 2016. Use of ecological sites in managing wildlife and livestock: an example with prairie dogs. Rangelands 38(1): 23-28.

Hendrickson, J.R., S.L. Kronberg, and E.J. Scholljegerdes. 2020. Can targeted grazing reduce abundance of invasive perennial grass (Kentucky bluegrass) on native mixed-grass prairie? Rangeland Ecology and Management, 73:547-551.

Higgins, K.F. 1984. Lightning fires in grasslands in North Dakota and in pine-savanna lands in nearby South Dakota and Montana. J. Range Manage. 37:100-103.

Higgins, K.F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. United States Department of Interior, Fish and Wildlife Service. Resource Publication 161. 39 pages.

High Plains Regional Climate Center, University of Nebraska, 830728 Chase Hall, Lincoln, NE 68583-0728. (http://hprcc.unl.edu)

Hirch, K.L. 1985. Habitat type classification of grasslands and shrublands of southwestern North Dakota. Ph.D. Thesis. ND State University.

Hopkins, D.G., M.D Sweeny, D.R. Kirby, J. L. Richardson. 1991. Effects of revegetation of surficial soil salinity on panspot soils. Journal of Range Management 44(3): 215-219.

Hopkins, D.G., M.D Sweeny, J. L. Richardson. 1991. Dispersive erosion and entisol-panspot genesis in sodium-affected landscapes. Soil Science Society American Journal Volume. 55: 171-177.

Johnson, Sandra. 2015. Reptiles and amphibians of North Dakota. North Dakota Game and Fish Department. 64 pages.

Jordan, N. R., D.L. Larson, and S.C. Huerd. 2008. Soil modification by invasive plants: effects on native and invasive species of mixed-grass prairies. Biological Invasions 10:177-190.

Mader, E., M. Shepherd, M. Vaughan, and S.H. Black. 2011. Attracting native pollinators: protecting North America's bees and butterflies. Accessed at https://xerces.org, May 1, 2017.

Montana Fish, Wildlife and Parks. 2015. Montana state wildlife action plan. 2015. Viewed at https://xerces.org/ on May 1, 2017.

North Dakota Division of Tourism, Accessed on February 25, 2019. Available at https://www.ndtourism.com/sports-recreation

North Dakota Parks and Recreation Department, Accessed on February 25, 2019. Available at http://www.parkrec.nd.gov/recreationareas/recreationareas.html

Palit, R., G. and E.S. DeKeyser. 2022. Impacts and drivers of smooth brome (*Bromus inermis* Leyes.) invasion in native ecosystems. Plants: 10,3390. https://www.mdpi.com/2223-7747/11/10/1340

Palit, R., G. Gramig, and E.S. DeKeyser. 2021. Kentucky bluegrass invasion in the Northern Great Plains and prospective management approaches to mitigate its spread. Plants: 10,817. https://doi.org/10.3390/plants10040817

Printz, J.L. and J.R. Hendrickson. 2015. Impacts of Kentucky bluegrass invasion (*Poa pratensis*) on ecological processes in the Northern Great Plains. Rangelands 37(6):226-232.

Redmann, Robert E. 1975. Production ecology of grassland plant communities in western North Dakota. Ecological Monographs 45:83-106.

Reeves, J.L., J.D. Derner, M.A. Sanderson, J.R. Hendrickson, S.L. Kronberg, M.K. Petersen, and L.T. Vermeire. 2014. Seasonal weather influences on yearling beef steer production in C_3-dominated Northern Great Plains rangeland. Agriculture, Ecosystems and Environment 183:110-117.

Royer, R. A., 2003. Butterflies of North Dakota: an atlas and guide. Minot State University, Minot, ND.

Sanford, R.C. 1970. Skunk bush in the North Dakota badlands: ecology, phytosociology, browse production, and utilization. Ph. D. Thesis. ND State University.

Seabloom, R. 2020. Mammals of North Dakota. North Dakota Institute for Regional Studies, Fargo, ND. 470 pages.

Sedivec, K.D., J.L. Printz. 2014. Ranchers guide to grassland management IV. NDSU Extension Service publication R1707.

South Dakota Dept. of Game, Fish and Parks. 2014. South Dakota wildlife action plan. Wildlife Division Report 2014-03.

Spaeth, K.E., Hayek, M.A., Toledo, D., and Hendrickson, J. 2019. Cool season grass impacts on native mixedgrass prairie species in the Northern Great Plains. America's Grassland Conference: Working Across Boundaries. The Fifth Biennial Conference on the Conservation of America's Grasslands. Bismarck, ND. 20-22 August.

Tidwell, D., D.T. Fogarty, and J.R. Weir. 2021. Woody encroachment in grasslands, a guide for understanding risk and vulnerability. Oklahoma State University, Oklahoma Cooperative Extension Service publication E-1054. 32 pages.

Toledo, D., M. Sanderson, K. Spaeth, J. Hendrickson, and J. Printz. 2014. Extent of Kentucky bluegrass and its effect on native plant species diversity and ecosystem services in the Northern Great Plains of the United State. Invasive Plant Science and Management 7(4): 543-552.

USDA, NRCS. 2021. National range and pasture handbook, (https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/?cid=stelprdb1043084)

USDA, NRCS. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296.

USDA, NRCS. National Soil Information System, 100 Centennial Mall North, Room 152, Lincoln, NE 68508-3866. (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/tools/?cid=nrcs142p2_053552)

USDA, NRCS. National Water & Climate Center, 1201 NE Lloyd Blvd, Suite 802, Portland, OR 97232-1274. (https://www.wcc.nrcs.usda.gov/)

USDA, NRCS. 2001. The PLANTS database, Version 3.1 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

USDA, NRCS, Various published soil surveys.

USDI BLM.1999. Utilization studies and residual measurements. Interagency Technical Reference 1734-3.

U.S. Fish and Wildlife Service. 2015. Endangered and threatened wildlife and plants; designation of critical habitat for the Dakota skipper and Poweshiek skipperling; Vol. 79 No. Final Rule October 1, 2015, 50 CFR Part 17.

Vinton, M.A. and E.M. Goergen. 2006. Plant-soil feedbacks contribute to the persistence of *Bromus inermis* in tallgrass prairie. Ecosystems 9: 967-976.

Whitman, W.H., H. Hanson, and R. Peterson. 1943. Relation of drought and grazing to North Dakota range lands. North Dakota Agricultural Experimentation Bulletin 340.

Zaczkowski, N. K. 1972. Vascular flora of Billings, Bowman, Golden Valley, and Slope counties, North Dakota. Dissertation, ND State University.

Zimmerman, G. M. 1981. Effects of fire upon selected plant communities in the little Missouri badlands. Thesis, ND State University.

Site Description Approval

ND, State Rangeland Management Specialist	Date	SD, State Rangeland Management Specialist	Date
MT, State Rangeland Management Specialist	Date		

INTERPRETING INDICATORS OF RANGELAND HEALTH, Version 5, REFERENCE SHEET

Ecological site name: __Limy Sands___ Ecological site code: __RO54XY045ND_____
Author(s)/participant(s): M. Hayek, J. Printz, S. Boltz, R. Kilian, D. Froemke, M. Rasmusson
Contact for lead author: _NRCS State Rangeland Management Specialist ___
Date: _Nov. 2021__ **MLRA:** _54_____ **LRU:** _____
Composition based on (check one): ☐ Cover ☒ Annual Production

Indicators. For each indicator, describe the potential for the site using the reference sheet checklist. Where possible, (1) use quantitative measurements; (2) include expected range of values for above- and below-average years and natural disturbance regimes for each community phase within the reference state, when appropriate; and (3) cite data sources used. Continue descriptions on separate sheet.
1. Rills: Rills are not expected on this site.
2. Water flow patterns: Water flow patterns would not be visible on this site when slopes are less than 15%. When slopes are greater than 15%, water flow patterns would be broken, irregular in appearance or discontinuous with numerous debris dams.
3. Pedestals and/or terracettes: Neither pedestals nor terracettes are expected when slopes are less than 15%. When slopes are greater than 15%, a few scattered pedestals may be observed.
4. Bare ground: Bare ground ranges from 20 to 25%. Bare ground patches should be scattered, unconnected, and less than 2 inches in diameter. Animal activity (burrows and ant mounds) may occasionally result in isolated bare patches of up to 24 inches in diameter.
5. Gullies: Active gullies are not expected on this site. If present, gully channel(s) are fully vegetated with no active erosion visible.
6. Wind-scoured and/or depositional areas: No wind-scoured or depositional areas expected on this site.
7. Litter movement: Plant litter movement not expected on this site when slopes are less than 15%. When slopes are greater than 15%, some movement of fine litter may be observable in association with water flow patterns.
8. Soil surface resistance to erosion: Stability class averages 4 to 6.
9. Soil surface loss and degradation: Structure is subangular blocky or granular within the upper A-horizon. A-horizons for this ecological site range from 3 to 8 inches thick. Hue 2.5Y or 10YR with value of 4 or less moist or 4 or 5 dry, and chroma 3 or less moist.
10. Effects of plant community composition and distribution on infiltration: Tall-statured rhizomatous grasses and Mid- and short-statured bunchgrasses are dominant and well distributed across the site. Grass-likes, mid- and short statured rhizomatous grasses and a diverse forb component are subdominant.
11. Compaction layer: No compaction layers occur naturally on this site.

12. Functional/structural groups: Due to differences in phenology, root morphology, soil biology relationships, and nutrient cycling Kentucky bluegrass, smooth brome, and crested wheatgrass are included in a new Functional/structural group, mid- and short-statured early cool-season grasses (MSeC3), **not expected for this site**.

Dominance Category[1]	**Relative dominance of F/S groups for community phases in the *Reference State*** *Minimum expected number of species for dominant and subdominant groups is included in parentheses.*		
	Dominance based on[1]: Annual Production _X_ or Foliar Cover __		
	Phase 1.1_	**Phase 1. __**	**Phase 1. __**
Dominant	**Tall C4 rhizomatous grasses (3); Mid & short C4 bunch grasses (4)**		
Subdominant	**Mid & short C3 bunch grasses (4); Grass-likes (2); Mid & short C4 rhizomatous grasses (1); Forbs (10)**		
Minor	**Shrub; Mid & short C3 rhizomatous grasses; Trees**		
Trace			

[1]Biological soil crust dominance is determined based on cover, rather than production. If biological soil crusts are an expected dominant or subdominant group, the number of expected life forms (e.g., lichen, moss) is listed, rather than number of individual species.

13. Dead or dying plants or plant parts: Rare to not occurring on this site. Some dead centers on warm-season bunchgrasses and shrub branches may be visible following multi-year drought.

14. Litter cover and depth: Plant litter cover is 15 to 35% with a depth of 0.25 to 0.5 inches. Litter cover is in contact with the soil surface.

15. Annual production: Annual air-dry production is 1800 lbs./ac (reference value) with normal precipitation and temperatures. Low and high production years should yield 1100 lbs./ac to 2500 lbs./ac, respectively.

16. Invasive plants: State and local noxious species, Kentucky bluegrass, smooth bromegrass, crested wheatgrass, quackgrass, and Rocky Mountain juniper/cedar.

17. Vigor with an emphasis on reproductive capability of perennial plants: Noninvasive species in all functional/structural groups are vigorous and capable of reproducing annually under normal weather conditions.

Site Type: Rangeland | Limy Sands
MLRA: 54-Rolling Soft Shale Plain | R054XY045ND

Functional/Structural Groups Sheet

State_____ **Office**_____ **Ecological site** Limy Sands **Ecol. site code** RO54XY045ND

Observers_____ **Date**_____

Evaluation site ID and/or name: _____
Dominance in ESD based on: Foliar Cover | Annual Production | Biomass

Species list of functional/structural groups in the **Reference State**	
Functional/Structural Group	Species List
Tall C4 rhizomatous grasses	big bluestem, sand bluestem, prairie sandreed
Mid & short C4 bunch grasses	blue grama, sand dropseed, plains muhly, red threeawn
Mid & short C3 bunch grasses	needle and thread, porcupinegrass, Scribner panicum, prairie Junegrass
Grass-likes	threadleaf sedge, sun sedge
Mid & short C4 rhizomatous grasses	sideoats grama
Forbs	please see plant community table 1.1
Shrub	fringed sagewort, leadplant, rose, shrubby cinquifoil*, skunkbush sumac*, western sandcherry*,
.	yucca*
Mid & short C3 rhizomatous grasses	western wheatgrass*
Trees	juniper*
Biological soil crust[1]	

Reference State - Relative dominance of functional/structural groups for each community phase

Relative dominance annotations: *Use the following annotations in the narrow columns to describe the relative dominance of the listed functional/structural groups: = "equal"; > "greater than"; >> "much greater than"*

Phase	Dominant **	>> > =	Subdominant **	>> > =	Minor **	>> > =	Trace **
1.1	Tall C4 rhizomatous grasses > Mid & short C4 bunch grasses	>>	Mid & short C3 bunch grasses > Grass-likes > Mid & short C4 rhizomatous grasses = Forbs	>	Shrub > Mid & short C3 rhizomatous grasses > Trees	.	
		.		.		.	
		.		.		.	

* Indicates species that may or may not be present on the site. Absence of these species may not constitute a departure.
** See IIRH Version 5 page 70.

Circle the community phase that most closely matches the evaluation area. *Revise functional/structural groups relative dominance for the community phase circled to represent changes in dominance given the time since disturbance(s) (see page 1 of site evaluation sheet).

Species list of functional/structural groups in the **Evaluation Area**	
Functional/Structural Group	Species List
Tall C4 rhizomatous grasses	
Mid & short C4 bunch grasses	
Mid & short C3 bunch grasses	
Grass-likes	
Mid & short C4 rhizomatous grasses	
Forbs	
Shrub	
Mid & short C3 rhizomatous grasses	
Trees	
Groups not expected:	
Mid & short early C3 grasses	
Biological soil crust[1]	

Evaluation Area - Relative dominance of functional/structural groups

Dominant **	>> > =	Subdominant **	>> > =	Minor **	>> > =	Trace **

Biological soil crust [1] - dominance is evaluated solely on cover, not composition by weight

** See IIRH Version 5 page 70.

Notes: