Ecological site FX052X99X061 Riparian Woodland (RW)

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General information

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

MLRA notes

Major Land Resource Area (MLRA): 052X–Brown Glaciated Plains

The Brown Glaciated Plains, MLRA 52, is an expansive and agriculturally and ecologically significant area. It consists of around 14.5 million acres and stretches across 350 miles from east to west, encompassing portions of 15 counties in north-central Montana. This region represents the southwestern limit of the Laurentide Ice Sheet and is considered to be the driest and westernmost area within the vast network of glacially derived prairie pothole landforms of the northern Great Plains. Elevation ranges from 2,000 feet (610 meters) to 4,600 feet (1,400 meters).

Soils are primarily Mollisols, but Entisols, Inceptisols, Alfisols, and Vertisols 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, and in some areas glacially deformed bedrock occurs at or near the soil surface (Soller, 2001). Underlying the till is sedimentary bedrock largely consisting of Cretaceous shale, sandstone, and mudstone (Vuke et al., 2007). It is commonly exposed on hillslopes, particularly along drainageways. Significant alluvial deposits occur along glacial outwash channels and major drainages, including portions of the Missouri, Teton, Marias, Milk, and Frenchman Rivers. Large glacial lakes, particularly in the western half of the MLRA, deposited clayey and silty lacustrine sediments (Fullerton et al., 2013).

Much of the western portion of this MLRA was glaciated towards the end of the Wisconsin age, and the maximum glacial extent occurred approximately 20,000 years ago (Fullerton et al., 2004). The result is a geologically young landscape that is predominantly a level till plain interspersed with lake plains and dominated by soils in the Mollisol and Vertisol orders. These soils are very productive and generally are well suited to dryland farming. Much of this area is aridic-ustic. Crop-fallow dryland wheat farming is the predominant land use. Areas of rangeland typically are on steep hillslopes along drainages.

The rangeland, much of which is native mixedgrass prairie, increases in abundance in the eastern half of the MLRA. The Wisconsin-age till in the north-central part of this area typically formed large disintegration moraines with steep slopes and numerous poorly drained potholes. A large portion of Wisconsin-age till occurring on the type of the level terrain that would typically be optimal for farming has large amounts of less-suitable sodium-affected Natrustalfs. Significant portions of Blaine, Phillips, and Valley Counties were glaciated approximately 150,000 years ago during the Illinoisan age. Due to erosion and dissection of the landscape, many of these areas have steeper slopes and more exposed bedrock than areas glaciated during the Wisconsin age (Fullerton and Colton, 1986).

While much of the rangeland in the aridic-ustic portion of MLRA 52 is classified as belonging to the “dry grassland” climatic zone, sites in portions of southern MLRA 52 may belong to the “dry shrubland” climatic zone. The dry shrubland zone represents the northernmost extent of the big sagebrush (Artemisia tridentata) steppe on the Great Plains. Because similar soils occur in both southern and northern portions of the MLRA, it is currently hypothesized that climate is the primary driving factor affecting big sagebrush distribution in this area. However, the precise factors are not fully understood at this time.

Sizeable tracts of largely unbroken rangeland in the eastern half of the MLRA and adjacent southern Saskatchewan are home to the Northern Montana population of greater sage-grouse (Centrocercus urophasianus), and large portions of this area are considered to be a Priority Area for Conservation (PAC) by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service, 2013). This population is unique among sage grouse populations because many individuals overwinter in the big sagebrush steppe (dry shrubland) in the southern portion of the MLRA and then migrate to the northern portion of the MLRA, which lacks big sagebrush (dry grassland), to live the rest of the year (Smith, 2013).

Areas of the till plain near the Bearpaw and Highwood Mountains as well as the Sweetgrass Hills and Rocky Mountain foothills are at higher elevations, receive higher amounts of precipitation, and have a typic-ustic moisture regime. These areas have significantly more rangeland production than the drier aridic-ustic portions of the MLRA and have enough moisture to produce crops annually rather than just bi-annually, as in the drier areas. Ecological sites in this higher precipitation area are classified as the moist grassland climatic zone.

Classification relationships

NRCS Soil Geography Hierarchy
• Land Resource Region: Northern Great Plains
• Major Land Resource Area (MLRA): 052 Brown Glaciated Plains
• Climate Zone: N/A

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: Northwestern Glaciated Plains 331D
• Subsection: Montana Glaciated Plains 331Dh
• Landtype association/Landtype phase: N/A

National Vegetation Classification Standard (Federal Geographic Data Committee, 2008)
• Class: Mesomorphic Tree Vegetation Class (1)
• Subclass: Temperate & Boreal Forest & Woodland Subclass (1.B)
• Formation: Temperate Flooded & Swamp Forest Formation (1.B.3)
• Division: *Populus deltoides* - Fraxinus pennsylvanica - Acer saccharinum Flooded & Swamp Forest Division (1.B.3.Na)
• Macrogroup: *Populus deltoides* - Fraxinus pennsylvanica / Salix spp. Flooded Forest Macrogroup (1.B.3.Na.4)
• Group: *Populus deltoides* - Fraxinus pennsylvanica / Pascopyrum smithii Floodplain Forest Group (1.B.3.Na.4.a)
• Alliance: *Populus deltoides* Floodplain Forest Alliance
• Association: *Populus deltoides* / *Cornus sericea* Floodplain 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: North Central Brown Glaciated Plains (42o) & Glaciated Northern Grasslands (42j)

Montana Riparian and Wetland Sites (Hansen et al., 1995)
• *Populus deltoides* / *Cornus sericea* Community Type

Ecological site concept

This provisional ecological site occurs in all climatic zones of MLRA 52. Figure 1 illustrates the distribution of this ecological site based on current data. This map is approximate, is not intended to be definitive, and may be subject to change. Riparian Woodland is an extensive ecological site occurring throughout MLRA 52. It occurs on flood plains and stream terraces and is an extremely dynamic site. Channel migration across the flood plain results in a continual cycle of erosion and deposition that drives soil development as well as plant succession. Flooding and sometimes ground water provide additional moisture for plant growth. Depth to a seasonal water table varies depending on the proximity to the channel.

The distinguishing characteristics of this site are that it is located on flood plains and that it supports woody vegetation. Soils for this ecological site are typically very deep (more than 60 inches) and derived from alluvium. Soil textures in the upper 4 inches are typically loam, silt loam, or sandy loam. Soils typically have an ochric epipedon and are commonly stratified (USDA-NRCS, 2016) due to deposition of sediment from multiple flood events. Characteristic vegetation is plains cottonwood (*Populus deltoides*), redosier dogwood (*Cornus sericea*), western snowberry (Symphoricarpos occidentalis), and willow (Salix spp.). Box elder (Acer negundo) may also be present in some areas.

Associated sites

FX052X99X060	**Overflow (Ov)** The Overflow site is adjacent to the Riparian Woodland site, typically on higher terraces where flooding is less frequent and riparian woody plants are rare or absent.
FX052X99X150	**Subirrigated (Sb)** The Subirrigated site is adjacent to the Riparian Woodland site, typically on lower terraces where ground water is closer to the surface and riparian woody plants are rare or absent.
FX052X99X084	**Slough (Sl)** The Slough site is adjacent to the Riparian Woodland site, typically in oxbows or channels where flooding is very frequent and a water table is shallow and persistent.
FX052X99X091	**Saline Overflow (Sov)** The Saline Overflow site is adjacent to the Riparian Woodland site, typically on higher terraces and in areas where salts have accumulated due to geology, hydrology, or soil properties.

Similar sites

FX052X99X060	**Overflow (Ov)** Overflow differs from the Riparian Woodland site in that it occupies higher terraces and is dominated by upland shrubs and herbaceous species. Trees are rare or absent.
FX052X99X150	**Subirrigated (Sb)** Subirrigated differs from the Riparian Woodland site in that it occupies lower terraces. Depth to a water table is 24 to 40 inches. Trees and shrubs are rare or absent.
FX052X02X756	**Woody Draw (Wd) Moist Grassland** Woody Draw Moist Grassland differs from the Riparian Woodland site in that it does not receive disturbance from flooding. It is located in upland swales rather than on flood plains, has a higher proportion of facultative shrubs, and typically does not support cottonwoods.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY061MT

Physiographic features

Riparian Woodland is an extensive ecological site occurring on flood plains, alluvial fans, and stream terraces.

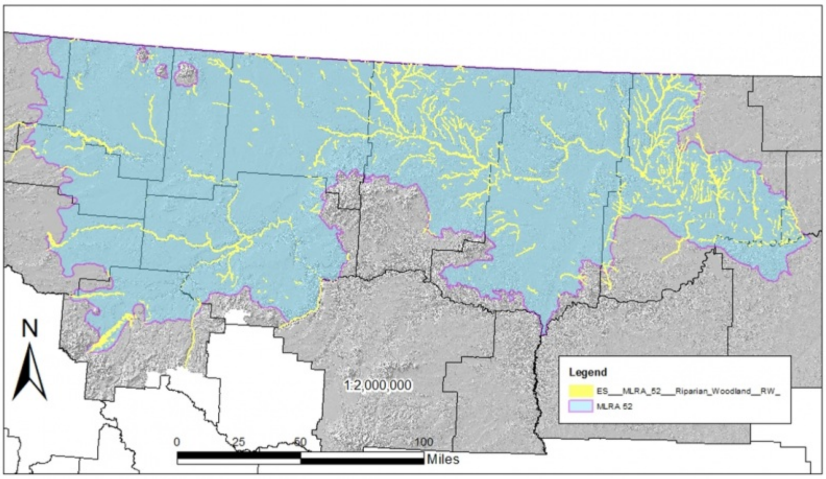

Figure 1. Figure 1. General distribution of the Riparian Woodland ecological site by mapunit extent

Table 2. Representative physiographic features

Landforms	(1) River valley > Flood plain (2) River valley > Stream terrace (3) River valley > Alluvial fan
Flooding duration	Brief (2 to 7 days)
Flooding frequency	Rare to frequent
Elevation	2,000–4,600 ft
Slope	0–2%
Water table depth	24–60 in
Aspect	Aspect is not a significant factor

Climatic features

The Brown Glaciated Plains is a semi-arid region with a temperate continental climate that is characterized by frigid winters and warm to hot summers (Cooper et al., 2001). The average frost-free period for this ecological site is 115 days. 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. Severe drought occurs on average in 2 out of every 10 years. Annual precipitation ranges from 10 to 17 inches, and 70 to 80 percent of this occurs during the growing season (Cooper et al., 2001). Extreme climatic variations, especially droughts, have the greatest influence on species cover and production (Coupland, 1958, 1961; Biondini et al., 1998).

During the winter months, the western half of MLRA 52 commonly experiences chinook winds, which are strong west to southwest surface winds accompanied by abrupt increases in temperature. The chinook winds are strongest on the western boundary of the MLRA near the Rocky Mountain foothills and decrease eastward. In addition to producing damaging winds, prolonged chinook episodes can result in drought or vegetation kills due to the reaction of plants to a “false spring” (Oard, 1993).

Table 3. Representative climatic features

Frost-free period (average)	115 days
Freeze-free period (average)	140 days
Precipitation total (average)	13 in

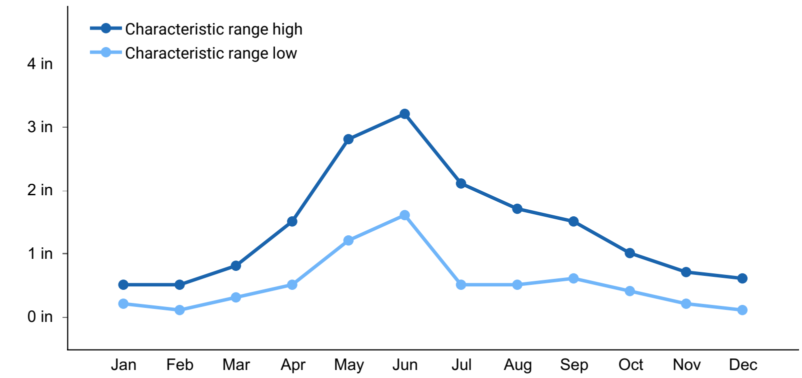

Figure 2. Monthly precipitation range

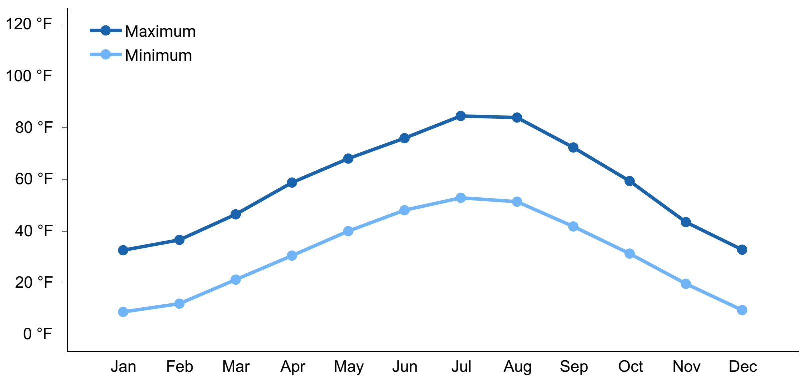

Figure 3. Monthly average minimum and maximum temperature

Climate stations used

- (1) GERALDINE [USC00243445], Geraldine, MT
- (2) CONRAD [USC00241974], Conrad, MT
- (3) TURNER 11N [USC00248415], Turner, MT
- (4) CONTENT 3 SSE [USC00241984], Zortman, MT
- (5) GOLDBUTTE 7 N [USC00243617], Sunburst, MT
- (6) SACO 1 NNW [USC00247265], Saco, MT
- (7) CARTER 14 W [USC00241525], Floweree, MT
- (8) CHESTER [USC00241692], Chester, MT
- (9) HARLEM [USC00243929], Harlem, MT
- (10) LOMA 1 WNW [USC00245153], Loma, MT

Influencing water features

This is a riparian site with hydrology typical of a riverine hydrogeomorphic (HGM) model. The site receives additional moisture from stream overflow and from subsurface hydrology associated with the stream. Streamflow peaks in late spring to early summer and is lowest in fall and winter. During peak flows the site is often flooded for brief durations, and flooding frequency is greatest near the channel. Outside of peak precipitation cycles, the stream system typically exhibits a losing hydrology pattern. Sometimes, a seasonal ground water table is present. Depth to ground water varies depending on proximity to the channel but is typically between 24 and 60 inches below the soil surface.

Soil features

The Riparian Woodland concept covers over 225,000 acres in MLRA 52. Soils that best represent the central concept for this ecological site are Glendive and Ryell. Both of these soils are in the Fluvents suborder. The Glendive soil is in the coarse-loamy family, meaning it contains less than 18 clay and less than 70 percent sand in the particle-size control section. The Ryell soil is in the coarse-loamy over sandy-skeletal family, meaning it contains greater than 35 percent coarse fragments in the underlying horizons. Both soils have mixed mineralogy. The typical parent material for these soils is alluvium. These and all other soils in this site concept are flooded for brief durations. Flooding frequency varies from frequent to rare depending on the proximity to the channel. Soils in this ecological site concept typically have a surface horizon that lacks enough organic matter to have a mollic epipedon. The soil moisture regime is ustic, 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. These soils have a frigid soil temperature regime (Soil Survey Staff, 2014).

Surface textures found on this site are commonly loam, sandy loam, or silt loam. The underlying horizons are typically comprised of stratified alluvial deposits. They are characterized by many thin layers of sediment deposited by past flood events. Textures in subsurface horizons are highly variable and may range from very gravelly loamy sand to silt loam. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. The surface horizon typically contains 1 to 3 percent organic matter, and moist colors vary from brown (10YR 4/3) to very dark grayish brown (10YR 3/2). Calcium carbonate equivalent is typically less than 15 percent throughout the soil profile. Soil pH classes are neutral to moderately alkaline in the surface horizon and neutral to strongly alkaline in the subsurface horizons. The soil depth class for this is site is typically very deep (more than 60 inches). Content of coarse fragments is extremely variable and ranges from 0 to 80 percent in the upper 20 inches of soil.

Table 4. Representative soil features

Parent material	(1) Alluvium
Surface texture	(1) Loam (2) Sandy loam (3) Silt loam
Drainage class	Well drained
Soil depth	60–72 in
Available water capacity (0-40in)	4.8–6.5 in
Calcium carbonate equivalent (0-5in)	0–14%
Electrical conductivity (0-20in)	0–3 mmhos/cm
Sodium adsorption ratio (0-20in)	0–12
Soil reaction (1:1 water) (0-40in)	6.6–9
Subsurface fragment volume <=3" (0-20in)	0–80%
Subsurface fragment volume >3" (0-20in)	0–80%

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 Riparian Woodland provisional ecological site in MLRA 52 Dry Grassland consists of four states: The Contemporary Reference State (1.0), the Herbaceous Understory State (2.0), the Invasive Tree State (3.0), and the Cropland State (4.0). Historically, plant communities associated with this ecological site evolved under the combined influences of climate, grazing, hydrology, and fire. Extreme climatic variability results in frequent droughts, which can have great influence on the relative contribution of species cover and production (Coupland, 1958, 1961; Biondini et al., 1998).

Hydrology, flooding in particular, is a crucial dynamic on this site. Annual flood events delivered water to the site, deposited sediment in some areas, and removed sediment in other areas. This natural erosion/deposition pattern facilitated a natural succession of plant communities. Pioneer species established on recent alluvial deposits, which gave way to more facultative and upland species as banks were built, soil developed, and water tables lowered. The process began anew when banks were eroded again and redeposited as the stream channel migrated back and forth across the flood plain. This natural cycle rejuvenated woodland stands, maintained high species diversity, and preserved the hydrologic function of the flood plain. Another phenomenon unique to this site are ice jams. In winter, the stream freezes over, then thaws during warmer weather, either during winter warming periods or spring thaw. The river ice breaks up into large pieces and floats downriver. When these ice flows are blocked by an obstruction, they accumulate and often are forced onto the floodplain. Ice jams can cause bank scouring and flooding, particularly on lower stream terraces. This creates bare sand and gravel bars which are colonized by pioneer species such as plains cottonwood.

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

The historic ecosystem also experienced relatively frequent 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). Generally, the riparian woodland ecosystem is resilient to fire and the historic fire return interval most likely had neutral or slightly positive effects on the plant community. However, long-term fire suppression in the 20th century removed periodic fire from the ecosystem altogether. Lack of periodic fires can result in an increase in litter accumulation, providing ideal conditions for seed germination and seedling establishment of invasive species. Heavy fuel loads associated with fire suppression also increase the risk of a severe, stand-replacing fire, which eliminates the woodland stand and exposes the site to bank destabilization and erosion.

The contemporary Riparian Woodland site is extremely altered, perhaps irreversibly, from its historic state. Most major rivers in MLRA 52 have been dammed for flood control, irrigation, or electric power generation, all of which significantly altered hydrology. Reduced flooding intensity and frequency have significantly reduced cottonwood regeneration. As a result, many stands are becoming decadent with very little seedling recruitment. Irrigation practices have removed water from streams and diverted it into canals. This has altered ground-water hydrology and stream recharge. On some rivers, unnaturally high flows caused by releasing irrigation water from storage reservoirs has triggered excessive downcutting and bank erosion. Non-native vegetation is also commonplace. Field investigations by Hanson et al. in 1995 and by NRCS in 2008 and 2015 were unable to identify a predominantly native herbaceous community. Due to the extreme alteration of this site, a contemporary reference state rather than a historic reference state is modeled for this provisional ecological site description. The implications of this alteration are not fully understood and require further investigation.

In the early stages of succession, gravel and sand are deposited on alluvial bars by flooding or ice scouring. These bars are quickly colonized by pioneer species such as plains cottonwood (*Populus deltoides*) and sandbar willow (*Salix exigua*). In the absence of further disturbance, higher seral species will begin to establish and the plains cottonwood stand will begin to mature. Over time, banks will build up, the channel will migrate further from the site, and the water table will lower. A diverse understory with species such as redosier dogwood (*Cornus sericea*) will establish under a canopy of mature cottonwood trees. As the cottonwoods die out they are commonly replaced by box elder or an upland shrub/herbaceous community. Disturbance in the form of flooding, ice scouring, or stand-replacing fire can return the site to a pioneer community. Flooding disturbance has been greatly reduced due to dams and flood-control practices and is generally infrequent and limited to the lowest sandbars and terraces.

This site can be important for livestock grazing due to its high productivity and proximity to water. Improper grazing of this site can result in a reduction in the diversity of the understory and an increase in less palatable shrubs (Hansen et al., 1995). 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 inadequate seasonal rotation moves over multiple years. The plant community will transition from a diverse shrub understory to one dominated by western snowberry. Prolonged severe grazing will eventually eliminate all shrubs and result in an herbaceous understory community. Once the stand has transitioned from a shrub-dominated understory to an herbaceous understory, returning it to its former state is very difficult (Hansen et al., 1995). Non-native and invasive species are common on this site. Introduced perennial grasses, such as Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*), are the most common grass species in all phases. Once established, they will displace native species and dominate the ecological functions of the site. Noxious weeds are a major concern on this site. Leafy spurge (*Euphorbia esula*), Canada thistle (*Cirsium arvense*), and hardheads (*Acroptilon repens*), better known as Russian knapweed, are common on this site and are capable of displacing native species. Russian olive (*Elaeagnus angustifolia*), an invasive tree species, is another common invader on this site. It will commonly establish in the understory, replace cottonwoods as they die out, become the dominant tree on the site, and prevent re-colonization by native tree species. Once established, Russian olive is very difficult to remove and may require extensive restoration practices, including tree removal, reestablishment of native tree/shrub species, and weed control.

The Riparian Woodland ecological site is often considered prime farmland. Many acres of this site have been cleared and converted to cropland, primarily irrigated hay. Common crop species include alfalfa, orchardgrass, and a grass/alfalfa mix. Annual crops, such as wheat, barley, and corn, are occasionally planted as part of a rotation or when renovating hay fields. Flood irrigation is common, and water is typically diverted from nearby streams and delivered to fields via canals. Irrigated cropland is extremely valuable in the region, and once the site is converted it is unlikely to be taken out of production.

The STM diagram 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 contemporary reference state 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 1: Contemporary Reference State
The Contemporary Reference State contains five community phases. This state is not considered to be the historic natural state but instead is an evaluation of contemporary conditions given the extreme alterations to the abiotic and biotic components of the ecosystem. Flooding disturbance is a key dynamic on this site, but it has been severely altered by manmade structures. Frequent flooding created open alluvial bars where native cottonwood and willow species could colonize. Reduction of flooding has limited such disturbances to the lowest-elevation terraces. In general, this state was resilient to grazing and fire, although these factors could influence species composition in localized areas. Vegetation is characterized by cottonwood, redosier dogwood, and willow species. Plains cottonwood is the principle species, but narrowleaf cottonwood (*Populus angustifolia*) may also be present as elevations increase. Box elder may also occur in later stages of development. Following disturbance, this state will exhibit an increase in seedling cottonwoods and sandbar willow (Hansen et al., 1995). Herbaceous understory has been significantly altered and is predominantly non-native species such as smooth brome and Kentucky bluegrass. Noxious weeds are a common concern for all phases.

Community Phase 1.1: Seedling Cottonwood – Sandbar Willow Phase
The Seedling Cottonwood – Sandbar Willow Phase is dominated by seedling cottonwoods and sandbar willow. The understory is very dense. Sandbar willow is by far the most abundant species. Other shrub species that may be present at low cover are yellow willow (*Salix lutea*) and redosier dogwood. Common forbs include Canada goldenrod (*Solidago canadensis*) and American licorice (*Glycyrrhiza lepidota*). Graminoids are commonly dominated by non-native species, such as smooth brome, Kentucky bluegrass, and quackgrass (*Elymus repens*). Other graminoid species that may be present are woolly sedge (*Carex pellita*), Canada wildrye (*Elymus canadensis*), and rush (Juncus spp.) (Hansen et al., 1995).

Community Phase Pathway 1.1a
Lack of flooding disturbance, natural plant growth, bank building, or a combination of these factors shift the Seedling Cottonwood – Sandbar Willow Phase (1.1) to the Pole Cottonwood – Yellow Willow Phase (1.2). Time periods with little or no disturbances permit natural growth of the overstory. The stream channel typically is migrating away from the site at this time. Distance to the water table increases, and some shade-tolerant shrubs start to inhabit the understory.

Community Phase 1.2: Pole Cottonwood – Yellow Willow Phase
The Pole Cottonwood – Yellow Willow Phase consists of mostly pole-stage cottonwoods and some sapling cottonwoods. In this phase, the stream channel has moved farther away and the ground-water table has lowered. The tree canopy is typically 60 to 80 percent, with tree diameters of 3 to 11 inches diameter at breast height (DBH). Higher seral species such as yellow willow dominate the understory, and redosier dogwood is becoming more common. Other shrub species that may be present are sandbar willow, Woods' rose (*Rosa woodsii*), and silver buffaloberry (*Shepherdia argentea*). The herbaceous understory is typically dominated by non-native species such as smooth brome and Kentucky bluegrass. Native species such as Canada wildrye may also be present. Canada goldenrod, American licorice, and fleabane (Erigeron spp.) are common forbs.

Community Phase Pathway 1.2a
Flooding, bank scouring by ice jams, or a combination of these factors shift the Pole Cottonwood – Yellow Willow Phase (1.2) to the Seedling Cottonwood – Sandbar Willow Phase (1.1). Flood control has reduced the occurrence of this transition, and it is typically confined to lower terraces near the channel.

Community Phase Pathway 1.2b
Decades of low disturbance, bank building, and lowering of the water table transition the Pole Cottonwood – Yellow Willow Phase (1.2) to the Mature Cottonwood – Dogwood Phase (1.3). The cottonwood overstory matures and begins to self-thin. The canopy starts to open, promoting understory growth.

Community Phase 1.3: Mature Cottonwood – Dogwood Phase
In the Mature Cottonwood – Dogwood Phase, the overstory consists of mature, old-growth cottonwoods. The tree canopy varies from 40 to 90 percent, with tree diameters of 12 inches or more DBH. The understory is characterized by a dense and diverse shrub layer. Common shrubs are redosier dogwood, chokecherry (*Prunus virginiana*), Woods' rose, yellow willow, currant (Ribes spp.), and western snowberry. As time progresses, the cottonwoods begin to die off and the stand thins. Other native trees such as box elder begin to inhabit the understory and will eventually replace the cottonwood stand (Hansen et al., 1995). The herbaceous layer remains dominated by non-native species. The most common are smooth brome and Kentucky bluegrass, but quackgrass and annual bromes may also occur.

The approximate canopy cover by species for the Mature Cottonwood – Dogwood Phase is as follows:

Percent canopy cover by species*
Cottonwood spp. 65%
Redosier Dogwood 55%
Common Chokecherry 20%
Western Snowberry 1%
Woods' Rose 10%
Other Native Shrubs 30%
Graminoids 20%
Perennial Forbs 40%

* Estimated from Hansen et al. (1995)

Community Phase Pathway 1.3a
Extremely long periods of low disturbance, bank building, and lowering of the water table transition the Mature Cottonwood – Dogwood Phase (1.3) to the Box Elder/Shrub Phase. The exact length of time required for this transition is unknown, but is estimated to be 80 to 100 years. The majority of the cottonwood stand has died out and has been replaced by box elder and facultative shrubs. At this point, the site is transitioning to a more upland site rather than a riparian site.

Community Phase Pathway 1.3b
Channel migration associated with major flooding or a stand-replacing fire transitions the Mature Cottonwood – Dogwood Phase (1.3) to the Seedling Cottonwood – Sandbar Willow Phase (1.1). A major flood event that causes the river channel to migrate or a stand-replacing fire that exposes the bank to scouring and collapse will effectively revert the site back to an alluvial bar and begin the process of succession over again.

Community Phase Pathway 1.3c
Improper grazing management transitions the Mature Cottonwood – Dogwood Phase (1.3) to the Mature Cottonwood – Snowberry Phase (1.5). Improper grazing management will reduce the diversity of the shrub understory, reducing canopy cover of redosier dogwood and chokecherry. The understory will become dominated by western snowberry and Wood's rose (Hansen et al., 1995).

Community Phase 1.4: Box Elder/Shrub Phase
The Box Elder/Shrub Phase occurs after extremely long periods without disturbance by flooding. The channel has migrated away from the site, and the ground-water table is no longer a significant contributor to site moisture. Cottonwoods are rare or absent, and the site is on the verge of transitioning to a drier ecological site. Common shrubs may include chokecherry, snowberry, or buffaloberry. Herbaceous species are dominated by non-native species but begin to shift to more drought-tolerant species, such as Kentucky bluegrass and field brome (*Bromus arvensis*). Unless the channel begins to migrate back toward the site, this phase will eventually transition to a drier site, such as Overflow or Swale.

Community Phase Pathway 1.4a
Channel migration in combination with major flooding or a stand-replacing fire transitions the Box Elder/Shrub Phase to the Seedling Cottonwood – Sandbar Willow Phase (1.1). A major flood event that causes the river channel to migrate back to the site in combination with bank slumping or a stand-replacing fire that exposes the bank to scouring and collapse will effectively revert the site back to an alluvial bar and begin the process of succession over again.

Community Phase 1.5: Mature Cottonwood – Snowberry Phase
The Mature Cottonwood – Snowberry Phase occurs due to improper grazing management of the Mature Cottonwood – Dogwood Phase. The diversity of the shrub understory is significantly reduced, and desirable species such as redosier dogwood have been replaced by less desirable species such as western snowberry and Woods' rose. The overstory consists of mature, old-growth cottonwoods. The tree canopy varies from 40 to 90 percent, with tree diameters of 12 inches or more DBH. As time progresses, the cottonwoods begin to die off and are replaced by other trees, such as box elder. The herbaceous layer is dominated by non-native species, particularly smooth brome.

Community Phase Pathway 1.5a
Proper grazing management will return the Mature Cottonwood – Snowberry Phase (1.5) to the Mature Cottonwood – Dogwood Phase (1.3).

Community Phase Pathway 1.5b
Channel migration associated with major flooding or a stand-replacing fire transitions the Mature Cottonwood – Snowberry Phase (1.5) to the Seedling Cottonwood – Sandbar Willow Phase (1.1). A major flood event that causes the river channel to migrate or a stand-replacing fire that exposes the bank to scouring and collapse will effectively revert the site back to an alluvial bar and begin the process of succession over again.

Transition T1A
Prolonged improper grazing management in combination with the absence of flooding disturbance transitions the Contemporary Reference State (1) to the Herbaceous Understory State (2). Prolonged improper grazing will eventually completely remove the shrub understory layer, leaving an understory of herbaceous vegetation. Long periods of low disturbance have built up banks and lowered the water table.

Transition T1B
Clearcutting, tillage or application of herbicide, and seeding of cultivated crops (such as wheat, barley or introduced hay) transitions the Contemporary Reference State (1) to the Cropland State (4).

Transition T1C
Establishment of invasive tree species, particularly Russian olive, transitions the Contemporary Reference State (1) to the Invasive Tree State (3).

State 2: Herbaceous Understory State
The Herbaceous Understory State (2) occurs when the shrub understory has been removed due to long-term

improper grazing practices. The overstory typically consists of a mature, open cottonwood stand but may include other trees in some cases. The tree canopy varies from 40 to 90 percent, with tree diameters of 12 inches or more DBH. The understory consists primarily of non-native grasses, particularly smooth brome. Noxious weeds such as leafy spurge and Canada thistle may be prominent in some cases. Once the site has converted from a shrub-dominated understory to one dominated by introduced herbaceous species, returning it to its former state is very difficult. A drastic change in management is needed, and it most likely will be labor intensive and costly (Hansen et al., 1995).

Community Phase 2.1: Native Tree/Smooth Brome Phase
The Native Tree/Smooth Brome Phase consists of a mature, open tree overstory with a non-native grass understory. The overstory is typically plains cottonwood but may also include box elder, peachleaf willow (*Salix amygdaloides*), or other native tree species. Narrowleaf cottonwood commonly replaces plains cottonwood as elevation increases. The understory is dominated by the introduced grass smooth brome but may also include other species, such as Kentucky bluegrass and quackgrass.

Community Phase 2.2: Native Tree/Noxious Weeds Phase
The Native Tree/Noxious Weed Phase consists of a mature, open tree overstory with a noxious weed understory. This community develops when removal of the understory by improper grazing occurs in proximity to a noxious weed seed source. The overstory is typically plains cottonwood but may also include box elder, peachleaf willow, or other native tree species. Narrowleaf cottonwood commonly replaces plains cottonwood as elevation increases. The understory is dominated by noxious weeds, particularly leafy spurge, Canada thistle, and Russian knapweed.

Transition T2A
Establishment of invasive tree species, particularly Russian olive, transitions the Herbaceous Understory State (2) to the Invasive Tree State (3).

Transition T2B
Clear cutting, tillage or application of herbicide, and seeding of cultivated crops (such as wheat, barley, or introduced hay) transitions the Herbaceous Understory State (2) to the Cropland State (4).

Restoration Pathway R2A
Proper grazing management, tree/shrub planting, and intensive weed management can transition the Herbaceous Understory State (2) back to the Contemporary Reference State (1). A change in management alone may not be sufficient. Replanting of desirable species and intensive weed management practices are generally needed in conjunction with proper grazing management. These restoration methods are labor intensive and costly and may not be a practical in all situations.

State 3: Invasive Tree State
The Invasive Tree State occurs when invasive tree species, particularly Russian olive, establish and dominate the site. Russian olive is a highly competitive tree native to southern Europe and western Asia. It is widely established and commonly forms dense thickets at the exclusion of native species (Hansen et al., 1995). In more open stands, Russian olive may occur in conjunction with widely scattered cottonwood stands and native shrubs, such as snowberry and Woods' rose. As the cottonwood stand dies out, Russian olive will replace it at the exclusion of the typical native tree species.

Community Phase 3.1: Russian Olive/Shrub Phase
The Russian Olive/Shrub Phase occurs in open stands on older alluvial bars and terraces. The overstory is dominated by Russian olive; however, an open, decadent stand of cottonwoods may be present in some cases. The understory is sparse, and diversity is low. Primary understory species are snowberry and Woods' rose. Herbaceous species are dominated by non-native grasses, particularly smooth brome.

Community Phase 3.1: Russian Olive/Noxious Weed Phase
The Russian Olive/Noxious Weed Phase occurs on flood plains and terraces, particularly where soils are slightly to moderately saline. Under these conditions, Russian olive typically forms a dense thicket at the exclusion of native tree species. The understory is extremely suppressed and is predominately noxious weeds. Canada thistle and leafy spurge are common understory species.

Transition T3A
Removal of invasive tree species transitions the Invasive Tree State (3) to the Herbaceous Understory State (2). Typically, tree/shrub planting is required to reestablish native woody species. When clearing the Russian Olive/Noxious Weed Phase (4.2), intensive weed management is critical. Removal of the overstory will release understory growth and cause noxious weed populations to increase exponentially. This transition is very costly and labor intensive and may not be practical in all situations.

Transition T3B
Clear cutting, tillage or application of herbicide, and seeding of cultivated crops (such as wheat, barley, or introduced hay) transitions the Invasive Tree State (3) to the Cropland State (4).

State 4: Cropland State
The Cropland State (4) occurs when land is put into cultivation. Deep, fertile soils and favorable moisture conditions make the Riparian Woodland ecological site prime farmland. Additionally, its proximity to perennial streams makes it ideal for irrigation. Because of this, many acres of the Riparian Woodland ecological site have been cleared and converted to farmland. It is commonly planted to non-native perennial species and irrigated for production of hay. Common species include alfalfa, orchardgrass, and grass/alfalfa mixes. Annual crops, such as wheat and barley, are commonly planted in rotation with perennial species at 5- to 15-year intervals. Silage corn is grown is some cases, but this crop is of limited extent. Flood irrigation is most common but center pivot sprinklers are also used. Several major storage reservoirs and large networks of irrigation canals are present in much of the Milk and Missouri River valleys. Cropping and irrigation projects have vastly altered vegetation and hydrology on much of the Riparian Woodland ecological site. Once the site is converted to production agriculture, land values increase significantly and it is unlikely that the site will be converted back to natural vegetation.

State and transition model

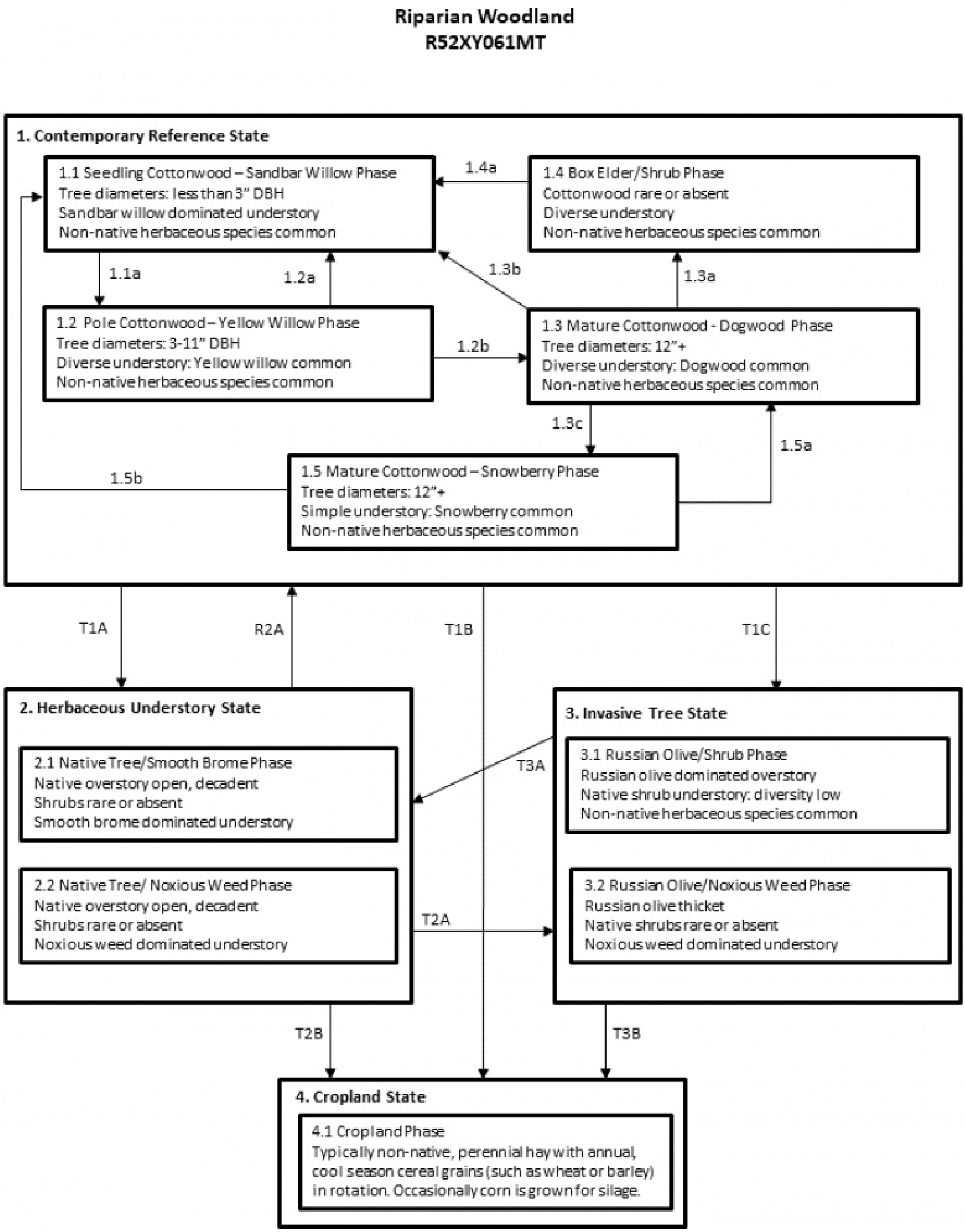

Figure 2. State-and-transition diagram

Riparian Woodland
R52XY061MT

Legend

- 1.1a Lack of disturbance, natural plant growth, and bank building
- 1.2a Flooding, bank scouring, or a combination of these factors
- 1.2b Lack of disturbance, bank building, and lowering of water table
- 1.3a Lack of disturbance, lowering of water table, cottonwood mortality
- 1.3b Major flooding or stand-replacing fire in combination with bank scouring/slumping
- 1.3c Improper grazing management
- 1.4a Major flooding or stand-replacing fire in combination with bank scouring/slumping
- 1.5a Proper grazing management
- 1.5b Major flooding or stand-replacing fire in combination with bank scouring/slumping
- T1A Prolonged improper grazing in combination with lack of flooding disturbance
- T1C, T2A Establishment of invasive tree species (primarily Russian olive)
- R2A Proper grazing management, tree/shrub planting, intensive weed management (management intensive and costly)
- T3A Removal of invasive tree species, sometimes combined with tree/shrub planting (management intensive and costly)
- T1B, T2B, T3B Clear cutting, tillage or herbicide application, and seeding of cultivated crops (frequently combined with irrigation practices)

Figure 3. State-and-transition legend

Inventory data references

Seven low-intensity plots were available for this 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.

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Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	
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:**