Ecological site R108XC515IA
Ponded Upland Depression Sedge Meadow

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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.

Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 108X–Illinois and Iowa Deep Loess and Drift

The Illinois and Iowa Deep Loess and Drift, West-Central Part (MLRA 108C) encompasses the eastern portion of the Southern Iowa Drift Plain and the Lake Calvin Basin of the Mississippi Alluvial Plain landforms (Prior 1991). It lies entirely in one state (Iowa), containing approximately 9,805 square miles (Figure 1). The elevation ranges from approximately 1,110 feet above sea level (ASL) on the highest ridges to about 505 feet ASL in the lowest valleys. Local elevation difference is mainly 10 to 20 feet. However, some valley floors can range from 80 to 200 feet, while some upland flats and valley floors only range between 3 and 6 feet. The MLRA is underlain by Pre-Illinoian glacial till, deposited more than 500,000 years ago and since undergone extensive erosion and dissection. In the northern half of the area the till thickness ranges from 150 to 350 feet and grades to less than 150 feet thick in the southern half. The till is covered by a mantle of Peoria Loess on the hillslopes and Holocene alluvium in the drainageways. Paleozoic bedrock, comprised of limestone, shale, and mudstones, lies beneath the glacial material (USDA-NRCS 2006).

The vegetation in the MLRA has undergone drastic changes over time. Spruce forests dominated the landscape 30,000 to 21,500 years ago. As the last glacial maximum peaked 21,500 to 16,000 years ago, they were replaced with open tundras and parklands. The end of the Pleistocene Epoch saw a warming climate that initially prompted the return of spruce forests, but as the warming continued, spruce trees were replaced by deciduous trees (Baker et al. 1990). Not until approximately 9,000 years ago did the vegetation transition to prairies as climatic conditions continued to warm and subsequently dry. Between 4,000 and 3,000 years ago, oak savannas began intermingling within the prairie landscape, while the more wooded and forested areas maintained a foothold in sheltered areas. This prairie-forest transition ecosystem formed the dominant landscapes until the arrival of European settlers (Baker et al. 1992).

Classification relationships

USFS Subregions: Central Dissected Till Plains (251C) Section, Central Dissected Till and Loess Plain (251Cc), Mississippi River and Illinois Alluvial Plains (51Cf), Southeast Iowa Rolling Loess Hills (251Ch) Subsections (Cleland et al. 2007)

U.S. EPA Level IV Ecoregion: Rolling Loess Prairies (47f), Upper Mississippi Alluvial Plain (72d) (USEPA 2013)

National Vegetation Classification – Ecological Systems: North-Central Interior Wet Meadow-Shrub Swamp (CES202.701) (NatureServe 2015)

National Vegetation Classification – Plant Associations: Carex lacustris Wet Meadow (CEGL002256) (Community Phase 1.1); Cornus sericea-Salix (bebbiana, discolor, petiolaris)/Calamagrostis stricta Shrub Swamp (CEGL002187) (Community Phase 1.2) (Nature Serve 2015)

Biophysical Settings: Central Interior and Appalachian Shrub-Herbaceous Wetland Systems (BpS 4314930) (LANDFIRE 2009)

Natural Resources Conservation Service – Iowa Plant Community Species List: Wet Meadow, Lake Sedge (Community Phase 1.1); Shrub Meadow, Dogwood – Mixed Willow (Community Phase1.2) (USDA-NRCS 2007)

Iowa Department of Natural Resources: Prairie Marsh (INAI 1984)

U.S. Army Corps of Engineers: Sedge Meadows (Eggers and Reed 2015)

Ecological site concept

Ponded Upland Depression Sedge Meadows are located within the green areas on the map (Figure 1). They occur in upland depressions on slopes generally less than 2 percent. The soils are Mollisols that are very poorly-drained and deep, formed in loess. The site experiences rare to frequent, brief to long ponding from precipitation, overland flow, and groundwater flow. The native plant community is comprised of hydrophytic herbaceous vegetation.

The historic pre-European settlement vegetation on this ecological site was dominated by herbaceous species adapted to temporarily ponded conditions. Wheat sedge (Carex atherodes Spreng.) and Hayden's sedge (Carex haydenii Dewey) are the dominant species of Ponded Upland Depression Sedge Meadows. Other sedges and grasses that may occur include woolly sedge (Carex pellita Muhl. ex Willd.), broom sedge (Carex scoparia Schkuhr ex Willd.), rigid sedge (Carex tetanica Schkuhr), and bluejoint (Calamagrostis canadensis (Michx.) P. Beauv.). Plant species typical of a natural plant community associated with this ecological site include pickerelweed (Pontederia cordata L.) and eastern marsh fern (Thelypteris palustris Schott) (Drobney et al. 2001; LANDFIRE 2009; Eggers and Reed 2015). Few shrubs may be present in very low densities and can include silky dogwood (Cornus amomum Mill.) and white meadowsweet (Spiraea alba Du Roi). Depth and duration of ponding as well as periodic fire are the primary disturbance factors that maintain this site, while drought is a secondary factor (LANDFIRE 2009; NatureServe 2015).

Associated sites

R108XC516IA	**Wet Loess Upland Flat Prairie** Wet-mesic prairies on broad upland flats that do not experience ponding, including Garwin, Kalona, Mahaska, Muscatine, and Taintor soils
R108XC517IA	**Wet Loess Upland Flat Savanna** Wet-mesic savannas on broad upland flats that do not experience ponding, including Atterberry, Givin, Rubio, and Walford soils

Similar sites

R108XC519IA	**Wet Upland Drainageway Prairie** Wet Upland Drainageway Prairies are similar in landscape position, but site is a SLOPE: topographic, flow-through wetland

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Carex atherodes* (2) *Carex haydenii*

Physiographic features

Ponded Upland Depression Sedge Meadows occur on upland depressions (Figure 2). They are situated on elevations ranging from approximately 600 to 1401 feet ASL. Ponding is rare to frequent and lasts from 2 to less than 30 days. Ponded water depths can be as high as 12 inches.

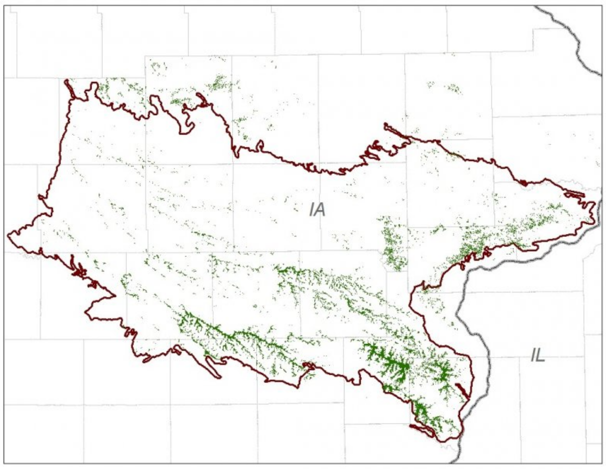


Figure 2. Figure 1. Location of Ponded Upland Depression Sedge Meadow ecological site within MLRA 108C.

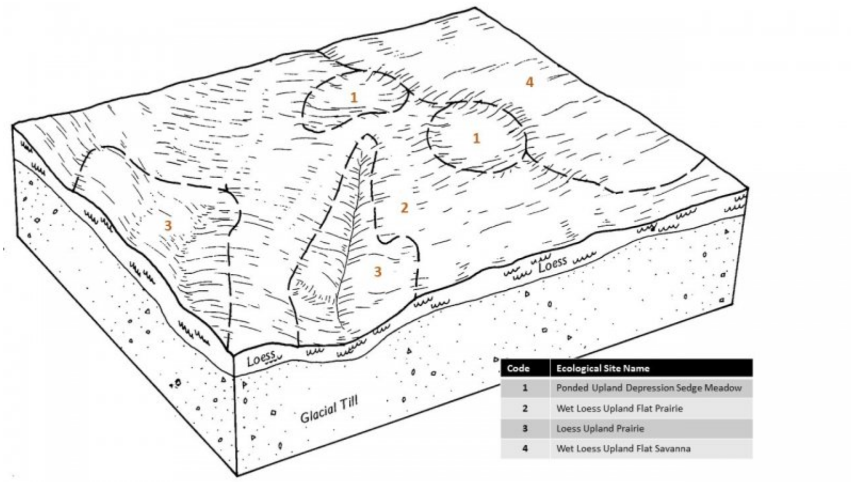


Figure 3. Figure 2. Representative block diagram of Ponded Upland Depression Sedge Meadow and associated ecological sites.

Table 2. Representative physiographic features

Slope shape across	(1) Concave
Slope shape up-down	(1) Concave
Landforms	(1) Upland > Depression
Runoff class	Negligible to low
Ponding duration	Brief (2 to 7 days) to long (7 to 30 days)
Ponding frequency	Rare to frequent
Elevation	183–427 m
Slope	0–2%
Ponding depth	0–30 cm
Aspect	Aspect is not a significant factor

Climatic features

The Illinois and Iowa Deep Loess and Drift, West-Central Part falls into the hot humid continental climate (Dfa) Köppen-Geiger climate classification (Peel et al. 2007). In winter, dry, cold air masses periodically shift south from

Canada. As these air masses collide with humid air, snowfall and rainfall result. In summer, moist, warm air masses from the Gulf of Mexico migrate north, producing significant frontal or convective rains. Occasionally, hot, dry winds originating from the Desert Southwest will stagnate over the region, creating extended droughty periods in the summer from unusually high temperatures. Air masses from the Pacific Ocean can also spread into the region and dominate producing mild, dry weather in the autumn known as Indian Summers (NCDC 2006).

The soil temperature regime of MLRA 108C is classified as mesic, where the mean annual soil temperature is between 46 and 59°F (USDA-NRCS 2006). Temperature and precipitation occur along a north-south gradient, where temperature and precipitation increase the further south one travels. The average freeze-free period of this ecological site is about 187 days, while the frost-free period is about 170 days (Table 2). The majority of the precipitation occurs as rainfall in the form of convective thunderstorms during the growing season. Average annual precipitation is approximately 39 inches, which includes rainfall plus the water equivalent from snowfall (Table 3). The average annual low and high temperatures are 40 and 61°F, respectively.

Climate data and analyses are derived from 30-year averages gathered from five National Oceanic and Atmospheric Administration (NOAA) weather stations contained within the range of this ecological site (Table 4).

Table 3. Representative climatic features

Frost-free period (characteristic range)	139-143 days
Freeze-free period (characteristic range)	167-175 days
Precipitation total (characteristic range)	914-965 mm
Frost-free period (actual range)	138-150 days
Freeze-free period (actual range)	166-180 days
Precipitation total (actual range)	914-965 mm
Frost-free period (average)	142 days
Freeze-free period (average)	172 days
Precipitation total (average)	940 mm

Climate stations used

- (1) WASHINGTON [USC00138688], Washington, IA
- (2) FAIRFIELD [USC00132789], Fairfield, IA
- (3) OSKALOOSA [USC00136327], Oskaloosa, IA
- (4) MT PLEASANT 1 SSW [USC00135796], Mount Pleasant, IA
- (5) NEWTON [USC00135992], Newton, IA

Influencing water features

Ponded Upland Depression Sedge Meadows are classified as a DEPRESSIONAL: Recharge, Ponded, Closed Depression; herbaceous wetland under the Hydrogeomorphic (HGM) classification system (Smith et al. 1995; USDA-NRCS 2008) and as a Palustrine Persistent Emergent Wetland under the National Wetlands Inventory (FGDC 2013). Precipitation, overland flow from adjacent uplands, and groundwater discharge are the main sources of water for this ecological site (Smith et al. 1995). Infiltration is very slow (Hydrologic Group D) for undrained soils, and surface runoff is negligible to low (Figure 5).

Primary wetland hydrology indicators for an intact Ponded Upland Depression Sedge Meadow may include: A1 Surface water, A2 High water table, A3 Saturation, and B7 Inundation visible on aerial photography. Secondary wetland hydrology indicators may include: C2 Dry-season water table, D1 Stunted or stressed plants, D2 Geomorphic position, and D5 FAC-neutral test (USACE 2010).

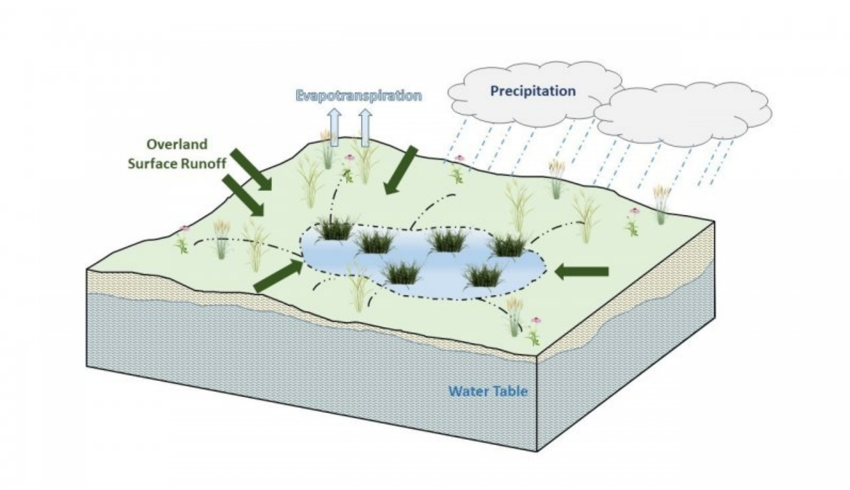


Figure 8. Figure 5. Hydrologic cycling in Ponded Upland Depression Sedge Meadow ecological site.

Soil features

Soils of Ponded Upland Depression Sedge Meadows are in the Mollisols orders, further classified as Typic Argialbolls that are impermeable with negligible to low runoff potential. The soil series associated with this site includes Sperry (Figure 6). The parent material is loess, and the soils are very poorly-drained and deep with seasonal high-water tables. Soil pH classes are strongly acid to slightly alkaline (Table 5). An abrupt textural change is noted as a rooting restriction for the soils of this ecological site.

Sperry soil map units in the MLRA may meet the definition of hydric soils and are listed as meeting criteria 2 and 3 of the hydric soils list (77 FR 12234).

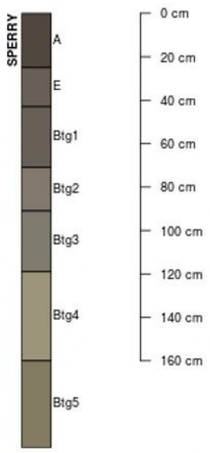


Figure 9. Figure 6. Profile sketch of soil series associated with Ponded Upland Depression Sedge Meadow.

Table 4. Representative soil features

Parent material	(1) Loess
Family particle size	(1) Fine
Drainage class	Very poorly drained
Soil depth	203 cm

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 MLRA lies within the transition zone between the eastern deciduous forests and the tallgrass prairies. The heterogeneous topography of the area results in variable microclimates and fuel matrices that in turn are able to support prairies, savannas, woodlands, and forests. Ponded Upland Depression Sedge Meadows form an aspect of this vegetative continuum. This ecological site occurs on upland depressions on very poorly drained soils. Species characteristic of this ecological site consist of hydrophytic herbaceous vegetation.

Ponding and fire are the most important ecosystem drivers for maintaining this ecological site. The depth and duration of ponding affect species composition, cover, and vegetative production due to alternating aerobic and anaerobic surface substrate conditions. Replacement fires likely occurred on a ten-year rotation interval and helped to reduce the accumulation of peat. The combination of fire and high-water levels prevented the establishment of shrubs for any significant amount of time (LANDFIRE 2009).

Drought has also played a role in shaping this ecological site. The periodic episodes of reduced soil moisture in conjunction with the very poorly-drained soils have favored the proliferation of plant species tolerant of such conditions. Drought can slow the growth of plants and result in dieback of certain species. When coupled with fire, periods of drought can eliminate or greatly reduce the occurrence of woody vegetation, substantially altering the extent of shrubs and trees (Pyne et al. 1996).

Today, Ponded Upland Depression Sedge Meadows have been virtually eliminated as the land has mostly been converted to agricultural production. Corn (*Zea mays* L.) and soybeans (*Glycine max* (L.) Merr.) are the dominant crops grown, but small patches of forage land may be present. A return to the historic plant community is likely not possible due to significant hydrologic and water quality changes in the watershed, but long-term conservation agriculture or habitat reconstruction efforts can help to restore some natural diversity and ecological functioning. The state-and-transition model that follows provides a detailed description of each state, community phase, pathway, and transition. This model is based on available experimental research, field observations, literature reviews, professional consensus, and interpretations.

STATE 1 – REFERENCE STATE

The reference plant community is categorized as a sedge meadow community, dominated by hydrophytic herbaceous vegetation. The two community phases within the reference state are dependent on ponding and fire. The depth and duration of ponding alters species composition, cover, and extent, while regular fire intervals keep woody species from encroaching. Drought has more localized impacts in the reference phases, but does contribute to overall species composition, diversity, cover, and productivity.

Community Phase 1.1 Wheat Sedge – Hayden’s Sedge – Sites in this reference community phase are dominated by sedges with grasses and forbs interspersed. Mature plants typically range between 1.5 and 3 feet tall, and ground cover is continuous (75 to 100 percent). Wheat sedge and Hayden’s sedge are the dominant species. Woolly sedge, broom sedge, rigid sedge, and bluejoint can also occur. Common forbs include knotweeds (*Polygonum sagittatum* L., *Polygonum amphibium* L., Polygonum pensylvanicaum L.), giant goldenrod (*Solidago gigantea* Aiton), marsh hedgenettle (*Stachys palustris* L.), and Virginia mountainmint (Pycnanthemum virginanum (L.) T. Dur. & B.D. Jacks. ex B.L. Rob. & Fernald) (LANDFIRE 2009; NatureServe 2015).

Pathway 1.1A – Reduced fire return intervals and/or periodic drying results in a reduction of the average soil water levels.

Community Phase 1.2 Silky Dogwood – White Meadowsweet/Wheat Sedge – Hayden’s Sedge – This reference community phase can occur when the frequency and depth of ponding are reduced such as from periodic drought. This phase can also occur when fire return intervals decrease. The community assumes more of a shrub-carr assemblage, and shrubs, such as silky dogwood and white meadowsweet, become more prominent in the community encompassing at least 25 percent cover (NatureServe 2015). Sedges and forbs are still present but are likely reduced in areas where shrubs create pockets of shade (LANDFIRE 2009).

Pathway 1.2A – Increased fire return intervals and/or average soil water levels rise.

Transition 1A – Direct and indirect alterations to the landscape hydrology from human-induced land development transition the site to the hydrologically-altered state (2).

Transition 1B – Cultural treatments to enhance forage quality and yield transition the site to the forage state (3).

Transition 1C – Installation of drain tiles, seeding of agricultural crops, and non-selective herbicide transition the site to the cropland state (4).

STATE 2 – HYDROLOGICALLY-ALTERED STATE

Hydrology is the most important determinant of wetlands and wetland processes. Hydrology modifies and determines the physiochemical environment (i.e., sediments, soil chemistry, water chemistry) which in turn directly affects the vegetation, animals, and microbes (Mitsch and Gosselink 2007). Human activities on landscape hydrology have greatly altered Ponded Upland Depression Sedge Meadows. Alterations such as agricultural tile draining and conversion to cropland on adjacent lands have changed the natural hydroperiod, increased the rate of sedimentation, and intensified nutrient pollution (Werner and Zedler 2003; Mitsch and Gosselink 2007).

Community Phase 2.1 Reed Canarygrass – Wheat Sedge – This community phase represents the early changes to the natural wetland hydroperiod, sedimentation, and nutrient runoff. Sedimentation results in a reduction of soil organic matter and high dry bulk density. It also leads to a homogenization of the local microtopography, reducing the surface area and associated species diversity (Green and Galatowitsch 2002; Werner and Zedler 2002). Wheat sedge continues to form a component of the herbaceous layer, but the highly-invasive reed canarygrass (*Phalaris arundinacea* L.) co-dominates.

Pathway 2.1A – Continuing alterations to the natural hydrology and increasing sedimentation.

Community Phase 2.2 Reed Canarygrass – Nodding Beggartick – Sites falling into this community phase have experienced significant sedimentation and are dominated by either a monoculture of reed canarygrass or a combination of reed canarygrass and nodding beggartick (*Bidens cernua* L.). Reed canarygrass stands can significantly alter the physiochemical environment as well as the biotic communities, making the site only suitable to reed canarygrass. These monotypic stands create a positive feedback loop that perpetuates increasing sedimentation, altered hydrology, and dominance by this non-native species, especially in sites affected by nutrient enrichment from agricultural runoff (Vitousek 1995; Bernard and Lauve 1995; Green and Galatowitsch 2002; Werner and Zedler 2002; Kercher et al. 2007; Waggy 2010).

Transition 2A – Cultural treatments to enhance forage quality and yield transition the site to the forage state (3).

Transition 2B – Installation of drain tiles, seeding of agricultural crops, and non-selective herbicide transition the site to the cropland state (4).

Restoration 2A – Hydroperiod restoration, site preparation, non-native species control, and seeding native species transition the site to the reconstructed sedge meadow state (5).

STATE 3 – FORAGE STATE

The forage state arises when the site is converted to a farming system that emphasizes domestic livestock production, known as grassland agriculture. Fire suppression, periodic cultural treatments (e.g., clipping, drainage, soil amendment applications, planting new species and/or cultivars, mechanical harvesting) and grazing by domesticated livestock transition and maintain this state (USDA-NRCS 2003). Early settlers seeded non-native species, such as smooth brome (*Bromus inermis* Leyss.) and Kentucky bluegrass (*Poa pratensis* L.), to help extend the grazing season (Smith 1998). Over time, as lands were continuously harvested or grazed by herds of cattle, these species were able to spread and expand across the landscape, reducing the native species diversity and ecological function.

Community Phase 3.1 Hayfield – Sites in this community phase consist of forage plants that are planted and mechanically harvested. Mechanical harvesting removes much of the aboveground biomass and nutrients that feed the soil microorganisms (Franzluebbers et al. 2000; USDA-NRCS 2003). As a result, soil biology is reduced leading to decreases in nutrient uptake by plants, soil organic matter, and soil aggregation. Frequent biomass removal can also reduce the site's carbon sequestration capacity (Skinner 2008).

Pathway 3.1A – Mechanical harvesting is replaced with domestic livestock utilizing continuous grazing.

Pathway 3.1B – Mechanical harvesting is replaced with domestic livestock utilizing rotational grazing.

Community Phase 3.2 Continuous Pastured Grazing System – This community phase is characterized by continuous grazing where domestic livestock graze a pasture for the entire season. Depending on stocking density, this can result in lower forage quality and productivity, weed invasions, and uneven pasture use. Continuous grazing can also increase the amount of bare ground and erosion and reduce soil organic matter, cation exchange capacity, water-holding capacity, and nutrient availability and retention (Bharati et al. 2002; Leake et al. 2004; Teague et al. 2011). Smooth brome, Kentucky bluegrass, and white clover (*Trifolium repens* L.) are common pasture species used in this phase. Their tolerance to continuous grazing has allowed these species to dominate, sometimes completely excluding the native vegetation.

Pathway 3.2A – Domestic livestock are removed, and mechanical harvesting is implemented.

Pathway 3.2B – Rotational grazing replaces continuous grazing.

Community Phase 3.3 Rest-Rotation Pastured Grazing System – This community phase is characterized by rotational grazing where the pasture has been subdivided into several smaller paddocks. Through the development of a grazing plan, livestock utilize one or a few paddocks, while the remaining area is rested allowing plants to restore vigor and energy reserves, deepen root systems, develop seeds, as well as allow seedling establishment (Undersander et al. 2002; USDA-NRCS 2003). Rest-rotation pastured grazing systems include deferred rotation, rest rotation, high intensity – low frequency, and short duration methods. Vegetation is generally more diverse and can include orchardgrass (*Dactylis glomerata* L.), timothy (Phleum pretense L.), red clover (*Trifolium pratense* L.), and alfalfa (*Medicago sativa* L.). The addition of native prairie species can further bolster plant diversity and, in turn, soil function. This community phase promotes numerous ecosystem benefits including increasing biodiversity, preventing soil erosion, maintaining and enhancing soil quality, sequestering atmospheric carbon, and improving water yield and quality (USDA-NRCS 2003).

Pathway 3.3A – Continuous grazing replaces rotational grazing.

Pathway 3.3B – Domestic livestock are removed, and mechanical harvesting is implemented.

Transition 3A – Land is abandoned and left fallow; natural succession by opportunistic species transition this site the hydrologically-altered state (2).

Transition 3B – Installation of drain tiles, seeding of agricultural crops, and non-selective herbicide transition the site to the cropland state (4).

Restoration 3A – Hydroperiod restoration, site preparation, non-native species control, and seeding native species transition the site to the reconstructed sedge meadow state (5).

STATE 4 – CROPLAND STATE

The cropland state is the dominant land condition throughout the MLRA today. Agricultural tile drains used to lower the water table and the continuous use of tillage, row-crop planting, and chemicals (i.e., herbicides, fertilizers, etc.) have effectively eliminated the reference community and many of its natural ecological functions in favor of crop production. Corn and soybeans are the dominant crops for the site, and oats (Avena L.) and alfalfa (*Medicago sativa* L.) may be rotated periodically. These areas are likely to remain in crop production for the foreseeable future.

Community Phase 4.1 Conventional Tillage Field – Sites in this community phase typically consist of monoculture row-cropping maintained by conventional tillage practices. They are cropped in either continuous corn or corn-soybean rotations. The frequent use of deep tillage, low crop diversity, and bare soil conditions during the nongrowing season negatively impacts soil health. Under these practices, soil aggregation is reduced or destroyed, soil organic matter is reduced, erosion and runoff are increased, and infiltration is decreased, which can ultimately lead to undesirable changes in the hydrology of the watershed (Tomer et al. 2005).

Pathway 4.1A – Tillage operations are greatly reduced, crop rotation occurs on a regular interval, and crop residue remains on the soil surface.

Pathway 4.1B – Tillage operations are greatly reduced or eliminated, crop rotation occurs on a regular interval, crop residue remains on the soil surface, and cover crops are planted following crop harvest.

Community Phase 4.2 Conservation Tillage Field – This community phase is characterized by rotational crop production that utilizes various conservation tillage methods to promote soil health and reduce erosion. Conservation tillage methods include strip-till, ridge-till, vertical-till, or no-till planting systems. Strip-till keeps seedbed preparation to narrow bands less than one-third the width of the row where crop residue and soil consolidation are left undisturbed in-between seedbed areas. Strip-till planting may be completed in the fall and nutrient application either occurs simultaneously or at the time of planting. Ridge-till uses specialized equipment to create ridges in the seedbed and vegetative residue is left on the surface in between the ridges. Weeds are controlled with herbicides and/or cultivation, seedbed ridges are rebuilt during cultivation, and soils are left undisturbed from harvest to planting. Vertical-till systems employ machinery that lightly tills the soil and cuts up crop residue, mixing some of the residue into the top few inches of the soil while leaving a large portion on the surface. No-till management is the most conservative, disturbing soils only at the time of planting and fertilizer application. Compared to conventional tillage systems, conservation tillage methods can improve soil ecosystem function by reducing soil erosion, increasing organic matter and water availability, improving water quality, and reducing soil compaction.

Pathway 4.2A – Intensive tillage is utilized, and monoculture row-cropping is established.

Pathway 4.2B – Cover crops are implemented to minimize soil erosion.

Community Phase 4.3 Conservation Tillage with Cover Crop Field – This community phase applies conservation tillage methods as described above as well as adds cover crop practices. Cover crops typically include nitrogen-fixing species (e.g., legumes), small grains (e.g., rye, wheat, oats), or forage covers (e.g., turnips, radishes, rapeseed). The addition of cover crops not only adds plant diversity but also promotes soil health by reducing soil erosion, limiting nitrogen leaching, suppressing weeds, increasing soil organic matter, and improving the overall soil ecosystem. In the case of small grain cover crops, surface cover and water infiltration are increased, while forage covers can be used to graze livestock or support local wildlife. Of the three community phases for this state, this phase promotes the greatest soil sustainability and improves ecological functioning within a cropland system.

Pathway 4.3A – Cover crop practices are abandoned.

Pathway 4.3B – Intensive tillage is utilized, cover crops practices are abandoned, monoculture row-cropping is established, and crop rotation is reduced or eliminated.

Transition 4A – Agricultural production abandoned and left fallow; natural succession by opportunistic species transition this site to the hydrologically-altered state (2).

Transition 4B – Cultural treatments to enhance forage quality and yield transition the site to the forage state (3).

Restoration 4A – Hydroperiod restoration, site preparation, non-native species control and seeding native species transition this site to the reconstructed sedge meadow state (5).

STATE 5 – RECONSTRUCTED SEDGE MEADOW STATE

Sedge meadow habitats provide multiple ecosystem services including flood abatement, water quality improvement, and biodiversity support. However, many sedge meadow communities have been stressed from watershed-scale changes in hydrology or eliminated as a result of type conversions to agricultural production, thereby significantly reducing these services (Zedler 2003). The extensive alterations of lands adjacent to Ponded Upland Depression

Sedge Meadows may not allow for restoration back to the historic reference condition. However, ecological reconstruction can aim to aid the recovery of degraded, damaged or destroyed functions. A successful reconstruction will have the ability to structurally and functionally sustain itself, demonstrate resilience to the natural ranges of stress and disturbance, and create and maintain positive biotic and abiotic interactions (SER 2002; Mitsch and Jørgensen 2004).

Community Phase 5.1 Early Successional Sedge Meadow – This community phase represents the early community assembly from sedge meadow reconstruction and is highly dependent on seed viability, hydroperiod, soil organic matter content, and site preparation. Successful establishment of sedges can be maximized by using seed collected during the same growing season, utilizing genotypes adapted to the environmental location, ensuring soil moisture is saturated at the time of seeding, and improving the water holding capacity and fertility of the soil (Budelsky and Galatowitsch 1999; van der Valk et al. 1999; Mitsch and Gosselink 2007; Hall and Zedler 2010). In addition, suppression and removal of non-native species is essential for reducing competition (Perry and Galatowitsch 2003).

Pathway 5.1A – Maintenance of proper hydrology and nutrient balances in line with a developed wetland management plant.

Community Phase 5.2 Late Successional Sedge Meadow – Appropriately timed disturbance regimes (e.g., hydroperiod, prescribed fire) and nutrient management applied to the early successional community phase can help increase the species richness, pushing the site into a late successional community phase over time (Mitsch and Gosselink 2007).

Pathway 5.2A – Reconstruction experiences a setback from extreme weather event or improper timing of management actions.

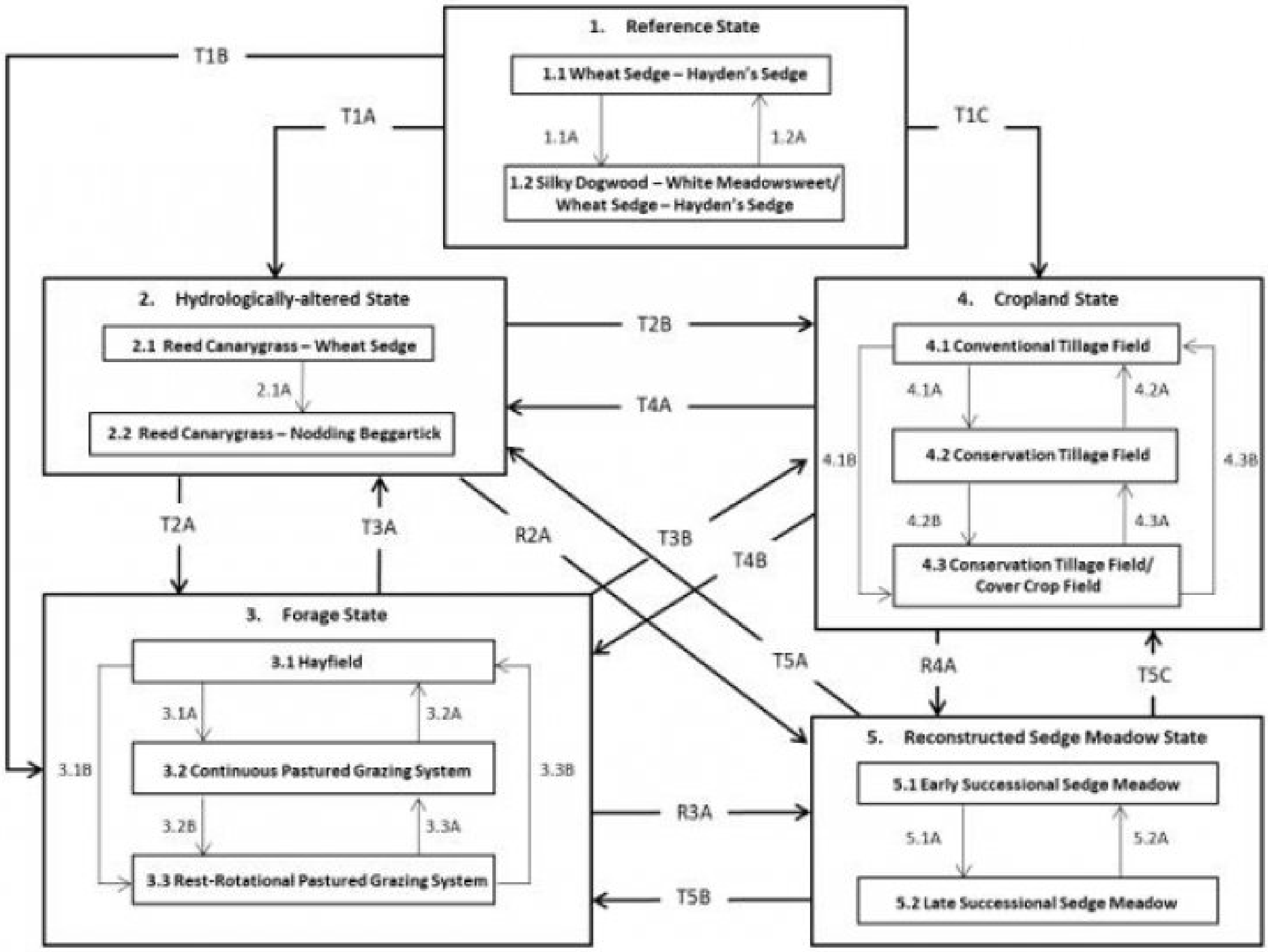
Transition 5A – Land is abandoned and left fallow; natural succession by opportunistic species transition this site the hydrologically-altered state (2).

Transition 5B – Cultural treatments to enhance forage quality and yield transition the site to the forage state (3).

Transition 5C – Installation of drain tiles, seeding of agricultural crops, and non-selective herbicide transition the site to the cropland state (4).

State and transition model

R108CY515IA Ponded Upland Depression Sedge Meadow



Code	Process
T1A, T3A, T4A, T5A	Changes to natural hydroperiod and/or land abandonment
T1B, T2A, T4B, T5B	Cultural treatments are implemented to increase forage quality and yield
T1C, T2B, T3B, T5C	Agricultural conversion via tillage, seeding, and non-selective herbicide
1.1A	Increased fire return interval and/or reduction in average soil water levels
1.2A	Reduced fire return interval and/or average soil water levels increase
2.1A	Increasing changes to hydrology and increasing sedimentation
R2A, R3A, R4A	Site preparation, non-native species control, and native seeding
3.1A	Mechanical harvesting is replaced with domestic livestock and continuous grazing
3.1B	Mechanical harvesting is replaced with domestic livestock and rest-rotational grazing
3.2A, 3.3B	Tillage, forage crop planting, and mechanical harvesting replace grazing
3.2B	Implementation of rest-rotational grazing
3.3A	Implementation of continuous grazing
4.1A	Less tillage, residue management
4.1B	Less tillage, residue management, and implementation of cover cropping
4.2B	Implementation of cover cropping
4.2A, 4.3B	Intensive tillage, remove residue, and reinitiate monoculture row cropping
4.3A	Remove cover cropping
5.1A	Invasive species control and implementation of disturbance regimes
5.2A	Drought or improper timing/use of management actions

Inventory data references

Tier 3 Sampling Plot used to develop the reference state, community phases 1.1 and 1.2:

State County Ownership Legal Description Easting Northing

Iowa Muscatine Shield Prairie – Iowa Department of Natural Resources T77N R2W S7 656760 4593869

Tier 3 Sampling Plot used to develop alternative state, community phase 2.2:

State County Ownership Legal Description Easting Northing
Iowa Muscatine Shield Prairie – Iowa Department of Natural Resources T77N R2W S18 656426 4593679

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Approval

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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:

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17. **Perennial plant reproductive capability:**
