

Ecological site FX053A99X756

Woody Draw (WD)

Last updated: 4/25/2025
Accessed: 09/25/2026

General information

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

MLRA notes

Major Land Resource Area (MLRA): 053A–Northern Dark Brown Glaciated Plains

The Northern Dark Brown Glaciated Plains, MLRA 53A, is a large, agriculturally and ecologically significant area. It consists of approximately 6.1 million acres and stretches 140 miles from east to west and 120 miles from north to south, encompassing portions of 8 counties in northeastern Montana and northwestern North Dakota. This region represents part of the southern edge of the Laurentide Ice Sheet during maximum glaciation. It is one of the driest and westernmost areas within the vast network of glacially derived prairie pothole landforms of the Northern Great Plains and falls roughly between the Missouri Coteau to the east and the Brown Glaciated Plains to the west. Elevation ranges from 1,800 feet (550 meters) to 3,300 feet (1,005 meters). Soils are primarily Mollisols, but Inceptisols and Entisols are also common. Till from continental glaciation is the predominant parent material, but alluvium and bedrock are also common. Till deposits are typically less than 50 feet thick (Soller, 2001). Underlying the till is sedimentary bedrock largely consisting of Cretaceous shale, sandstone, and mudstone (Vuke et al., 2007). The bedrock is commonly exposed on hillslopes, particularly along drainageways. Significant alluvial deposits occur in glacial outwash channels and along major drainages, including portions of the Missouri, Poplar, and Big Muddy Rivers. Large eolian deposits of sand occur in the vicinity of the ancestral Missouri River channel east of Medicine Lake (Fullerton et al., 2004). The northwestern portion of the MLRA contains a large unglaciated area containing paleoterraces and large deposits of sand and gravel known as the Flaxville gravel. Much of this MLRA was glaciated towards the end of the Wisconsin age, and the maximum glacial extent occurred approximately 20,000 years ago (Fullerton and Colton, 1986; Fullerton et al., 2004). Subsequent erosion from major stream and river systems has created numerous drainageways throughout much of the MLRA. The result is a geologically young landscape that is predominantly a dissected till plain interspersed with alluvial deposits and dominated by soils in the Mollisol and Inceptisol orders. Much of this area is typic ustic, making these soils very productive and generally well suited to production agriculture. Dryland farming is the predominant land use, and approximately 50 percent of the land area is used for cultivated crops. Winter, spring, and durum varieties of wheat are the major crops, with over 48 million bushels produced annually (USDA-NASS, 2017). Areas of rangeland typically are on steep hillslopes along drainages. The rangeland is mostly native mixed-grass prairie similar the *Stipa-Agropyron*, *Stipa-Bouteloua-Agropyron*, and *Stipa-Bouteloua* faciations (Coupland, 1950; 1961). Cool-season grasses dominate and include rhizomatous wheatgrasses, needle and thread, western porcupine grass, and green needlegrass. Woody species are generally rare; however, many of the steeper drainages support stands of trees and shrubs such as green ash and chokecherry. Seasonally ponded, prairie pothole wetlands may occur throughout the MLRA, but the greatest concentrations are in the east and northeast where receding glaciers stagnated and formed disintegration moraines with hummocky topography and numerous areas of poorly drained soils.

Classification relationships

NRCS Soil Geography Hierarchy • Land Resource Region: Northern Great Plains • Major Land Resource Area (MLRA): 053A Northern Dark Brown Glaciated Plains National Hierarchical Framework of Ecological Units (Cleland et al., 1997; McNab et al., 2007) • Domain: Dry • Division: Temperate Steppe • Province: Great Plains-Palouse Dry Steppe Province 331 • Section: Glaciated Northern Grasslands Section 331L • Subsection: Glaciated Northern Grasslands Subsection 331La • Landtype association/Landtype phase: N/A National Vegetation Classification Standard (Federal Geographic Data Committee, 2008) • Class: Forest and Woodland Class (1) • Subclass: Temperate and Boreal Forest and Woodland Subclass (1.B) • Formation: Cool Temperate Forest and Woodland Formation (1.B.2) • Division: North American Great Plains Forest and Woodland Division (1.B.2.Ne) • Macrogroup: Great Plains Forest and Woodland Macrogroup (1.B.2.Ne.1) • Group: Great Plains Mesic Forest and Woodland Group (1.B.2.Ne.1.b) • Alliance: Great Plains Ash - Elm Ravine Forest EPA Ecoregions • Level 1: Great Plains (9) • Level 2: West-Central Semi-Arid Prairies (9.3) • Level 3: Northwestern Glaciated Plains (42) • Level 4: Glaciated Dark Brown Prairie (42i) Glaciated Northern Grasslands (42j)

Ecological site concept

Woody Draw is an extensive ecological site occurring on moderately steep to very steep landscapes where the till plain has been dissected by streams or rivers. It typically occurs in the narrowest, most sheltered swales and is most common on northerly aspects. The

distinguishing characteristic of this site is that it receives additional moisture via surface runoff from adjacent sites and that it supports a predominantly woody plant community. Soils for this ecological site are typically very deep (more than 60 inches), well drained, and derived from alluvium or till. Characteristic vegetation is green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), chokecherry (*Prunus virginiana*), and serviceberry (*Amelanchier alnifolia*).

Associated sites

FX053A99X040	Loamy Steep (LoStp) The Loamy Steep ecological site is found on slopes of 15 percent or greater upslope from the Woody Draw ecological site. It occurs on backslope positions whereas the Woody Draw ecological site occurs on toeslopes on swale microfeatures.
FX053A99X029	Limy Steep (LyStp) The Limy Steep ecological site is found on slopes of 15 percent or greater upslope from the Woody Draw ecological site. It occurs on convex backslope positions whereas the Woody Draw ecological site occurs on swale microfeatures.
FX053A99X062	Swale (Se) The Swale ecological site is found adjacent to the Woody Draw ecological site on similar landforms. It is typically downslope from the Woody Draw ecological site and generally occurs on broader, less sheltered swale microfeatures.
FX053A99X032	Loamy (Lo) The Loamy ecological site is found upslope from and commonly surrounding the Woody Draw ecological site. It is typically found in summit positions where the upper 4 inches of soil contains 18 to 35 percent clay.

Similar sites

FX053A99X061	Riparian Woodland (RW) This site differs from the Woody Draw ecological site in that it is on flood plains rather than upland swales. It generally is on stream terraces adjacent to a perennial stream reach. Woody vegetation typically contains riparian species such as sandbar willow and plains cottonwood.
FX053A99X032	Loamy (Lo) This site differs from the Woody Draw ecological site in that it is in higher topographical positions that do not receive additional moisture and it does not support woody vegetation whereas the Woody Draw ecological site is in the bottoms of coulees or swales and receives additional moisture.
FX053A99X062	Swale (Se) This site differs from the Woody Draw ecological site in that it is dominated by herbaceous species. Bunchgrasses dominate the site in terms of cover and production.

Table 1. Dominant plant species

Tree	(1) <i>Fraxinus pennsylvanica</i> (2) <i>Ulmus americana</i>
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Shrub	(1) <i>Prunus virginiana</i> (2) <i>Amelanchier alnifolia</i>
Herbaceous	Not specified

Legacy ID

R053AY723MT

Physiographic features

This ecological site occurs on moderately steep to very steep landscapes, typically where the landscape has been dissected by streams, rivers, or drainageways. Slopes typically range from 15 to 45 percent. This site occurs most commonly on northern aspects.

Table 2. Representative physiographic features

Landforms	(1) Till plain > Draw (2) Till plain > Drainageway
Flooding frequency	None
Ponding frequency	None
Elevation	550 – 1,010 m
Slope	20 – 50 %
Aspect	NW, N, NE

Climatic features

The Northern Dark Brown Glaciated Plains is a semi-arid region with a temperate continental climate that is characterized by frigid winters and warm to hot summers (Coupland, 1958; Richardson and Hanson, 1977; Heidel et al., 2000). The majority of precipitation occurs as steady, soaking, frontal system rains in late spring to early summer. Summer rainfall comes mainly from convection thunderstorms that typically deliver scattered amounts of rain in intense bursts. These storms may be accompanied by damaging winds and large-diameter hail and result in flash flooding along low-order streams. Approximately 80 percent of the annual precipitation occurs during the growing season. June is the wettest month, followed by July and May (Richardson and Hanson, 1977; Heidel et al., 2000). Average annual precipitation ranges from 11 inches (280 mm) near Richey, Montana, to 15 inches (380 mm) in the Little Muddy drainage near Williston, North Dakota, but precipitation varies greatly from year to year. On average, severe drought and very wet years occur with the same frequency, which is 1 out of 10 years (Coupland, 1958; Heidel et al., 2000). Extreme climatic variations, especially droughts, have the greatest influence on species cover and production (Coupland, 1958, 1961; Biondini et al., 1998). The frost-free period for this ecological site ranges from 90 to 130 days, and the freeze-free period ranges from 115 to 155 days.

Table 3 Representative climatic features

Frost-free period (characteristic range)	90-130 days
Freeze-free period (characteristic range)	120-160 days

Precipitation total (characteristic range)	280-380 mm
Frost-free period (average)	110 days
Freeze-free period (average)	140 days
Precipitation total (average)	330 mm

- (1) BREDETTE [USC00241088], Poplar, MT
- (2) CULBERTSON [USC00242122], Culbertson, MT
- (3) OPHEIM 10 N [USC00246236], Opheim, MT
- (4) OPHEIM 12 SSE [USC00246238], Opheim, MT
- (5) PLENTYWOOD [USC00246586], Plentywood, MT
- (6) SCOBAY 4 NW [USC00247425], Scobey, MT
- (7) SIDNEY [USC00247560], Sidney, MT
- (8) VIDA 6 NE [USC00248569], Vida, MT
- (9) WILLISTON SLOULIN INTL AP [USW00094014], Williston, ND

Influencing water features

This is an upland ecological site and is not influenced by a water table but does receive run in from adjacent sites. Due to the semi-arid climate in which it occurs, the water budget is normally contained within the soil pedon. Soil moisture is recharged by spring rains, but it but rarely exceeds field capacity in the upper 40 inches before being depleted by evapotranspiration. During intense precipitation events, precipitation rates frequently exceed infiltration rates and this site receives additional moisture from upslope sites via surface runoff. Moisture loss through evapotranspiration exceeds precipitation for the majority of the growing season, but this site receives enough moisture from runoff to remain moist much longer than adjacent sites.

Soil features

Soils for this ecological site are typically very deep (more than 60 inches), well drained, and derived from alluvium or till. Most soils in this concept are classified as pachic, meaning they have a mollic epipedon that is at least 16 inches thick. They have a typic ustic soil moisture regime, which means that the soils are moist in some or all parts for either 180 cumulative days or 90 consecutive days during the growing season but are dry in some or all parts for over 90 cumulative days, and a frigid soil temperature regime (Soil Survey Staff, 2014).

Surface textures found in this site are most commonly loam, silt loam or clay loam and typically contain between 25 to 35 percent clay. The underlying horizons typically contain 18 to 35 percent clay and have loam or clay loam textures. Calcium carbonate equivalent is typically less than 10 percent throughout the soil profile. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. Soil pH classes are neutral in the surface horizon and moderately to strongly alkaline in the subsurface horizons. Content of coarse fragments is less than 35 percent in the upper 20 inches of soil and is typically less than 15 percent.

Table 4. Representative soil features

Parent material	(1) Alluvium – igneous, metamorphic and sedimentary rock (2) Till – igneous, metamorphic and sedimentary rock
Surface texture	(1) Loam (2) Silt loam (3) Clay loam

Drainage class	Well drained
Soil depth	150 – 180 cm
Calcium carbonate equivalent (0-182.9cm)	0 – 10 %
Electrical conductivity (0-50.8cm)	Not specified
Sodium adsorption ratio (0-50.8cm)	0 – 10
Subsurface fragment volume <=3" (0-50.8cm)	0 – 20 %
Subsurface fragment volume >3" (0-50.8cm)	0 – 20 %

Table 5. Representative soil features (actual values)

Drainage class	Not specified
Soil depth	Not specified
Calcium carbonate equivalent (0-182.9cm)	Not specified
Electrical conductivity (0-50.8cm)	Not specified
Sodium adsorption ratio (0-50.8cm)	Not specified
Subsurface fragment volume <=3" (0-50.8cm)	0 – 30 %

Subsurface fragment volume >3" (0-50.8cm)	0 – 30 %
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Ecological dynamics

The information in this ecological site description, including the state-and-transition model (STM), was developed based on historical data, current field data, professional experience, and a review of the scientific literature. As a result, all possible scenarios or plant species may not be included. Key indicator plant species, disturbances, and ecological processes are described to inform land management decisions.

The Woody Draw provisional ecological site in MLRA 53A consists of four states: the Historic Reference state (1), the Current Potential state (2), the Shrub Dominated state (3), and the Herbaceous Understory state (4). Plant communities associated with this ecological site evolved under the combined influences of climate, grazing, and fire. Extreme climatic variability results in frequent droughts, which have the greatest influence on the relative contribution of species cover and production (Coupland, 1958, 1961; Biondini et al., 1998). Due to the dominance of cool-season graminoids, annual production is highly dependent upon mid- to late-spring precipitation (Heitschmidt and Vermeire, 2005; Anderson, 2006).

The historic ecosystem experienced periodic lightning-caused fires with estimated fire return intervals of 6 to 25 years (Bragg, 1995). Historically, Native Americans also set periodic fires. The majority of lightning-caused fires occurred in July and August, whereas Native Americans typically set fires during spring and fall to correspond with the movement of bison (Higgins, 1986). The precise effects of the historic fire return interval are not definitive, but in general the woody draw ecosystem was resilient to fire. The primary effect of fire is believed to be a temporary reduction in tree and shrub cover.

Native grazers also shaped these plant communities. American Bison (*Bison bison*) were the dominant historic grazer, but pronghorn (*Antilocapra americana*), elk (*Cervus canadensis*), and deer (*Odocoileus* spp.) were also common. Additionally, small mammals such as prairie dogs (*Cynomys* spp.) and ground squirrels (*Urocitellus* spp.) influenced this plant community (Salo et al., 2004). Grasshoppers and periodic outbreaks of Rocky Mountain locusts (*Melanoplus spretus*) also played an important role in the ecology of these communities (Lockwood, 2004).

Following European settlement, fire was largely eliminated, domestic livestock replaced native ungulates as the primary grazers, and non-native species were introduced to the ecosystem. Aside from drought, livestock grazing is now the principle disturbance on the landscape.

Improper grazing of this site can result in a reduction of shrub diversity and an increase in less palatable shrubs (Hansen et al., 1995). Improper grazing in combination with a stand replacing fire can result in a shrub dominated state with low species diversity. Improper grazing practices include any practices that do not allow sufficient opportunity for plants to physiologically recover from a grazing event or multiple grazing events within a given year and/or that do not provide adequate cover to prevent soil erosion over time. These practices may include, but are not limited to, overstocking, continuous grazing, and/or inadequate seasonal rotation moves over multiple years. Further degradation of the site due to improper grazing will eventually eliminate nearly all shrubs and result in an open, decadent stand of green ash and American elm in the top canopy with an herbaceous dominated understory. Once the stand has transitioned from a shrub-dominated understory to an herbaceous dominated understory, returning it to its former state is very difficult (Hansen et al., 1995).

Most, if not all, extant examples of this site have some degree of invasion by non-native species. Introduced bluegrasses (*Poa* spp.) are the most common invasive species, but smooth brome (*Bromus inermis*) and noxious weeds can also be a concern in some areas. These species are widespread throughout the Northern Great Plains can invade relatively undisturbed grasslands (Toledo et al., 2014). Evidence suggests that long-term fire suppression can result in accumulations of litter and may contribute to increased abundance of non-native grasses (Murphy and Grant, 2005).

Due to the steep and broken topographic setting, this ecological site is generally not suitable for cropland. In general, this site has not been converted to cropland and has remained in native vegetation.

The state-and-transition model (STM) suggests possible pathways that plant communities on this site may follow as a result of a given set of ecological processes and management. The site may also support states not displayed in the STM diagram. Landowners and land managers should seek guidance from local professionals before prescribing a particular management or treatment scenario. Plant community responses vary across this MLRA due to variability in weather, soils, and aspect. The reference community phase may not necessarily be the management goal. The lists of plant species and species composition values are provisional and are not intended to cover the full range of conditions, species, and responses for the site. Species composition by dry weight is provided when available and is considered provisional based on the sources identified in the narratives associated with each community phase.

State and transition model

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 7. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 8. Community 2.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 9. Community 2.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 10. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 11. Community 4.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 12. Community 4.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Inventory data references

Two low-intensity plots were available for this provisional ecological site. These plots were used in conjunction with a review of the scientific literature and professional experience to approximate the plant communities for this provisional ecological site. Information for the state-and-transition model was obtained from the same sources. All community phases are considered provisional based on these plots and the sources identified in this ecological site description.

Other references

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

Biondini, M.E., and L. Manske. 1996. Grazing frequency and ecosystem processes in a northern mixed prairie, USA. *Ecological Applications* 6:239-256.

Biondini, M.E., B.D. Patton, and P.E. Nyren. 1998. Grazing intensity and ecosystem processes in a northern mixed-grass prairie, USA. *Ecological Applications* 8:469-479.

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

Cleland, D.T., et al. 1997. National hierarchical framework of ecological units. In: M.S. Boyce and A. Haney (eds.) *Ecosystem Management Applications for Sustainable Forest and Wildlife Resources*, Yale University Press, New Haven, CT.

Coladonato, M. 1992. *Ulmus americana*. In: *Fire Effects Information System*, U.S. Department of Agriculture, Forest Service <https://www.fs.fed.us/database/feis/plants/tree/ulname/all.html> (Accessed 16 October 2018).

Coupland, R.T. 1950. Ecology of the mixed prairie of Canada. *Ecological Monographs* 20:271-315.

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

Coupland, R.T. 1961. A reconsideration of grassland classification in the Northern Great Plains of North America. *Journal of Ecology* 49:135-167.

Coupland, R.T., and R.E. Johnson. 1965. Rooting characteristics of native grassland species in Saskatchewan. *Journal of Ecology* 53:475-507.

DeKeyser, E.S., M. Meehan, G. Clambey, and K. Krabbenhoft. 2013. Cool season invasive grasses in northern Great Plains natural areas. *Natural Areas Journal* 33:81-90.

DeKeyser, 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.

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

Dix, R.L. 1960. The effects of burning on the mulch structure and species composition of grasslands in western North Dakota. *Ecology* 41:49-56.

Dormaar, J.F., and W.D. Willms. 1990. Effect of grazing and cultivation on some chemical properties of soils in the mixed prairie. *Journal of Range Management* 43:456-460.

Federal Geographic Data Committee. 2008. The national vegetation classification standard, version 2. FGDC Vegetation Subcommittee, FGDC-STD-005-2008 (Version 2), p. 126.

Fryer, J. L. 1997. *Amelanchier alnifolia*. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service <http://www.fs.fed.us/database/feis/plants/shrub/amealn/all.html> (Accessed 23 March 2017).

Fullerton, D.S., and R.B. Colton. 1986. Stratigraphy and correlation of the glacial deposits on the Montana Plains. U.S. Geological Survey.

Fullerton, D.S., R.B. Colton, C.A. Bush, and A.W. Straub. 2004. Map showing spatial and temporal relations of mountain and continental glaciations on the northern plains, primarily in northern Montana and northwestern North Dakota. U.S. Geologic Survey pamphlet accompanying Scientific Investigations Map 2843.

Fullerton, D.S., R.B. Colton, and C.A. Bush. 2013. Quaternary geologic map of the Shelby 1° x 2° quadrangle, Montana: U.S. Geological Survey Open-File Report 2012–1170, scale 1:250,000.

Grant, T.A., B. Flanders-Wanner, T.L. Shaffer, R.K. Murphy, and G.A. Knutsen. 2009. An emerging crisis across northern prairie refuges: Prevalence of invasive plants and a plan for adaptive management. *Ecological Restoration* 27:58-65.

Gucker, C. L. 2005. *Fraxinus pennsylvanica*. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service <https://www.fs.fed.us/database/feis/plants/tree/frapen/all.html> (Accessed 16 October 2018).

Hansen, P.L., et al. 1995. Classification and management of Montana's riparian and wetland sites. University of Montana, Montana Forest and Conservation Experiment Station, Miscellaneous Publication No. 54.

Hauser, A. S., 2007. *Symphoricarpos occidentalis*. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service <http://www.fs.fed.us/database/feis/plants/shrub/arttriv/all.html> (Accessed 23 March 2017).

Heidel, B., S.V. Cooper, and C. Jean. 2000. Plant species of special concern and plant associations of Sheridan County, Montana. Report to U.S. Fish and Wildlife Service. Montana Natural Heritage Program, Helena.

Heitschmidt, R.K., and L.T. Vermeire. 2005. An ecological and economic risk avoidance drought management decision support system. In: J.A. Milne (ed.) *Pastoral Systems in Marginal Environments*, XXth International Grasslands Congress, July 2005, p. 178.

Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, and W.G. Whitford. 2009. Monitoring manual for grassland, shrubland and savanna ecosystems. U.S. Department of Agriculture, Agricultural Research Service, Jornada Experimental Range, Las Cruces, NM.

Higgins, K.F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. U.S. Fish and Wildlife Service Resource Publication 161.

Johnson, K. A. 2000. *Prunus virginiana*. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service <http://www.fs.fed.us/database/feis/plants/tree/pruvir/all.html> (Accessed 23 March 2017).

Knopf, F.L. 1996. Prairie legacies—birds. In: F.B. Samson and F.L. Knopf (eds.) *Prairie Conservation: Preserving North America's Most Endangered Ecosystem*, Island Press, Washington, DC, pp. 135-148.

Knopf, F.L., and F.B. Samson. 1997. Conservation of grassland vertebrates. In: F.B. Samson and F.L. Knopf (eds.) *Ecology and Conservation of Great Plains Vertebrates: Ecological Studies* 125, Springer-Verlag, New York, NY, pp. 273-289.

Laycock, W.A. 1991. Stable states and thresholds of range condition on North American rangelands. *Journal of Range Management*

Lesica, P. and P. Husby. 2006. Field Guide to Montana's Wetland Vascular Plants. Montana Wetlands Trust. Helena.

Lockwood, J.A. 2004. Locust: The devastating rise and mysterious disappearance of the insect that shaped the American frontier. Basic Books, New York, NY.

McNab, W.H., et al. 2007. Description of ecological subregions: Sections of the conterminous United States [CD-ROM]. USDA Forest Service, General Technical Report WO-76B.

Montana State College. 1949. Similar vegetative rangeland types in Montana. Montana State College, Agricultural Experiment Station.

Murphy, R.K., and T.A. Grant. 2005. Land management history and floristics in mixed-grass prairie, North Dakota, USA. *Natural Areas Journal* 25:351-358.

Nesser, J.A., G.L. Ford, C.L. Maynard, and D.S. Page-Dumroese. 1997. Ecological units of the Northern Region: Subsections. USDA Forest Service, Intermountain Research Station, General Technical Report INT-GTR-369.

Richardson, R.E., and L.T. Hanson. 1977. Soil survey of Sheridan County, Montana. USDA Soil Conservation Service, Bozeman, MT.

Rowe, J.S. 1969. Lightning fires in Saskatchewan grassland. *Canadian Field Naturalist* 83:317-327.

Salo, E.D., et al. 2004. Grazing intensity effects on vegetation, livestock and non-game birds in North Dakota mixed-grass prairie. *Proceedings of the 19th North American Prairie Conference*, Madison, WI.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils. Version 3.0. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Shay, J., D. Kunec, and B. Dyck. 2001. Short-term effects of fire frequency on vegetation composition and biomass in mixed prairie in south-western Manitoba. *Plant Ecology* 155:157-167.

Smith, B., and G.J. McDermid. 2014. Examination of fire-related succession within the dry mixed-grass subregion of Alberta with the use of MODIS and Landsat. *Rangeland Ecology and Management* 67:307-317.

Soil Survey Staff. 2014. Keys to soil taxonomy, 12th edition. USDA Natural Resources Conservation Service.

Soller, D.R. 2001. Map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains. U.S. Geological Survey Miscellaneous Investigations Series I-1970-E, scale 1:3,500,000.

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 States. *Invasive Plant Science and Management* 7:543-552.

U.S. Department of Agriculture, National Agricultural Statistics Service. 2017. Montana Annual Bulletin, Volume LIV, Issue 1095-7278. https://www.nass.usda.gov/Statistics_by_State/Montana/Publications/Annual_Statistical_Bulletin/2017/Montana_Annual_Bulletin_2017.pdf (Accessed 14 February 2017).

U.S. Department of Agriculture, Natural Resources Conservation Service. Glossary of landform and geologic terms. National Soil Survey Handbook, Title 430-VI, Part 629.02c. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054242 (Accessed 13 April 2016).

Vuke, S.M., K.W. Porter, J.D. Lonn, and D.A. Lopez. 2007. Geologic Map of Montana - information booklet: Montana Bureau of Mines and Geology Geologic Map 62-D.

Wilson, S.D., and J.M. Shay. 1990. Competition, fire, and nutrients in a mixed-grass prairie. *Ecology* 71:1959-1967.

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Acknowledgments

A number of USDA-NRCS staff supported this project. Staff contributions are as follows: Soil Concepts, Soils Information, and Field Descriptions Charlie French, USDA-NRCS (retired) Steve Sieler, USDA-NRCS NASIS Reports, Data Dumps, and Soil Sorts Bill Drummond, USDA-NRCS (retired) Pete Weikle, USDA-NRCS Peer Review Kirt Walstad, USDA-NRCS Mark Hayek, USDA-NRCS Kami Kilwine, USDA-NRCS Robert Mitchell, USDA-NRCS Quality Control Kirt Walstad, USDA-NRCS Quality Assurance Stacey Clark, USDA-NRCS

Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	04/25/2025
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. Number and extent of rills:

2. Presence of water flow patterns:

3. Number and height of erosional pedestals or terracettes:

4. Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):

5. Number of gullies and erosion associated with gullies:

6. Extent of wind scoured, blowouts and/or depositional areas:

7. Amount of litter movement (describe size and distance expected to travel):

8. Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):

9. Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):

10. Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:

11. Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):

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

Dominant:

Sub-dominant:

Other:

Additional:

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

14. Average percent litter cover (%) and depth (in):

15. Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):

16. Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:

17. Perennial plant reproductive capability:
