

Ecological site FX052X99X091 Saline Overflow (Sov)

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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 approximately 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). The bedrock 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 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 Illinoian 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 climatic 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 typical-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 Shrub and Herb Vegetation Class (2)
- Subclass: Shrub and Herb Wetland Subclass (2.C)
- Formation: Salt Marsh Formation (2.C.5)
- Division: *Distichlis spicata* - *Hordeum jubatum* Great Plains Saline Marsh Division (2.C.5.Na)
- Macrogroup: Great Plains Saline Wet Meadow and Marsh Macrogroup (2.C.5.Na.1)
- Group: Western Great Plains Saline Wet Meadow Group (2.C.5.Na.1.b)
- Alliance: *Sarcobatus vermiculatus* Great Plains Wet Shrubland Alliance
- Association: *Sarcobatus vermiculatus* / *Pascopyrum smithii* - (*Elymus lanceolatus*) Shrub Wet Meadow

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) and Glaciated Northern Grasslands (42j)

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. Saline Overflow is a moderately extensive ecological site, approximately 136,000 acres, occurring on alluvial landscapes throughout MLRA 52. It occurs on floodplains, alluvial fans, and stream terraces where seasonal flooding occurs and salts have accumulated. Sometimes, but not always, a seasonal water table is present at a depth of more than 40 inches below the soil surface, especially during peak runoff periods.

The distinguishing characteristics of this site are that it receives additional moisture from surface water and that saline, sodic, or saline-sodic conditions are evident in the upper 20 inches of soil. Soils for this ecological site are typically very deep (more than 60 inches) and derived from clayey alluvium. Soil textures in the upper 4 inches are typically clay or silty clay. Characteristic vegetation is mostly western wheatgrass (*Pascopyrum smithii*). The

principal shrub is greasewood (*Sarcobatus vermiculatus*). Other shrubs that may occur are silver sagebrush (*Artemisia cana*) and Gardner's saltbush (*Atriplex gardneri*). Total shrub cover is approximately 5 percent.

Associated sites

FX052X99X092	Saline Subirrigated (Ssb) This site is adjacent to the Saline Overflow ecological site, usually on lower terraces where groundwater is closer to the surface.
FX052X99X060	Overflow (Ov) This site is adjacent to the Saline Overflow ecological site on similar landscapes and terrace positions, but in areas that have not accumulated salts in the soil profile.
FX052X99X084	Slough (SI) This site is adjacent to the Saline Overflow ecological site, usually in oxbows or channels where flooding is very frequent and a water table is shallow and persistent.
FX052X99X061	Riparian Woodland (RW) This site is adjacent to the Saline Overflow ecological site, usually on lower terraces where flooding is more frequent, salts have not accumulated, and riparian woody plants are dominant.

Similar sites

FX052X03X012	Dense Clay Sodic (Dcsd) Dry Shrubland This site differs from the Saline Overflow ecological site in that it occurs in uplands or ephemeral drainageways and does not receive enough additional moisture to increase production; whereas the Saline Overflow ecological site is found on higher order stream reaches and receives enough additional moisture to significantly increase production.
FX052X99X092	Saline Subirrigated (Ssb) This site differs from the Saline Overflow ecological site in that it receives additional moisture primarily from groundwater rather than from surface water. Depth to a water table is 24 to 40 inches.
FX052X99X003	Alkali Flat (Af) This site differs from the Saline Overflow ecological site in that it occurs in depressions rather than floodplains. This site is poorly drained and ponds water for long durations; whereas the Saline Overflow ecological site does not.
FX052X01X012	Dense Clay Sodic (Dcsd) Dry Grassland This site differs from the Saline Overflow ecological site in that it occurs in uplands or ephemeral drainageways and does not receive enough additional moisture to increase production; whereas the Saline Overflow ecological site is found on higher order stream reaches and receives enough additional moisture to significantly increase production.
FX052X99X060	Overflow (Ov) This site differs from the Saline Overflow ecological site in that soils do not contain accumulated salts in the upper 20 inches. This site supports a diverse herbaceous plant community and is more productive.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY091MT

Physiographic features

Saline Overflow is a moderately extensive ecological site occurring on floodplains, alluvial fans, and stream terraces.

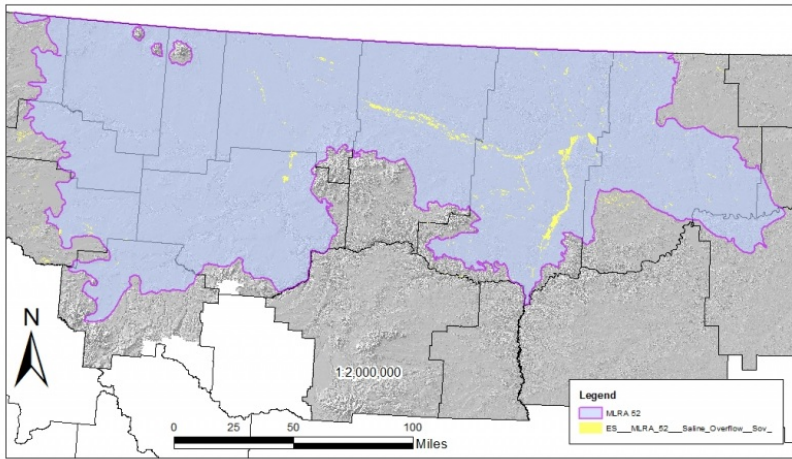


Figure 1. Figure 1. General distribution of the Saline Overflow ecological site by map unit extent.

Table 2. Representative physiographic features

Landforms	(1) Flood plain (2) Alluvial fan (3) Stream terrace
Flooding duration	Brief (2 to 7 days)
Flooding frequency	Rare to occasional
Elevation	610–1,180 m
Slope	0–2%
Water table depth	102–152 cm
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)	330 mm

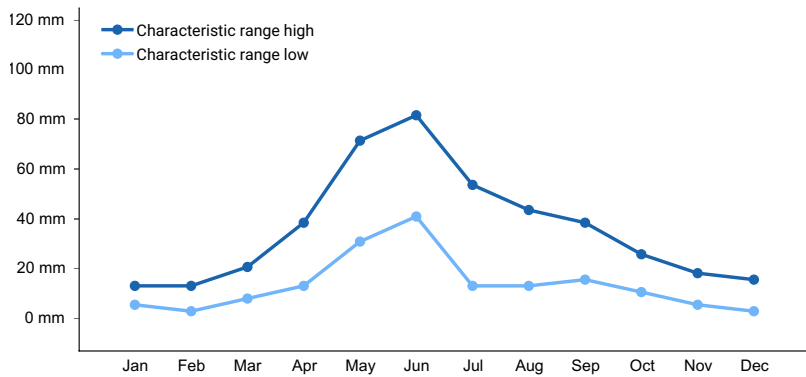


Figure 2. Monthly precipitation range

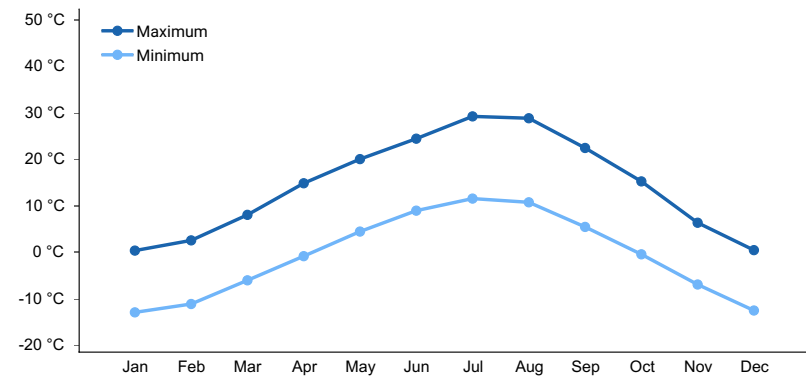


Figure 3. Monthly average minimum and maximum temperature

Climate stations used

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

Influencing water features

This is a floodplain site that receives additional moisture via surface runoff and from stream overflow. During major flood events, the site may be flooded for brief durations. The site receives additional moisture from surrounding uplands which fills the soil profile and enters the stream system. Due to high clay content and very slow permeability rates most recharge is via surface flow, especially during peak precipitation cycles (May-June). Outside of peak precipitation cycles, the site may contribute stored recharge to the system as water slowly infiltrates through the soil profile. Sometimes, a seasonal groundwater table deeper than 40 inches below the soil surface is present, particularly during spring runoff, but the soil does not exhibit hydric features.

Soil features

Soils that best represent the central concept for this ecological site is the Bowdoin soil. The Bowdoin soil is in the Haplusterts great group. Its underlying horizons are extremely hard and exhibit strong shrink-swell characteristics, as evidenced by slickensides (USDA-NRCS, 2016). The particle-size family for this soils is very fine, meaning that it contains more than 60 percent clay in the particle-size control section, and the mineralogy is smectitic. The typical parent material for this series is clayey alluvium. This and all soils in this concept are characterized by an accumulation of salts in the upper 20 inches and a surface horizon that lacks enough organic matter to have a

mollic epipedon. The soil moisture regime for all soils in this ecological site concept is ustic bordering on aridic, 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 horizon textures in this site are commonly clay or silty clay. The upper 4 inches of soil typically contains 50 to 70 percent clay. The underlying horizons typically contain over 60 percent clay and have clay textures. Organic matter in the surface horizon typically ranges from 1 to 2.5 percent organic matter, and moist colors vary from olive gray (5Y 5/2) to dark gray (5Y 4/1). Darker colors are typically inherited from the parent material and are not a result of an accumulation of organic matter. Calcium carbonate equivalent is typically less than 15 percent throughout the soil profile. The upper 20 inches of soil contain accumulated salts, as evidenced by an electrical conductivity of 4 or more, a sodium absorption ratio of 13 or more, or both. Soil pH classes are slightly alkaline to strongly alkaline in all horizons. The soil depth class for this site is typically very deep (more than 60 inches). Content of coarse fragments is less than 35 percent in the upper 20 inches of soil.

Table 4. Representative soil features

Parent material	(1) Alluvium
Surface texture	(1) Clay (2) Silty clay
Drainage class	Well drained
Soil depth	152–183 cm
Available water capacity (0-101.6cm)	9.91–12.95 cm
Calcium carbonate equivalent (0-12.7cm)	0–14%
Electrical conductivity (0-50.8cm)	4–16 mmhos/cm
Sodium adsorption ratio (0-50.8cm)	13–40
Soil reaction (1:1 water) (0-101.6cm)	7.4–9
Subsurface fragment volume ≤3" (0-50.8cm)	0–34%
Subsurface fragment volume >3" (0-50.8cm)	0–34%

Ecological dynamics

The information in this ecological site description, including the state-and-transition model (STM) (Figure 2), 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 Saline Overflow provisional ecological site in MLRA 52 Dry Grassland consists of five states: The Reference State (1), the Altered State (2), the Invaded State (3), the Cropland State (4), and the Post-Cropland State (5). 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).

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. Small mammals such as prairie dogs (*Cynomys* spp.) and ground squirrels (*Uroditellus* spp.) also

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).

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). Generally, the mixed grass ecosystem is resilient to fire and the historic fire-return interval had neutral or slightly positive effects on the plant community (Vermeire et al., 2011, 2014). However, studies have shown that shorter fire-return intervals can have a negative effect, shifting species composition toward warm-season, short-statured grasses (Shay et al., 2001; Smith and McDermid, 2014). Nonnative annual bromes have become naturalized in relatively undisturbed grasslands (Ogle et al., 2003; Harmoney, 2007). They can be present in any state within the scope of this ecological site, but their abundance varies depending on precipitation and germination conditions. They typically are not abundant enough to have a significant ecological impact, but further study is required to assess this.

Hydrology, flooding in particular, is another major ecological driver for this site. Hydrologic alterations, particularly alterations that cause excessive ponding or flooding of the site, may have a significant effect on species composition and production. In some cases, severe salinization may occur. On a large portion of this site the hydrology has been significantly altered by irrigation, major dams, and diversions. The implications of this alteration have not been fully studied and require further investigation.

Improper grazing of this site can result in a reduction in the cover of the mid-statured, cool-season rhizomatous wheatgrasses and an increase in foxtail barley (*Hordeum jubatum*) and unpalatable forbs. 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 can result in a community dominated by foxtail barley. Cover and vigor of mid-statured rhizomatous grasses is severely reduced. Unpalatable forbs such as povertyweed (*Iva axillaris*) are common. An Invaded State (3) occurs when non-native species invade the site. Potential invasive species on this site are curly dock (*Rumex crispus*), knotweed (*Polygonum* spp), and kochia (*Bassia scoparia*). Invasive species dynamics are not well understood at this time and further investigation is needed to fully document ecological pathways and processes.

The Saline Overflow ecological site is poorly suited to cropland. Regardless, many acres have been converted to cropland. Cereal grains such as wheat and barley are, at best, marginally successful on this site. Typically, cropping operations are directed at increasing perennial hay production. Seeding of introduced grasses for hay production may be successful, particularly if salt-tolerant species such as RS or hybrid wheatgrass (*Elymus hoffmannii*) are used. Irrigation is sometimes used in an effort to increase production, but this site is poorly suited to irrigation practices due to accumulated salts and very low intake rates.

When taken out of production, the site is either allowed to revert back to perennial grassland or is seeded with introduced species. Sites left to undergo natural plant succession after cultivation can, over several decades, support cool-season rhizomatous wheatgrasses, although cover and production of these species are lower than in the Reference State (1). Those sites seeded with non-native species, particularly salt-tolerant grasses, may persist with this cover type indefinitely. When reseeded to native species, it may take over 75 years for the soil on productive sites to return to the pre-disturbed state (Dormaar and Willms, 1990). The Saline Overflow ecological site may take longer due to the difficult growing conditions. Further investigation is needed to better evaluate this.

The state-and-transition model (STM) (Figure 2) 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 1: Reference State

The Reference State (1) contains two community phases. This state evolved under the combined influences of climate, grazing, and fire, with climatic variation having the greatest influence on cover and production. In general, this state was resilient to grazing and fire, although these factors could influence species composition in localized areas. Vegetation is characterized by mid-statured cool-season rhizomatous grasses, salt-tolerant deciduous shrubs, and short-statured grasses.

Phase 1.1: Reference Community Phase

The Reference Community Phase (1.1) is typically dominated by rhizomatous wheatgrasses. Western wheatgrass is the principle species, but thickspike wheatgrass (*Elymus lanceolatus*) may be present as well, particularly in the northern extent of this site. Other grass species are rare and may include foxtail barley and Sandberg bluegrass (*Poa secunda*). Common forbs are povertyweed, wooly plantain (*Plantago patagonica*), and scarlet globemallow (*Sphaeralcea coccinea*). The predominant shrub is greasewood, which is present at low cover. Other shrubs that may occur are Gardner's saltbush and silver sagebrush. Total canopy cover of shrubs is approximately 5 percent. The approximate species composition of the reference plant community is as follows:

Percent composition by weight

Rhizomatous Wheatgrass 70%

Other Native Grasses 5%

Native Forbs 10%

Greasewood 5%

Other Native Shrubs/Subshrubs 10%

Estimated Total Annual Production*

Low - 500

Representative Value - 850

High - 1200

* Estimated based on current observation – subject to revision

Phase 1.2: At-Risk Community Phase

In the At-Risk Community Phase (1.2), rhizomatous wheatgrasses are in decline and are in nearly equal proportion to foxtail barley, which increases in this phase. Unpalatable forbs such as povertyweed are also increasing. Greasewood may also increase in this phase.

Community Phase Pathway 1.1a

Drought, improper grazing management, or a combination of these factors can shift the Reference Community Phase (1.1) to the At-Risk Community Phase (1.2). These factors favor a decrease in rhizomatous wheatgrasses and an increase in foxtail barley.

Community Phase Pathway 1.2a

The At-Risk Community Phase (1.2) can return to the Reference Community Phase (1.1) with normal or above-normal spring precipitation and proper grazing management.

Transition T1A

Improper grazing practices, hydrologic alteration, or a combination of these factors weaken the resilience of the Reference State (1) and drive its transition to the Altered State (2). The Reference State (1) transitions to the Altered State (2) when cool-season rhizomatous wheatgrasses become rare and contribute little to production. Foxtail barley and unpalatable forbs such as povertyweed dominate the plant community.

Transition T1B

The Reference State (1) transitions to the Invaded State (3) when invasive plant species invade the Reference State (1). Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced. In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered from the Reference State (1).

Transition T1C

Tillage or application of herbicide followed by seeding of cultivated crops such as wheat, barley, or introduced hay, transitions the Reference State (1) to the Cropland State (4).

State 2: Altered State

The Altered State (2) consists of one community phase. The dynamics of this state are driven by improper grazing management, hydrologic alteration, or a combination of these factors. The site is dominated by foxtail barley while rhizomatous wheatgrasses have been eliminated or nearly so. Unpalatable forbs are common and may account for as much as 50 percent of the total annual production. Proper grazing management or hydrologic restoration can reduce foxtail barley cover and increase the cover of rhizomatous wheatgrasses. This recovery may take decades, especially if soil properties are substantially altered (Dormaar and Willms, 1990).

Phase 2.1: Foxtail Barley/Forb Community Phase

The Foxtail Barley/Forb Community Phase (2.1) occurs when site conditions decline due to long-term drought or when flooding duration increases due to altered hydrology. Rhizomatous wheatgrasses have been eliminated or nearly so. Foxtail barley and unpalatable forbs such as povertyweed are common and may account for as much as 90 percent of the total production. Greasewood may also be common in this phase.

Transition T2A

The Reference State (1) transitions to the Invaded State (3) when invasive plant species invade the Reference State (1). Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced. In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered from the Reference State (1).

Transition T2B

Tillage or application of herbicide followed by seeding of cultivated crops such as wheat, barley, or introduced hay, transitions the Altered State (2) to the Cropland State (4).

Restoration Pathway R2A

Reduction in livestock grazing pressure alone may not be sufficient to restore the Altered State (2) to the Reference State (1) (Dormaar and Willms, 1990). Practices such as range seeding (Hart et al., 1985) or restoration of the natural hydrology may be necessary, but these are management intensive and costly. Therefore, returning the Altered State (2) to the Reference State (1) can require considerable energy and cost and may not be feasible within a reasonable amount of time.

State 3: Invaded State

The Invaded State (3) occurs when invasive plant species invade adjacent native grassland communities. Invasive species dynamics on this site are not well understood. Potential invasive species that have been documented on this site are curly dock, knotweed, and kochia. Noxious weeds such as saltcedar have not been confirmed on this site, but do have the potential to invade. Saltcedar is very aggressive and typically will displace native species and dominate ecological function when it invades a site. Further study is needed to fully assess the ecological dynamics of the Invaded State (3).

Transition T3A

Tillage or application of herbicide followed by seeding of cultivated crops such as wheat, barley, or introduced hay, transitions the Invaded State (3) to the Cropland State (4).

State 4: Cropland State

The Cropland State (4) occurs when land is put into cultivation. This site is poorly suited to cultivation, but many acres are cultivated despite the limitations. The most common crop type on this ecological site is perennial hay. In some cases, the site is planted to non-native perennial species, but in other cases, the native vegetation is retained and harvested for hay or seed. In either case, irrigation is frequently applied to increase production. Flood irrigation is most common although center pivot sprinklers are used in some cases. Occasionally, cereal grains such as wheat and barley are attempted, but this site is poorly suited to such crops and cereal grain production is generally unsuccessful.

Cropping and irrigation projects have vastly altered vegetation, nutrient cycling, and hydrology on much of the

Saline Overflow ecological site. Irrigation, particularly sprinkler irrigation, frequently results in salinization due to the combination of very low intake rates and accumulated salts in the soil. Foxtail barley is common on salinized sites.

Transition T4A

The transition from the Cropland State (4) to the Post-Cropland State (5) occurs with the cessation of cultivation. The site may also be seeded to perennial forage species. Such seedings may be comprised of introduced grasses/legumes or a mix of native species.

State 5: Post-Cropland State

The Post-Cropland State (5) occurs when cultivated cropland is abandoned and allowed to either re-vegetate naturally or is seeded back to perennial species for grazing or wildlife use. This state can transition back to the Cropland State (4) if the site is put back into cultivation.

Phase 5.1: Abandoned Cropland Phase

The Abandoned Cropland Phase (5.1) occurs when cropland is abandoned. In the absence of active management the site can re-vegetate naturally and, over time, potentially return to a perennial grassland community with western wheatgrass. Shortly after cropland is abandoned, annual forbs, biennial forbs, and foxtail barley invade the site. Eventually, these pioneering species are replaced by western wheatgrass. Invasion of the site by exotic species, such as curly dock, will depend upon the site's proximity to a seed source. Fifty or more years after cultivation, these sites may have species composition similar to phases in the Reference State (1). However, soil quality is consistently lower than conditions prior to cultivation (Dormaar and Smoliak, 1985), making a shift to the Reference State (1) is unlikely within a reasonable timeframe.

Phase 5.2: Perennial Grass Phase

The Perennial Grass Phase (5.2) occurs when the site is seeded to perennial forage species. When seeded to introduced species, particularly salt-tolerant perennial grasses such as RS or hybrid wheatgrass, this community phase can persist for several decades. Such seedings may also occur in conjunction with irrigation or water spreading practices. A mixture of native species may also be seeded to provide species composition and structural complexity similar to that of the Reference State (1). However, the site is unlikely to return to pre-cultivation conditions within a reasonable timeframe, particularly if irrigation or water spreading is applied.

Transition 5A

The Post-Cropland State (5) transitions back to the Cropland State (4) when the site is converted to cropland.

State and transition model

**Saline Overflow
R052XY091MT**

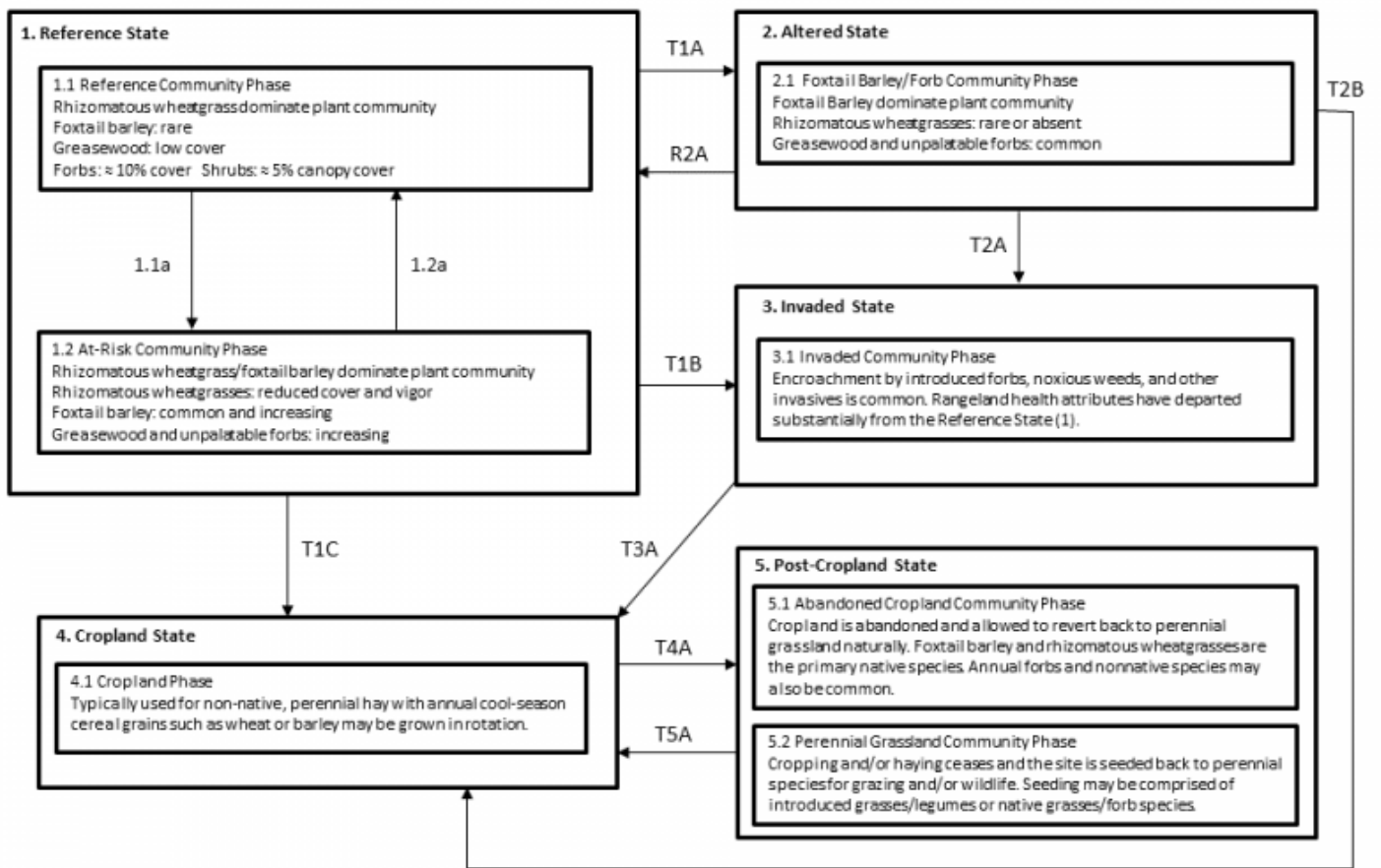


Figure 2. State-and-transition model diagram.

**Saline Overflow
R052XY091MT**

Legend

1.1a - drought, improper grazing management

1.2a - normal or above-normal spring moisture, proper grazing management

T1A - improper grazing, hydrologic alteration, or a combination of these factors

T1B, T2A - introduction of non-native invasive species (introduced forbs and/or noxious weeds)

R2A - range seeding, normal or above-normal moisture, proper grazing management
(management intensive and costly)

T1C, T2B, T3A, T5A - tillage or herbicide application and seeding of non-native hayland or annual crops
(frequently combined with irrigation practices)

T4A - cessation of annual cropping and haying

Figure 2 (continued). State-and-transition model legend.

Inventory data references

Three medium-intensity plots were available for the Saline Overflow ecological site. A plot from a similar phase within the Alkali Flat ecological site was also used for reference. These plots, in combination with professional experience and a review of the scientific literature, were used to approximate the reference plant community. Information for other states and community phases was obtained from a review of the scientific literature and professional experience. All community phases are considered provisional based on these plots and the sources identified in this ecological site description.

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Approval

Kirt Walstad, 12/28/2022

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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	05/07/2024
Approved by	Kirt Walstad
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:
