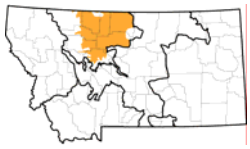
UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION



ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Shallow Clay 10-14 inch p.z. (precipitation zone)

Site ID: R052XN179MT

Major Land Resource Area: 52XN - Northern Glaciated Plains

Physiographic Features: This ecological site occurs on rolling or strongly dissected uplands with shale outcrops. Soils generally have a clay loam to clay surface layer, subsoil, and shale bedrock at a depth of 10 to 20 inches. Slopes usually range from 15 to 35%, but can be less than 15%, and can occasionally reach 60%. Elevations normally vary from 2,200 to 3,500 feet.

Land Forms:
(1) plain
(2) hill
(3) ridge

	Minimum	Maximum
Elevation (feet):	1875	3800
Slope (percent):	0	60

Water Table Depth (inches):

Flooding:

Frequency: none
Duration: none

Ponding:

Depth (inches): none
Frequency: none
Duration: none

Runoff Class: Very high

Aspect: occurs on all aspects

Climatic Features

A semi-arid, temperate climate characterizes the Glaciated Plains. The predominance of cool season species has evolved to take advantage of the precipitation regime that peaks in late spring-early summer (June). Seventy-five percent of the annual precipitation usually falls as steady, soaking, frontal system rains. Summer rains usually come with thunderstorms. Precipitation is the most important factor influencing production (Heitschmidt et al 2005). Severe drought occurs on average in two out of every ten years (Cooper, et al., 2001).

	Minimum	Maximum
Frost-free period (days):	85	123
>32F, 90% probability = Minimum 50% probability = Maximum		
Freeze-free period (days):	116	142
>28F, 90% probability = Minimum 50% probability = Maximum		
Mean annual precipitation (inches):	10	14

Climate Stations:
(1) #241088 - Bredette
(2) #241692 - Chester
(3) #243558 - Glasgow AP
(4) #243996 – Havre WSOAP
(5) #245572 - Medicine Lake
(6) #247500 - Shelby

Influencing Water Features

This site is not influenced by water from wetlands or streams.

Representative Soil Features

These shallow, well drained soils formed in material weathered from clay shale. The soils occupy upland positions. Clay shale bedrock is at a depth of 10 to 20 inches. The surface texture is clay or silty clay. Subsoil textures are usually silty clay. Permeability is very slow. Soil ph varies from 6.6 – 8.4. This site is characterized by the following soil components: Lisam, Neldore, Yawdim and Neldohr.

Predominant Parent Materials:
Kind: residuum
Origin: shale
Surface Texture: (1) clay loam
(2) clay
(3) silty clay
Surface Texture Modifier: (1) none
Subsurface Texture Group: clay, silty clay, or clayey
Surface Fragments < = 3" (% cover): 0
Surface Fragments >3" (% cover): 0
Subsurface Fragments < = 3" (% Volume): 6-19
Subsurface Fragments > 3" (% Volume): 0-2
Drainage Class: Well
Permeability Class: Very slow

	Minimum	Maximum
Depth (inches):	>10	<20
Electrical Conductivity (mmhos/cm):	0	8
Sodium Adsorption Ratio:	0	13
Calcium Carbonate Equivalent (percent):	0	5
Soil Reaction (1:1 Water):	6.6	8.4
Soil Reaction (0.1M CaC12):	---	---
Available Water Capacity (inches):	1.5	3.0

Plant Communities

Ecological Dynamics of the Site

This site developed through time under the influence of climate, geological materials, fire, plants and animals. Research on upland ecological sites consistently shows that precipitation is the principal factor altering productivity (Heitschmidt et al. 2005). The same authors concluded that grazing reduces herbage standing crop, whereas its effects on aboveground net primary production vary with timing of grazing and precipitation events, along with the functional and structural composition of the plant community. Prior to the arrival of European man, these lands may have burned every 10-12 years (Frost 1998).

The resultant historic climax plant community (HCPC) is the basis for plant community interpretations. The HCPC has been determined by evaluating rangeland relic areas, and other areas protected from excessive disturbance.

The HCPC is comprised of a mixture of cool and warm season grasses and shrubs. About 85% of the annual production is from grasses and sedges, most of which is produced during the cool season. Forbs and shrubs contribute 10% and 5%, respectively, to total annual production. Total vegetative production averages 1000 lbs/ac in normal years, 700 lbs/ac in "unfavorable" years, and 1300 lbs/ac in "favorable" years.

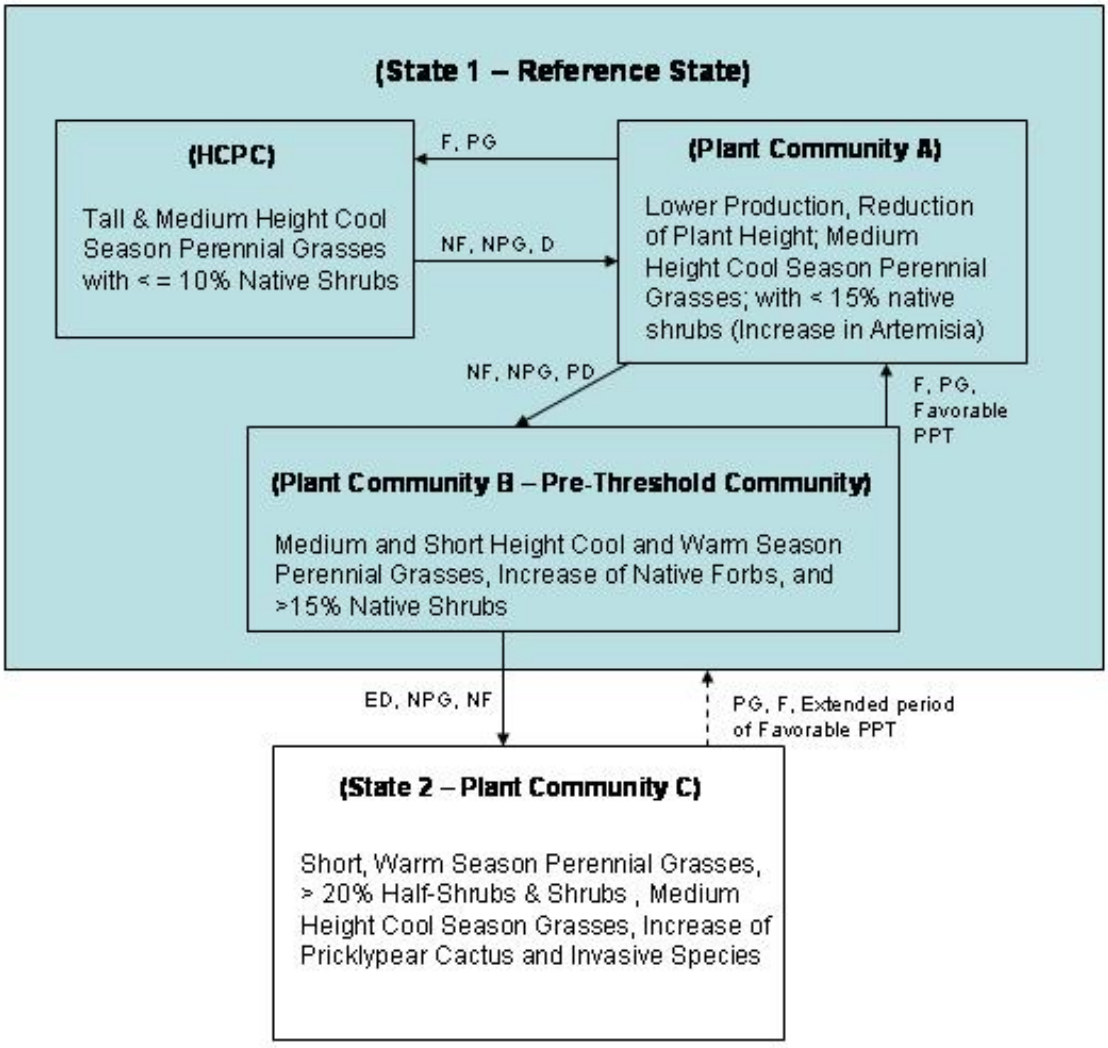
This site is resistant to disturbance, especially when late-successional plants dominate the site. Departures from the HCPC generally result from management actions, drought, and/or a change in the natural fire regime. The site is considered fragile in the sense that vegetative vigor and composition will rapidly decline with continued adverse impacts. Plant communities that retain a high percentage of late successional species are highly resilient. With favorable precipitation and/or prescribed grazing treatments these plant communities can return to the HCPC. In contrast, significant succession is unusual within early-seral communities.

State and Transition Diagram

Successional pathways of Shallow Clay 10-14" p.z. ecological sites cannot be satisfactorily described using traditional theories of plant succession leading to a single climax community (Briske et al. 2005). As the HCPC regresses to an early seral state, it is theorized that a threshold is crossed somewhere within the mid-seral state. Plant communities occurring below this threshold are in a steady state. Succession back to the HCPC does not occur within a reasonable length of time, and/or without a large input of energy.

Three plant communities and the successional pathways that commonly occur within the Reference State (State #1) are shown in the following diagram. The transition from State #1 to State #2 and a plant community representative of State #2 are also illustrated. Ecological processes are discussed in the plant community descriptions that follow the diagram.

Shallow Clay 10-14" p.z. RRUs 52XC, 52XN, and 53AE



Legend:
NF – No Fire
F – Fire (natural interval 10-12 years)
NPG – Non-prescribed Grazing
PG – Prescribed Grazing
PPT -- Precipitation
D – Drought (3-5 years)
PD – Prolonged Drought (5-7 years)
ED – Extended Drought (> 7years)

State #1: Historic Climax Plant Community (HCPC):

The cool season western wheatgrass and green needlegrass are the dominant plants on this ecological site. They account for about 75% of the total annual production in the HCPC. Drought and non-prescribed grazing reduces the competitiveness of the dominant species, and allows lower successional grasses (plains reedgrass, prairie junegrass, needleandthread, sandberg bluegrass, and blue grama) to increase on the site. Plains muhly, a palatable, warm season, short grass may occur in this community. About 10% of the total production is made by a mix of warm and cool season short grasses and sedges.

Forbs contribute about 5% of the total annual production. Two warm season legumes (purple and white prairie clover) and a cool season legume (American vetch) are important components of the HCPC. They fix nitrogen, and are highly palatable forage for livestock and many species of wildlife. Three additional legumes (milkvetch, scurfpea and prairie thermopsis) also occur in the community however their value as forage plants is much lower. Onion, hoods phlox, buckwheat, hoods phlox, scarlet globemallow and biscuitroot may occur as small percentages of the total annual production. The latter group contains a mix of warm and cool season species whose relative occurrence on the site is largely influenced by the timing and amount of precipitation.

Nuttall saltbush and winterfat are two common shrubs on this site. Both species make most of their growth during the cool part of the growing season, and are excellent browse for grazing animals. Silver sagebrush, big sagebrush, fringed sagebrush, rubber rabbitbrush, prairie rose, and pricklypear cactus may occur as small percentages of the total annual production. Shrubs normally make up about 10% of the total annual production.

Broom snakeweed, annual bromes, and annual forbs are not a part of the HCPC. Their presence indicates possible ecological deterioration, or downward trend.

Total annual production averages 1000 lbs/ac during normal years. However, production declines as the site regresses from the HCPC to lower successional communities. Regression may result from grazing management strategies that do not allow adequate recovery periods between grazing events, drought, and/or the disruption of the normal fire regime. The above disturbances favor the replacement of green needlegrass and western wheatgrass by blue grama, sandberg bluegrass, prairie junegrass, scarlet globemallow, onion, and hoods phlox. Nuttall saltbush may also be replaced by broom snakeweed, fringed sagewort, etc. Cheatgrass and Japanese brome may colonize the site as it further deteriorates from the HCPC and associated plant communities. As a result of these vegetative changes, there is less litter to protect the soil and infiltration is reduced. Hydrologic cycles are impaired when plant communities are unable to effectively use precipitation.

Plant basal cover averages 25%. Litter varies from 50-60%, and bare ground averages 10%. Thus, runoff and erosion are not major concerns in the HCPC on the shallow clay ecological site. Runoff and soil erosion normally increase as the HCPC regresses to earlier seral states.

(Insert HCPC Plant Community photo)

The major plant species composition and production by dry weight are shown for the HCPC in the following table. Total annual production has been derived from several sources, and has been adjusted to represent a typical annual moisture cycle.

Historic Climax Plant Community Plant Species Composition:

GRASSES /GRASSLIKES **85% of Community**					Annual Production in Pounds Per Acre	
			Group Allowable			
Common Name*	Scientific Name*	Group	Pounds Per Acre		Low	High
			Low	High		
Bluebunch wheatgrass	*Pseudoroegneria spicata*				300	500
Green needlegrass	*Nassella viridula*		100	300	100	300
Western wheatgrass	*Pascopyrum smithii*	1			50	150
Thickspike wheatgrass	*Elymus macrourus*	1			50	150
Plains muhly	*Muhlenbergia cuspidata*				0	500
Little bluestem	*Schizachrium scoparium*				0	50
Sideoats grama	*Bouteloua curtipendula*				0	50
Blue grama*	*Bouteloua gracilis**				0	100
Sand dropseed*	*Sporobolus cryptandrus**		*100 lbs/ac allowed		0	50
Plains reedgrass*	*Calamagrostis montanensis**		for total of all species		0	50
Threadleaf sedge*	*Carex filifolia**		in this group; no		0	50
Needleleaf sedge*	*Carex duriuscula**		more than 20 lbs for		0	50
Sandberg bluegrass*	*Poa secunda**		any one species.		0	50
Praire junegrass*	*Koeleria macrantha**				0	50
Other native grasses*					0	50

FORBS **10% of Community**					Annual Production in Pounds Per Acre	
			Group Allowable			
Common Name	Scientific Name	Group	Pounds Per Acre		Low	High
			Low	High		
American vetch	*Vicia americana*				10	50
Purple prairieclover	*Dalea purpurea*	2	20	100	10	50
White prairieclover	*Dalea candida*	2			10	50
Scarlet globemallow*	*Sphaeralcea coccinea**				0	50
Aster*	*Aster spp.**		*40 lbs/ac is max for		0	50
Scurfpea*	*Psoralidium spp.**		all species in this		0	50
Western yarrow*	*Achillea millefolium**		group; and no more		0	50
Bastard toadflax*	*Comandra umbellata**		than 15 lbs/ac for a		0	50
Milkvetch*	*Astragalus spp.**		single species.		0	50
Prairie thermopsis*	*Thermopsis rhombifolia**				0	50
Hoods phlox*	*Phlox hoodii**				0	50
Onion*	*Allium spp.**				0	50

Other native forbs*			100 lbs/ac is maximum allowed for all forbs.	

SHRUBS AND HALF-SHRUBS **5% of Community**						
			Group Allowable		Annual Production in Pounds Per Acre	
Common Name	Scientific Name	Group	Pounds Per Acre		Low	High
			Low	High		
Nuttall Saltbush	*Atriplex nuttallii*				10	50
Winterfat	*Krascheninnikovia lanata*				10	50
Silver sagebrush	*Artemisia cana*		50 lbs/ac is the max		10	50
Big sagebrush*	*Artemisia tridentate**		allowed for all shrubs.		0	50
Fringed sagewort*	*Artemisia frigida**				0	50
Greasewood*	*Sarcobatus vermiculatus**		*No more than 30		0	50
Plains pricklypear*	*Opuntia polyacantha**		lbs/ac for total of all		0	T
Brittle pricklypear*	*Opuntia fragilis**		species in this group;		0	T
Other native shrubs*			and no more than 15		0	50
			lbs/ac for any one species.			

Structure and Cover

Soil Surface (%)

Basal Cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & <= 3"	Surface Fragments > 3"	Bedrock	Water	Bare Ground
Grass/ Grasslike	Forb	Shrub/ Vine	Tree								
20	1-2	1-5	0								

Ground Cover (%)

Vegetative Cover						Non-Vegetative Cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & <= 3"	Surface Fragments > 3"	Bedrock	Water	Bare Ground
				0-1	0-1	50-60	0-T	0-T	T	0	10

Structure of Canopy Cover (%)

	Grass/Grasslike	Forb	Shrub/Vine	Tree
<= 0.5 feet	15	25	T	0
>0.5 - <=1 feet	40	50	40	0
>1 - <=2 feet	40	25	50	0
>2 - <=4.5 feet	5		10	0
>4.5 - <=13 feet				0
>13 - <= 40 feet				0

Annual Production by Plant Type:

Plant	Annual Production (lbs/AC)		
Type	Low	RV*	High
Grasses/Grasslike	600	850	1100

Forb	20	50	70
Shrub	80	100	130
Total	700	1000	1300

*RV means "representative value".

***Successional Pathway from HCPC to Plant Community A:**
Non-prescribed grazing, drought and/or a cessation of the natural fire regime will cause regression from HCPC to Community A.

Plant Community A (State #1):

Non-prescribed grazing and drought reduce plant height and plant litter. Total annual production is about 80% of the production found in HCPC. Surface runoff and soil temperature increases and infiltration decreases. Shallow-rooted short grasses (sandberg bluegrass, blue grama, and prairie junegrass) and sedges gain a competitive advantage over medium height, deep-rooted cool season perennial grasses (bluebunch wheatgrass, green needlegrass and western wheatgrass). They are able to compete more successfully with the mid-grasses because of the ability of relatively shallow root systems to utilize shallowly penetrating moisture.

Western wheatgrass, bluebunch wheatgrass, and green needlegrass contribute about 60% of the total annual production. Vigor of these high-successional grasses has declined, and individual plant growth is reduced from what it is in the HCPC. Production of the short grasses increases relative to their percentage contribution in the HCPC. Although a few annual forbs are present on disturbed areas, the forb component continues to contribute about 10% of the total annual production. Fringed sagewort and silver sagebrush increased at the expense of nuttall saltbush and winterfat. Therefore, total shrub production is 5-10% of total annual production.

Most of the species characteristic in the HCPC community are present in Community A. Therefore, it is highly resilient and resistant to change. Trend is influenced by the interaction of climatic factors and livestock grazing management practices.

(Insert Plant Community A photo)

***Successional Pathway from Community A to HCPC:**
Favorable growing conditions, the implementation of prescribed grazing, or periodic fire will move Plant Community A to the HCPC. This succession is possible within a couple of years.

***Successional Pathway from Community A to Plant Community B:**
Community A will regress to Community B under non-prescribed grazing, prolonged drought, or an extended period lacking a natural fire regime. The rate of regression varies with the intensity of the disturbances. Severe drought may cause retrogression within a couple years.

Plant Community B (State #1):

This Community is dominated by a mix of medium and short height, cool and warm season grasses. Western wheatgrass, green needlegrass, and

bluebunch wheatgrass represent from 40-50% of total annual production. Littlle bluestem is present only in trace amounts. Blue grama, threadleaf sedge, sandberg bluegrass and other low successional grasses expanded their influence in the community. Total annual production is about 75% of the production in Community A, or about 50% of what it was in the HCPC.

Prairie thermopsis, hoods phlox, wild onion, western yarrow, and scarlet globemallow increased and now contribute about 15% of the total annual production. The density of fringed sagewort and broom snakeweed (warm season half-shrubs) increased relative to their presence in the higher successional communities. Pricklypear cactus is usually present in this community. Total annual production averages 550 lbs/ac.

In comparison to the HCPC, total plant cover and amount of litter declines. A disproportionate amount of litter that is on the ground is material from lower successional plants. Bare ground increases to about 20%.

Plant community B is called the "pre-threshold community". It is critical that this community be recognized and strategies implemented to prevent further regression. Compared to the HCPC, water flow patterns are more numerous than expected, there is slight to moderate active pedestalling, there is more bare ground than expected, there is moderate movement of smaller size litter deposits into depressions or against obstructions, infiltration is slightly to moderately decreased due to the shift toward more short grasses in the plant community. The reproductive capabilities of green needlegrass and western wheatgrass are somewhat limited relative to recent climatic conditions (USDI and USDA 2000). Community B is less resilient and much less resistant to change than Community A. Once Community B regresses to a lower state, normal successional processes are less likely to occur in a timely fashion.

(Insert Plant Community B photo)

***Successional Pathways from Community B to Community A:**
Community B is fairly resilient, and it does not persist in a steady state. Prescribed grazing and/or a period of favorable precipitation will usually induce succession from Community B to Community A (Branson and Miller 1981).

***Transition from Community B (State 1) to State #2:**
Community B is much less resistant to change than Community A. Lower production, lower vegetative cover, less litter, and increased bare ground increases Community B's susceptibility to disturbance. Extended drought and non-prescribed grazing can cause regression to State #2.

Plant Community C (State #2):

This plant community is dominated by blue grama and other short warm season perennial grasses. Prairie junegrass, sandberg bluegrass and other cool season short grasses are also common. Western wheatgrass persists as slender stalks, with minimal seed production. Low-successional grasses and sedges contribute about 50% of the total annual production.

Fringed sagewort, broom snakeweed and Nuttall saltbush contribute more than 20% of the total annual production. Low successional forbs also contribute about 20% of the production.

Broom snakeweed and pricklypear cactus are conspicuous in the community. Total annual production averages about 400 lbs/ac, a 25% reduction from Community B.

Litter cover averages about 15%. Water flow patterns are numerous and there is moderate active pedestalling. Bare ground is moderately to much higher than expected. Compared to the HCPC, there has been a structural shift from medium height to short grasses, and a functional shift from cool to warm season plants. Reproductive capability of mid height cool season grasses is greatly reduced relative to recent climatic conditions.

(Insert Plant Community C photo)

***Transition from State #2 to Reference State (State #1):**
Prescribed grazing reduces the probability of further regression in this State, but it does not ensure significant succession to State #1. Succession from State #2 to State #1 may occur with prescribed grazing combined with an extended period of favorable precipitation. This potential succession is depicted with a "dashed" arrow in the state and transition diagram. Succession can also be induced by mechanical treatments and range seeding.

Ecological Site Interpretations

Animal Community

Livestock Management

The Shallow Clay 10-14" p.z. ecological site is fairly productive and is suited for livestock grazing. However, prescribed grazing management is needed. This site is often associated with slopes that may be susceptible to erosion. Species composition is favorable to livestock, and is susceptible to heavy stocking and season long grazing. The cool season medium height grasses are generally selectively grazed, giving the short grasses a competitive advantage. Grazing during early spring may also result in soil compaction. Any additional factors reducing infiltration and increasing runoff on this site are management concerns. Shorter grazing periods developed in conjunction with adequate periods of deferment to facilitate regrowth, replenish carbohydrate pools, and accumulate litter on the soil surface are recommended.

This ecological site, as do most other sites in the northern mixed prairie, has a short grass component. The short grasses usually increase with grazing and decrease with protection or prescribed grazing. However, succession in direct response to a change in grazing pressure is not guaranteed in the Northern Great Plains.

Sampling four-year old ungrazed exclosures and grazed areas with 35% utilization, Vogel and Van Dyne (1966) found essentially the same basal cover of grasses, sedges, forbs, litter and bare soil on protected and grazed sites. They concluded that four years was too short of a time for cover to change

significantly. Hofmann and Ries (1989) observed similar results following a four-year study in North Dakota. Even after 41 years of exclosure, changes in species composition can be relatively small when the site is in the dry, low production portion of northern mixed prairie (Brand and Goetz, 1986). They concluded that site characteristics limited the development of potential vegetation with the exclusion of grazing, but the potential impacts of prescribed grazing on succession were not discussed. The shallow clay ecological site is not as productive as the sites evaluated by Vogel and Van Dyne, Hofmann and Ries, or by Brand and Goetz. Therefore, range managers should recognize the environmental limitations of this site. While a prescribed grazing system is always a good recommendation, it may not guarantee significant succession.

This ecological site is suited for prescribed grazing by livestock. Because of the terrain, and propensity of shrubs, this site may be more compatible for sheep, rather than cattle grazing. Although poisonous plants are not normally a problem, death camas and other forbs may cause losses if livestock are grazing in early spring, before there is adequate growth of suitable forage plants.

Wildlife Interpretations

The HCPC associated with this ecological site provides diverse and valuable wildlife habitat. This site often occurs as a mosaic with other ecological sites, thus creating "ecotones" that serve as a magnet to attract many species of wildlife. Antelope and mule deer prefer grazing this site because of the Nuttall saltbush and other shrubs. When this site occurs in the landscape as a mosaic with other sites, thermal and escape cover are provided for many species of wildlife.

This ecological site becomes less valuable for deer and antelope when plant diversity declines with regression. For example, the disappearance of the bluebunch wheatgrass, green needlegrass, western wheatgrass, and the reduction of Nuttall saltbush would shorten the length of the "green forage" season. The increase of blue grama, hoods phlox etc. is associated with the loss of palatable forbs. These changes also adversely impact foraging opportunities for deer, antelope, upland birds, etc. Because of insufficient vegetative structural diversity, residual grass carry-over and litter cover, the value of the plant community found in State #2 is greatly reduced for wildlife habitat.

Hydrology Functions

Water is the main factor limiting vegetative production on this site. Soil components in this ecological site are normally classed into Hydrologic Group D. These soils have a very high runoff potential, with hydrologic runoff curves of 89 to 80. Field investigations are needed to adjust the curves when plant communities deteriorate from the HCPC. Areas with ground cover less than 50% have the greatest potential for reduced infiltration and higher runoff.

Recreational Uses

This site provides hunting opportunities for upland game species. Outdoor enthusiasts may also appreciate the serenity and openness of this site.

Wood Products

This site has no significant value for wood products.

Other Products

Other Information

This ecological site is not highly resistant to disturbances. Species diversity is adversely affected by season long continuous grazing and by heavy stocking. Medium height grasses are replaced by short grasses. The number of structural/functional groups is reduced with regression from the HCPC. The amount of solar energy that is captured and converted to carbohydrates for plant growth is reduced in State #2. A reduction in total vegetative growth results in less potential vegetation that can be transformed into litter. Litter reductions result in less infiltration, and more runoff and soil erosion.

Supporting Information

Associated Sites The following sites may be found in association with the Shallow Clay 10-14" p.z. ecological site. The Site ID indicates in which Rangeland Resource Unit (RRU) these sites occur. For example, Site ID R052XN162MT occurs in RRU 52XN.

Site Name	Site ID	Site Narrative
Clayey 10-14" p.z.	R052XN162MT	soils >20 inches in depth, higher production, and no hardpan, different species composition
Shallow to Gravel 10-14" p.z.	R052XN176MT	similar position in landscape, soils with depth restriction that limits available moisture, soils 10-20" deep to sands or loamy sands
Shallow 10-14" p.z.	R052XN178MT	soil depth less than or equal to 20 inches to a restrictive layer; less forage production; parent material variable
Dense Clay 10-14" p.z.	R052XN172MT	has a hard restrictive layer in the soil at or near the surface, salt

tolerant plants may be present but are rarely dominant

Similar Sites

Site Name	Site ID	Site Narrative
Shallow Clay 10-14" p.z.	R052XC215MT	Little bluestem is still a part of the HCPC, especially in eastern portions of this RRU.
Shallow Clay 10-14" p.z.	R053AE078MT	Bluebunch wheatgrass is only a trace species in HCPC.

State Correlation

This site has been correlated with the following states: Montana

Inventory Data References

Data Source	Number of Records	Sample Period	State	County
SCS-Range-417	1	1991-92	MT	Phillips
(note: regarded with skepticism; SI = 66%; production = 520lbs/ac, of which 180 lbs were forbs)				
ECS-1				
Modified Double Sampling	8	2002-2004	MT	Phillips, Blaine, Valley, Roosevelt, Daniels

Ross, R. L. and H. E. Hunter. 1976. Climax vegetation of Montana. USDA Soil Conservation Service. Bozeman, MT.

USDA-SCS-MT 1981 Technical Range Site Description

Type Locality

State: MT
County:
Township:
Range:
Section:
UTM: Datum: NAD__ _____E ____N
General Description:
Sensitivity: Yes___ No___

Relationship to Other Classifications:

Other References

Brand, M.D. and H. Goetz. 1986. Vegetation of exclosures in Southwestern North Dakota. J. Range Manage. 39:434-437.

Branson, F. A., and R. F. Miller. 1981. Effects of increased precipitation and grazing management on Northeastern Montana rangelands. J. Range Manage. 34(1):3-11.

Briske, D. D., S. D. Fuhlendorf, and F. E. Smeins, 2005. State-and-transition models, thresholds, and rangeland health: a synthesis of ecological concepts and perspectives. Rangeland Ecol. Manage 58:1-10.

Frost, C. C. 1998. Presettlement fire frequency regimes of the United States: a first approximation. Pages 70-81. in Teresa L. Pruden and Leonard A. Brennan (eds.). Fire in ecosystem management: shifting paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings. No. 20. Tall Timbers Research Station, Tallahassee, FL.

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

Hofmann, L. and R.E. Ries. 1989. Animal performance and plant production from continuously grazed cool-season reclaimed and native pastures. J. Range Manage. 42:248-251.

U.S. Department of Interior and U.S. Department of Agriculture. 2000. Interpreting indicators of rangeland health. Tech. Ref. 1734-6.

Vogel, W.G. and G.M. Van Dyne. 1966. Vegetation responses to grazing management on a foothill sheep range. J. Range Manage. 19:80-85.

Site Description Revisions

The 2005 Shallow Clay 10-14" p.z. ecological site description replaces earlier dated versions of the Shallow Clay 10-14" p.z. description in Rangeland Resource Unit 52XN. This 2005 revision incorporates the State and Transition Model theory, additional data on site productivity, and an improved understanding of many rangeland health indicators.

Site Description Approval

This ecological site description is approved with the understanding that it is no more than another step in our continual effort to update the NRCS technical guide. In order to facilitate the process, NRCS field personnel are encouraged to forward existing information and/or new data that can be used to improve the utility of this site description. Please forward the information and data to the State Rangeland Management Specialist.

Authors	Date	Approval	Date
Dr. John Lacey	02/28/2005	Loretta J. Metz	03/19/2005

Maxine Rasmussen, Area RMS, Glasgow, MT
Jon Siddoway, Area RMS, Great Falls, MT
Rick Bandy, Area RSS, Great Falls, MT
Greg Snell, Area RSS, Glasgow, MT