Understanding Western South Dakota Prairie Streams: A Guide to Stream Health, Classification, and Management

South Dakota State University Extension

The Nature Conservancy

USDA United States Department of Agriculture

Natural Resources Conservation Service

Credits, Acknowledgments, and Disclosures

Mni Wiconi: Water is life. This is a phrase that has long been recognized by the Očhéthi Šakówiŋ Oyate (People of the Great Sioux Nation), whose traditional homelands cover all of western South Dakota. We wish to acknowledge and give our special appreciation to the past, present, and future generations of land stewards who have cared for these places since time immemorial, and who continue to work to protect our sacred waters.

This report was written by Kristen Blann, Lori Brown, Corissa Busse, and Christian Lenhart with contributions from Julie Brazell, Nina Hill, and Angela Thomas, all staff members at the Minnesota, North Dakota, and South Dakota Chapter of The Nature Conservancy (TNC). Krista Ehlert from South Dakota State University assisted with writing and editing. Additional editors and reviewers included Mitch Faulkner, Ryan Beer, Emily Helms, Jeremy Maestas, and Timmie Mandish of the Natural Resources Conservation Services (NRCS); Chancey O'Dell from the United States Forest Service (USFS); Chuck Pyle from the United States Fish and Wildlife Service (USFWS); Tim Olson from the South Dakota Department of Game, Fish, and Parks (SDGFP); Dan Rasmussen of the South Dakota Grassland Coalition; and Eric Jennings of the South Dakota Cattlemen's Association.

Over 40 landowners across western South Dakota graciously opened their ranches to allow this crew to survey over 80 stream sites for this publication. Data collection and survey work were done by the authors, with assistance from two TNC Globe interns in 2018, Emma Link and Charlotte Moore, and two volunteers, Nick Gilmartin and Henry McCarthy, from The University of Minnesota and Macalester College, respectively. Nick Gilmartin was supported by an Undergraduate Research Opportunity from the University of Minnesota. Montana Biological Survey was also contracted to survey sites and collect data for this publication. We are enormously appreciative of the many field specialists who helped identify sites for survey, including Rebecca Newton from the Bureau of Land Management (BLM); Mark "Buck" Buchanen, Paul Drayton, Alex Michalek, Bob Novotny, Chancey O'Dell, and Denise Zolnoski from USFS; and Trudy Ecoffey, Mitch Faulkner, Tanse Herrmann, and Lealand Schoon from NRCS.

A photo is worth a thousand words, and stories hold a special power. Our appreciation to Joe Dickie and Generation Photography, Inc., as well as Kurt Lawton, for compiling the landowner stories and photos featured in this guide—including on the cover. Our special thanks to the ranchers and land managers who shared their time, streams, and perspectives for the featured stories of this guide: Robert Boylan, Markus Erk, Pat Guptill, Mimi Hillenbrand, Jilian and Colton Jones, Todd Mortenson, and Al and Simone Wind.

The project was funded by NRCS, through a Collaborative Conservation Grant received in 2017. Mitch Faulkner and Tate Lantz of the NRCS coordinated with TNC to help complete the project.

This document provides information and guidance for landowners and land managers in western South Dakota who are managing small intermittent streams. It is not meant to provide exact engineering or technical plans or procedures to design and install stream restorations. Please consult with your local NRCS and Soil and Water Conservation District staff to determine appropriate restoration and management activities for your land. You may also wish to consult with nonprofits and state agencies that work with ranchers (e.g., American Bird Conservancy, Bird Conservancy of the Rockies, World Wildlife Fund, SDGFP) and federal partners (e.g., BLM, USFWS, USFS).

Finally, just as our streams are constantly changing and adapting, this guide is also a living document. It was produced to help begin a conversation about stream health using the best available science and understandings at the time of its publication. As we continue to learn more about these systems and their resilience, the teachings of this guide may be altered and adapted. Our ultimate goal is for the knowledge provided here to strengthen and restore the natural balance of prairie streams in western South Dakota for all those who depend on them.

Note: Words shown in **bold** are defined in the glossary section.

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Section 1: Introduction

Livestock and wildlife rely heavily on draws and drainages in the Northern Great Plains (NGP) for forage, water, and cover. Large perennial river systems (streams that flow year-round) are few and far between in the grasslands of South Dakota west of the Missouri River—also known as the West River region. In comparison, small stream systems that do not hold water throughout the year are common and occur on most ranches. Because of their prevalence, these small stream systems are incredibly important for the animals and people that make their home on the vast prairie landscape. There are ample resources available to guide managers of larger river systems, but there is little guidance for the management of streams in western South Dakota that do not flow all year round.

This publication describes the **intermittent** (flowing only seasonally/part of the year) and **ephemeral** (flowing only briefly after snowmelt or rain events) streams in the prairie habitats of western South Dakota, provides instructions on assessing **stream type** and condition, and explains management options to help restore or protect streams in a working rangeland. To make the guide user-friendly for landowners or managers who want to improve their riparian corridors (transition areas between drier **uplands** and wet channels), much of the technical information has been separated into appendices that provide additional detail about the data and methods.

The goals of this guide are to: 1) educate readers on why prairie stream and riparian health are important; 2) help readers identify the type of stream in their area and assess its health and functionality; 3) provide recommendations for management according to stream type and condition, with a focus on adaptive management; and 4) inspire readers about the potential to improve stream and riparian health in western South Dakota.

You will also notice a variety of stories scattered throughout the guide from stewards and land managers across western South Dakota. These stories help to illustrate some of the on-the-ground real-life examples of those working to restore, heal, and improve prairie streams in this landscape. These individuals share lessons learned, opportunities, challenges, and thoughts for how we can work together on restoring stream systems one ranch at a time.

Note that this guide is not intended to cover the streams of the Black Hills, an **ecological region** that is surrounded by but not a part of the Great Plains. Black Hills streams are distinct from prairie streams and, in part because of their **groundwater** connections and ability to support cold-water fisheries such as trout, have been extensively studied and described elsewhere.

The Nature Conservancy (TNC) and South Dakota State University (SDSU) Extension created this guide in response to partner interest and using **Natural Resources Conservation Service (NRCS)** Collaborative Conservation Grant funding, specifically to aid land managers in understanding and managing smaller ephemeral and intermittent prairie streams and stream channels of the West River region of South Dakota.

Section 2: Prairie Streams, Riparian Areas, and Why They Matter

> Though prairie streams and riparian areas compose less than 2% of the physical landscape, they are often the most utilized areas, providing critical forage, water, and habitat for livestock and wildlife alike.

The headwater streams and small rivers of western South Dakota's prairies are a critical part of grassland ecosystems and a lifeline for aquatic life, wildlife, and livestock of the NGP—historically and today. These small prairie stream systems and the **riparian areas** they create are among the most critical, heavily used, and declining habitats within the NGP.

Sage grouse and other grassland birds; grazing animals such as deer, elk, and pronghorn antelope; bats; and other wildlife all depend on riparian systems for nourishment and habitat, and as corridors to move through the landscape. Fish, amphibians, and reptiles, as well as other aquatic organisms within the Missouri River headwaters, depend on intermittent flows to sustain their populations. Likewise, riparian areas are vital for the success of working lands, providing livestock with forage, drinking water, protective cover, flood mitigation, and drought resilience.

Figure 1: Prairie streams—even those that do not hold water year-round—are critical resources for livestock and wildlife alike. Photo © Joe Dickie, Generation Photography, Inc.

Despite the importance of these features, we lack comprehensive knowledge and understanding of ephemeral and intermittent prairie-region streams (Dodds et al. 2004). The impacts of grazing on western U.S. stream ecosystems have been well documented, but the specific impacts on stream stability, plant community structure, and water quality vary greatly by region and even from site to site (Platts 1979; BLM 1997; George et al. 2002; Agouridis et al. 2005; Van de Kamp et al. 2013). Many areas are degraded or threatened by a variety of activities that have impaired their function, including overutilization; fire suppression; the elimination of beaver from the landscape; dams, road crossings, irrigation withdrawals and impoundments, and other hydrologic alterations; conversion to row crop agriculture; and oil and gas development (Stagliano et al. 2006). The cumulative result of these activities has changed stream and riparian dynamics, function, and plant communities and has reduced the services they provide as well as their resilience to disturbance.

To address these knowledge gaps, we collected data from small streams in western South Dakota (West River) so that we could assess stream conditions in the region, relate those conditions to past stream management practices, identify reference streams and "best functioning" examples, and provide management recommendations. We assessed over 80 sites and stream reaches (portions of streams) during the summers of 2018 and 2019. This data collection, a literature review, and GIS analyses form the basis for the stream classification system and management framework presented in this guide.

Why riparian areas are important

> Water is life—over 80% of prairie species depend on prairie streams for their survival.

In the western United States, riparian areas make up less than 1% of the land area, yet they are among the most productive and valuable natural resource areas (US EPA 1991). They are very effective at storing water, reducing stream flow energy, improving water quality, trapping sediment, protecting streambanks from erosion, and converting solar energy into energy for the food chain. This is particularly true in western South Dakota, where riparian areas or complexes provide vital corridors for wildlife in the semi-arid prairies. Intermittent and ephemeral streams that carry water for only a part of the year are often some of the only areas supporting water at or near the surface.

Although riparian areas can vary greatly, they have several things in common:

- They are shadier, cooler, and moister than the adjacent uplands.
- They attract a wide variety of animals, including insects, amphibians, reptiles, fish, birds, and mammals. Water is life—and over 80% of prairie species depend on these systems for survival (Kreuper 1993).
- Lastly, riparian areas provide suitable habitat (food, water, and shelter) that may not exist in surrounding, drier areas.

Because riparian areas are at the margin between water and land, their soils are often deposited by or vulnerable to erosion by water. Riparian plants help to protect soil, streambanks, or shoreline areas from excess erosion. Properly functioning riparian areas absorb the water, nutrients, and energy from high-flow (stormwater runoff) events and use these resources to recover from disturbances while improving water quality. The toughness of riparian plants (which have dense, strong root systems, stems that slow floodwaters, and often woody debris that forms pools) adds to riparian stability and habitat diversity.

Some riparian areas—especially those that are not functioning properly or that are in high-energy, high-sediment locations—are very dynamic and disturbance driven. Their plant communities may experience rapid changes in soil and water conditions, such as:

- Flooding or lack of flooding, either temporary or long-term
- Deposition of sediment on streambanks and across floodplains
- Dewatering of a site by water withdrawal for irrigation, construction of drainage ditches, or channel downcutting
- Changes in channel location or elevation

Figure 2: These two headwater streams are both located in Butte County, South Dakota. The photo on the left shows a system lacking in riparian vegetation, unable to slow and hold the force of water it receives. The photo on the right shows a strong riparian community that continues to hold water and green vegetation late into the season. Photos © Corissa Busse, TNC

Why Riparian Areas Matter for Ranch Operations

Healthy riparian areas can:

- Store and hold water on the ranch
- Reduce drought vulnerability
- Filter and cool water supplies—reducing stagnation, salinization, and algae blooms
- Slow down, spread out, and reduce the force of water during floods
- Prevent erosion and stabilize streambanks
- Preserve stream crossings and connect pastures
- Provide a significant portion of a ranch's forage potential on less than 2% of the landscape
- Hold high levels of crude protein, often until the first frost
- Provide valuable winter cover and natural windbreak protection
- Increase wildlife diversity—including grassland birds and large game
- Raise the water table, providing benefits to surrounding uplands

Degraded riparian areas:

- Cannot slow and hold water
- Are vulnerable to drought
- Suffer from erosion, scouring, and loss of soil during high flows
- Become difficult or impossible for livestock and land managers to cross due to channel erosion
- Separate access to pastures and forage
- Lower the water table—decreasing forage, tree cover, and resilience
- Are used less by wildlife

Future challenges and the importance of resilience

> It is ***critical*** to understand prairie streams and processes so that we can manage them effectively to benefit people and nature, while maintaining their natural services.

As changes in climate and land use affect the landscape, it is important to manage streams and their riparian corridors more carefully. South Dakota's West River region experienced very high amounts of rainfall in 2018 and 2019, with record stream flow levels and flooding. In comparison, 2021 was one of the driest year on record for portions of the Dakotas. Future decades will continue to bring uncertainty, with extreme flooding events mixed with extreme drought and reduced water availability. There is also increased pressure to convert pasture and grassland to crops, particularly in the eastern part of the region. At the same time, it has become increasingly challenging for working ranches to remain economically sustainable in the face of unstable markets, input costs and increased land prices. Invasive species and plant disease add additional challenges to maintaining healthy grasslands and **riparian complexes**.

These challenges mean that there is a greater need to manage for resilience in the western South Dakota landscape. **Resilience** is the capacity of a system to recover after stress or disturbance. Resilient stream systems are those that will support a full spectrum of biodiversity and maintain their functional integrity even as conditions change in response to climate change. Resilience is important not only ecologically, but also socially and economically. This guide will not explore social and economic aspects of ranching but does note that healthy stream–riparian systems can improve the forage and water capacity of ranchlands, which ultimately results in social and economic benefits. Livestock and wildlife depend on the success of healthy rangelands—and these systems depend on the success of those who steward them. The resilience of stream–riparian complexes is especially critical for the future of wildlife and ranching, as both wild animals and livestock use riparian corridors very heavily.

How a stream recovers and withstands changes in the environment is directly related to how connected it is to the landscape. As streams erode, they lose their connection to the adjacent land, including the floodplain, as well as up- and downstream sections. Floodplains have a critical role in stream health and resilience, whether they are broad and flat or limited by steep stream valley slopes. When streams can spill out onto the floodplain, floodwaters can spread out, slow down, and soak back into the ground. Streamside plants, shrubs, and trees also help slow down the water. In severely eroded streams, the floodwaters' energy is concentrated in the channel, scouring the channel sides and bottom. Floodplains, riparian areas, and connectivity will be discussed in greater detail throughout the guide.

As water flows, it forms a network that ultimately connect all lands together. When water lands on one ranch, it will flow to another and another through stream systems. We will discuss the importance of watersheds in this guide as a way of thinking about how all lands and ranches are connected and feed into each other's successes or challenges. As the vast majority of land West River is privately owned, implementing good grazing practices in riparian areas and their connected uplands will be up to private landowners. Management of these systems is vital for the future viability of these areas. Complete restoration of our stream systems simply may not be possible in many situations. However, focusing on system resilience and connectivity is a very achievable management goal and will help to produce ecosystem benefits.

Nature Guides Ranch to Grow Grass and Profit

> *"A ranch journey from cactus to cattails teaches the value of healthy soil and streams."*

The Mortenson Ranch is legendary as a story of restorative ranch management. Its history is steeped in early soil and water conservation principles and riparian rebuilding, as well as more holistic rangeland healing practices that keep nature in balance.

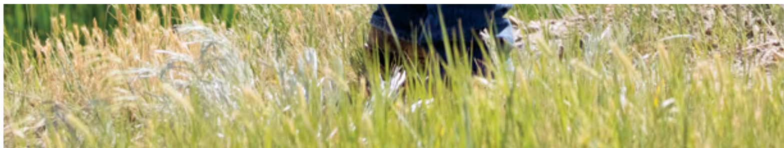
Todd Mortenson and his brother Curt are third-generation caretakers of the rangeland that their father Clarence began rebuilding many decades ago. Clarence's vision and management goal was that every drop of water that fell on the ranch should stay on the ranch to support plant and animal growth and human needs. His efforts were detailed in the 2015 book from the SDSU Extension, *The Mortenson Ranch Story: Balancing Environment and Economics*.

Not only have the Mortensons helped nature rehabilitate the landscape, they have also improved grassland production capacity and boosted the ranch's economic resilience. "With our rotational grazing strategy, we're growing more grass on the same acreage, which makes a huge difference," Mortenson says. "A lot of West River ranches graze 30 acres per animal unit, but we're able to graze in the 15- to 20-acre per animal range by harvesting the right amount of grass, then giving it a long rest and recovery time."

Repairing the riparian areas

In the late 1940s, the ranch featured two streams (Todd's Draw and Foster Creek) with steep banks, deep erosion, and gullies washed down to bare shale. "Dad knew this impaired creek view probably wasn't normal, since there were noticeable Indian campsite along the creeks," Mortenson says. Years ago, "there were probably fruit and shade trees along with running water. So, he brought in a bulldozer to create a series of nine or 10 small check dams on Todd's Draw to slow the water down and begin to repair what looked like a desert."

Todd Mortenson, rancher
Stanley County, SD



As water was slowed and diverted into underground gravel beds, Todd's Draw began to heal. By the 1970s, the small dams proved successful. Time, water, and silt accumulation allowed nature to grow trees and shrubs to cover the banks. Cattails and prairie cordgrass grew in the wetland riparian areas and creek bottoms. "Even though we planted a lot of trees, our success rate isn't near as good as Mother Nature, as she created an explosion of trees behind those dams," Mortenson says.

With Todd's Draw on the mend, the Mortensons applied their lessons learned to Foster Creek, adding dams to slow the water on that creek in the 1980s. "It is still healing and showing amazing recovery. Now when we get a big rain, it spreads out over the entire floodplain of Foster Creek, going across the grass instead of mud. And we're even growing native grasses in hardpan clay that never grew anything," he says.

The importance of upland grazing

Mortenson notes that grazing management has been a big part of the comeback success of their creeks. "It wasn't until the mid-1980s, when I took some holistic grazing management courses, that we really dug into what it takes to grow more grass in both the riparian and upland areas," Mortenson says. "And if you don't slow the water down on the uplands, your streams don't have a chance."

This holistic mindset change to a rotational grazing system that builds a healthier plant community—from grasses, forbs, and legumes to bushes and trees—helps the entire ranch ecosystem. "Moving from season-long grazing to now moving cattle every week or every several days has made the biggest difference across the ranch," he says. "We use different pastures in different seasons with different numbers of cattle. Then we move them when they've made the proper impact on the land."

Monitoring riparian areas

Being patient and constantly monitoring grazing can make a significant impact on riparian areas. "We don't fence off our creeks, as cattle can have a positive healing impact on streambeds and banks, as long as they are moved before damage occurs, as cattle like to camp in riparian areas during summer. In winter, these healthy areas provide good beds and shelter for the cattle during storms."

Proper grazing and healthier soils help percolate more water into the ground. Todd's Draw now has so many springs feeding into it that it's almost running full-time. "It'll dry up a little bit in summer when the trees and grasses are pulling more water but start flowing again in the fall."

Mortenson says it's exciting to see beavers coming back in the spring to build dams, but they're not quite permanent residents during the dry periods. "Before they were trapped out of existence, they were a major part of stream health in western South Dakota. We look forward to their full-time return as nature continues to rebuild a complete ecosystem."

Abundant wildlife

When he was growing up on the ranch, Mortenson says that wildlife was scarce. The healthier streams and pastures have created a perfect habitat for many birds, deer, coyotes, bobcats, and turkeys. "We have every form of wildlife as regulars around here, thanks to our holistic management. Grouse, pheasants, even prairie chickens with their deep booming nightly sounds are so cool to hear," he adds.

Mortenson sees a bright future for the ranch and appreciates the research, guidance, and documentation of their efforts provided by South Dakota State University's College of Agriculture and Biological Sciences. The Mortenson family also received the Leopold Conservation Award in 2011 to recognize their voluntary stewardship and management of their natural resources.

"I feel that after all the efforts we've put in place by working with nature, I'm just along for the ride as Mother Nature helps us continue to pass on the ranch to future generations," Mortenson states. "It's gratifying to watch the transition take place over time, and even more rewarding to know that my sons' similar beliefs give me great confidence in our future."

Figure 1. Todd Mortenson.

Figure 2. In the late 1940s, Clarence Mortenson installed a series of small check dams in Todd's draw to help slow and hold water, mimicking what beaver would have done. At the time, very few trees dotted this landscape which was very eroded.

Figure 3. With holistic management practices, Todd's draw is now lush with trees and vegetation.

Figure 4. Todd's draw is now filled with trees of diverse ages in the marshy bottoms.

Figure 5. With the success of Todd's draw, the Mortensons have been working to also restore Foster Creek shown here. Foster Creek was deeply incised, but with a focus on winter grazing and hot season rest, the stream has expanded its riparian belt and begun to close in and reconnect across its valley bottom.

Section 3: Landscape and Watershed Setting of the Northern Great Plains of Western South Dakota

To begin thinking about prairie streams, it is important to first understand the basics of the landscape setting in which they are found. This section introduces the regional features that make western South Dakota prairie streams unique. It also describes how streams and lands are connected through watersheds.

Understanding the Landscape Setting of Western South Dakota Prairie Streams

Except for the Black Hills region, South Dakota falls entirely within the Great Plains, a landscape that stretches from coastal Texas to southern British Columbia and Alberta. The state is bisected by the Missouri River, which also separates the temperate tallgrass prairie of eastern South Dakota—including the Prairie Pothole Region—from the semi-arid prairies of the NGP region. The NGP region extends into the eastern two-thirds of Montana, northeastern Wyoming, northern Nebraska, and southern Alberta and Saskatchewan, as shown in Figure 3.

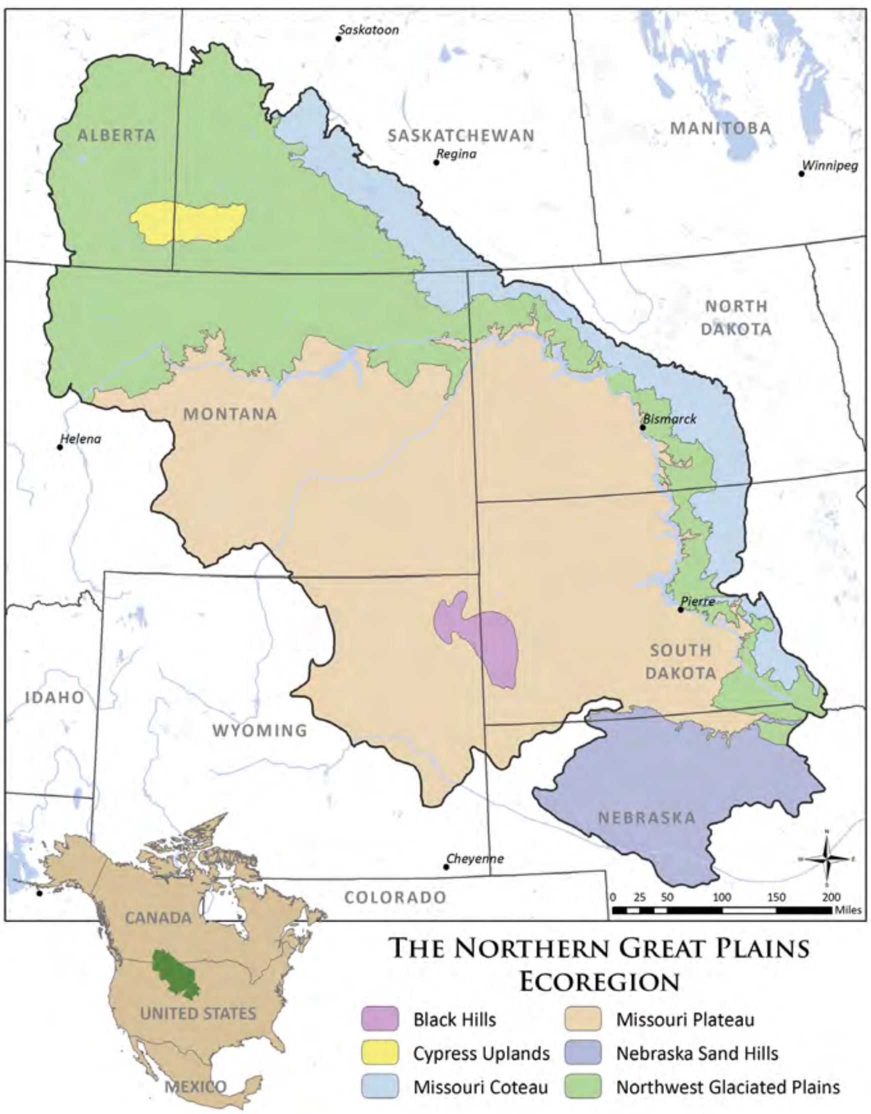


Figure 3: The Northern Great Plains region has a dry climate and is dominated by open prairie landscapes. All areas of western South Dakota outside the Black Hills are a part of the Northern Great Plains ecoregion. Map © World Wildlife Fund

Unlike eastern South Dakota, which is primarily a young landscape formed during the recent glacial period of the Pleistocene, western South Dakota is an ancient landscape set in the marine sediments of the Mesozoic and Cenozoic Eras (formed hundreds to tens of million years ago). It is dominated by erosive processes (Schumm 1956). Today's western South Dakota prairie streams flow in the networks of drainage channels formed by water moving across and cutting down through this landscape over millions of years.

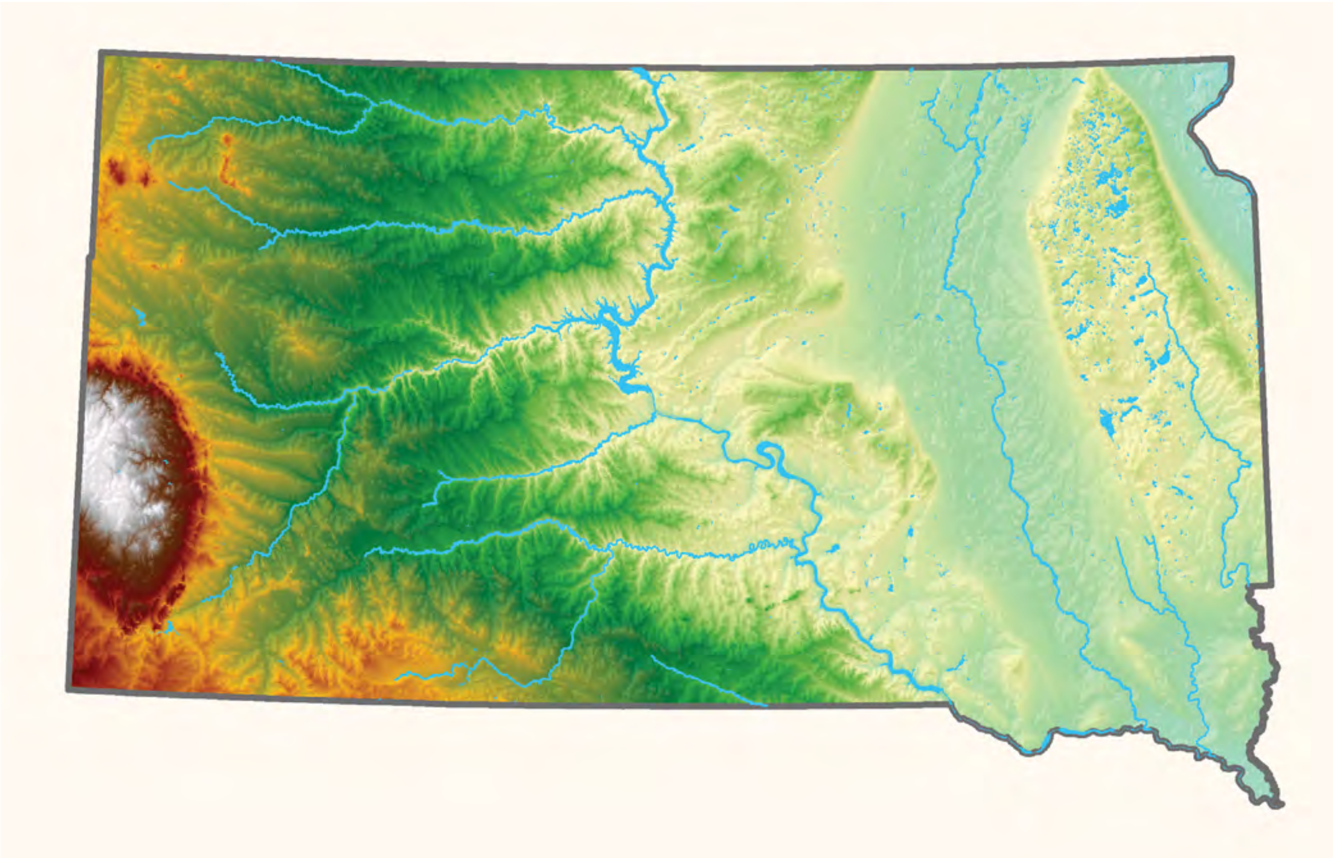


Figure 4: This shaded relief map demonstrates the strong geographic difference between East River and West River South Dakota—and the resulting difference in water formations. Eastern South Dakota was more recently glaciated, resulting in smoother topography and a complex of prairie pothole features left behind. In comparison, western South Dakota has a rugged topography of drainages and channels that formed over millions of years of erosion. As a result, western South Dakota's dominant water features are a matrix of prairie streams acting like a network of veins across the region—all flowing to the main artery of the Missouri River. Map © Dale Watt, TNC

The NGP region is dominated by mixed grass prairie, a rolling topography, and thinner, older shale soils than the glacial tills that support the tallgrass prairie to the east. These older sediments are mostly composed of fine-textured clays and silt that are easily eroded by flowing water, so streams in West River are prone to rapid **downcutting** and **incision** when land cover or climate changes cause flows to increase. This erosion can generate steep embankments along the stream as water removes materials from the stream bed. Much of this sediment is carried downstream by larger rivers and deposited in floodplains of the Missouri River tributaries—such as the White, Bad, and Belle Fourche Rivers—and deposited in the reservoirs and bays of the Missouri River. This historic erosion and downstream depositing are responsible for the creation of landscape features such as the Louisiana delta where the Mississippi River meets the Gulf of Mexico—a long journey for soils from the headwaters in South Dakota. This natural erosion occurred over millions of years.

In recent centuries, however, erosion has significantly accelerated in many prairie streams, due to increased disturbance. This has resulted in the loss of valuable soils from rangelands across the West. This dramatic movement of soils and sediments has filled in extremely large reservoirs along the Missouri River in only a few decades. As shown in Figure 5, this sediment loss is a testament to the importance of every small drainage and tributary scattered across the landscape and the cumulative impacts they can have.

Figure 5: This image shows the enormous amount of sediment loss from the western South Dakota landscape that has now filled in the Lake Oahe Reservoir. The reservoir was completed in 1962, and for years recreationalists enjoyed boating and water skiing through the area photographed. Today, less than 60 years after the dam was created, the reservoir has filled with sediment from upstream rangelands. This sediment trapped now measures 30–50 feet deep and stretches for miles. Photo: Joe Dickie, Generation Photography, Inc.

Climate

South Dakota lies in a semi-arid part of the Great Plains. Here, the 100th meridian closely follows the Missouri River and cuts the state into the nearly equal portions of eastern and western South Dakota. The 100th meridian is the boundary between the humid eastern United States and the arid western plains. This longitude was first identified as the boundary between these two regions by the geologist and explorer John Wesley Powell in the 1800s. East of the 100th meridian, precipitation exceeds potential **evapotranspiration (ET)**, so rainfall does not typically limit plant growth. These sub-humid and humid climate zones are typically highly vegetated. In contrast, west of the 100th meridian, **potential evapotranspiration** exceeds annual precipitation. As a result, rainfall can limit plant growth across West River South Dakota. Annual average precipitation ranges from 12 to 20 inches per year in western South Dakota, making this a semi-arid climate (see Figures 6 and 7).

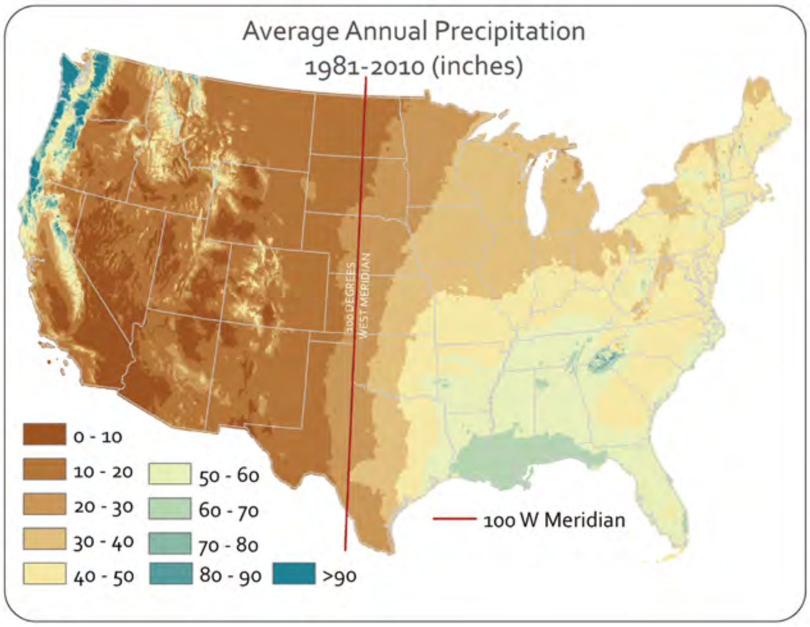


Figure 6: Average annual precipitation in the United States. Map © Dale Watt, TNC

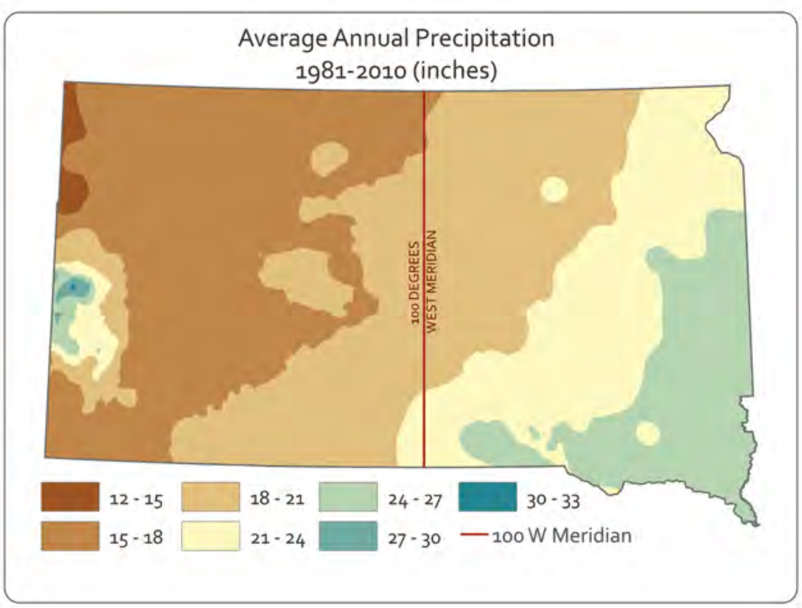


Figure 7: Most of western South Dakota receives 15–21 inches of rainfall per year. Map © Dale Watt, TNC

Significant differences in precipitation between the eastern and western United States have led to major differences in their riparian areas. In the humid climate of the eastern United States, it is sometimes difficult to define the boundaries between riparian areas and terrestrial uplands. In contrast, in the semi-arid landscapes of the West, the transition between riparian and upland systems is easily recognized, as shown in Figure 8. Riparian areas in the arid western United States have unique plant communities and are typically more lush and green than the adjacent, drier uplands. Riparian areas following the stream may appear like a green ribbon of vegetation on the landscape. This is especially noticeable as summer dries out the surrounding upland plant communities, while riparian areas continue to hold moisture.

Figure 8: Riparian areas along streams form a green line or "ribbon" of lush vegetation on the prairie, especially as summer heat dries out the surrounding uplands. Photo © Joe Dickie, Generation Photography, Inc.

In the eastern United States, more water infiltrates the soil, resulting in more subsurface flow reaching streams and more soil moisture. In contrast, in the western United States, there is usually less groundwater feeding streams. Due to this water deficit, most streams in the western region are intermittent or ephemeral rather than **perennial**. About 90% of South Dakota's nearly 100,000 stream miles are considered intermittent or ephemeral, according to the South Dakota Department of Environment and Natural Resources (SDDENR 2018), and the percentage is even higher in western South Dakota, excluding the Black Hills.

Evapotranspiration is the process by which water goes back into the air, either through evaporation or transpiration. Evaporation is water drying from a surface as it returns to the air in vapor form. Transpiration is the water vapor that plants release from their leaves as they transpire or "breathe."

Potential evapotranspiration is simply the amount of evaporation that would occur if sufficient water were available.

Major Land Resource Areas of western South Dakota

The USDA NRCS uses a classification system called **Major Land Resource Areas** (MLRAs) to identify geographically associated areas with similar land use, elevation, topography, climate, water resources, potential natural vegetation, and soils. Each MLRA has unique strengths and challenges for land stewardship. MLRAs are intended to support land and water resource planning and management, primarily at the statewide scale. More information about this can be found in the NRCS Field Office Technical Guide (USDA NRCS).

The mixed and shortgrass prairie of western South Dakota primarily overlaps with eight MLRAs, as shown in Figure 9:

- MLRA 63A: The Northern Rolling Pierre Shale Plains encompassing the lower Cheyenne River drainage west of the Missouri
- MLRA 63B: The Southern Rolling Pierre Shale Plains encompassing the lower Bad River drainage west of the

Missouri

- MLRA 66: The Dakota-Nebraska Eroded Tableland along the Nebraska border
- MLRA 65: The Nebraska Sand Hills
- MLRA 64: The Mixed Sandy and Silty Tablelands of the White River, Pine Ridge, and Badlands
- MLRA 54: The Rolling Soft Shale Plain of north–central South Dakota and North Dakota
- MLRA 60A: The Pierre Shale Plains and Badlands encircling the Black Hills and Foothills
- MLRA 58D: The Northern Rolling High Plains of northwest South Dakota, including most of Harding County and the northern portion of Butte County

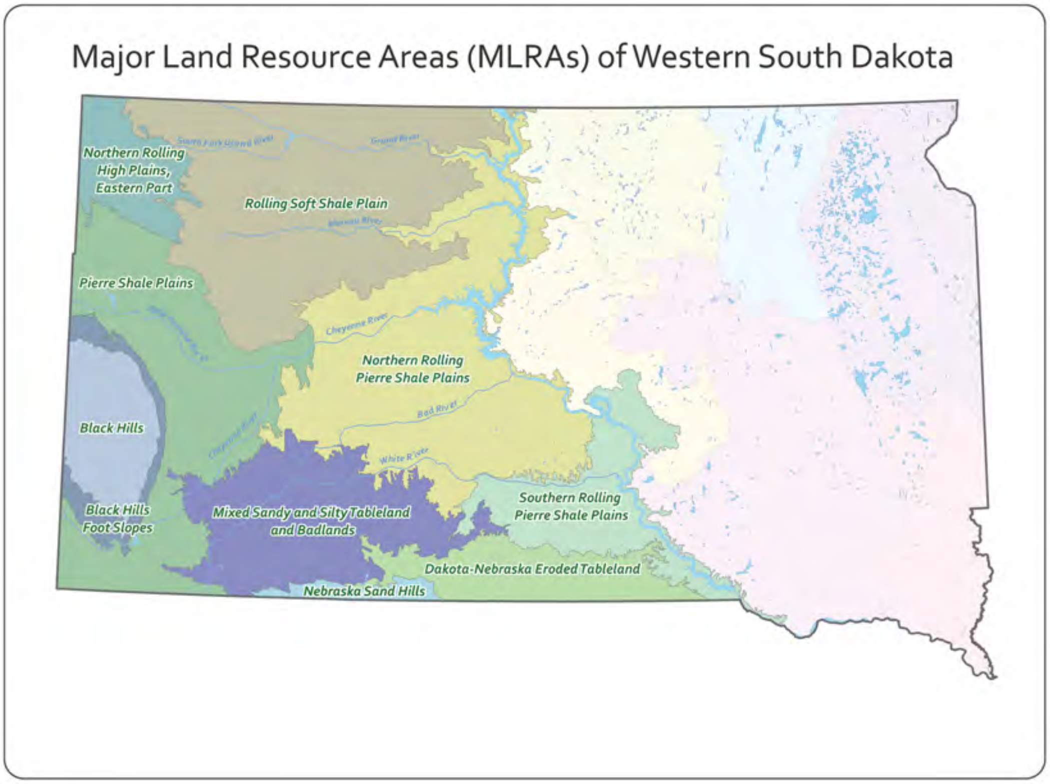


Figure 9: This map shows the Major Land Resource Areas (MLRAs) of western South Dakota. Each of these MLRAs has similar characteristics that affect land and stream management. Map © Dale Watt, TNC

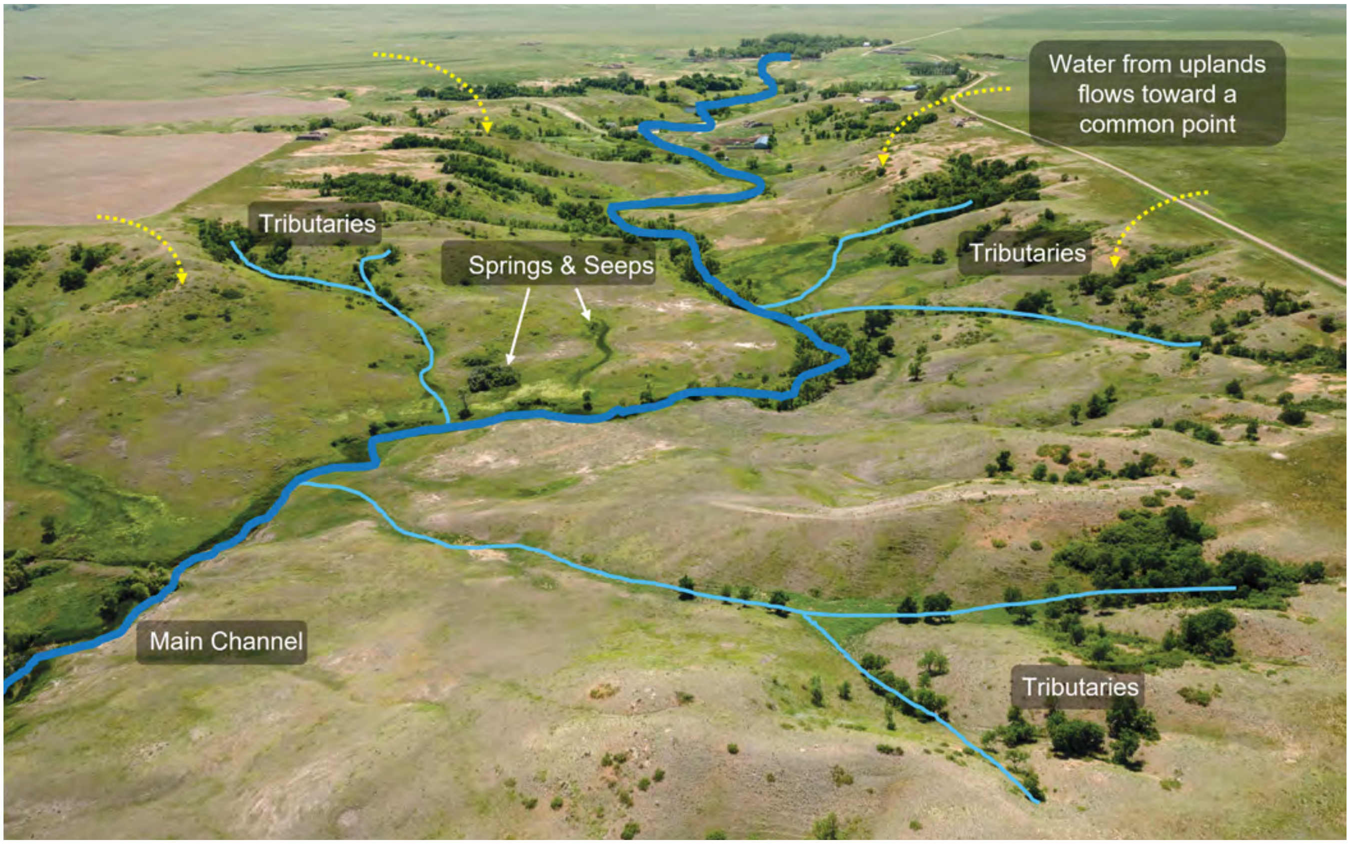


Figure 10: A watershed is an area of land that drains all the streams and rainfall to a common outlet such as a reservoir, or any point along a stream's main channel. Watersheds can be small, such as in the picture here, or large, such as the entire Missouri River Basin. Photo © Joe Dickie, Generation Photography, Inc.

What Is a Watershed and Why Does It Matter?

A **watershed**, or **catchment**, is an area of land where all surface water converges (or drains) to a common point (see Figure 10). In a landscape or a stream network, the watershed consists of all the land upstream that drains to that point. Whatever happens above you in your watershed will influence your section of stream health—and whatever you do will influence stream health in watersheds that are downstream from you. All lands ultimately drain into others and influence each other at different scales. Understanding and knowing your watershed can help you identify potential challenges and opportunities you may encounter.

River basins and watersheds of western South Dakota

The prairie streams of western South Dakota can also be divided based on the major river systems or watersheds (see Figure 11) to which they are tributaries, all of which eventually flow to the Missouri River:

- The Little Missouri River, which flows northeast out of Montana into North Dakota and across the northwestern corner of South Dakota
- The Grand and Moreau Rivers, which flow directly east to the Missouri from the northwestern quarter of South Dakota
- The Cheyenne River, which flows east around the southern end of the Black Hills, picking up the Belle Fourche River from the north side east of Rapid City, and becomes the Lake Oahe reservoir in its lower reaches as it joins the Missouri River
- The Bad River, which joins the Missouri below Pierre, South Dakota
- The White River, which flows east to the Missouri across southern South Dakota, including the **badlands** (a region of sparse vegetation)

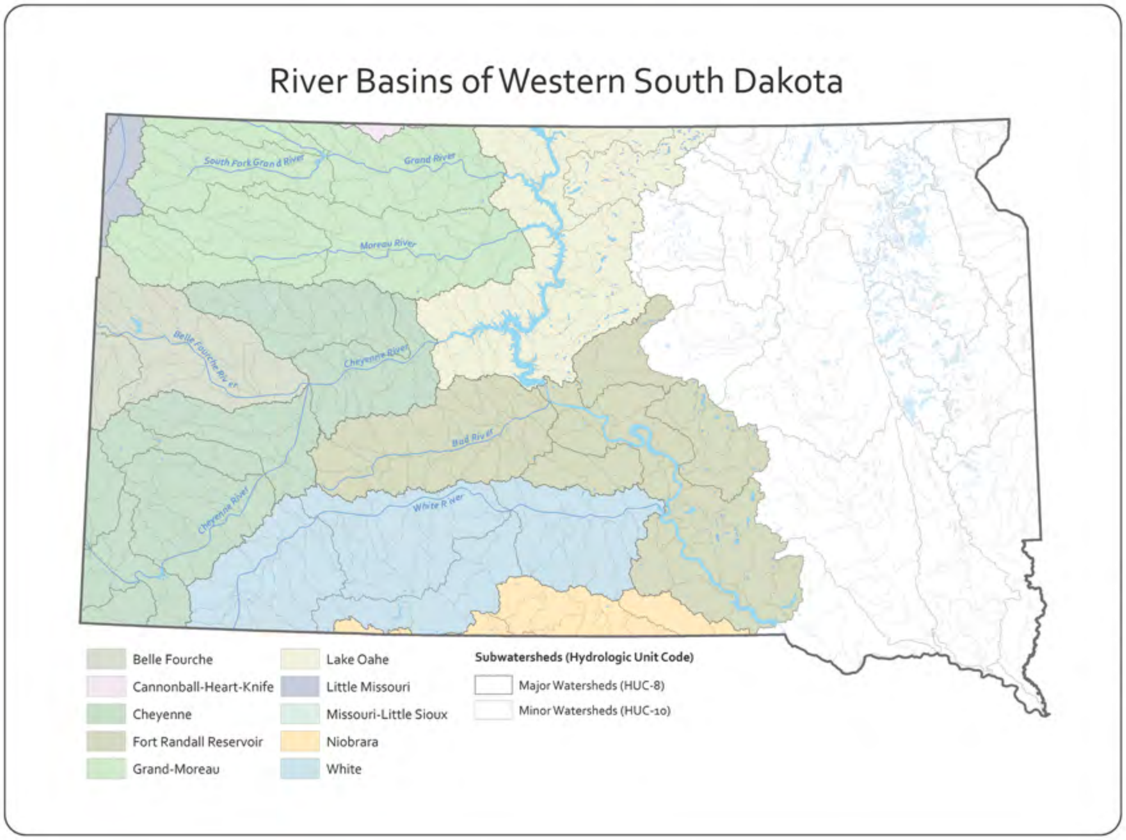


Figure 11: This map shows the major watersheds and river basins of western South Dakota. This map also illustrates the way in which watersheds are nested with smaller sub-watersheds, forming larger major watersheds. Map © Dale Watt, TNC

Each watershed in western South Dakota is influenced by the soils, topography, vegetation, and other factors of the MLRAs through which its waters flow. The following information gives a few examples of how several dominant MLRAs of western South Dakota influence major river systems and headwaters of these landscapes.

The Northern Rolling High Plains of Montana and South Dakota include portions of the Little Missouri, Grand, and Moreau River headwaters on the dry western edge of South Dakota, where rainfall rarely exceeds 14 inches per year. Shortgrass prairie and gray sagebrush are interrupted by eroded buttes, badlands, and salt pans. Rocky Mountain juniper grows on the hillslopes, while cottonwood and green ash often line the riparian areas, particularly in the lower reaches.

As the Grand and Moreau rivers continue their flow downstream, they enter the Rolling Soft Shale Plain, which dominates most of the middle and lower watersheds of these rivers. This MLRA includes the relatively productive agricultural soils of the Missouri Plateau and the more alkaline soils of the Moreau Prairie.

The Cheyenne River originates in the **spring**-fed streams and drainage of the Black Hills and Foothills. This region includes the Belle Fourche River—at one time known as the North Fork of the Cheyenne—which flows around the north side of the Black Hills, where it serves as a significant source of water for irrigation and joins the Cheyenne River east of Rapid City.

The **River Breaks** are **landforms** of broken terraces and uplands that descend to the Missouri River and its major tributaries across all the lower West River tributaries, across the soft, easily erodible strata of the shales of these MLRAs. The dissected topography, wooded draws, and non-farmed areas of these landforms are especially important as wildlife corridors. Ephemeral, flashy streamflow creates steep, downcut channels in the erodible soft silts and clays along the tributaries. Riparian gallery forests of cottonwood and green ash line major tributaries such as the Moreau and Cheyenne Rivers, but have largely been eliminated along the Missouri River by impoundments (water reservoirs created by dams).

The White River begins partly in southwest South Dakota, along the border with Nebraska, in the Pierre Shale Plains and Badlands. It also has southern tributaries that flow north out of the Tablelands and White River Badlands, which are highly erodible landscapes. Barren areas are interrupted by grass-covered, perched sod tables that support grazing and may be farmed. Channels range from entrenched gullies in areas that are downcutting to meadow plateaus where eroded sediments have accumulated and aggraded (built up into a landform).

Every river system will look and act differently based on the various aspects of the MLRA that they flow through, as described in these examples. A comparison of the MLRA map in Figure 9 with the watershed and river basin map in Figure 11 can highlight how the two are related and influence each other.

Using Hydrologic Unit Codes to identify river basins and watersheds

The **Hydrologic Unit Code (HUC)** is a watershed naming system developed by the U.S Geological Survey (USGS) that reflects the nested nature of watersheds and can be used to identify specific areas by their watershed, somewhat similar to a postal code. The largest river basins are identified by the first two to four digits of the HUC number. For example, all Missouri River Basin HUCs start with the first two digits '10.' The Missouri River Basin is a large watershed covering ~529,400 square miles (or more than 338 millon acres) in portions of 11 western states. The Cheyenne River Basin is a smaller watershed nested within the Missouri River Basin that covers approximately 1 million acres and portions of four states. All watersheds within the Cheyenne River Basin start with the HUC '1012.' This borrows the '10' from its parent, the Missouri River Basin, and adds the two new digits '12' for its own identification. Each time a watershed is broken down into smaller chunks, it passes on its own parent code to these smaller nested watersheds. Each nested watershed HUC begins with the parent code and then adds its own unique two digits to the end. As a result, the smallest watershed units have the most digits, because many of them join together to create a larger drainage area. A common unit for watershed planning is the 12-digit HUC, which typically has a drainage area ranging from about 10,000 to 25,000 acres.

Rancher Sees Beavers as Vital to Creek Health

> *To slow creek water coming from cropland not on your ranch, just add beaver habitat.*

In hindsight, Pat Guptill wishes his beaver-trapping youth had not been so successful. “The felt and beaver hat business was a big thing that changed the environment in the western U.S. more than anything. Taking the beaver out changed streamflow leading to faster water, gully erosion and loss of plant biodiversity,” the rancher explains. While Guptill didn’t hunt beavers for hats, he did trap them because of a common impression that beavers were a nuisance. Now he wants them back, this time as allies for ranch improvement.

This beaver-trapper-turned-conservationist has spent his 34-year career creating healthier soil and grass to improve profits and cope with years of drought on his cow–calf ranching operation.

“My wife Mary Lou’s father started initial conservation efforts on the ranch. Then we took it to another level to grow our soil organic matter profile, beginning in the late 1980s,” Guptill says. “We needed to get water flowing into the ground, not running off the top and creating erosion.”

Finding Spring-Fed Water

When he took over the ranch in 1987, neighbors told Guptill that finding a spring would be a big deal, since there was only one intermittent creek on the property. “We had a damp area, but it went dry during the severe drought of 2002–2003, so I figured we wouldn’t see that again.”

But the creek eventually returned. “Years later, thanks to a stream bed analysis by The Nature Conservancy, they found freshwater shrimp and lily pads, indicating a permanent spring running into the creek. I thought it was just leftover water from when the creek ran earlier in the year.”

That’s when Guptill realized the value of his deeper soil organic matter profile. The organic matter depth

Pat Guptill, rancher
Pennington County, SD

improved from 18 inches to 36 inches after his first five years of rotational grazing. “This effort that is making our land and grass healthier is also saving water in the profile to feed the springs and our stream,” he says. “Our dams are dry, but we don’t need them.”

Grazing Rotation Is Critical

The initial reason that Guptill changed his grazing management was to increase his profits. However, he began realizing many more benefits as he rotated more cows more frequently by dividing his land into more pastures.

“We’ve learned over time that our grass needs total recovery time to build the root system that grows organic matter, soil health, and pasture resilience. We graze using a high stocking density (not rate) because these cloven-hoofed animals massage the ground for the week or so that they graze each pasture. Then the grass gets a long rest. We won’t graze that pasture again for a whole year so that the grass can reach full recovery,” Guptill says.

Thanks to the increase in organic matter and other improvements on the land, he started seeing riparian area benefits. More moisture in the creek bottom leads to more tree growth as the riparian area in and along the creek continues to heal.

Bringing Beavers Back

While improving the ranch soils on his property help, Guptill cannot control the water before it reaches his ranch. The fast-flowing stream entering his property can cause erosion. “I’ve got a lot of farm ground above me, and it’s difficult to slow that water down. In addition, our creek is going deeper, and we’re losing more soil. So, we have to implement beavers back into the stream beds,” he explains. Beavers build dams that capture the water and create rich riparian zones.

A technique that Guptill hopes might help heal his riparian area is to allow cattle access to about 200 yards of creek at a time. He puts only his yearlings in these creek areas, as they are more athletic, to begin to minimize the steeper bank slopes. “As the cattle help these banks slough off, we’re seeing prairie cordgrass and other plant life growing to stabilize the area and take care of itself. All I need to do is get beavers in here to hurry the process along.”

Guptill believes that as the riparian areas heal, the beavers will come back. “There are beavers within three to four miles of our ranch, so I know they’ll be here sooner or later.”

Focusing on the Land

Amidst the current drought in 2021, Guptill has reduced his cow–calf herd by two-thirds to protect his grass. “We don’t look at what our cattle are doing anymore. Instead, we pay attention to what the landscape is doing. By putting the land first, that focus is what gave us those springs along the creek.”

The Guptill family received the Leopold Conservation Award in 2013 to recognize their voluntary stewardship and management of their natural resources.

“Our goal is to improve the land for future generations, and we’re confident that our kids will continue the legacy that my wife Mary Lou and I started,” Guptill says. “Our management has proven that if you take care of the land, it will take care of you. That’s how these springs have come back.”

Figure 1. Years ago, beaver were trapped from these portions of stream. Now, Pat is working to help them return. Photo © Joe Dickie, Generation Photography, Inc.

Figure 2. Pat leaves woody debris from down trees to fall into the creek and help create diversity and complexity to the flow - like beaver would have done previously. Photo © Joe Dickie, Generation Photography, Inc.

Figure 3. The ranch's streams are intermittent and usually go dry during hot summer months. Springs continue to provide water to small pools. Photo © Joe Dickie, Generation Photography, Inc.

Figure 4. The stream has been increasing in tree diversity and growth. Photo © Joe Dickie, Generation Photography, Inc.

Section 4: Prairie Stream and Riparian Ecology 101

This section is intended to provide basic background on prairie stream, riparian area, and hydrology and geomorphology concepts. This technical information can help you understand why and how streams function.

What Is a Prairie Stream?

Prairie streams in the Great Plains region are primarily vegetated by prairie grasses and **forbs** in a landscape that was historically kept open by grazing and fire (Figure 12). Today, they exist in a precarious balance between flooding and drying.

Figure 12: This mixed shortgrass prairie in western South Dakota features shrubs and intermittent and ephemeral streams. Photo © Corissa Busse, TNC

Unlike streams in the mountainous western United States, prairie streams receive only a small amount of their annual flow from snowmelt, and this supply is quickly cut off come spring. Most of the flow in prairie streams comes from rain events. As a result, prairie streams tend to be much “flashier,” with more extreme experiences of flooding and dry periods.

These streams are incredibly unique and highly adaptive systems. Like the Great Plains themselves, prairie streams experience extreme heat and cold, severe weather events, and high fluctuation between drought and wet years. The plants and animals that depend on these habitats are adapted to survive here (Lytle 2002). Some of the aquatic and water-dependent animals that live in these harsh conditions are unique to the landscape (Dodds et al. 2004) and are resilient to the natural variation in drought and flood cycles. Some species respond to this variation through physical adaptations (such as insect eggs being able to dry out in the mud during dry periods, and some plant species being able to withstand having their roots either completely inundated or totally dry). Others adapt through their life history strategies, such as seasonal habitat use and migration.

Figure 13: Although high turbidity is often stressful to aquatic life, many prairie species are relatively well adapted to it. Here, a western hog-nosed snake navigates the waters in the North Fork of the Moreau. Photo © Dave Stagliano, Montana Biological Survey

Upstream reaches of prairie streams are characterized by frequent drying, little canopy cover, and limited leaf input. Headwater prairie fish communities are adapted to these conditions and to high **turbidity**, or high levels of suspended sediment in the water that can appear murky or stagnant (Matthews 1988; Perkin et al. 2017) (Figure 13). In lower stream reaches where more water collects from a larger land area, floods may be more intense and drying may be less common, which can result in more extensive floodplain forests.

Most of the research on stream ecology has focused on larger rivers and perennial streams (Allan and Castillo 2007). Small prairie streams have been understudied and most likely undervalued (Perkin et al. 2017), and there are limited data on small ephemeral and intermittent streams in western South Dakota (Matthews 1988, Dodds et al. 2004). These systems cover over 18,000 stream miles in West River and may be useful indicators of overall watershed health (South Dakota Natural Heritage Database). Riparian areas also have a high potential for restoration and functional improvement through management and low-cost inputs, as they are naturally more productive and responsive to change than upland areas.

History and Current Status of Prairie Streams and Riparian Areas

> Prairie streams have seen significant change over the last several hundred years. Rather than managing for the return of ideal historic conditions, which are generally unknown, this guide recommends managing for continuous improvement.

Over the last 200 years, there have been significant alterations to prairie grassland systems and the natural disturbance regimes to which they are adapted. In the early 1800s, trappers and fur traders nearly eliminated beavers from the North American landscape. Prior to this period, beavers were likely located on nearly all stream systems and had an estimated population of 60–400 million animals. These beavers created networks of dams and pools to slow and hold water across the prairie. However, by the 1900s, due to heavy trapping to feed the fur trade, these stream engineers were nearly eliminated from most streams. With the loss of beavers, the pools, dams, and habitat that they created were also lost, and streams across the country suffered significant erosion and loss by the early 1900s.

Around this time, homesteaders also began to enter the landscape, often settling along stream areas where water and wood were available. Many trees from these lands were cut to build homes and fences, or for firewood. These settlers also brought new forms of livestock, such as sheep and cattle, which were not as adapted to the landscape as native grazers. Many areas of western South Dakota also served as summer feeding grounds for large herds of livestock that were brought from the south and held over until train shipments could move them elsewhere. This resulted in heavy utilization of certain landscapes, especially riparian areas, further adding stress to these systems.

Many prairie streams and rivers continue to be degraded or threatened by a variety of activities that have impaired their function, including overutilization by livestock; fire suppression; invasion of non-native cool season grasses and lack of grazing; roads; dams, irrigation withdrawals, and other hydrologic alterations; and outright conversion to agriculture, oil and gas development, and other uses.

It is unclear how much today's prairie streams have changed from their pre-settlement conditions. Historically, many prairie rivers were likely turbid (i.e., they naturally carried high loads of fine sediment), especially in the badlands region of southwestern South Dakota. However, turbidity and sediment load in many areas have likely increased with agricultural expansion, channel disturbances, and other hydrologic alterations. Many fishes and other aquatic species that were once common have disappeared or have become rare (Hoagstrom et al. 2007; Barrineau et al. 2010).

Prairie streams are naturally subject to highly unstable flows and harsh fluctuations in temperature, moisture, and flow regime. However, climate change is likely to exacerbate these extreme conditions, by changing the patterns of timing and seasonality to which species are currently adapted. For instance, current climate change models predict that the NGP will experience even more intense rain activities (such as several inches within an hour), with more severe or prolonged dry or even droughty periods between precipitation events (USGCRP, 2018). We are already beginning to see these changes occur, and they are predicted to continue and become more extreme over time.

Due to these hundreds of years of alteration, nearly all prairie streams have suffered significant loss or change from their historic conditions, and these changes continue to occur. As a result, it is difficult to know for certain the true potential that prairie stream systems hold. "Reference conditions" or ideal, healthy, unaltered systems can serve within ecological planning as a benchmark or guide for what healthy streams could or should look like. However, given the significant degree of historic changes, reference prairie streams likely no longer exist. Instead of describing a benchmark or ideal, this guide intends to provide a pathway toward continuous improvement and adaptive management.

The Formation of Channels in Prairie Streams

The surface geologic material of western South Dakota consists primarily of marine sediments originating from the

Cretaceous period, over 65 million years ago, when the area was under a shallow ocean. This oceanic history is why many of our soils tend to have conditions of high salinity—due to ancient bodies of salt water that have now receded. Since that time, various erosion events have transported that material downstream.

Over millions of years, the landscape has developed a dense, branching channel network, most of which consists of small, ephemeral streams that are found on nearly every ranch in western South Dakota. The upstream end of the channel migrates farther upstream over time into the upland areas, extending the channel network. Although channel migration is an ongoing and continuous natural process, this process of drainage development has been accelerated by land use and climate changes and now occurs much more rapidly.

Headcuts (also known as **"knickpoints"**) are commonly found at places of high disturbance, such as areas where livestock gather, at road crossings, along fencelines, etc. These are usually points where water can accelerate and erode its channel.

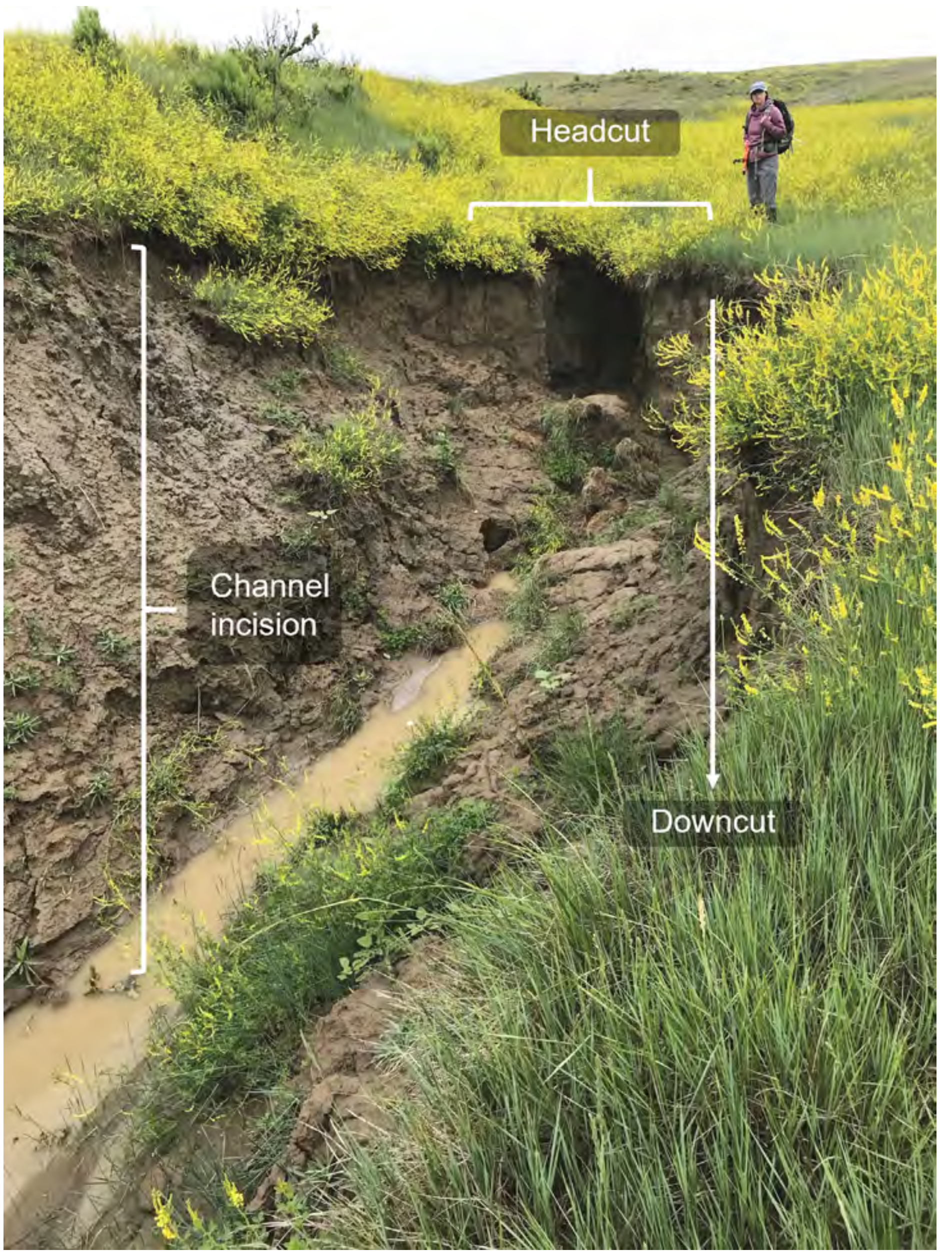


Figure 14: This image shows a headcut that is marching up into a prairie system. The headcut causes the stream to downcut or incise. Below this area, the stream channel is now deeply incised, is disconnected from its floodplain, and drains quickly. Above the headcut, there is almost no channel formation and stream waters spread out over a valley and are stored in the landscape. Photo © Kristen Blann, TNC

As the rate of channel formation increases higher into the uplands through headcuts and incision, this can result in critical water supplies draining more quickly from the prairie landscape. These management challenges are described in more detail, along with possible solutions, in the latter sections of this guide. Our ability to manage streams toward healthy conditions that slow and hold water on the landscape is important for plants, wildlife, and livestock alike that depend on these waters—especially in the hot summer season.

What Does a Healthy Stream System Need?

Healthy prairie streams support self-sustaining ecological, hydrological, and **geomorphic processes** that provide critical ecosystem services. As a general rule, healthy streams are dynamic, yet resilient (or less sensitive), to changes and stressors. Resilient streams can more easily respond to large and intense rain events, severe and prolonged drought, and wildfire events. In turn, these resilient systems provide us with improved water storage, increase forage production, reduce the force of floods, and increase habitat for many diverse species. Each stream is unique, and healthy, resilient systems vary in their specific dimensions, flow regimes, plant compositions and more. Yet, all healthy systems depend on several interrelated requirements (adapted from Wheaton et al. 2019):

1) **Healthy streams need space.** Healthy streams flood often and are highly interactive with their floodplains. An active stream will move and shift where water flows (both vertically and horizontally), allowing waters to access new areas and shift the course of water during major storm events. Healthy streams have the freedom to "exercise" and dissipate energy. This exercise will also involve the movement of sediments during high flow events, resulting in erosion and deposition of materials into new and dynamic features and structures in the valley bottom. As a result, healthy stream channels and their adjacent floodplains are also dynamic and ever-changing.

   In comparison, a static stream system without the ability to change will not have flexible room to exercise its "streamness" (picture, for instance, an irrigation ditch). Seeking to armor or prohibit a stream from changing or exercising its dynamic nature can cause long-term damage to the site as well. Imagine breaking an arm and putting it in a cast, but then never removing the cast later. Healthy systems—including streams—need movement and activity to heal and strengthen. The challenge is noting when this movement and activity is heading toward a healthy state, and when it is degrading. We will discuss this more throughout the guide.

2) **Healthy streams need complexity.** Elements such as vegetation, woody debris that falls into streams, and beaver dams in valley bottoms provide physically diverse and structurally complex habitats that build resilience in the system. These elements add "roughness" to valley bottoms, which forces the flow of water to change and adapt. In a complex stream with strong structural diversity, water must navigate a series of obstacles in its path; it is forced to wander over, flow around, back up behind, or slowly trickle through these obstacles. Ultimately, these physical alterations cause the stream's flow to spread out and slow down, forming pockets, pools, bends, and turns in the stream. This physical diversity adds complexity and ultimately resilience to the system by reducing the speed of the water in high-flow events, storing water longer during dry times, and providing refugia and habitat during floods, drought, and wildfire events.

   It is important to remember, however, that the importance and types of structure vary in each stream. No two streams are the same, and each stream is influenced by its position in the watershed, flow regime, valley setting, and stream type. Some prairie streams of western South Dakota may never have supported woody vegetation and tree species. It is important to respect the diversity of each stream and recognize that streams are influenced by their landscape—and are constantly changing as a result.

3) **Healthy streams are inefficient at moving water and sediment.** Healthy streams will work to slow down the flow of surface and underground water through the watershed, helping to reduce the force of floods and prolong the time that water and nutrients stay high in a watershed or landscape. The result is that a healthy stream system can act like a "sponge," slowly releasing water over long periods of time. This storage and slow-release process is not only beneficial to the health of the stream, but critical for wildlife and livestock as well—especially in times of drought or wildfire.

   The more diverse and connected a stream is, the more time it will take for water and sediment to move, thereby extending its availability in our riparian areas. It's important to note that this does not apply to structures that completely stop water and sediment, as they decrease the connectedness of the system. In comparison, a simplified channel like the irrigation ditch example above will rapidly transport water and sediment off-site and down to the Missouri River, which limits its ability to benefit plants and animals here in the upper watershed.

As mentioned above, a healthy, resilient stream is a connected stream, and all these pieces are interrelated and feed into one another. For a stream to slowly transport more water, it needs floodplain connection and physical complexity. One indicator of system resilience and health is a decrease in sensitivity to changes in precipitation over time. A healthy and resilient system will have less dramatic differences between wet and dry years.

Understanding the Basic Landscape Features of a Prairie Stream

Often, when we think of a stream, we think of just the defined path where water is flowing most often. This zone where flowing water is contained (when not flooding) is known as the stream channel. The bottom of the **stream channel** is known as the **stream bed**, and the sides of the stream channel are known as the **streambanks**.

Many streams in western South Dakota tend to have one defined channel, often narrow in width, that a person could easily jump across. However, stream channels can take many different shapes and forms. Some streams may have multiple channels that spread across a landscape, braiding and twisting together. Other streams may not have a channel at all, but instead act like a **wet meadow** with water flowing through and over the ground across a wide area.

A stream's channel does not represent a full stream system however. Instead, the stream is also connected to its floodplain – and together, the stream channel and floodplain form a valley bottom. This connected series of parts is also referred to as a **riverscape**. The important point to note here is that a stream is made up of far more than just the channel where water flows most often. In reality, a stream is more of a *system of landscape features working together to influence the flow of water*. This section of the guide will describe some basic features that affect prairie streams, including valley bottoms, riparian areas, floodplains, and uplands.

How to Identify and Read a Valley Bottom

A **valley bottom** is a low area in the landscape generally located between hillsides or mountains. These low areas are where water will flow to and collect. As a result, a valley bottom will typically have a stream flowing through it. The movement of water and resulting erosion over thousands and millions of years is what ultimately forms the shape of the valley itself.

In western South Dakota prairies, many valleys are wide, open, and known as flat-floored valleys. Streams in these valleys may tend to wind and meander and have more room to spread out during flood events. In steeper areas, however, such as on hillsides and buttes, water tends to run downhill faster, increasing erosive forces. This creates more of a V-shaped confined valley bottom where water has less room to spread out.

Hillslopes are the features that flank the valley, where the topography rises as hillsides or buttes (or as mountains in areas farther to the west). The **toeslope** is the portion of the hillslope that becomes more gradual as it transitions to the valley bottom. Sediment and erosion that flow down the hillslope will often slow down and accumulate in the toeslope area.

An **alluvial fan** is another landscape feature that forms when eroded gravels, sediments, and silts (known collectively as alluvium) are carried through steeper water courses such as woody draws and steep streams. When these steeper waters reach a flat area such as a valley bottom, they slow down and spread out, often forming a triangle-type pattern that resembles the shape of a fan or shell. Alluvial fans indicate areas where water collects and deposits from the uplands into a flatter landscape. Alluvial fans usually contain many diverse plant species that have deep roots to access groundwater below the fan's surface.

When getting to know a stream system, it is important to look up and away from the stream channel itself. Notice the valley depression and hillslopes within the landscape that surrounds the stream. As noted, this valley depression was formed over time by the stream itself. The flat valley bottom represents the area that was historically flooded with water during significant high-flow events. In healthy systems where streams still have access to their floodplains, large areas of the valley bottom may still be accessed during these high floods, resulting in greater forage and water storage capacity in these areas. In contrast, in systems where a stream has incised, the stream may now be separated from spilling over across these historic floodplains, resulting in a loss of forage productivity and water retention in large areas of the valley bottom.

What Is a Riparian Area?

> Riparian areas are the most productive and critical habitat features of the landscape—for livestock and wildlife alike.

The term **riparian** refers to the area that borders a stream or other body of water: the strip of green that links water to land. Riparian areas are distinctly different from surrounding upland areas and have many important functions. These areas are often the most productive sites on the landscape and remain green and lush far into summer when other areas have dried. A study from eastern Oregon, for instance, showed that though riparian areas only composed about 2% of a ranch's physical area, these zones were able to produce up to 20% of the ranch's forage potential (Roath et al. 1982). Because riparian plants remain wetter for longer, they also can hold crude protein for greater periods of time—even up to the first frost. Ultimately, a riparian area is a unique feature on the landscape, distinctly different from the uplands, that is composed of plant communities affected by their connection or proximity to a water source.

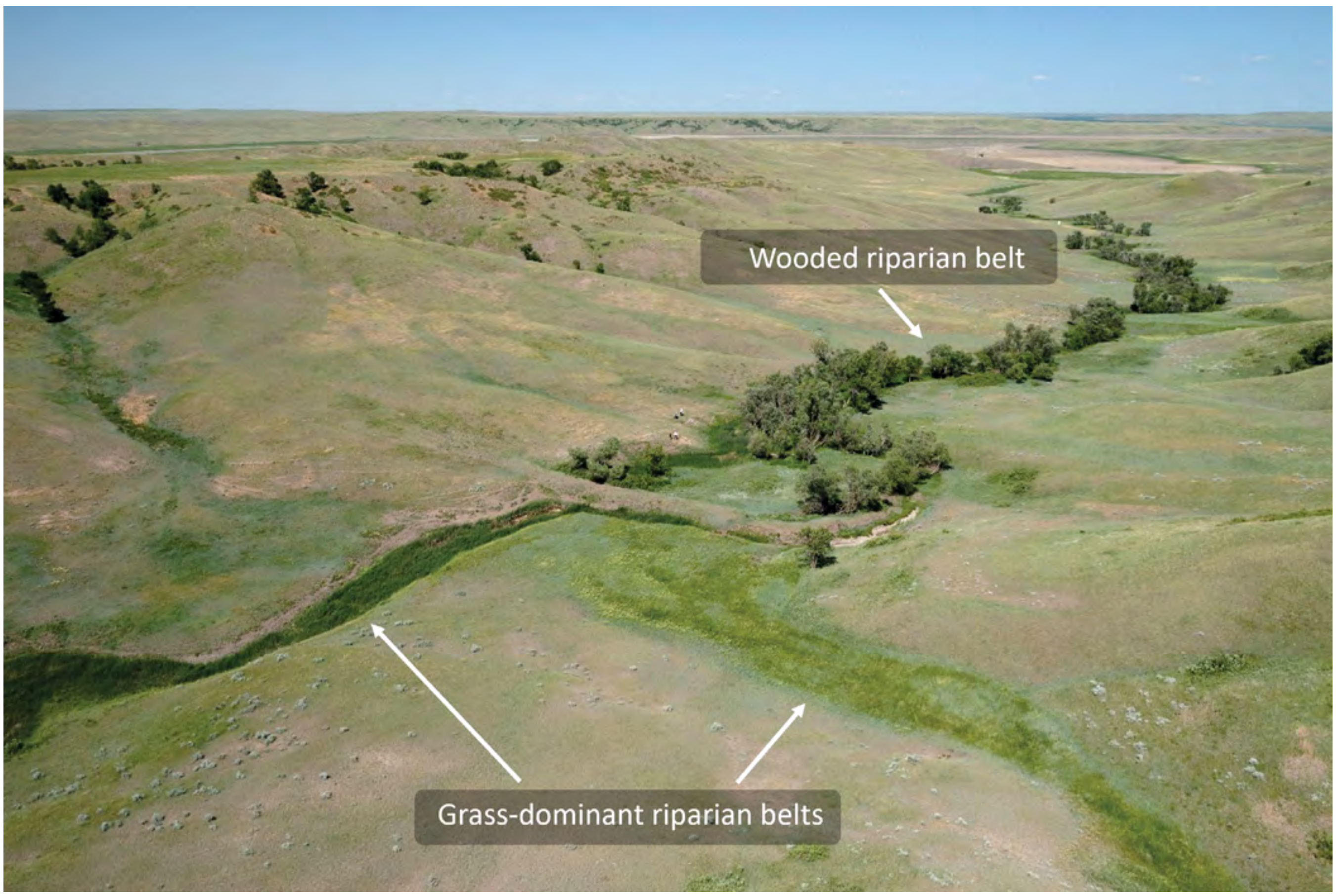


Figure 15: This image shows different riparian corridors intersecting. Riparian areas are unique features on the landscape with more lush, green vegetation than the surrounding uplands. Photo © Joe Dickie, Generation Photography, Inc.

The dense vegetation of riparian areas and the plants' strong, fibrous root systems also help to slow and hold water on the landscape, recharging groundwater, reducing erosion (especially during high flows), and trapping or exporting sediment. Strong riparian plant communities can help dissipate or lessen the intense energy of flood events. Without riparian plants, flood waters can scour out bare soils along a stream edge, causing the stream to incise and erode. In contrast, strong riparian plant communities can act like a buffer and create "drag" to slow the force of flood waters that flow over them. Riparian areas also provide increased shade, cover, and beneficial habitat to support a wide variety of plants and animals, including insects, fish, birds, and game species. Livestock also benefit from and appreciate the same features that attract wildlife to these critical areas.

Figure 16: These photos show two streams of similar size, both in northwest South Dakota. The stream on the left does not have a strong riparian community and lacks complexity. The stream on the right has a developing riparian community with willow and other dense vegetation to help slow and hold water and provide greater habitat and cover. Generally, streams with a healthy riparian area are more complex and diverse. Photos © Corissa Busse, TNC

Defining the riparian area can be challenging, as it depends on the size of the stream and its valley, the distinctness of the slopes adjacent to the channel, and how gradually vegetation transitions to an upland plant community. Riparian areas vary greatly in size and extent, but their contribution and value far exceed their relatively small size.

Riparian areas are found at every elevation and in all landforms. They differ depending on local physical conditions (e.g., water, soil, temperature) and their location (e.g., elevation, valleys, canyons). In mountainous regions, they may be narrow and confined to deep ravines or canyons, while in lowland floodplains, they may meander across broad valleys. Desert washes and dryland areas may be sandy or canyon-like **arroyos**, containing water for only a short time each year. These differences in vegetation, landform, and geology have led to a wide variety of terms used to denote riparian areas: riparian buffer zones, gallery forests, cottonwood floodplains, woody draws, alluvial floodplains, floodplain forests, stream valleys, and streamside meadows.

In summary, although riparian areas may look different from one another, they all provide critical benefits to the landscape and health of the stream. Figure 17 identifies the riparian area or corridor in a few different examples and types of systems. The healthier the riparian area, the greater its complexity and diversity.

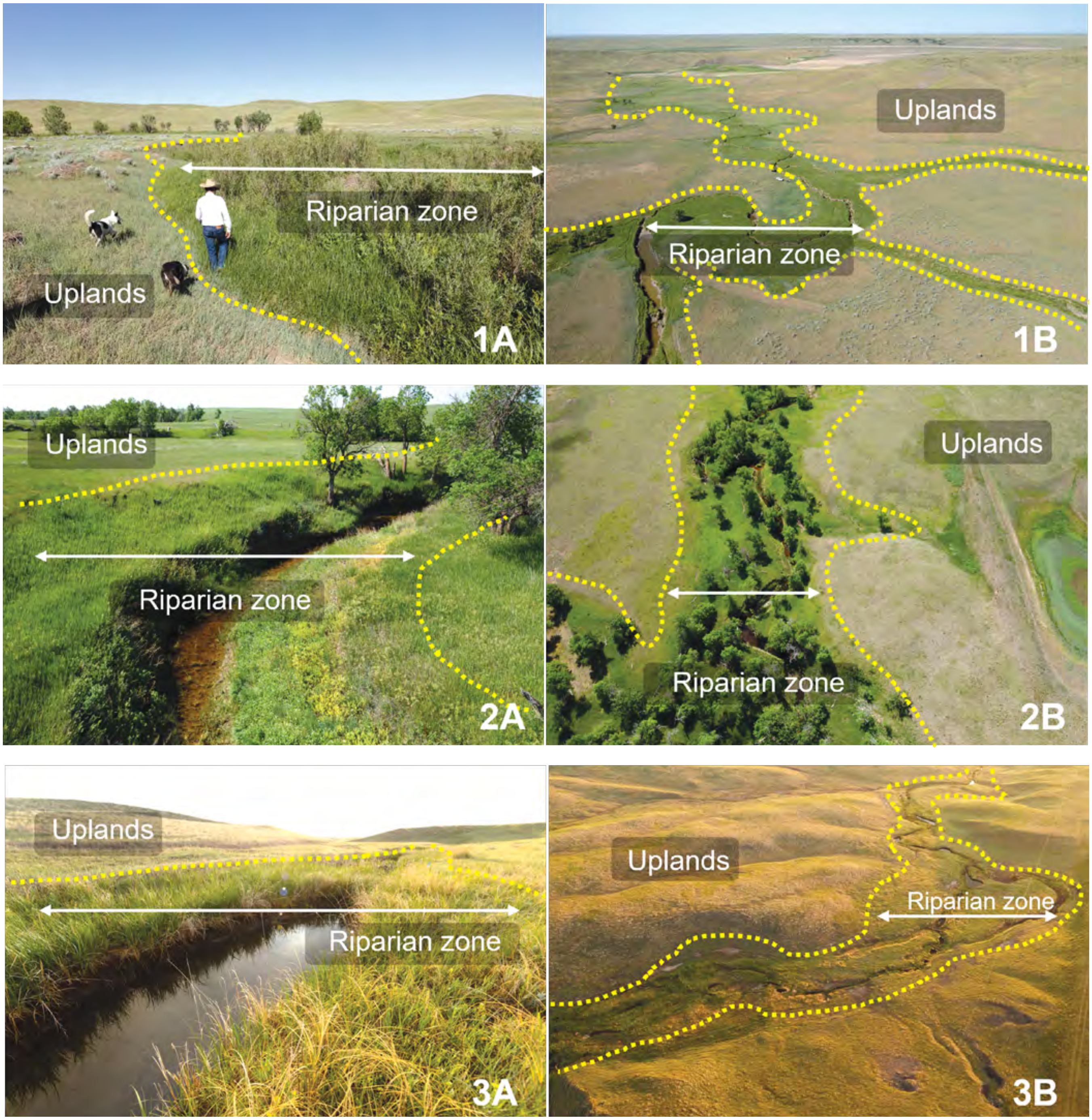


Figure 17: These images show a variety of riparian systems across western South Dakota. The photos on the left side (column A) show these systems at ground level, and the photos on the right (column B) show these same streams from an aerial perspective. Each riparian system is dynamic and they have different features and appearances in different portions of the stream. Photos © Joe Dickie, Generation Photography, Inc.

What Is a Floodplain?

A floodplain that is connected to its stream helps to slow down and spread out the intense erosive power of flood events. Streams that have separated from their floodplain, however, will often experience greater erosion and incision during high rain events and floods.

The **floodplain** is the relatively flat area adjacent to a stream channel that tends to flood when flowing water exceeds the capacity of the channel (Figure 18). In a relatively natural stream that is in balance with its landscape, the active floodplain will be inundated (or covered in flood water) an average of two years out of three. In this instance, we say that the stream is "connected" to its floodplain. A larger, more extensive topographic floodplain may be associated with channels that have been developing for longer periods of time, and this larger floodplain may be inundated only during much larger, less frequent floods (as shown in Figures 18 and 19).

In the semi-arid American West, riparian areas are the thin ribbons of mesic habitat that support life on the prairie. The term mesic refers to areas with a balanced supply of moisture throughout the growing season.

Depending on local stream type and history, some streams may not have functioning floodplains, particularly those that have gone through a period of instability or downcutting. This is often referred to as the stream "separating" from its floodplain or losing connectivity due to incision.

The floodplain is a very important functional part of the riparian area. It acts to dissipate the energy of floods and helps prevent excessive soil erosion. It provides temporary storage space for floodwaters and sediment carried from the watershed. As floodwaters spread out over the floodplain, they typically slow down and their ability to transport large amounts of sediment or rock diminishes, allowing much of that sediment to be deposited within the floodplain.

Figure 18: This photo shows the historic valley bottom and floodplain of a stream that has incised. This incised stream channel now no longer regularly accesses the broader floodplain, creating far less area for floodwaters to spread out. Photo © Joe Dickie, Generation Photography, Inc.

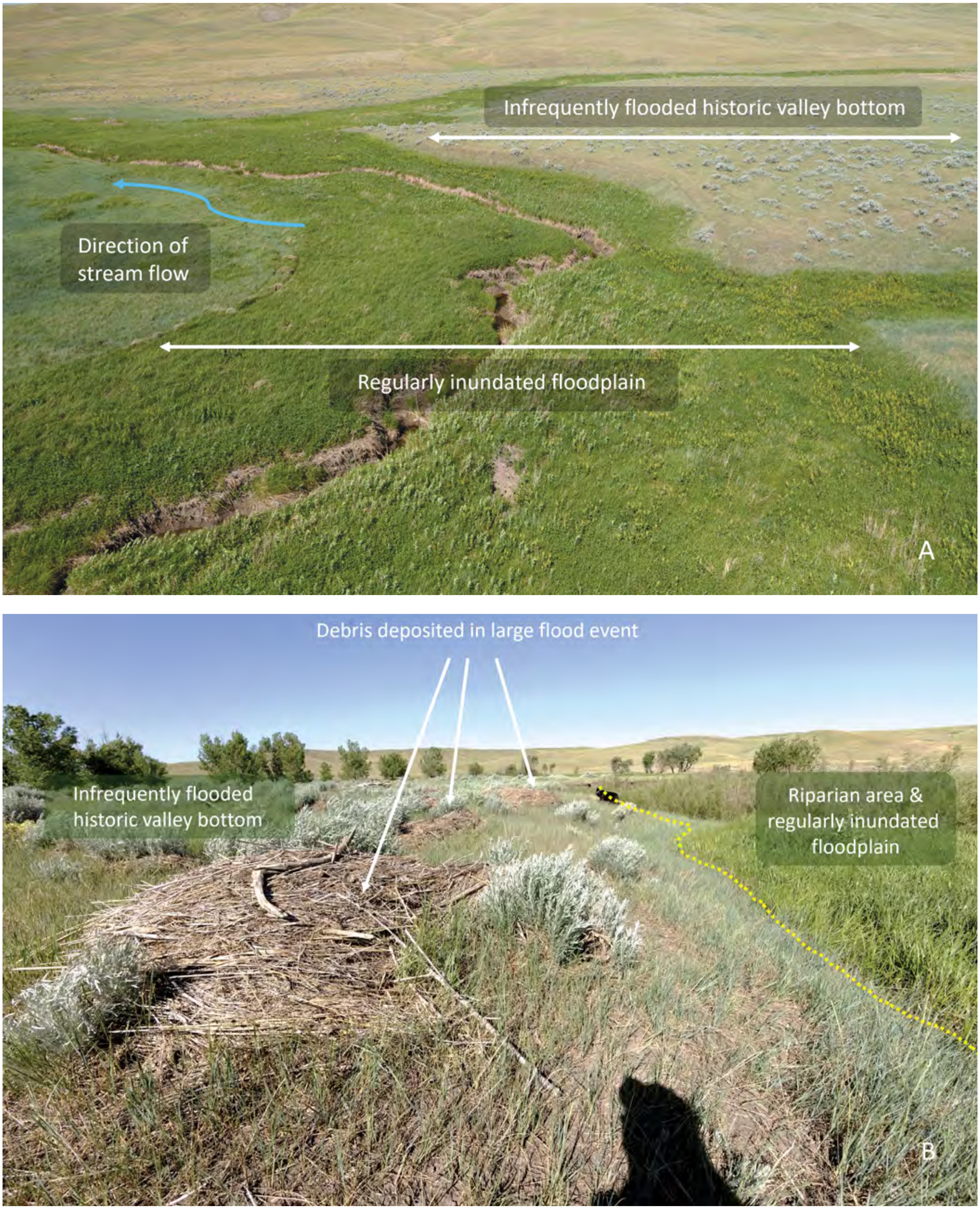


Figure 19: The top photo shows a less-accessed floodplain where sagebrush (an upland plant) is prevalent compared with the lush green riparian belt closer to the stream. Historically, this entire valley bottom was more regularly accessed by flood waters before the stream channel became incised. In high-flow events, however, flood waters still move over the historic floodplain, which slows the force of the water, trapping debris and sediment in the sagebrush and limiting erosive forces. The lower photo shows the contrast between infrequently flooded and regularly inundated areas. Photos © Joe Dickie, Generation Photography, Inc.

A **terrace** is defined as a bench (or flat area) associated with an upland area that is no longer flooded. Terraces may have been floodplains at one time but were cut off from floods as the stream cut down or incised in response to flow changes in the watershed. When streams have begun this incision process or are separate from their floodplains, flood waters funnel within smaller and steeper corridors. This creates more erosive pressure and more forceful flowing water. For example, imagine the same amount of water flowing through a 2" pipeline, compared with a 1/2" pipeline. As the pipeline become smaller, the water pressure becomes greater.

Figure 20: When a stream goes through an incision process, it no longer has easy access to historic floodplain areas, which become known as terraces. The inset stream now flows through a tighter channel with more erosive power. Photo © Joe Dickie, Generation Photography, Inc.

Understanding and Noting Stream Sediment and Stream Bed Material

Stream bed material can also be an indicator of your stream's potential and the conditions and habitat it creates. A variety of material in a stream bed is an indicator of resilience and is good for aquatic life and diversity. Coarser materials such as gravel or pebbles have more cracks and crevices between the particles where invertebrates and small stream fish can nest, feed, and find shelter. Streams that have consistent, fast-flowing water (such as low-gradient rivers) typically sort the bed material and flush out finer sediments, creating patterns of riffles with coarser material. Streams with coarser material also are generally more stable than those with fine silts. Ephemeral streams with slower-moving water (often in headwater systems) tend to have unsorted bed material. In many areas of western South Dakota, this is usually fine sediment (silt and clay), which tends to support lower aquatic life diversity. Having a fine sediment is not inherently a negative characteristic, merely a stream feature that is largely driven by the local parent material of your system, but it can be an indicator of your overall stream potential. Figure 21 illustrates various stream bed materials.

Recognizing the bed material is also important in understanding which management and/or restoration practices may be most applicable. In western South Dakota, a gravelly substrate often has more potential for natural cottonwood recruitment than a heavy clay or silty system. Likewise, a clay or silty substrate can be an attribute when installing in-channel structures because the system will build point bars and new floodplains more quickly. Restoration options are discussed in greater detail later in the guide.

Figure 21: A variety of stream bed materials are found in western South Dakota. The left photo is from a headwater stream and is composed of fine silts. The center photo is from a mid-sized stream and has a mixture of sands and gravels. The right photo is from a larger low-gradient prairie stream and is composed of larger pebbles and rock. Photos (L to R) © Montana Biological Survey; Chris Lenhart, TNC; Joe Dickie, Generation Photography, Inc.

Understanding Stream and Riparian Areas as Ecosystems

Riparian areas and complexes are ecosystems. An **ecosystem** is a functional system that includes both **biotic** parts (living organisms such as plants, animals, and microbes) and **abiotic** parts (physical components such as geology, soil, and topography). These biotic and abiotic components interact with each other over time and space. In other words, a riparian area is made up of both living and non-living things interacting together. For example, plants and animals interact with water and soil in unique ways in riparian areas.

Figure 22: Riparian areas have both biotic or living elements (plants, animals, microbes) and abiotic or non-living elements (rocks, sediment, topography). All of these elements affect each other as an ecosystem. Photo © Chris Lenhart, TNC

Everything in an ecosystem is interdependent. If one element of the ecosystem is struggling, it will affect other parts of the network as well. In addition, if one element improves, it will improve other parts of the ecosystem too. This interdependence is important to remember as you work to improve or strengthen the health of riparian areas.

Riparian areas are also transition zones, or **ecotones**, between aquatic (water-based) systems and terrestrial (land-based) systems and usually include a mixture of both characteristics. The characteristics and location make these areas important habitat for many species. Each ecosystem is distinct due to its unique interaction of biotic (living) and abiotic (non-living) components.

The main abiotic characteristics that define riparian ecosystems are hydrology, soils, and landforms, all of which are structured and acted upon by **fluvial processes** (i.e., the work that water does as it moves across the landscape). In turn, these structure the biotic components, mainly the vegetation. Consequently, riparian complexes may be identified and classified based on their **hydrology**, or flow; their **geomorphology**, or soils and landforms; or their vegetation zones and characteristic vegetation communities. The term **hydrogeomorphology** refers to how the abiotic components—flow, hydrology, and shape of the landscape—interact.

The terms "hydrogeomorphology" and "hydrogeomorphic" are both derived from the words hydrology and geomorphology. "Hydro" refers to water, "geo" to landform and land surface, and "morph" to shape.

Hydrogeomorphology is also a way to describe the study of landforms caused by the action of water. The Grand Canyon is an example of a giant and impressive hydrogeomorphologic process where water has shaped and altered the landscape. On a smaller but equally impressive level, western South Dakota has been highly affected by water flowing over the land for millions of years, creating the various buttes, draws, ravines, floodplains, and stream features across the landscape.

Figure 23: The western South Dakota landscape has been heavily shaped by hydrogeomorphic processes (or the movement of water over the land) for millions of years. Photo © Joe Dickie, Generation Photography, Inc.

How Water Flows In and Shapes a Landscape

Much of the western South Dakota landscape has been heavily shaped by the flow of water throughout its long history. Our streams and riparian areas remain highly important ecosystems that continue to influence and shape the future of this landscape.

Relationships Among Streams, Riparian Areas, and Uplands

All areas of a watershed affect a stream's health. How water flows over or through the uplands can directly impact when and how a stream receives water (whether heavy rainfall scours a landscape and creates erosion, or whether it slowly flows through the water table below ground). This also affects how long water can remain in the headwater landscape. Healthy upland management is critical to slowing and holding water in the landscape for longer periods.

The stream corridor itself includes the active channel (where water is flowing) and the immediate riparian area (adjacent to or touching the active channel). Transitional areas are not regularly inundated with water or are not directly adjacent to the stream corridor but are still affected by the stream. These include areas such as valley slopes, riparian forests, or **wetland** areas, as well as the floodplain and terraces of the stream valley, depending on whether these areas are identifiable as distinct bands of vegetation or landforms.

Managers and scientists often refer to the areas of the watershed or catchment that are not wet as uplands. Uplands may be flat, highly sloping, or gently sloping hillslopes; however, they are not regularly inundated or saturated by floodwater or a high water table. Often, water infiltrates in upland areas that have permeable soils, recharging local groundwater supplies and supplying downstream baseflow to streams through **springs** or **seeps**. These spring and seep features play a large role in the flow of many streams across western South Dakota. Although they often arise where hillslopes intersect the water table, their specific occurrence is hard to predict due to the variability of soils, topography, etc. across the landscape, as well as variation in rainfall and water table volumes over time.

Figure 24: The dark green vegetation shown in this photo is largely created by seeps or springs from the surrounding uplands that emerge at certain areas along and beside the stream drainage. These seeps and springs create pockets of more lush vegetation and in some areas, form pools of water. Photo © Joe Dickie, Generation Photography, Inc.

Uplands with strong root systems and minimal bare ground tend to capture rainwater, pulling it down into the soil and slowly releasing the water through discharge areas of the water table or through springs. You may recognize this pattern when, for instance, stock dams do not fill immediately after a rain event, but instead fill days later from the water table below ground. In contrast, uplands with greater areas of bare ground, dense clay soils, or struggling soil health can form a seal during intense rain events, causing water to flow over the surface directly into catchment areas or streams—rather than down and through the soil profile. This above-surface flow can increase erosion and sediment levels in the water and can cause headcuts and incision.

In parts of western South Dakota, groundwater recharge is limited because of low rainfall and a predominance of clay soils, particularly in the Pierre Shale Plains. Western South Dakota is **semi-arid**, meaning that there is little excess water, and the soils are primarily fine-grained silts and clays that have very low permeability and poor drainage. Almost all streams outside the Black Hills region have less than 2 inches of sustained water flow between rain events (Ahiablame et al. 2017); this low-flow stage is commonly referred to as the **baseflow**.

Landform, landscape position, geology, and soil characteristics—in addition to hydrology, drainage area, and slope—affect the way water flows across the surface of the land, as well as groundwater movement toward and within the riparian area. For example, groundwater seeps frequently emerge at the base of hillslopes. In contrast, in flat saturated areas underlain by tight soils, surface water runoff tends to form ponds and remain longer.

Springs and seeps play an especially important role in ephemeral and intermittent systems that do not carry flowing water year-round but may nonetheless preserve perennial pockets and pools of water in portions of the channel (as shown in Figure 25). These perennial or long-lasting pools of water are especially critical for wildlife—including microbes, insects, and fish—that are adapted to prairie streams. Some species have evolved ways to lie dormant in these stagnant pools through long periods of summer or drought until heavy rainfall once again provides flowing water through the channel, at which time they can migrate, recolonize areas, and move up- or downstream (Dodds et al. 2004).

Figure 25: Intermittent and ephemeral streams that go dry or lose their flow may still hold more perennial pools of water on the landscape—especially where springs or seeps are present. These pools are critical for wildlife that are highly adapted to this flooding and drying cycle. Photo © Joe Dickie, Generation Photography, Inc.

Elements of Riparian Site Dynamics

Riparian areas and prairie streams are naturally dynamic. Change—including erosion or shifting plant communities—does not necessarily indicate that a stream is declining in health. Instead, it can indicate that a stream is healing or "exercising" in its natural state.

Riparian ecosystems are highly dynamic and continuously changing due to the constant action of the moving water, called **fluvial activity**. This activity forms channels and causes plant communities to shift in response to erosion, deposition, and water table on the fluvial surface. **Fluvial surfaces** are the floodplains and terraces associated with a stream. The stability and shape of a stream changes in response to shifts in climatic patterns and alterations in vegetation and management. These changes may be natural, the result of human activity on the landscape, or both.

The following topics and concepts discussed in this section will help you "read" your stream and interpret why it acts the way it does. It is critical to know the basics of these elements in order to understand and use the monitoring tools offered at the end of this guide. These concepts may seem technical in nature, but if you practice in the field, you will become more comfortable with them as you observe and see different streams in different states.

Streamflow (a.k.a. Discharge)

Discharge is the volume of water moving down the channel per unit of time, or the amount of flow. Discharge is usually expressed in units of cubic feet per second (ft^3/s) or cfs. Because discharge is directly related to the work that water can do, it is one of the important variables that determines the size and shape of the channel. Streams with higher discharge contain more water and more energy. Streams with lower discharge contain less water and there is less energy in the system.

Discharge and Channel Morphology

During flood events, a stream is likely to move the most sediment; form new features such as bars, bends, and meanders; and change the structure of the channel.

Discharge directly relates to the ability of a stream to transport sediment and to shape the channel. The shape of the channel may be winding with many turns (where water takes longer to get from point A to point B) or straight like a chute (where water flows more quickly). The channel may be filled with diverse features such as point bars or debris at the inside of turns, or it could be deep and incised with steep walls and little diversity inside the channel. These elements of channel shape are largely controlled by the discharge of the stream. Larger flows move much more sediment and do most of the work of shaping the channel. The power of water that moves and shapes the channel and the landscape is evident after very large floods, when floodwaters may carve out new channels; move large boulders, trees, and other objects; and/or deposit large amounts of sand and silt downstream when floodwaters recede. In a natural landscape where the stream channel is stable and at equilibrium, the flow that does the most work to shape the channel over time is called the **channel-forming** (or dominant) discharge.

However, the most important and frequently referenced concept used by stream ecologists and restoration practitioners is the **bankfull discharge**, the discharge that occurs when water just begins to reach the height of the active streambanks and spreads into the floodplain, assuming that the stream is well-connected and not entrenched. Bankfull discharge is the measurement we will primarily use in this guide and assessments.

Figure 26: These two photos are of the same stream. The photo on the left is from the upper headwaters, where the stream has less drainage area and less flow. The photo on the right is from downstream, where the flow has increased to a mid-sized stream with more erosive power. Photos © Corissa Busse, TNC

Bankfull Discharge

> Bankfull discharge is the water that overflows when floodwaters fill to the banks of a stream and are about to spill into the floodplain. In stable streams, this occurs every year or two, or every few years in dry times.

The bankfull discharge fills a stable stream channel up to the elevation of the active floodplain. In channels that are not highly entrenched, it is the discharge that just fills the cross-section without overtopping the banks (hence the term bankfull). This discharge is significant to the shape of the channel because it represents the breakpoint between the processes of channel formation and floodplain formation. In stable stream channels, bankfull discharge corresponds closely to channel-forming discharge, and it occurs every one to two years, although it may be less frequent in arid and semi-arid streams (Leopold 1994; FISRWG 1998). Flows that are smaller than an annual flood don't move as much sediment at one time but occur more frequently; larger flows do move a lot of sediment, but don't happen very often. Flows that exceed the bankfull discharge also lose some of their initial power and speed as they spread out over the floodplain and their energy is dissipated.

Discharge is directly related to **drainage area**. Drainage area is the total surface area of a watershed upstream from a point on the creek to which all water will flow. As a drainage area becomes larger, it captures more rainfall and groundwater and the total streamflow volume tends to increase. Thus, downstream portions of a creek will have more water and discharge than areas upstream or in the headwaters, as shown in Figure 26.

In South Dakota, the USGS has developed statistical relationships between drainage area and streamflow for high flows and flood events ranging from a two-year to a 500-year flow event (Sando 1998). Much of this information can be accessed through the USGS StreamStats site https://streamstats.usgs.gov/ss/. This information is helpful in recognizing a stream's ability to change over time and is key when evaluating what management and/or restoration practices may be effective and appropriate for an area.

Bankfull Height and Width

Bankfull stage can be estimated by the average elevation of the highest surface of the channel bars (Wolman and Leopold 1957). To determine where the active bankfull level is located, look for flat, depositional areas up and down the stream reach. (See the USFS guide at https://www.fs.fed.us/biology/nsaec/products-videoswebinars-bankfull-ne.html or visit https://youtu.be/UuS7H2NxJIM for a guide to field identification of bankfull stage in the western United States.) It is often difficult to identify bankfull stage indicators in the field. This is particularly true in unstable streams (e.g., streams that are changing in response to climate, disturbance, or land-use change). In these situations, check for visual estimates of bankfull discharge, such as depositional features, breaks in slope, and changes in vegetation. It is important to make estimates at many points along the stream, not just one cross-section. We recommend reviewing additional guidelines from the U.S. Forest Service, which provides useful videos on the identification of bankfull stage in the field.

Figure 27: These images show the measuring of bankfull width and height (or the width of the channel and height of water when it just begins to fill the stream's banks before spilling into the floodplain). This measuring process is described more in the assessment portion of this guide. Photos © TNC

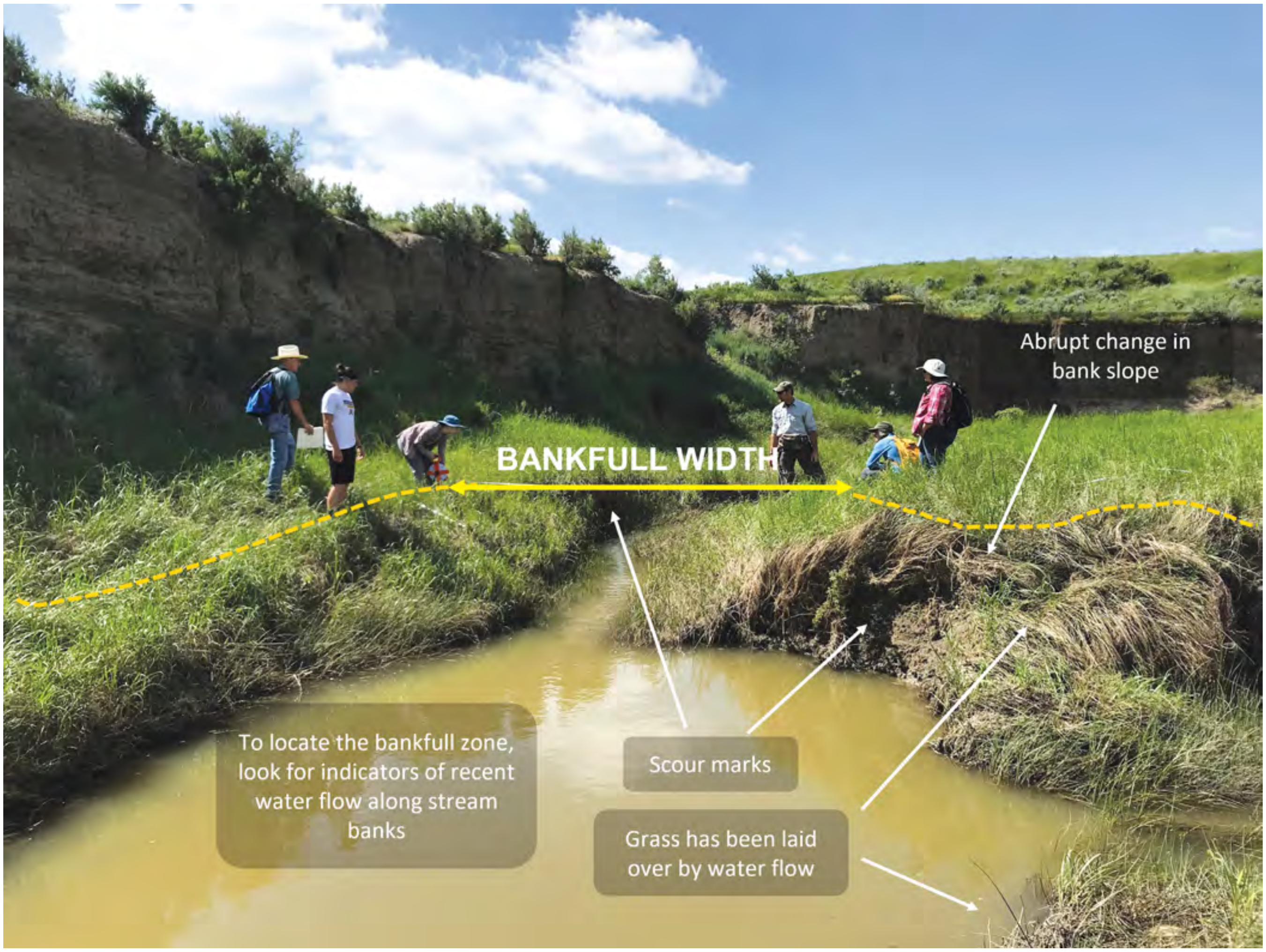


Figure 28: To locate the bankfull zone, look for indicators of annual or more regular high-water events along the streambanks. Photo © Corissa Busse, TNC

Measuring Entrenchment

Entrenchment is an estimate of how confined the stream is and the degree to which it is incised in the valley floor. The lower the entrenchment ratio, the more vertically confined the flow is. Higher entrenchment ratios mean there is more floodplain development and connectivity.

Figure 29: The entrenchment ratio (ER) is the width of the floodprone width (FW) divided by the bankfull width (BW). A lower entrenchment ratio indicates high entrenchment, or incision. [Source: Bernard et al. 2007] Photos © Corissa Busse, TNC; Joe Dickey, Generation Photography, Inc.

How to assess the entrenchment of a stream:

The entrenchment ratio is equal to the floodprone width, divided by the bankfull discharge width of the stream. This stream feature is determined in the following way:

- **Step 1. Measure or estimate the active floodprone width.**
  This is the point where the water begins to leave the channel and spread out onto the floodplain. This area can be identified by looking for flooding evidence like debris piles that were deposited during flooding events and vegetation that has been laid over by water flow. See Figure 30 below.
- **Step 2. Measure or estimate the bankfull width.**
  For most streams, this flow occurs approximately every 1.5 to 2 years. Look for indicators of bankfull such as changes in vegetation and slope. The bankfull edge is located at the edge of this floodplain. Often the floodplain slopes down gradually and then more abruptly; this abrupt slope-break is usually a good indicator. Sometimes, you find the slope-break on only one bank. Also, look for bare soil and scour patterns where the high flows cause erosion; this is another good indicator of your bankfull edge. See Figure 31 below.
- **Step 3. Divide the floodprone width by the bankfull width measurements.**
  The number that results is your entrenchment ratio. A lower entrenchment ratio indicates that the stream is more incised. A higher entrenchment ratio indicates that the stream is more connected to its floodplain. Figure 32 below shows all three of these steps.

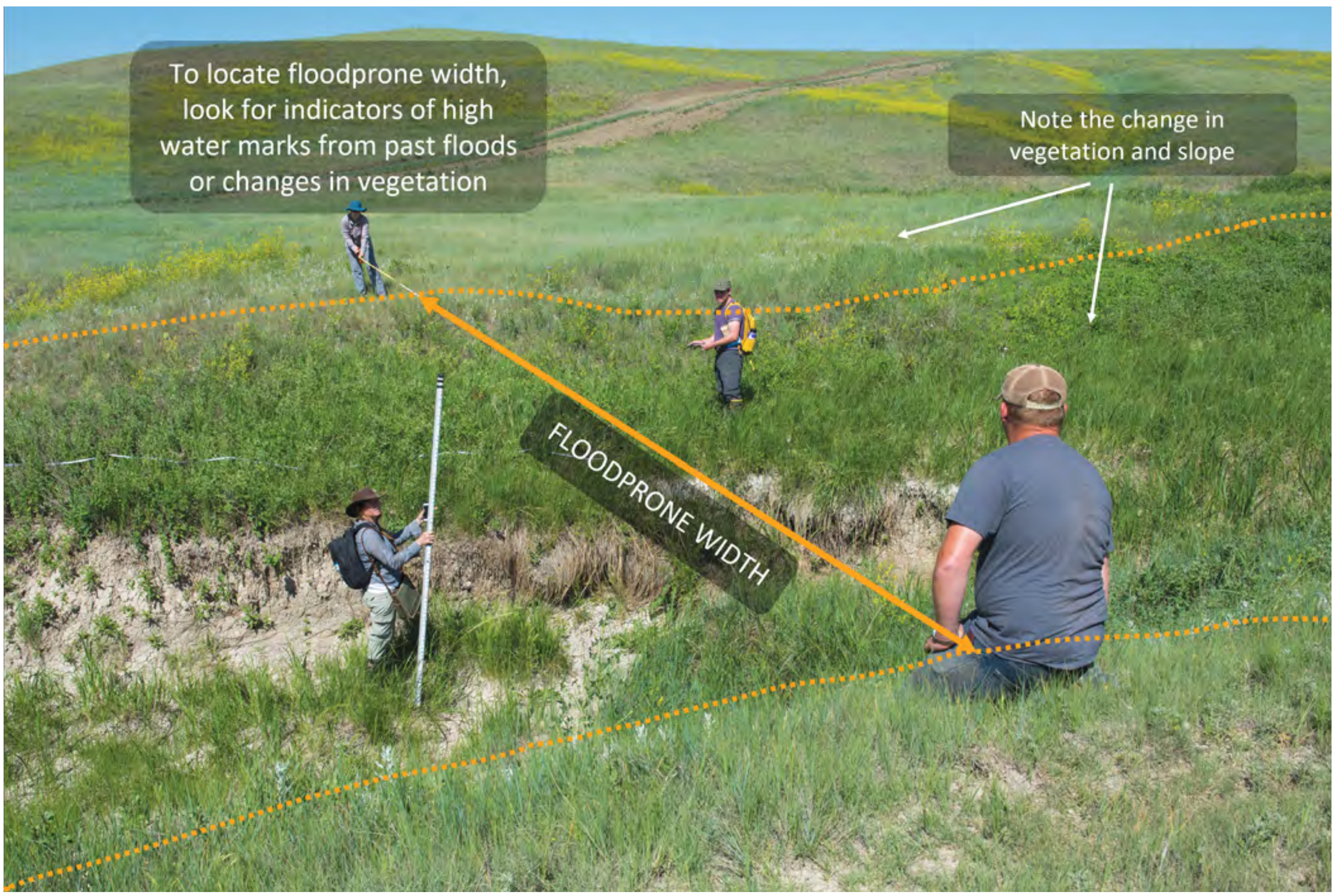


Figure 30: This image demonstrates how to locate and measure floodprone width, as described in Step 1 above. Photo © Nancy Johnson

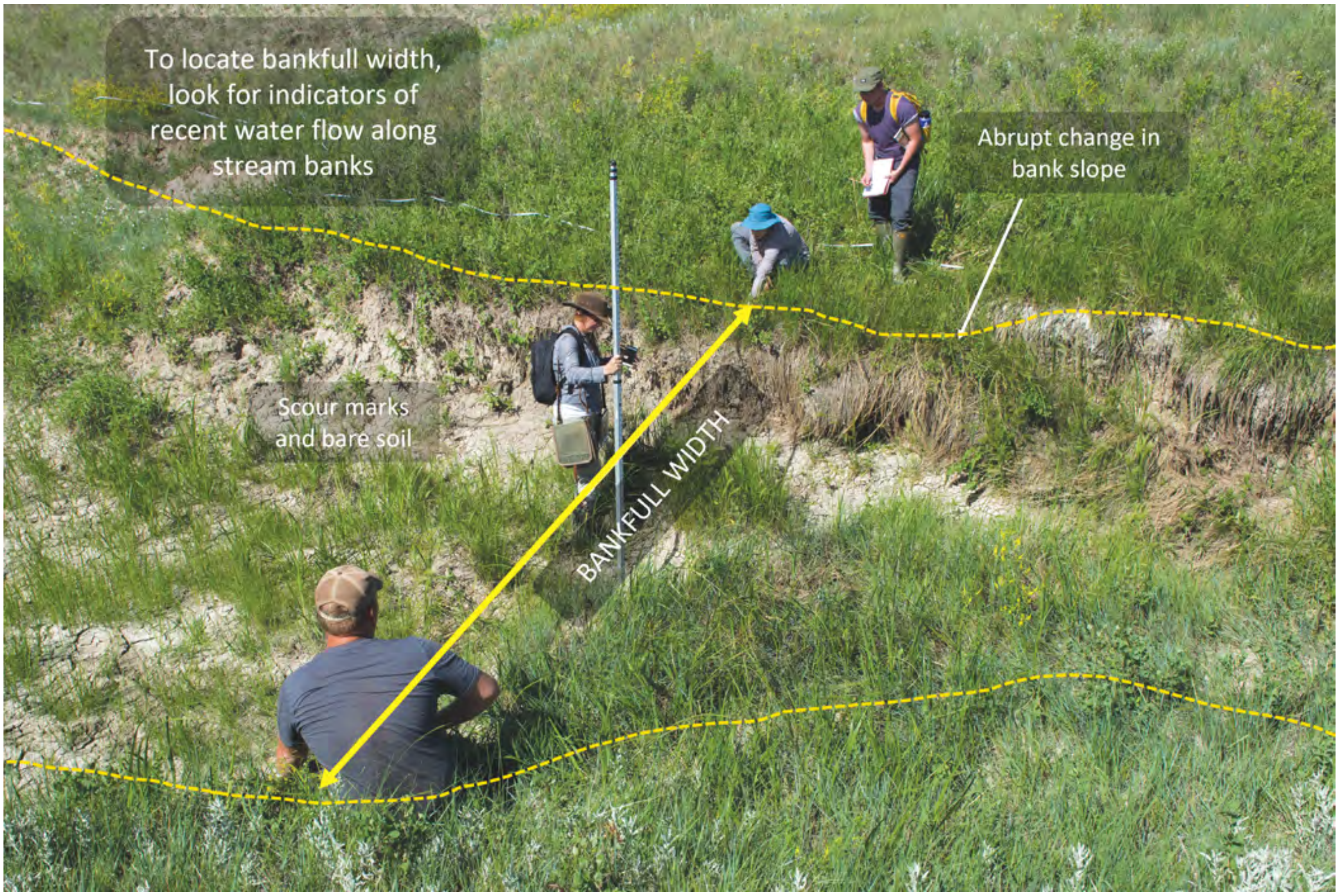
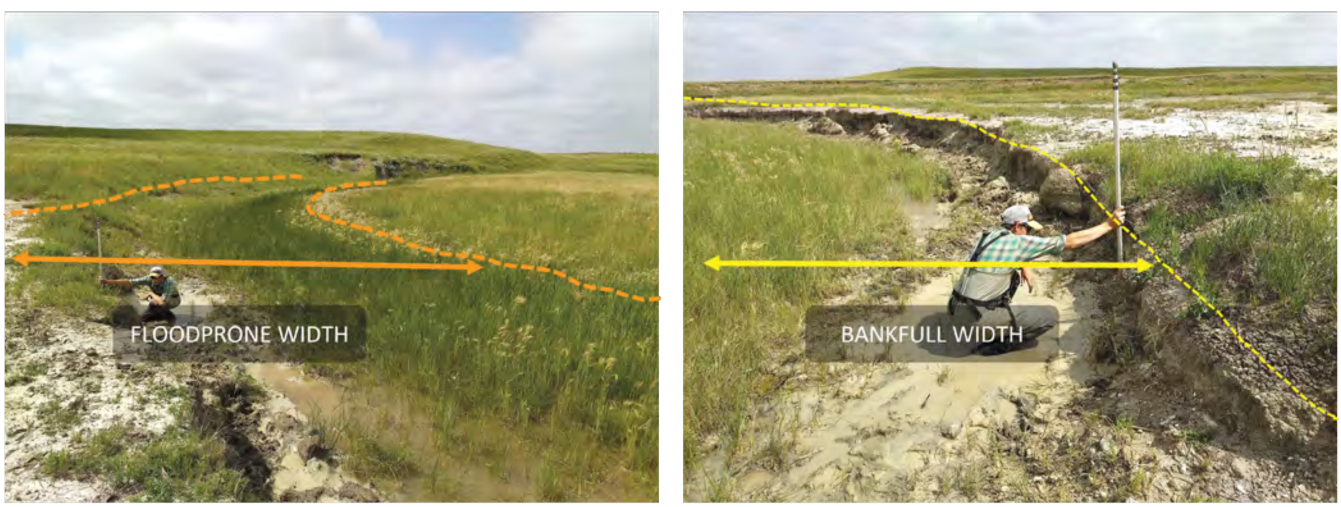


Figure 31: This image demonstrates how to locate and measure bankfull width, as described in Step 2 above. Photo © Nancy Johnson

Measuring Entrenchment Ratio



Step 1: Measure floodprone width

Step 2: Measure bankfull width

Step 3: Divide
floodprone width ÷ bankfull width = entrenchment ratio

Figure 32: Measure entrenchment ratio by following the three steps outlined above. Photos © Dave Stagliano, Montana Biological Survey.

Using these assessments, you can then choose which of the following options best describes the entrenchment of your stream.

- ❑ < 1.4 (highly entrenched)
- ❑ 1.4–2.2 (moderately entrenched)
- ❑ > 2.2 (not or only slightly entrenched)

Understanding How Stream Channels Change Over Time

Streams are naturally dynamic, alternating between dry periods and times of flood. **Channel evolution** is the natural process by which the landscape responds to these changing volumes of water flowing across it, trying to reach equilibrium between sediment load and erosion. The extent and rates of erosion and sedimentary processes vary greatly by region and stream type. Typically, streams that experience increased flow, direct channelization, or human alterations undergo accelerated change or evolution. Channel change often occurs in predictable patterns, as outlined by the channel evolution model shown in Figure 33. While channel erosion is a natural process, it can cause problems for ranchers and managers in western South Dakota by making pastures inaccessible due to high or unstable banks. It may also lower the water table in meadows, making them less productive, and threaten farm buildings and/or pastures located next to streams.

Positive change can also occur in channel evolution, however, through management interventions to reverse incision and help heal, restore, and rebuild stream beds toward connected states, as shown in Figure 33. Positive management interventions are discussed in the latter sections of this guide.

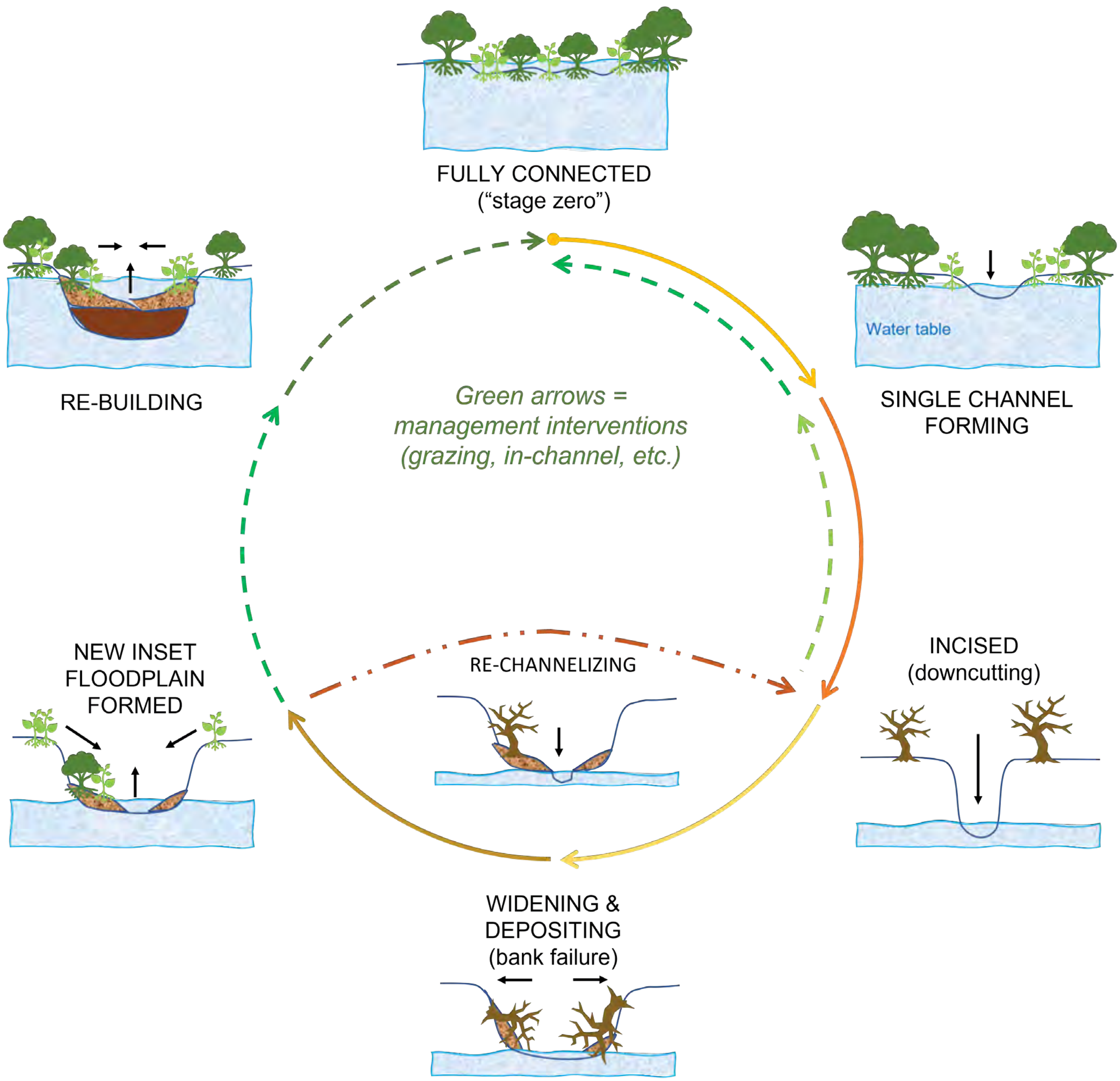


Figure 33: A stream may evolve through various processes. A healthy "stage zero" stream is highly connected with multiple or braided channels, if a channel is present at all. Streams in this stage may even be sheet flows of water over prairie meadows with no defined channel. Once a channel forms, the stream enters a cycle of evolution. If it further degrades, it will begin to incise or downcut. Over time, and with enough force, it will widen out and redeposit sediment into a new inset floodplain. Without management intervention, a stream can get stuck in a recurring bottom cycle: incising, widening, depositing, re-channelizing, and repeating. With positive management intervention, however, the stream can exit the incision stage and rebuild itself toward a connected stage; or it can go through the full evolution process and then begin rebuilding and reconnecting. Graphic © Corissa Busse, TNC

The Channel Evolution Cycle

Streams in a state of equilibrium tend to remain relatively stable with high levels of connection (or **anastomosis**). Heavy flows from rainfall easily spill out into the floodplain to reduce the stream's energy (or sheet flow over a meadow with no stream channel at all, for streams in "stage zero").

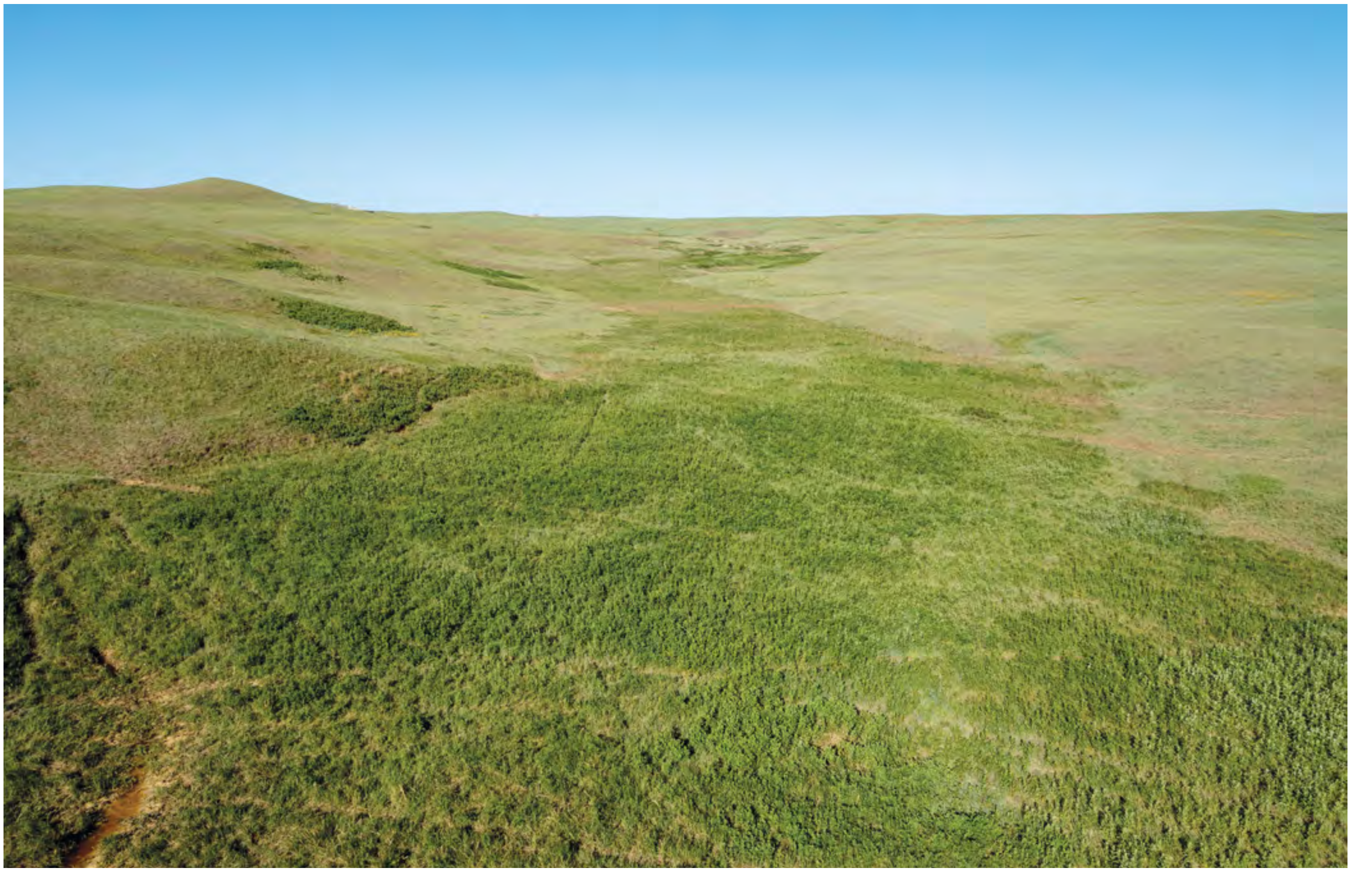


Figure 34: This stream bed has no defined channel and the stream is in a highly connected phase sometimes referred to as "stage zero." Photo © Joe Dickie, Generation Photography, Inc.

Many western South Dakota prairie streams are no longer in a highly connected "stage zero" phase. Instead, they have lost some amount of connectivity by consolidating waters into a defined channel. This single-channel stage can continue to have strong floodplain connection, however, and can be a relatively healthy status that supports strong riparian areas.

Figure 35: While this stream still has strong floodplain connectivity, it has gone through a phase of single-channel formation. All water flow now concentrates into this smaller channelized area, resulting in a narrower riparian zone. Photo © D. Stagliano, Montana Biological Survey

Once a stream experiences a knickpoint or headcut in the stream bed, however, the first effect of this altered flow is often cutting downward into the stream bed or incising, as depicted in the Incision phase of Figure 33. See Figure 14 for an image of a significant headcut and the resulting channel incision.

Also referred to as downcutting, **channel incision** reduces the connectivity of the channel to its floodplain (Schumm 1977; Schumm et al. 1984; Simon and Hupp 1986; Schumm 1999; Simon and Darby 1999). Channel incision can affect stream function, riparian plant community composition, and the wildlife that use those corridors. It also makes water less accessible to livestock and makes stream crossing more challenging, if not impossible, depending on the depth of incision. Incision typically makes the riparian area drier, as it lowers the water table in the land adjacent to the channel. This results in a loss of the lush green productive areas along streams that are valuable for grazing forage. Trees that had been present in these areas often die off due to the lower water table that is no longer accessible to their root systems.

Figure 36: This stream is going through a phase of incision or downcutting and separation from its historic floodplain. Photo © Kristen Blann, TNC

Certain levels of channel incision are possible to heal using low-cost, low-tech solutions or alternative grazing management, as described in section 10 of this guide. This is also reflected by the green dotted arrows reversing the direction of the cycle in Figure 33. However, once incision reaches a certain level of intensity, it is typically followed by a phase of channel widening and depositing as the banks fall into the stream. This is a natural phase that streams go through after reaching a certain level of incision to heal and find a new equilibrium. You may have heard the phrase "It's going to get worse before it gets better." This phrase seems to reflect the look or feel of bank failure as a stream progresses into the widening stage.

Figure 37: This stream has entered a phase of widening and depositing. The steep banks are collapsing into the stream and depositing sediment to restore diversity to the inset channel. Photo © Kristen Blann, TNC

This bank failure is critical to create a new floodplain to which the stream can reconnect and helps dissipate and spread out flows in high-energy events, preventing further incision.

Once the widening stage has caused bank failure, the stream begins a phase of depositing eroded material into features that “aggrade” or rebuild stream diversity. Eventually, this results in a new inset floodplain forming. The stream uses this lower, inset floodplain going forward while working to rebuild connectivity.

Figure 38: This stream has formed a new inset floodplain. The historic floodplain now stands high above the current channel as a terrace. Photo © Corissa Busse, TNC

No stage in the model is completely stable or static, however. If negative disturbance forms new headcuts, the inset floodplain of a stream can once again degrade. The stream will repeat the cycle of rechannelizing, incision, widening, and depositing—this time at an even lower level separated farther from both the historic and new inset floodplains. If this cycle continues to occur, the water table will be severely depleted from the area and a deep gully may form over time. However, with positive management interventions, a stream can potentially enter a phase of rebuilding in which the stream channel will close back in. This rebuilding can occur both laterally (the stream bed will build back and trap sediment from the bottom up), and horizontally (lush vegetation on the sides of the stream can create biomass that rebuilds soil from the sides). This phase of rebuilding may even achieve a new connected state with time.

As the stream progresses through the stages in the stream (channel) evolution model, the riparian and aquatic vegetation communities change as well. Many of the aquatic and emergent plant communities are reduced during the active degradation (incision) and widening phases due to drying of the floodplain. Decreasing water table depth is linked with dryer (xeric) plant communities, while higher water tables are linked with wet meadow or hydrophytic vegetation (Loheide and Gorelick 2007). The water table depth has important consequences for management. Typically, wet meadow vegetation is more productive and provides better forage for grazing animals (Smika et al. 1965; Silverman et al. 2018). In contrast, streams that are deeply entrenched may be challenging and costly to recover, negatively impacting a manager’s ability to use the stream as a water and forage source for livestock.

It can take hundreds to thousands of years for a stream to go through the full evolution process. In the management section, we will talk about possibilities and ways to “expedite” this process toward healing.

Section 5: Riparian Vegetation and Complexes

Understanding and managing riparian vegetation is one of the most important practices that can improve overall stream health. This section will describe the various types of plant communities found in different portions and complexes of riparian areas.

Strengths of Riparian Vegetation

In the humid regions of the United States, riparian areas are usually forested. However, in the NGP prairie region, grasses and forbs cover most of the riparian areas. The type of vegetation plays a key role in stream and floodplain ecosystem function. Due to their extensive root systems, riparian plants work to stabilize soils, absorb and recycle nutrients, add organic matter, and reduce flood energy. Riparian plants are often highly adapted to changing flows of water—especially the force of floods—and can bend and sway more easily to this pressure, while capturing sediment and debris. Willow branches, for instance, are very flexible and nimble and make great weaving material as a result. Many of these woody species also do well when grown from cuttings—an indicator of their historic relationship with beaver, which would clip branches of these plants and use them in dams from which rows of willow or cottonwood would later grow.

Figure 39: Healthy riparian areas are complex and may appear "messy." The strong root systems, fibrous plants, and dense stands of biomass help to slow and hold water, catch debris (as shown in the left of this photo), and prevent erosion during high-flow rain and flood events. This enhances habitat diversity and builds resilience for the stream and surrounding landscape. Photo © Joe Dickie, Generation Photography, Inc.

Riparian vegetation also provides shade and cover both for wildlife and livestock. In hot summer months, this shade can help cool streams and provide more consistent temperatures and higher oxygen levels for fish species. In winter months, dense riparian vegetation can provide valuable cover, windbreaks, and shelter for livestock and wildlife alike.

Riparian areas are also known to be highly productive areas. Some riparian plants are excellent forage for livestock and wildlife, while others may be undesirable or invasive species. Management practices like haying, grazing, and prescribed fire can greatly influence and alter these communities. Understanding the dynamics of the system will allow you to manage for desired species more effectively. Section 10 of this guide describes different grazing management techniques for a variety of riparian conditions.

How Water Affects Riparian Vegetation

The fluctuation of water levels due to changes in precipitation or evaporation is the primary driving force behind the species composition and structure of riparian and wetland ecosystems. Some riparian plants cannot survive without consistent water supplies, while others are highly adaptive and flexible. As such, plant species found in riparian areas can tell you a lot about how much water is available at a site, and for how long.

Different plant community types that can be found in and along riparian areas include the following:

- Upland dry short to mixed grass prairie (western wheatgrass, blue grama)
- Upland dry shrubs (sagebrush, snowberry, buffaloberry)
- Woody riparian draw with trees and shrubs (willow, bur oak, green ash)
- Riparian forest (cottonwood, willow, boxelder)
- Wet land/wet meadow (prairie cordgrass, sedges)
- Aquatic (emergent, submergent)

Appendix B of this guide lists common riparian plant species. You can use this collection of plant species in the field to identify species found along riparian areas, and to understand what they are telling you about the site's condition.

It is important to understand the role of both hydrology and how landforms affect water flow and availability. Riparian vegetation is strongly influenced by landform, **valley** type, and **channel morphology** (i.e., the shape of the channel); these factors strongly influence both annual and seasonal water availability as well as the substrate and nutrients that plants receive. For instance, landforms with strong slopes, such as hillsides, drain water quickly and have long dry periods. Conversely, low-lying areas collect and pool water from the landscape, creating long wet periods. The water that drains from upland areas through the water table will also exit into streams or adjacent areas through seeps or springs for prolonged periods, well after rain has fallen. Just as the topography of any area is complex, so too are plant communities and compositions. These factors combine to produce dynamic and unique plant communities, the composition of which can change across different zones of the riparian area. This is detailed further in the description of riparian complexes later in this section.

Fluctuating water levels can increase the amount of open water and bare soils present during a growing season (LaBaugh et al. 1998). Open water generally increases immediately following a precipitation event. As water runs off, discharges, or evaporates from the site, a drawdown phase may occur that exposes bare soil and leads to opportunistic species colonizing or recolonizing portions of the wetland. Water depths and related stages of cover distribution often change drastically from year to year and season to season, due to these fluctuating water levels (Stewart and Kantrud 1971). The fluctuation may also influence the amounts and types of vegetation zones over time; for example, a stream could develop a moister vegetation zone during a period of above-average precipitation or lose a vegetation zone during a time of below-average precipitation.

Some plants are only adapted to certain soil moisture or texture conditions; others can grow in a range of conditions from wet to dry and are often opportunistic pioneer species that grow in recently disturbed or scoured areas. Many of these are considered "weedy" or undesirable species (e.g., cocklebur, foxtail barley, common plantain). However, they can play a role in helping a site recover from disturbance. Many of these pioneer species are as likely to be found on disturbed upland sites as on mudflats or shorelines. Other plant species, such as big bluestem, sunflower, western wheatgrass, and common yarrow, are not pioneering but still capable of growing in a variety of moisture regimes. These species grow in wet meadows and mesic places, as well as in upland habitats. Species found in riparian zones may range from true aquatic plants to upland species (see plant guide in Appendix B for a list of species according to moisture regime).

Trees vs. No Trees

Trees can occur naturally wherever there is sufficient moisture, protection from wildfire, low grazing pressure, and/or sufficient soil fertility. For example, most of the eastern United States supports forests, as it has higher rainfall and lower fire frequency than the West. In contrast, grasslands cover most of the Great Plains, where annual rainfall is < 20 inches.

Whether, where, and which species of trees belong in prairie grassland systems have long been debated among scientists and nonscientists. European explorers and settlers in the 19th century described the landscape west of the Missouri as a vast expanse of treeless prairie. They mostly attributed the lack of trees to fire and grazing by bison and other wildlife. However, they also described extensive bottomland forests along the larger prairie rivers and Missouri tributaries, as well as thickets of native trees and shrubs, such as chokecherry and wild plum, in the buttes and woody draws. Many of these bottomland forests, or gallery forests, were cut down for firewood and construction materials.

Today, most ecologists agree that the amount of woody cover (including shrubs and trees) has probably increased in the upland grassland areas but has decreased in the riparian areas and floodplains (Dixon et al. 2010). While western South Dakota is primarily grassland, there is significant coverage of trees in riparian areas where there is enough moisture and bare soil to support the establishment of willows and cottonwoods. Riparian forests and shrubs are common along the larger rivers, such as the Moreau, White, Bad, and Cheyenne. In addition to cottonwood and willows in the wetter zones, trees and shrubs, including green ash, boxelder, chokecherry, and hackberry, are common along the mid-size prairie streams in areas protected from fire and grazing. Trees and shrubs are also common along woody draws, where drier, upland species, such as snowberry and eastern red cedar (as well as Rocky Mountain juniper), can become established and thrive. These sites are shady and protected from wind, reducing water losses to evapotranspiration, as well as being under less grazing pressure.

Figure 40: Dry species like sagebrush do not like having their roots wet and are an indicator that an area is not frequently flooded, whereas willow require wet soil conditions. Photo © Joe Dickie, Generation Photography, Inc.

Perennial native prairie grasses and forbs dominate the vegetative cover in most small intermittent and perennial streams in western South Dakota. However, woody plants (trees and shrubs) also play an important role along rivers and streams. Many mid-sized streams support patches of cottonwood, green ash, boxelder, and/or willow, particularly along sandbars or active floodplains. The wetter margins in and along the stream typically support vegetation associated with wetlands (e.g., bulrushes, spikerush) in ponded areas. Prairie cordgrass often dominates in ephemeral swales. It can also be found along the mesic edges of perennial and intermittent streams in soils that are moist but not completely saturated, such as intermittent streams with the water table near the surface. Dry prairie communities often dominate high banks and terraces, which are not frequently flooded (such as sagebrush). The areas in between (5–100-year floodplains) are often on gradually sloping narrow valley bottoms, featuring shrubs and a variety of wet and dry prairie species.

In areas where moisture is ephemeral and is frequently lost to evapotranspiration, such as along the margins of these intermittent and ephemeral swales, saline conditions can be created by the accumulation of salts as water is lost to the atmosphere. Salt-tolerant plants such as foxtail barley and inland saltgrass indicate that a saline environment is present. When saline content is higher, it may prevent plant growth.

In highly incised or entrenched channel types, the riparian area may be dominated by upland species, a sign that the water table is well below the ground surface most of the time.

Wetland Indicator Status

> Riparian vegetation helps to stabilize soils, improve water infiltration, dissipate flood energy, and provide forage and wildlife habitat. Understanding the dynamics of the plant community helps managers see whether they are moving toward or away from their management goals.

Characterizing plants according to their moisture needs is a strategy for identifying and classifying wetlands. Plant species are assigned a wetland indicator status that describes how flexible versus specialized they are with respect to certain moisture conditions. The wetland indicator status is often described in plant guides using one of the following acronyms: OBL, FACW, FAC, FACU, or UPL (see below for definitions). The indicator status is widely used in wetland delineation and is a valuable tool in understanding the hydrologic characteristics of a site. Looking at a plant community is an easy and common way to evaluate the overall health of a site. Some species tolerate only a narrow range of growing conditions, so their presence signals some distinctive aspect of that place.

- **Obligate wetland (OBL)** plant species almost always occur in wetlands under natural conditions and are strong indicators of wet soil conditions during the growing season. OBL plants include the common cattail and many species of bulrush.
- **Facultative wetland (FACW)** plant species usually occur in wetlands (> 2/3 of the time) but are also occasionally found in non-wetlands (up to 1/3 of the time). FACW plants include several willow species and prairie cordgrass.
- **Facultative (FAC)** plant species are equally likely to occur in wetlands and non-wetlands. They include trees such as green ash and cottonwood.
- **Facultative upland (FACU)** plant species usually occur in non-wetlands (estimated 67%–99% of the time) but are occasionally found in wetlands (estimated 1%–33% of the time). They include common sunflower and big bluestem.
- **Obligate upland (UPL)** plant species almost always occur in non-wetlands under natural conditions. UPL plants include big sagebrush and blue grama.

In addition, plants that inhabit wet meadows, shores, exposed mudflats, and other marginal habitat that is saturated for only part of the growing season may be either obligate or facultative species. It is important to note that indicator status can vary based on geographic region. For example, a species that is facultative in eastern South Dakota may be an obligate wetland species in western South Dakota. More information on riparian plants, their habitats, and wetland indicator status can be found in Appendix B.

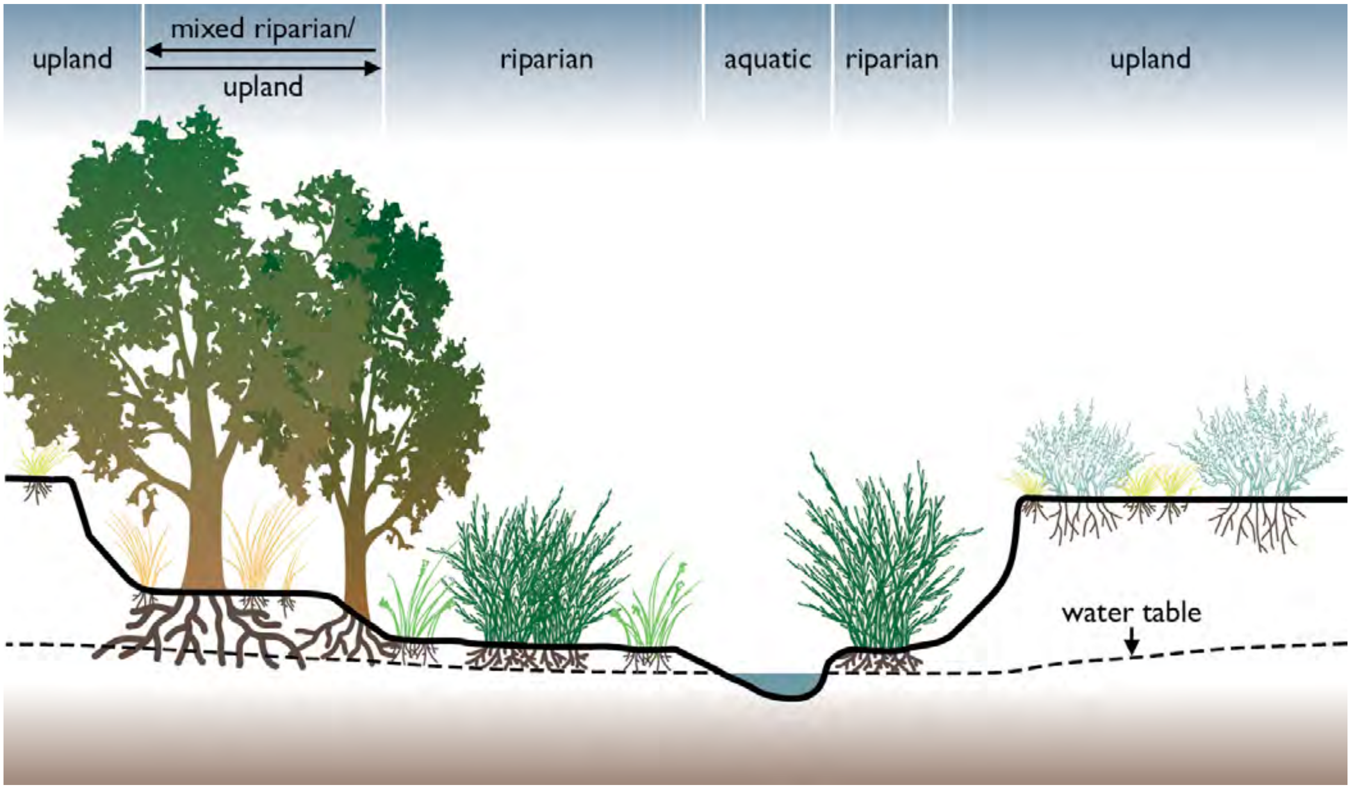


Figure 41: A riparian area is the transition from the aquatic part of the landscape to the upland area. In the landscape pictured, an assessment of riparian function would consider the aquatic area, riparian areas, and mixed riparian/upland area. Not all riparian areas have all these features, and the width of each zone can vary depending on how deeply the stream has downcut into its valley (see previous section on riparian site dynamics). [Source: Dickard et al. 2015; Department of Interior, Bureau of Land Management, Technical Reference 1737-15.]

Putting It All Together: Riparian Complex Ecological Sites

Riparian sites are highly varied and dynamic. Riparian complexes include many factors that come together to affect a site. These factors include the way water flows in and through the landscape (above and below ground). These vary greatly from one landscape to another, from one section of a stream to another, and even from year to year based on moisture availability.

Every riparian site is highly varied and dynamic. A riparian area for one stream will look very different from that of another stream in a different landscape (for instance, streams in northwest South Dakota look and act differently from those closer to the Missouri River breaks). A riparian area may even look different from another riparian area a few feet away on the same stream. And each of those areas may look different from one year to the next, depending on how much water is available.

A riparian complex is a way of describing the unique ecosystem that results from biotic and abiotic factors that come together along a stream and its riparian area. The landscape surfaces and plant communities in a riparian complex are a result of geomorphology and hydrologic processes (sometimes combined in the term **"hydrogeomorphic"** processes), as discussed in the previous sections. Thus, a riparian complex is created by several unique factors affecting the site:

- geomorphology (or stream and valley type)
- stream gradient
- substrates or stream bed material
- fluvial surfaces
- vegetation patterns

These factors vary across western South Dakota due to differences in geology, soils, water, climate, and topography. Each of these differences may be described, characterized, and classified to better understand the unique set of factors present at a specific site.

Landscape Setting Review

- **Major Land Resource Areas (MLRAs)** provide the context and physical setting, describing landscape, climate, soils, and geomorphology.
- **Valley types and stream types** are characterized by the shape, gradient, width, side-slope gradient, and aspect of each landform.
- **Fluvial surfaces** (also called water flow features) within stream valleys feature particular soil and hydrological characteristics that influence the plant communities across the riparian zone.

The concept of a riparian complex allows us to combine valley types and channel types into a unit to describe, inventory, and manage riparian ecosystems. **Riparian Complex Ecological Sites (RCES)** combine the valley type and stream channel classifications noted in the box to the right with the concept of riparian complexes (Stringham and Repp 2010). A recent guide to RCES developed by North Dakota State University used this approach to describe small northern prairie-region stream types that are very similar to those in western South Dakota. In fact, South Dakota and North Dakota share many MLRAs (Meehan et al. 2016).

RCES can be composed of many different plant communities, fluvial surfaces, and hydrologic regimes. A RCES may be a mosaic of **lentic** (ponds, marshes, and lakes) and **lotic** (streams and rivers) features, as well as landforms and surfaces, each with distinct plant communities reflecting the hydrogeomorphology of that smaller area within the mosaic.

Different zones of a stream valley are prone to flooding at different frequencies based on the distance of the zone from the stream and the elevation of the fluvial surfaces. The **overbank zone** is frequently flooded, whereas the **floodprone elevation** is the height at which less frequent floods occur (e.g., the approximate 50-year **recurrence interval** flows) (Rosgen 1994). (See also previous section on riparian site dynamics.)

Depending on valley type and stream channel hydrology, multiple fluvial surfaces may occur within the basin. These gradients of fluvial surfaces, soil, and hydrological features are associated with different plant communities (Stringham and Repp 2010). Distinct plant communities are associated with alluvial bars, streambanks, floodplains, overflow channels, and terraces.

The fluctuation in water levels resulting from changes in precipitation or evaporation is a primary disturbance influencing the species composition and structure of different zones within an RCES. Fluctuating water levels can increase the amount of open water and bare soils that are present during a growing season. Variable hydrology across the riparian zone may be identified by different amounts and arrangements of vegetation types. The composition and extent of each of these zones may vary from year to year, depending on whether it is wetter or drier than average in terms of precipitation.

Ultimately, it is important to remember that when evaluating a riparian site, the more complex it is, the better. A healthy riparian site will appear “messy” and complicated, with unique features and plant communities that change from one stream section to another, and even with a few feet of each other on the same stream. There is no cookie-cutter riparian area. Each has its own features and form. These features might also change from year to year, as well as season to season. Like a mosaic, each piece of a riparian complex plays a role and is affected by the pieces and influences that surround it, as shown in Figure 42.

Figure 42: This patchwork or mosaic of different vegetation and riparian features together form a riparian ecological site complex. Each pocket of plant communities is created by the unique factors that surround it, such as topography, landform, and presence of springs. Together, these factors affect how much water a site receives and what vegetation will grow as a result. Photo © Joe Dickie, Generation Photography, Inc.

Ranchers Build Soil and Repair Riparian Areas

> *"The right plan and execution, using nature and small grazing cells, can turn overgrazed and eroded ground into healthy soil and highly productive grass."*

"In 2007, we bought one of the ugliest pieces of real estate in western South Dakota," says rancher Al Wind. "Fourteen years later, our planning and hard work have turned seven pastures into a 31-pasture, specialized rest and rotation system that has increased grass production 350% and hayfield production by 250%."

Such impressive results, achieved by Al and his wife Simone on their 3,400-acre ranch in Butte County, South Dakota, began with a detailed management plan. They based their plan on their experience with a ranch in Montana and on a research report that detailed the accomplishments of the local Mortenson Ranch 30 years earlier.

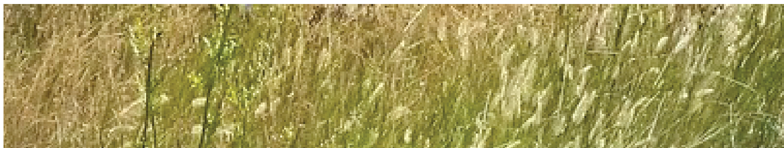
"We searched far and wide for a model to help us restore this ranch, using nature-based management to improve soil health, bring back native species, and reclaim our riparian areas. This model works, and it isn't talked about enough," Al says.

Back in 2008, few people believed that the couple could make pastures as small as 100 acres or even 200 acres work. "Everyone told us this wouldn't work in West River," Simone says. Fortunately, range specialist Matt Stoltenberg, with Belle Fourche River Watershed Partnership, believed in their vision. He worked with the Winds to conduct a range inventory and help fund some fencing needs, along with South Dakota Game, Fish, and Parks.

Eventually, the Winds learned that even a 100-acre pasture was too big, so they cut that acreage in half, and then in thirds. They learned that a shorter grazing period and longer recovery period was better for plant and soil health.

"Our initial goal was to figure out what plants would have been here, what should be here, and how to bring them

Al & Simone Wind, ranchers
Butte County, SD



back in a natural way. We wanted to create conditions where plants could express themselves with the help of livestock, instead of introducing them through seeding and planting using tractors and implements," Al says. "We faced an uphill battle, as 60% of the rangeland was moderately to severely overgrazed, and the trees and vegetation in the riparian areas were gone."

Reawakening riparian areas

Wind Ranch has two intermittent creeks running through it, sections of Butte and Jug Creeks. The 2007 inventory described a decimated area with excessive bank erosion and deep channels that dropped the water table. There were no woody species along the banks, and there was no vegetation in the creek bed.

A critical component of their plan that helped it succeed was establishing different goals and tactics for their range and riparian areas. The riparian goals included the following:

1. Maintain approximately 200 acres of riparian pasture for annual native hay production.
2. Rotate hay production on a rest-and-rotation basis through the approximately 550 available acres to improve pasture health and minimize the impact of hay production on wildlife.
3. Improve pasture conditions by improving the quality and quantity of native grasses.
4. Avoid overuse of riparian areas by livestock while improving riparian health.
5. Encourage trees and shrubs to return to riparian areas.
6. Change the depth of the stream channel back to a shallow meander. Decrease the speed of the flow to encourage more frequent and gentler flooding. Decrease erosion of the stream channel and raise the water table.
7. Increase the diversity of wildlife habitat and encourage riparian animals to expand their ranges.
8. Allow wildlife to move from range to riparian habitats.

"A range scientist at South Dakota State University told us that most seeds of plant species exist in the soil, even after they've been missing for 25 to 50 years. You just need to create the right conditions for them to reappear. And that re-emergence is exactly what happened after about eight to 10 years of controlling our grazing and using our rest/rotation system," Al says.

One day, he called up the SDSU range specialist to joyously proclaim the return of western snowberry. "He wanted to know how many plants we saw, and I told him there's so many in an area that's the size of our house! He was amazed, and we were excited that the riparian area had reached a level of health where long-dormant species were expressing themselves. And we didn't just see sprouts of 25 willows or a few sprigs of rose bushes—our work with nature developed a willow field that stretched hundreds of yards along the streambank and rose bushes in areas the size of a truck."

Protecting the creeks

By separating the upland pastures from the riparian areas using permanent and temporary fencing, the Winds controlled grazing and haying based on the needs of different riparian areas. "We came up with different ways—from limited cattle exposure to late-season haying and hay/graze/rest rotations—to utilize the areas that were in recovery, versus areas slower to recover, versus heavily impacted riparian areas. Then the creek heals itself," Al explains.

"It was basically the rest period that let these plants express themselves," Simone adds. "You just have to keep the cattle off of it during the right time periods."

Not only did plants reappear, but so did the wildlife. The Wind Ranch management plan included monitoring and evaluation techniques that were more in-depth than the Audubon Society's bird-friendly grazing plan, which led them to become an Audubon-certified ranch.

"For us, the best benefit was the audit by Audubon, because we wanted the results we were seeing to be backed up by an outside observer. There are a lot of gurus out there preaching things that are not backed by results. We wanted to open up our ranch for inspection, and Audubon offered the only program to provide that service," Al says.

The Wind Ranch management plan also listed all the animals that should be present in a healthy riparian area. "Within six years of instituting our plan, beavers began showing up in the creek after a 20-year absence," Al says. "Initially, they moved out until the riparian area healed enough to provide the habitat, they needed to sustain themselves. Now beavers and muskrats build check dams to help slow the water and raise the water table that sustains the natural vegetation."

The Winds' restoration efforts over the last 14 years are nothing short of remarkable. "Our plan—given time, patience, hard work, and a lot of passion—has proven that a holistic conservation-based grazing system gets you the most production possible from your land," Al says. "Economically, it's one of the most viable things you can do, and it has helped us grow about two to three times more grass than most ranches in Butte County."

Figure 1. After changing their grazing management, the Winds saw dramatic changes to their riparian vegetation. Here, Simone is seen standing in an area where prairie cord grass has returned. Photo: © Simone Wind

Figure 2. Al and Simone Wind use photo monitoring to assess the health of their streams. Here a before photo taken in 2008 looking south from a confluence of streams on the ranch. Photo: © Simone Wind

Figure 3. Al and Simone Wind use photo monitoring to assess the health of their streams. Here an after photo taken ten years later in 2018, looking south from the same confluence of streams on the ranch. Photo: © Simone Wind

Figure 4. With changes to grazing timing and duration, the stream and riparian areas regained healthy with many species of grasses and trees restoring to the area. Eventually beaver also returned to the Wind's ranch. Photo: © Simone Wind

Figure 5. The Winds manage cattle grazing along stream areas by creating riparian pastures to allow for short duration, high-intensity grazing. Photo © Joe Dickie, Generation Photography, Inc.

Figure 6. Because of the restored access of their stream to a wide valley bottom, the Wind Ranch has created a system with a healthy green belt (the darker green vegetation), indicative of the soil storing and holding moisture. Photo: Corissa Busse, TNC

Figure 7. The Wind Ranch has restored access of their stream to a wide valley bottom, increasing vegetation and productivity throughout the area. Photo: Corissa Busse, TNC

Section 6: Understanding Western South Dakota Stream Types and Why We Classify Streams

Streams are dynamic and complex. They don't fit nicely into perfect boxes and are prone to change. So why put them into categories or types at all? This section describes why we classify (or identify and group) streams into types.

Classification is a process of putting similar items into groups or classes based on shared qualities and characteristics. As noted, streams are complex, with many factors influencing their health and behavior. Stream classification helps to organize these complex ecosystems into a reduced number of types. By simplifying streams into categories or types, we can then help to define reference (or healthy) conditions, understand similarities and differences in stream response or behavior, and help landowners and managers make management decisions that are based on feasible, appropriate, and achievable goals. Classification can help identify and draw out these shared challenges, strengths, and responses between different stream sites and help us further learn from the way that streams respond to different management scenarios.

There are many ways to classify streams. Classifications are typically based on physical and ecological characteristics, such as hydrology and flow, drainage area, **stream order** (a measure of the relative position of a stream in a watershed; the smallest tributaries are referred to as first-order streams), flow regime, and geomorphology (interaction of landscape, landform, and flow regime to shape the channel, channel size and/or channel materials, soil type, or geologic traits). Ecological classifications attempt to integrate many of these concepts to describe plant or animal communities in relation to their underlying hydrogeomorphology.

Ecological Site Descriptions (ESDs)

Ecological Site Descriptions are a tool that the USDA NRCS uses to describe and understand the potential of a site based on its soil type, topography, and plant communities. These descriptions can help a land manager understand how a site responds to a variety of disturbances over time; this process of change is also described in "state and transition models." ESDs can be very helpful during site assessment because they show how a site compares with others that have similar characteristics or are within the same landscape.

ESDs and their previous iteration, range sites, have provided ecological perspectives and guided rangeland management for more than 60 years (NRCS National Instructions 2015). Recent guidance recognizes that riparian ecological sites require a slightly different approach than upland or wetland ESDs. Site characteristics such as climate, landscape position, and soil features in the latter remain relatively stable over time. In contrast, water continually reshapes the landscape in riparian systems (Stringham and Repp 2010).

The following are the most common ESDs used to describe riparian areas in western South Dakota and beyond.

- *Wet lands* and *wet meadows*: These sites have poor water drainage with accumulated clay and silt and long periods of flooding or ponding. The increase in surface and groundwater makes these sites resistant to drought and critical for watershed function. The soil remains very moist throughout most of the growing season, resulting in distinct wetland plant communities. These sites are dynamic but often very stable and can recover quickly under favorable management.
- *Sub-irrigated* and *overflow sites*, also referred to as mesic areas: These sites range from poorly drained to moderately well drained and typically have adequate soil moisture to meet plant needs during the growing season. However, they can dry out during periods of extended drought. They can be very sensitive yet resilient features on the landscape, and under appropriate management are very stable. Degraded plant communities often become invaded with exotic cool-season grasses, such as Kentucky bluegrass and/or smooth bromegrass, which reduce biotic integrity.

Riverine Sites and Western South Dakota Wetlands

Another method used to classify western South Dakota streams and their adjacent habitat is called wetland delineation.

For centuries, wetlands have been a poorly understood and undervalued resource on the landscape. As a result, many have been drained, degraded, or lost over time. In the 1960s, Western science realized this loss and began working to better understand and protect these features. There was an effort to delineate (or define) wetland types (Cowardin et al. 1979). However, wetland sites are inherently complex and tricky to define. There are many types of wetlands in all types of landscapes.

East River and West River South Dakota each have unique wetland features. As noted earlier in this guide, in eastern South Dakota, glaciation smoothed the landscape and left pockets for prairie potholes and ponds to form as the dominant wetlands. In comparison, West River was not glaciated during the last ice age and has a very different and more rugged topography, with a network of streams and creeks. The vast majority of hydrogeomorphic wetland types found in western South Dakota are therefore associated with these streams or rivers (even ephemeral and intermittent systems) and are known as riverine sites.

Riverine sites are the technical term used to define western South Dakota wetlands and refer to all areas potentially impacted by stream flow. They include the active stream channel and the adjacent floodplain accessed when the stream overflows its banks. They also include areas impacted by water flowing below the ground's surface and shallow groundwater associated with the stream. Sources of water in riverine sites include runoff and subsurface flow from adjacent uplands, **tributary inflow**, and precipitation. (See Figure 10 in the previous section for examples of how water flows in a landscape.)

At the headwaters of the streams, the landscape may transition to **slope** or **depressional wetlands** where the channel morphology may disappear, and the land may become poorly drained flats or uplands that can hold water for periods of time. Depressional wetlands that hold water for longer periods are not common but do occur in West River.

Western South Dakota Stream Types Used in This Guide

In this guide, we break down western South Dakota streams into four broad categories:

1. Headwater streams and wet meadows
2. Steep woody draws
3. Mid-size prairie streams
4. Low-gradient prairie rivers

These types are based on three primary factors that are unlikely to alter or change within the next several generations:

- Watershed position of the stream
- Size of drainage area
- Slope of the channel

The following sections of this guide describe these stream types in more detail. Section 7 describes how to identify your stream type using a series of "reading the landscape" questions. Section 8 describes each stream type and its common characteristics and challenges. Later sections of the guide discuss ways to manage toward stream health.

It is important to remember that all streams are capable of enormous change and potential, and we are still learning much about what western South Dakota streams could or "should" look like in their healthiest states. Due to hundreds of years of alteration, reference (or ideal) conditions are unknown for most prairie streams. Instead of looking to restore an unknown historic potential, or to manage toward a limited potential we might anticipate from current stream conditions, we strongly recommend managing for continuous improvement. Western South Dakota streams might surprise us in the future as we continue to heal them and learn more from what they have to show us.

Section 7: Determining Your Stream Type

There are four main categories or types of streams in western South Dakota: headwater streams and wet meadows, steep woody draws, mid-size prairie streams, and low-gradient prairie rivers. These four types are discussed in greater detail in section 8, along with general trends and characteristics that are common to each type. Most rivers exhibit all or most of these types somewhere along their course as they make their way to the Missouri River. The following questions will help you narrow down the likely stream type that you are working with at the given reach (or portion of stream) by helping you to "read the landscape."

Where Is Your Stream Located in its Watershed?

Why this matters: Streams high in the watershed are generally smaller and have less permanent flow. They generally serve as a source of sediment, which is eroded and carried downstream, depositing in depressions and floodplains along the way. In comparison, streams that are lower in the watershed receive more water from above them, as well as sediment, which results in more permanent flow and deposition.

The following graphic describes the concept of a stream order. High in the watershed, a first-order stream begins. Small, low-flowing, first-order streams come together to form larger second-order streams (where two streams come together). These second-order streams have more water volume, but still are not high-flowing. Third-order streams and above are where multiple second-order streams, and all of the waters above them, continue to converge and form much larger systems with more water flow. As streams continue to converge and drain larger areas of the watershed, the stream order number becomes larger, as shown in Figure 43.

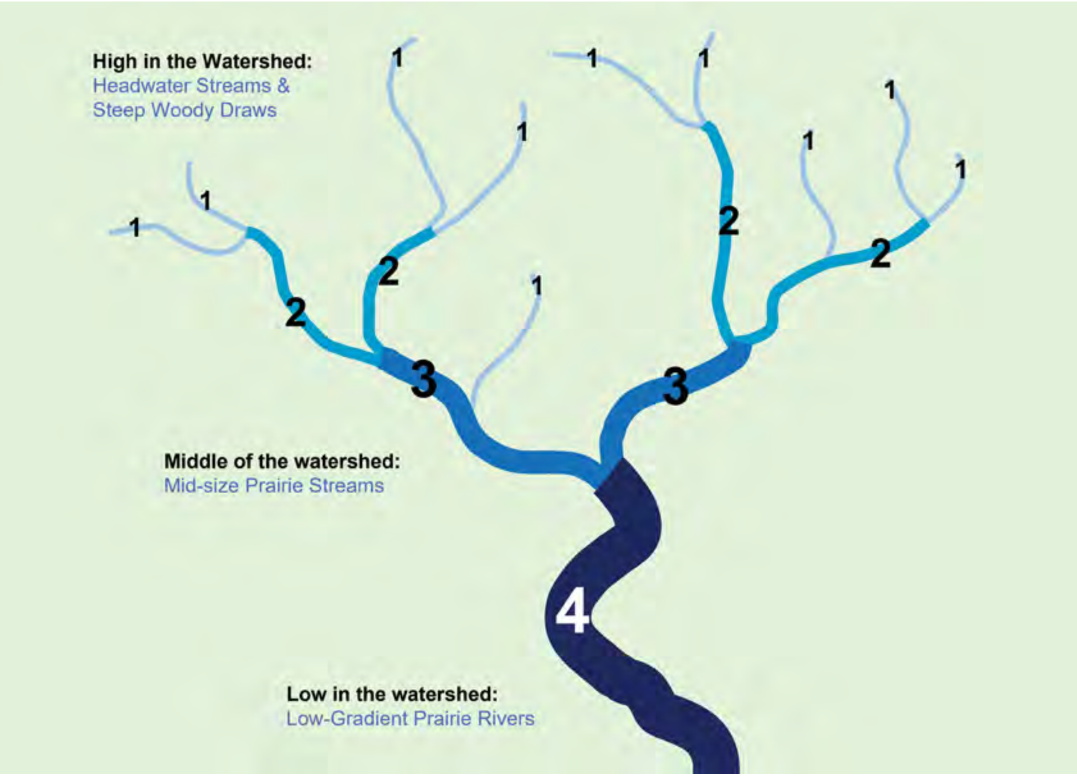


Figure 43: Stream order affects stream type. Streams labeled "1" are in the headwaters and are commonly referred to as first-order streams. They are dominated by overland flow of water and have no upstream concentrated flow. When two or more first-order streams merge, they form a second-order stream. Lower in the watershed, these second-order streams come together to form third-order streams, and so on. The larger the stream order number, the larger the area it drains. Graphic © Corissa Busse, TNC

How to assess the landscape position: Think about what streams flow into your stream before it arrives at your location, or what your stream flows into after it leaves your location. Are there multiple streams and drainages or draws that flow into your channel upstream from where you are assessing?

Based on your assessment, which option best describes your watershed position?

- High in the watershed: There are few draws and no streams upstream from your location.
- Middle of the watershed: Several small streams, drainages, and/or draws come together upstream from your location, adding flow.
- Low in the watershed: Many larger streams flow together upstream from your location.

What is the Drainage Area of the Stream Reach You Are Assessing?

Why this matters: A primary factor in stream type is the amount of water that feeds into it. This is determined in part by the size of your drainage area. The amount of water that the stream manages also dictates the amount of force that water can exhibit; more water typically has more force or energy. This will impact how the stream functions and often affects its condition and potential.

How to assess the drainage area:
Method 1: An accurate means for determining your drainage area is to use the USGS Stream Stats tool: streamstats.usgs.gov/ss/. This tool uses satellite data to identify your location, the surrounding topography, and the size of your drainage area. Staff at many NRCS or SWCD offices can help you complete this assessment if requested.

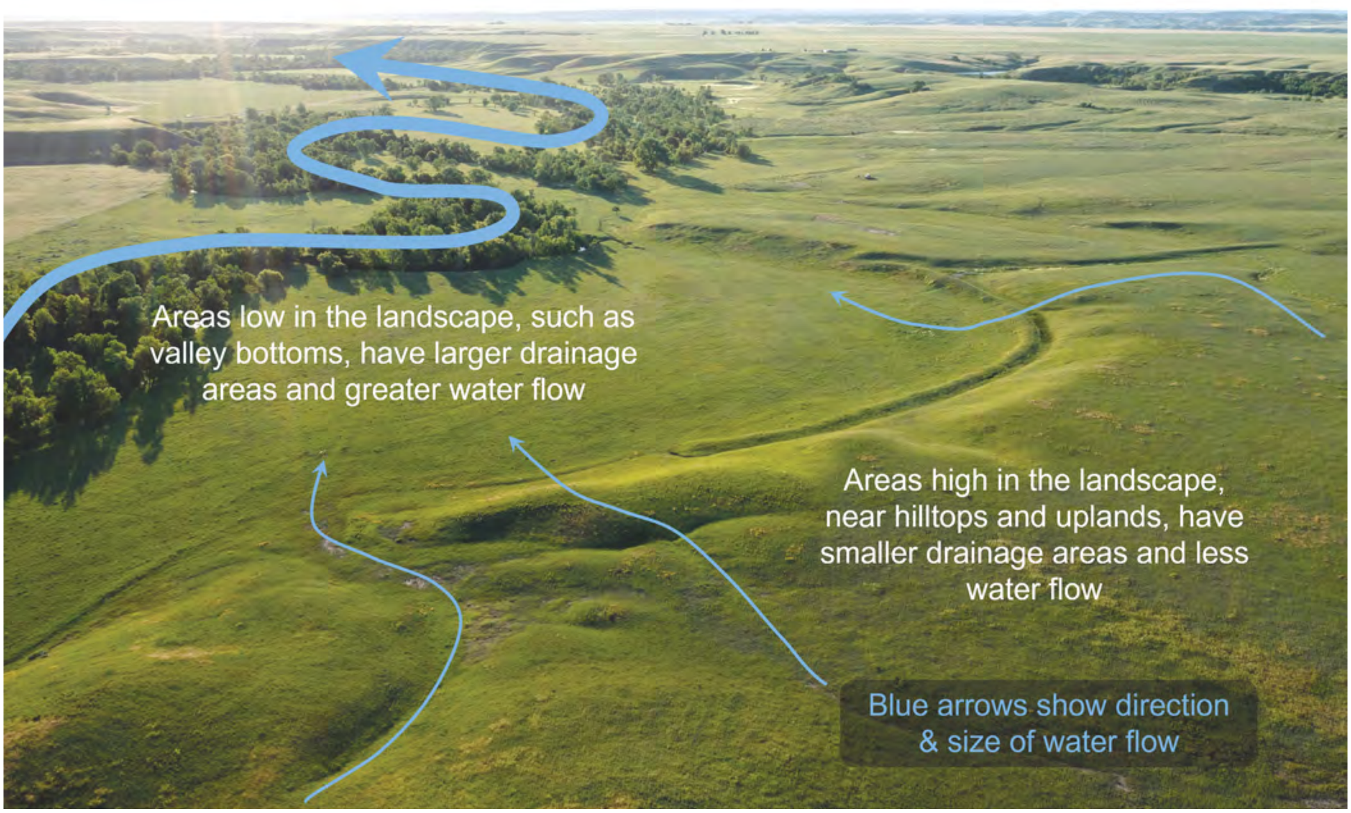


Figure 44: Areas higher in the landscape have smaller drainage areas and less flow. Valley bottoms and lowlands collect water from these surrounding uplands over larger drainage areas and have more water flow. Photo © Joe Dickie, Generation Photography, Inc.

Method 2: Previously, you assessed your landscape position. What are the landscape features where the stream is located? Are you located at the top of the slope, or in a valley bottom or lowland? A high landscape position is associated with a smaller drainage area. Low areas such as valley bottoms will have larger drainage areas, as shown in Figure 44. Stream order and drainage area are also closely related, as shown in Figure 45.

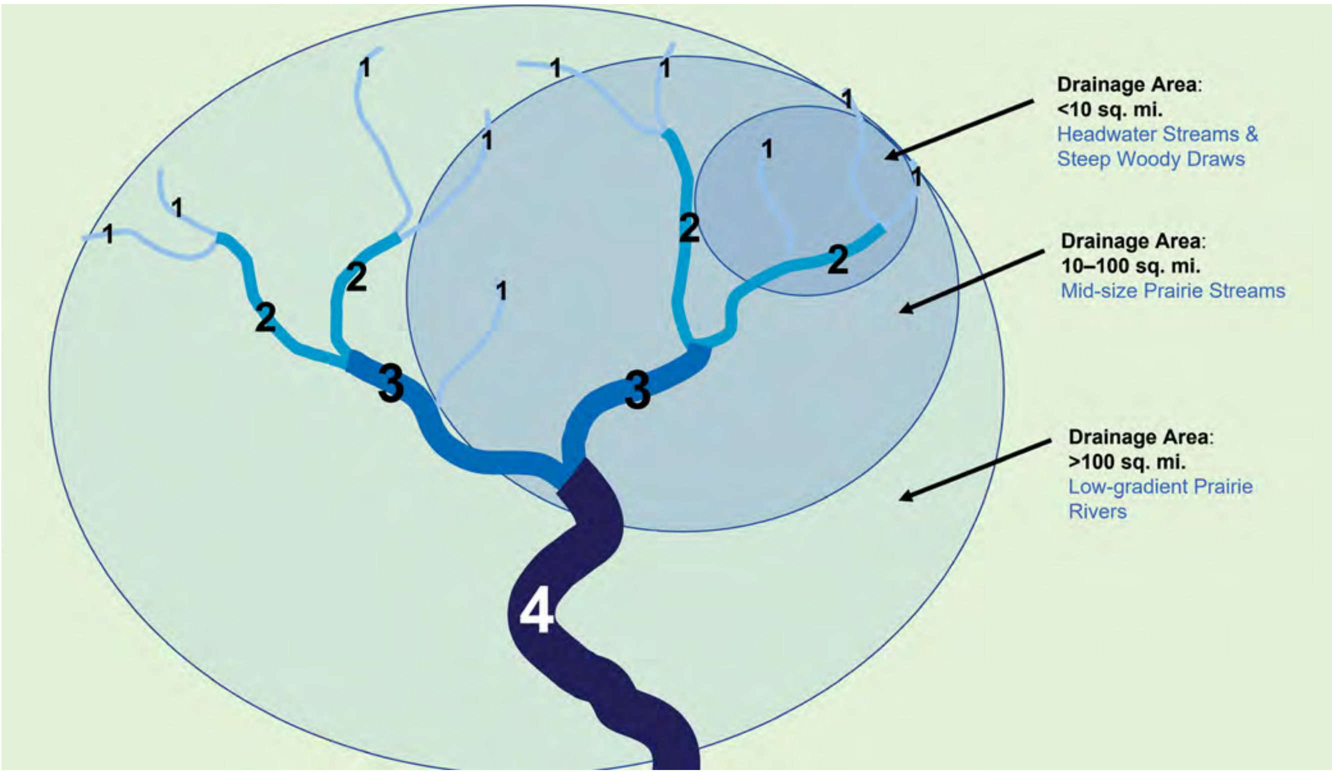


Figure 45: Stream order and drainage area are closely related. The larger the stream order number, the more area it will drain in the landscape. Graphic © Corissa Busse, TNC

Drainage area less than 10 square miles:

- Typically, at or near the start of the stream (the headwaters)
- No or very few streams and drainages flow into the stream prior to your location
- May be near the top of a landscape feature, such as a hill or butte

Drainage area of 10–100 square miles:

- Often a few miles from the start or headwaters of the stream
- A few small streams or drainages flow into the stream prior to your location
- Typically located in a valley or other lowland

Drainage area greater than 100 square miles:

- Located many miles from the headwaters of the stream
- Several streams and drainages flow into the stream prior to your location
- Located in a valley bottom, river bottom, or lowland

Based on your assessment, which option best describes the size of your drainage area?

- ❑ Less than 10 square miles (less than 6,400 acres)
- ❑ 10–100 square miles (6,400–64,000 acres)
- ❑ Greater than 100 square miles (greater than 64,000 acres)

What Is the Slope within Your Channel at This Reach?

Why this matters: The slope will partially determine how quickly water flows through the stream. Water runs downhill, and as a hill gets steeper, the water has the potential to run faster and pack more force. The slope of the channel will also help determine whether you are in a woody draw or river break stream type, both of which tend to have slopes greater than 2%. Slopes range from about 0.1% to 10% in western South Dakota prairie streams; most streams have a slope of less than 0.5%.

How to assess the slope:

Method 1: Use the USGS Stream Stats: streamstats.usgs.gov/ss/. This site provides you with average slope for your watershed, drainage area, and average flow discharge in cubic feet per second (cfs). It is important to note that the slope measurement on this website may be misleading because it is an average for the entire upstream watershed and is not specific for your site, but it will give you a general idea.

Method 2: You can do a visual guesstimate of the slope of your stream channel. A 2% slope would be the equivalent of your stream dropping roughly 6 feet (about the height of a tall person) over the course of 100 yards (or the length of a football field). Standing from a good vantage point, guesstimate whether the slope of your stream drops by more or less than 6 feet across a 100-yard distance (following the meanders of the stream). (Note: Most western South Dakota prairie streams have stream bed slopes well below 1%.)

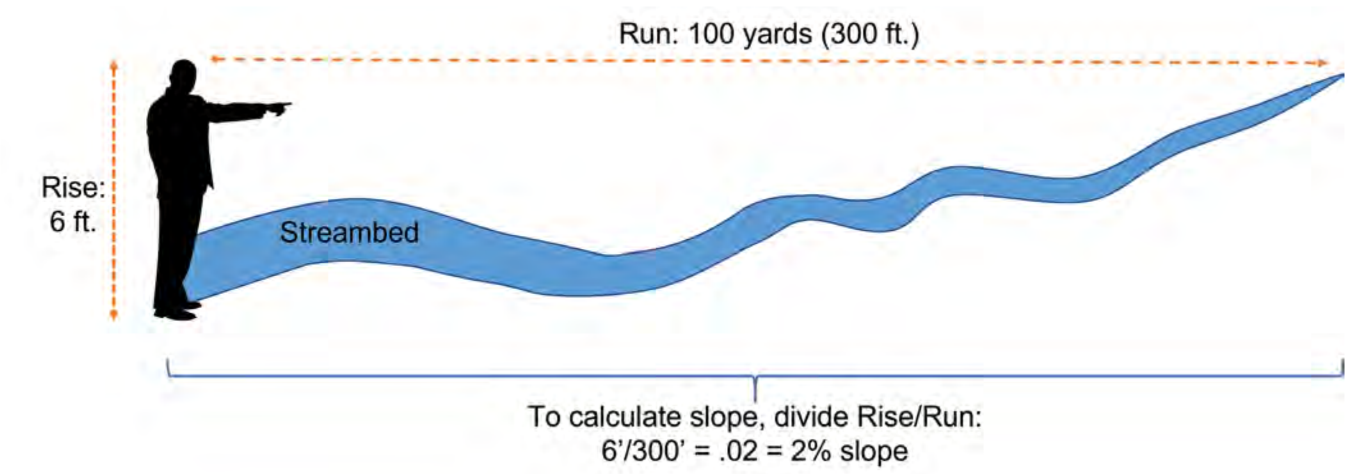


Figure 46: Calculate stream bed slope by estimating how far the stream bed drops over a span of 100 yards. Graphic © Corissa Busse, TNC

Method 3: Look at the channel form. The shape of the stream and its bed may serve as a rough indicator of slope. Streams with very little slope (< 0.2%) tend to meander a lot. More moderately sloping streams typically have a flat bed without steep drops. Very steep channels (> 3% slope) often have steps and pools with drops of several feet occurring between flatter parts of the channel. In western South Dakota, streams with slopes > 3% are very uncommon outside the Black Hills, and most stream reaches in this region have < 0.5% slope.

Figure 47: This flat stream system has < 0.2% slope. Photo © Joe Dickie, Generation Photography, Inc.

Figure 48: Steep woody draws coming off a butte will have slopes of 3% or greater. Photo © Joe Dickie, Generation Photography, Inc.

Based on your assessment, which option best describes the slope of your stream?

- ❑ Less than 0.2% (flat)
- ❑ 0.2 to 3% slope (moderate)
- ❑ Greater than 3% (steep)

Determining Your Stream Type

Using your answers to the questions outlined in this section, follow the charts shown in Figure 49 to determine your stream type.

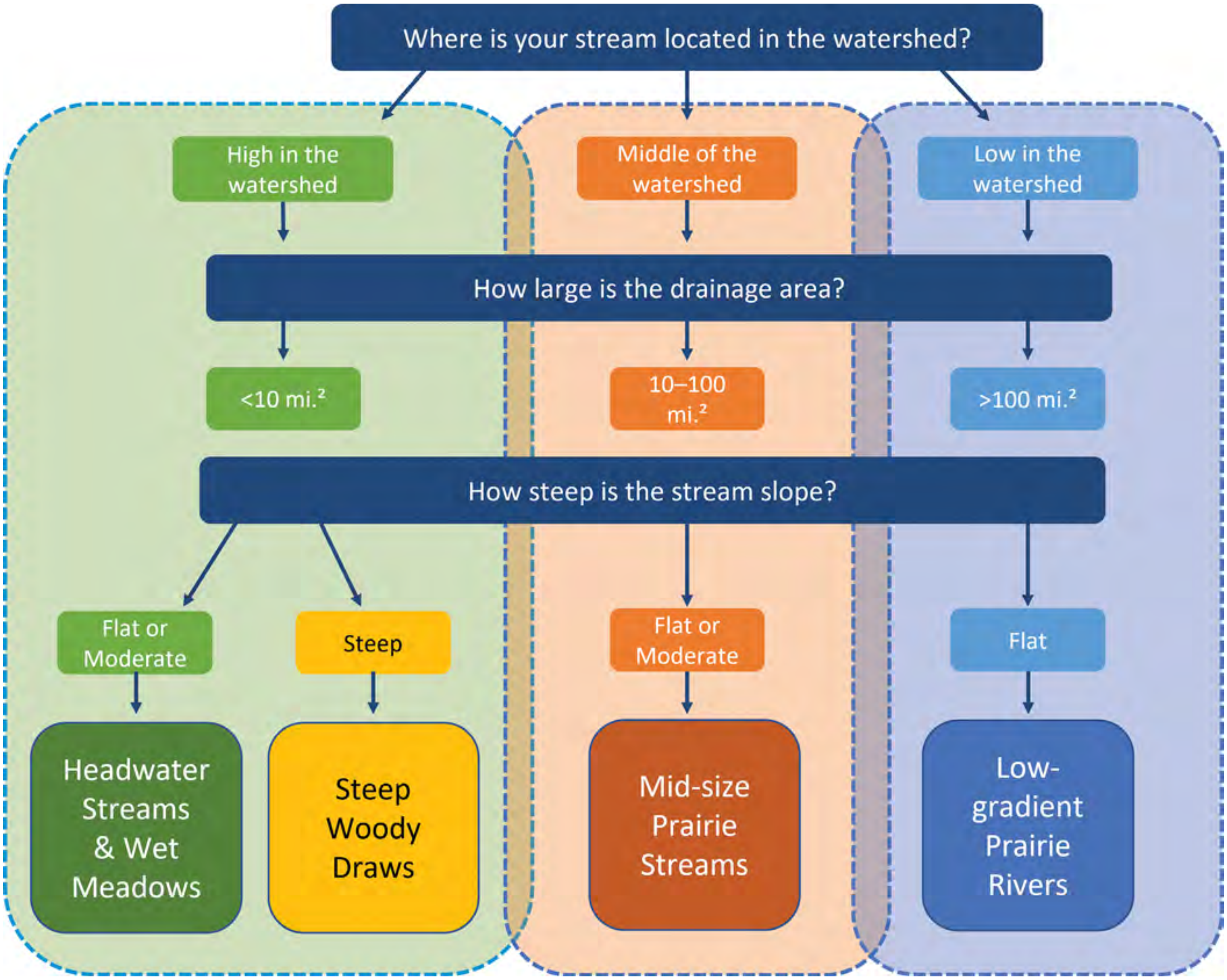


Figure 49: This flowchart will help you identify the type of stream you are assessing. Note that there is overlap between the stream types, and that some streams may exhibit characters crossing these boundaries. Graphic: Corissa Busse, TNC

Table 1: Summary of Stream Types

Description	Stream Type
High in the watershed, drainage area less than 10 square miles, slope flat or moderate	**Headwater streams and wet meadows**
High in the watershed, drainage area less than 10 square miles, slope steep	**Steep woody draws**
Middle location in the watershed, drainage area between 10 and 100 square miles, slope flat or moderate	**Mid-size prairie streams**
Low in the watershed, drainage area greater than 100 square miles, slope flat	**Low-gradient prairie rivers**

Section 8: Stream Type Descriptions

This section describes four main types of prairie streams found in western South Dakota and gives an overview of the common characteristics, challenges, and responses of each. We focus on streams that have low or no flow for much of the year and do not include large river systems, such as the Missouri River or downstream portions of the Belle Fourche, Cheyenne, and White Rivers. This technical guide also does not focus on the eroded badlands, although many of the gullies and canyons in this area do act as intermittent streams. The four types that we discuss are:

1) Headwater streams and wet meadows
2) Steep woody draws
3) Mid-size prairie streams
4) Low-gradient prairie rivers

These stream types act as benchmarks and guides for the health and management options of streams that you monitor using the tools outlined in the following sections.

Type 1: Headwater Streams and Wet Meadows

Headwater streams and wet meadows:
• Are located high in the watershed
• Drain an area of less than 10 square miles
• Usually have a slope of less than 1%

Common Characteristics and Trends

Headwater streams are the smallest stream types; it would be relatively easy to jump across many of them. They carry water from the uppermost reaches of the watershed to the main channel of mid-sized or larger river systems. Often, these systems are unnamed or may be recognized as drainages or grassy draws instead of as streams. This is the most abundant stream type in western South Dakota and can be found on nearly every ranch.

In very healthy streams that start in gentle terrain, there may be no defined channel at all. These “stage zero” streams are fully connected according to the channel evolution model described in Figure 33. We refer to these systems as wet meadows (see Figure 50). They act like large sponges, slowing runoff so that water moves as a sheet flow during heavy rain events. Sheet flow is water runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel. They may have numerous braided flow pathways and subsurface flow, but no clearly defined channel. This stream type is very common throughout western South Dakota, but stage zero wet meadows are uncommon, as many of our stream systems have experienced downcutting in recent history. This stage is characterized by limited erosion, prolonged connection with groundwater, and high level of vegetation cover. Stage zero sites may incise but can recover quickly. This stage is often regarded as a reference condition for many streams where there is very limited erosion and vegetation covers the entire channel. They often represent the upstream point at which many stream channels begin and are a valuable resource that provides livestock forage and wildlife habitat.

Figure 50: Wet meadows may have no defined channel but instead act like a large sponge on the landscape, with water flowing over the surface. This is referred to as a “stage zero” or connected stage. Photo © Joe Dickie, Generation Photography, Inc.

This stream type is typically found at the top of the watershed along drainage divides, forming where flow is first concentrated by mild hillslopes. In mountainous areas, we typically think of the top of the drainage divide as the “summit.” In the northern and northwestern Great Plains, drainage divides are often very subtle, and even the top of the watershed may feature large, relatively flat expanses of grasslands dominated by upland prairie. In areas featuring buttes and badlands, this stream type can form in the flattened-out areas, or “tablelands” at the top of the buttes, or as slopes level out at the base of the buttes. This stream type typically occurs in the upper portions of watersheds with drainage areas of less than 10 square miles. Many reaches drain less than 1 square mile.

Most headwater streams and wet meadows are not steep (with a slope of less than 2%). Slope in headwater meadows is often less than 1% (about 50 feet of vertical drop per mile of stream length) and is more typically in the range of 0.1%, which is a vertical drop of only 5 feet per mile of stream. However, in some cases, steeper headwater ephemeral draws do exist that may be more like gullies than meadows. These are especially common in the Badlands region and along the “river breaks” where streams descend rapidly to the valley elevations of the large prairie rivers, such as the lower Cheyenne, Moreau, Grand, and Missouri Rivers.

Because they do not have a lot of drainages flowing into them, most headwater streams and wet meadows do not receive as much flow as larger stream types described in this guide. As a result, these systems are usually ephemeral or intermittent in nature. Ephemeral flow is supported by most streams with less than 10 square miles of drainage. Exceptions do occur, however, in very resilient systems that are able to slow and hold rainwater longer, or where springs or strong pathways of groundwater seepage add water to the stream. With a lower volume of water flow and flatter slopes, headwater streams tend to have less energy than steeper stream types.

As noted above, headwater systems tend to have less stream flow than downstream reaches; the water has less energy and slower velocity. Because they have less energy, these systems often remain relatively connected to their floodplains and are not highly entrenched. Often, these streams are in a fully connected stage or have a single channel formed. Some are in early incision stages as well (see Figure 33). These streams are typically more stable than steeper or more powerful streams. A few may have evolved from earlier changes and have formed an inset floodplain; this stage is also stable, but downcut from the historic floodplain and provides less function to the surrounding area.

As these streams are less entrenched and less impacted by upstream land cover change and flow increases, they are often in good physical condition compared with other stream types. However, these areas often overutilized, which results in a decline in plant community diversity and cover and an increase in undesirable species.

Vegetation

The vegetation of headwater streams and wet meadows is typically dominated by prairie grasses and forbs that may transition very gradually from upland to mesic and wetland species. Degraded meadows may have significant coverage of annual brome grasses and other undesirable invasive grasses and forbs (see plant guide in Appendix B). These systems are not naturally protected from fire or grazing and may not provide adequate soil moisture to support woody species; they often lack significant tree or shrub coverage as a result.

Common Challenges

These riparian areas and meadows typically support good production of palatable grasses and vegetation that are easily accessible to livestock prior to incision or downcutting. These areas are more vulnerable to being overutilized than other stream types, particularly during drought conditions, as they stay greener and can regrow as upland areas dry out. Despite their forage production, because these areas don’t have streamflow most of the year, they tend to be undervalued for their ecological benefits.

Sensitivity to Disturbance

The headwater stream type includes ephemeral grassed swales and headwater channels of the rolling shale prairies with small upstream drainage areas. Many streams are just starting to form channels and may be at risk for **headcuts** moving upstream (see Figure 51). In areas that have undergone downcutting, the stream may be more of a **gully** than a meadow.

Figure 51: Headwater streams can be particularly vulnerable to overutilization, which results in a loss of vegetative cover. This creates a risk of headcuts and incision in the stream during high-flow events, even if water is only present after rainfall. Photo © Corissa Busse, TNC

Most of the headwater meadow streams assessed in the production of this guide were used more intensively for grazing, hay, or crop production than other stream types because they tended to have flatter topography. Headwater streams with less disturbance tend to be only slightly entrenched and still provide many of the ecological services of small prairie streams. The photos below show a variety of headwater streams, many of which have very little entrenchment and remain covered with grasses, sedges, and rushes.

Examples of Type 1: Headwater Streams and Wet Meadows

Figure 52: These photos show a headwater stream/wet meadow system in Pennington County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of < 5 square miles and a slope of ~0.5%. Photos © Joe Dickie, Generation Photography, Inc.

Figure 53: These photos show a headwater stream in Butte County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~6 square miles and a slope ~< 1%. Photos © Joe Dickie, Generation Photography, Inc.

Figure 54: The photos show an upper headwater stream in Custer County, South Dakota, in the Mixed Sandy and Silty Tablelands and Badlands Major Land Resource Area, with a drainage area of 1.5 square miles and a slope of 1.1%. Photos © Nancy Johnson

Figure 55: This headwater stream in Corson County is in the Rolling Soft Shale Plains Major Land Resource Area, with a drainage area of 5.4 square miles and a slope of 0.5%. Photo © Dave Stagliano, Montana Biological Survey

Figure 56: This headwater stream is in Butte County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area ~5 square miles and a slope of ~0.5%. Photo © Corissa Busse, TNC

Type 2: Steep Woody Draws

Steep woody draws:
• Are located high in the watershed • Drain an area of less than 10 square miles • Have a slope of greater than 1%

Common Characteristics and Trends

Steep woody draws are typically found in the intermediate hillslope positions (the shoulder down to the foot or toe slope) with higher gradients. As a result, this stream type includes higher gradient draws draining off the buttes and badlands. This type can support flows ranging from ephemeral to perennial, despite their small drainage areas. The flow may include small perennial reaches, sustained by groundwater springs and seeps. The steep slope of woody draws (more than 1% stream gradient with up to 5–10% valley slopes in areas of badlands, buttes, and river breaks) and higher moisture availability help support more tree and shrub coverage, and more overall plant diversity. Snowdrifts and snow accumulation occur naturally in these areas, aiding the establishment of woody species. These streams are typically straighter and less meandering, have less floodplain function, and are prone to gullying (**headcutting** and **downcutting**).

Woody draws typically have very small drainage areas of less than 10 square miles. The river breaks can be slightly larger streams, provided they still have the valley protection to help maintain woody vegetation. This stream type includes all stream reaches with the steepest slopes, > 1% slope (= 53 ft/mile), draining the areas of the prairie landscape that have greater topographic relief. Slopes may vary greatly from region to region.

Figure 57: In this woody draw in Butte County, South Dakota, notice the trees growing along the channel. Photo © Joe Dickie, Generation Photography, Inc.

Vegetation

As the name implies, woody draws often include a riparian area dominated by trees or shrubs. Because woody draws are sheltered from wind and grazing and often associated with springs and seeps, they are more able to support woody plants. Ash, elm, hackberry, and oak are common trees found in woody draws. In the steeper draws, Rocky Mountain juniper and Eastern red cedar can both occur, either infrequently or in dense thickets. Cottonwood may be dominant in wetter areas. Shrub species may include buffaloberry, chokecherry, wild plum, wild rose, western snowberry, and many others. Common grasses can include big bluestem, Canada wildrye, side-oats grama, and sedge species. The plant community is highly variable, depending on the climatic conditions and fire interval.

Figure 58: These woody draws on the Mortenson Ranch show healthy growth of willows and other woody species. Photo © Joe Dickie, Generation Photography, Inc.

Common Challenges

Because of their steeper gradients, woody draws are prone to headcutting and gullying, and they typically exist in stages of incision or widening and depositing sediment within the channel evolution model (Figure 33). Woody draws often experience heavy livestock utilization for shelter in western South Dakota. Exotic species such as Russian olive and Siberian elm can invade and dominate in these systems. Due to long-term fire suppression, they can become overgrown with native species, such as eastern red cedar and Rocky Mountain juniper. Over time, if these events happen, they may become less attractive to livestock that find it difficult to move through the thick woody vegetation. These areas will still be utilized by wildlife for escape cover, loafing areas, and protection.

Sensitivity to Disturbance

Woody draws are greatly influenced by fire activity. Lack of fire over an extended period can lead to juniper encroachment. Hot, severe fires can result in an invasion of non-native, cool-season grasses. As mentioned above, this stream type has a lot of natural variability and can be responsive to restoration efforts through targeted management. Good management can re-establish cover of native trees and shrubs such as boxelder, willow, and cottonwood. The Mortenson Ranch, west of the Missouri River in west-central South Dakota, has several woody draws that have been revegetated with woody plants due to focused grazing management and strategic placement of check dams to hold flow upstream and prevent headcuts (Johnson and Volke 2015).

Examples of Type 2: Steep Woody Draws

Figure 59: This steep woody draw is in Harding County, South Dakota, in the Northern Rolling High Plains Major Land Resource Area, Eastern Part, with a drainage area of 4.5 square miles and a slope of ~1%. Photo © Doug Shaw, TNC

Figure 60: This steep woody draw is in Butte County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~5 square miles and a slope of > 2%. Photo © Joe Dickie, Generation Photography, Inc.

Figure 61: Both photos show a steep woody draw in Mellette County, South Dakota, in the Mixed Sandy and Silty Tableland and Badlands Major Land Resource Area, with a drainage area of 0.81 square miles and a slope of ~2%. Photos © Kristen Blann, TNC

Figure 62: Both photos show steep woody draws in Stanley County, South Dakota, in the Northern Rolling Pierre Shale Plains Major Land Resource Area, with a drainage area of < 10 square miles and slope of > 3%. Photos © Joe Dickie, Generation Photography, Inc.

Type 3: Mid-size Prairie Streams

Mid-size prairie streams:
• Are located in the middle of the watershed • Drain an area of 10–100 square miles • Have a slope of less than 1%

Common Characteristics and Trends

Mid-size prairie streams occur throughout western South Dakota. They are often found in the middle of a watershed, below headwater streams and upstream of large low-gradient rivers. The drainage area is from 10 to 100 square miles. They typically collect runoff from a small number of headwater catchments. In contrast with woody draws and river breaks, mid-size prairie streams draining the low-relief, rolling plains are characterized by more gradual stream bed slopes, typically in the range of 0.2% to 1%. This stream type includes both mid-size prairie streams and valleys draining the rolling prairies and badlands.

Mid-size prairie streams have a wide range of characteristics compared with the previous two stream types described. They are more meandering (except where they have been channelized at road crossings or ditches). Streams of this type start to develop point bars or sand bars within the river bends. During the field assessments and surveys for this guide, we identified several highly functioning streams in this category. However, many streams in this category tend to be less connected to their floodplains. As these streams receive flow from upper headwater streams and steep woody draws, they drain a larger area, resulting in more stream power and more erosive potential. This often leads to active incisions or widening processes, as described below.

Figure 63: Mid-size prairie streams drain larger watershed areas than headwater streams and woody draws. As they have greater flow, these streams tend to have more erosion and may often be in stages of incision or channel widening and depositing. Photo © Kristen Blann, TNC

Streamflow for these systems ranges from ephemeral to perennial. Most are intermittent or ephemeral, except where seeps or springs contribute baseflow, or when they have sufficient drainage area to capture and sustain baseflow later into the dry season. Typically, streams and rivers draining the semi-arid landscape of western South Dakota are not classified by the USGS National Hydrography Dataset as being perennial unless they have a drainage area of 1,000 square miles or more.

Due to their lower gradients, mid-size prairie streams generally have greater sinuosity (i.e., they are more meandering) but are not as highly meandering as many large low-gradient rivers that drain larger areas of a watershed. These streams are frequently in stages of incision or widening and deposition according to the channel evolution model (i.e., it is in the active evolution stage that downcutting and widening are common) (see Figure 33). As they are meandering streams, they often experience lateral bank erosion as a naturally occurring process.

Figure 64: This mid-size prairie stream in Butte County, South Dakota, has a drainage area of approximately 30 square miles. Mid-size prairie streams tend to have more meandering channels than headwater streams and steep woody draws, though they may have less meander than low-gradient prairie rivers. Photo © Joe Dickie, Generation Photography, Inc.

Vegetation

Mid-size prairie streams most often are dominated by grasses, grass-like species (sedges and rushes) and shrubs. Due to their slope and landscape position (the transition to the uplands is gradual), they can easily be influenced by grazing and fire. Depending on their orientation to the sun (aspect), soil moisture, flood frequency, and history of grazing and channel downcutting, they can support woody vegetation. They often have a low density of mature trees such as ash or cottonwood, occasional pockets of woody shrubs, and/or extensive thickets of western snowberry. Steep, north-facing banks or bluffs may support more riparian forest species, as well as streams with well-developed floodplain benches.

Common Challenges

Small dams, water diversions, stock ponds, road crossings, and removal of beaver have all had a significant negative impact on this stream community type. Anywhere impoundments are present, even small stock pond earthen dams, upstream and downstream reaches are affected by altered water temperatures, increased salinity concentrations, unnatural water level fluctuations, and changes in sediment and nutrient transport. Dams prevent small natural flood events, which are important for sediment transport and floodplain development, and as dams age they pose a risk of breaches and failures, which threaten downstream stability, water quality, and the overall economic and ecological performance of the area. Likewise, culverts, road crossings, and the removal of beaver have increased downcutting and channel instability. Other threats include livestock overutilization of the riparian areas, which can increase bank erosion.

Sensitivity to Disturbance

This stream type is sensitive to landscape alteration and disturbance. Landscape changes influencing hydrology may occur across a significant portion of the small to mid-size drainage areas, triggering a channel response. The channel can also show a rapid response to increased runoff or storm flows that are driven by climate or upland management. Some of these streams have been channelized, which often leads to greater entrenchment, reducing floodplain connectivity. Many of these streams are adversely affected by road crossings and culverts. Poorly designed or poorly maintained culverts will concentrate and accelerate flow, which can cause bank slumping, erosion, and scouring. The consequences of culvert design often affect large portions of the downstream channel. Because of the increased size of the drainage area and compounding effect of alterations, improving stream conditions for mid-size prairie streams may require a watershed-level approach rather than working solely at the site level.

Examples of Type 3: Mid-size Prairie Streams

Figure 65: This mid-size prairie stream is in Butte County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~12.5 square miles and a slope of ~0.2%. Photo © Kristen Blann, TNC

Figure 66: This mid-size prairie stream is in Butte County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~25 square miles and a slope of < 1%. Photo © Corissa Busse, TNC

Figure 67: This mid-size prairie stream is in Harding County, South Dakota, in the Northern Rolling High Plains Major Land Resource Area, Eastern Part, with a drainage area of ~30 square miles and a slope of < 1%. Photo © Doug Shaw, TNC

Figure 68: This mid-size prairie stream is in Butte County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~30 square miles and a slope of ~0.2%. Photo © Joe Dickie, Generation Photography, Inc.

Figure 69: This mid-sized prairie stream is in Pennington County, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~32 square miles and a slope of 0.1%. Photo © Christian Lenhart, TNC

Figure 70: This mid-size prairie stream is in Jones County, South Dakota, in the Northern Rolling Pierre Shale Plains Major Land Resource Area, with a drainage area of ~75 square miles and a slope of 0.3%. Photo © Christian Lenhart, TNC

Figure 71: This mid-size prairie stream is in Pennington County, South Dakota, in the Northern Rolling Pierre Shale Plains Major Land Resource Area, with a drainage area of ~80 square miles and a slope of ~0.1%. Photo © Joe Dickie, Generation Photography, Inc.

Figure 72: This mid-size prairie stream is in Butte County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~93 square miles and a slope of ~0.2%. Photo © Corissa Busse, TNC

Type 4: Low-gradient Prairie Rivers

Low-gradient prairie rivers:
• Are located low in the watershed • Drain an area of 100–1,000 square miles • Have a slope of less than 1%

Common Characteristics and Trends

Low-gradient prairie rivers have mid-to-large drainage areas, typically greater than 100 square miles but less than 1,000 square miles (Table 2). They occur in lower areas of a watershed with wider valleys and sandy soil (called **alluvial**) deposits. This stream type includes the lower reaches of mid-size prairie streams, as well as larger systems where they enter the **bottomlands** of river valley floodplains. They are usually located between the lower tributaries and upper reaches of larger river systems such as the Grand, Moreau, Cheyenne, White, and Bad Rivers. (Note: Larger perennial prairie rivers are well described in other materials and consequently lie outside the scope of this guide.)

Low-gradient prairie rivers include the mid-to-large streams of the western South Dakota prairies, typically found in lower hillslope landscape positions or valley bottoms. They have relatively low stream bed slope/gradients, well below 1%, and often less than 0.1% (a drop of less than 5 feet per mile). Stream flow is typically intermittent to perennial, with streams that have the largest drainage basins having the greatest potential to support perennial flow.

Due to their low gradient and higher sediment load, these streams are often highly meandering. As they wind across the landscape, the channel length may be 1 to 2 times more than the distance covered "as the crow flies." Low-gradient prairie rivers are also less prone to downcutting and are commonly in a stage of widening from lateral erosion and/or forming a new inset floodplain (see Figure 33).

Figure 73: Low-gradient prairie rivers tend to be highly meandering. Photo © Joe Dickie, Generation Photography, Inc.

Low-gradient prairie rivers often have point bars (areas where sediment is deposited) along the inside of meanders or bends in the stream. They have greater river width and overall size than the other stream types. During field assessments and surveys to produce this guide, we identified several high-functioning streams in this category. Low-gradient prairie rivers are less prone to incision and may be more resilient to change because floodplain plants readily grow and stabilize streambanks. They often have greater sediment load from upstream reaches and bank erosion. Streambank height tends to increase with increased drainage area. This reduces the stream's ability to connect with its floodplain.

Vegetation

Forest trees and shrubs such as willow, cottonwood, boxelder, and green ash are common along this stream type and prefer habitats associated with low-gradient rivers and the floodplains connected to them. As the stream constantly changes, it creates different vegetation zones. In general, as these streams restabilize, floodplain zone with trees and shrubs form. For example, on higher terraces that are rarely flooded, ash and boxelder thrive; lower, more active floodplains support willow and cottonwood. These areas may have large mature cottonwoods spaced in an open forest, referred to as **riparian gallery forests**, or they may have had such a forest in the past.

Common Challenges

Low-gradient prairie rivers have a larger drainage area than other stream types, making it more challenging to restore channels that have excessive erosion, downcutting, or other signs of instability. Conditions in a particular segment of the stream may reflect past watershed disturbances as headcuts or erosive areas moving upstream or downstream over time. As these types of streams move across their floodplains, they can threaten roads and structures due to the amount of flow and energy they can carry. Like mid-size prairie streams, they are also affected by changes in upland land use, dams and impoundments, road crossings, and the removal of beaver from the landscape—all of which have caused changes in flow and accelerated downcutting.

Sensitivity to Disturbance

Their larger drainage areas make low-gradient prairie rivers more resilient to local or temporary disturbances, such as high flows or periods of intensive grazing. Larger streams reflect the dominant condition of the overall watershed, making them less sensitive to small, short-term, and more local influences. They have been extensively altered by the removal of beaver, and although they are fairly resilient to short-term variability, these systems are becoming structurally starved through low-term ecosystem changes.

Examples of Type 4: Low-gradient Prairie Rivers

Figure 74: This low-gradient prairie river is in Harding County, South Dakota, in the Rolling Soft Shale Plain Major Land Resource Area, with a drainage area of ~200 square miles and a slope of ~0.1%. Photo © Corissa Busse, TNC

Figure 75: This low-gradient prairie river is in Fall River County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~208 square miles and a slope of < ~0.1%. Photo © Christian Lenhart, TNC

Figure 76: Both photos show a low-gradient prairie river in Custer County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of 322 square miles and a slope of 0.2%. Photos © Joe Dickie, Generation Photography, Inc.

Figure 77: This low-gradient prairie river is in Butte County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~756 square miles and a slope of < 0.1%. Photo © Dave Stagliano, Montana Biological Survey

Figure 78: This low-gradient prairie river is in Fall River County, South Dakota, in the Pierre Shale Plains Major Land Resource Area, with a drainage area of ~916 square miles and a slope of < 0.1%. Photo © Christian Lenhart, TNC

Summary of Stream Types 1–4

We have described four small prairie streams that occur throughout western South Dakota (Table 1). Streams located higher in landscape and watershed positions are more likely to be ephemeral or intermittent. Watersheds with flatter plateaus in the headwaters often have wet meadows or swales that are more like wetlands than streams. Headwater meadows are the smaller streams that occur where channels start to form, near their origin in the watershed. In steeper reaches of the stream, woody draws, which are partly or mostly covered by trees or shrubs, are most common.

As you move downslope, the streams can change into mid-size prairie streams that typically have more than 10 m2 of drainage area. These streams tend to have more stream flow and energy, resulting in common incision and widening stages among mid-size prairie streams.

All the previous stream types eventually flow into low-gradient rivers. These rivers are highly meandering and are often lined with trees such as cottonwood, willow, or boxelder.

Each of the various channel types described here occurs on a continuum with overlap between types and processes. The following charts and graphics in this section describe these types further and how they relate to each other, as well as to landscape features such as hillslope, and processes such as channel evolution, erosion, and deposition.

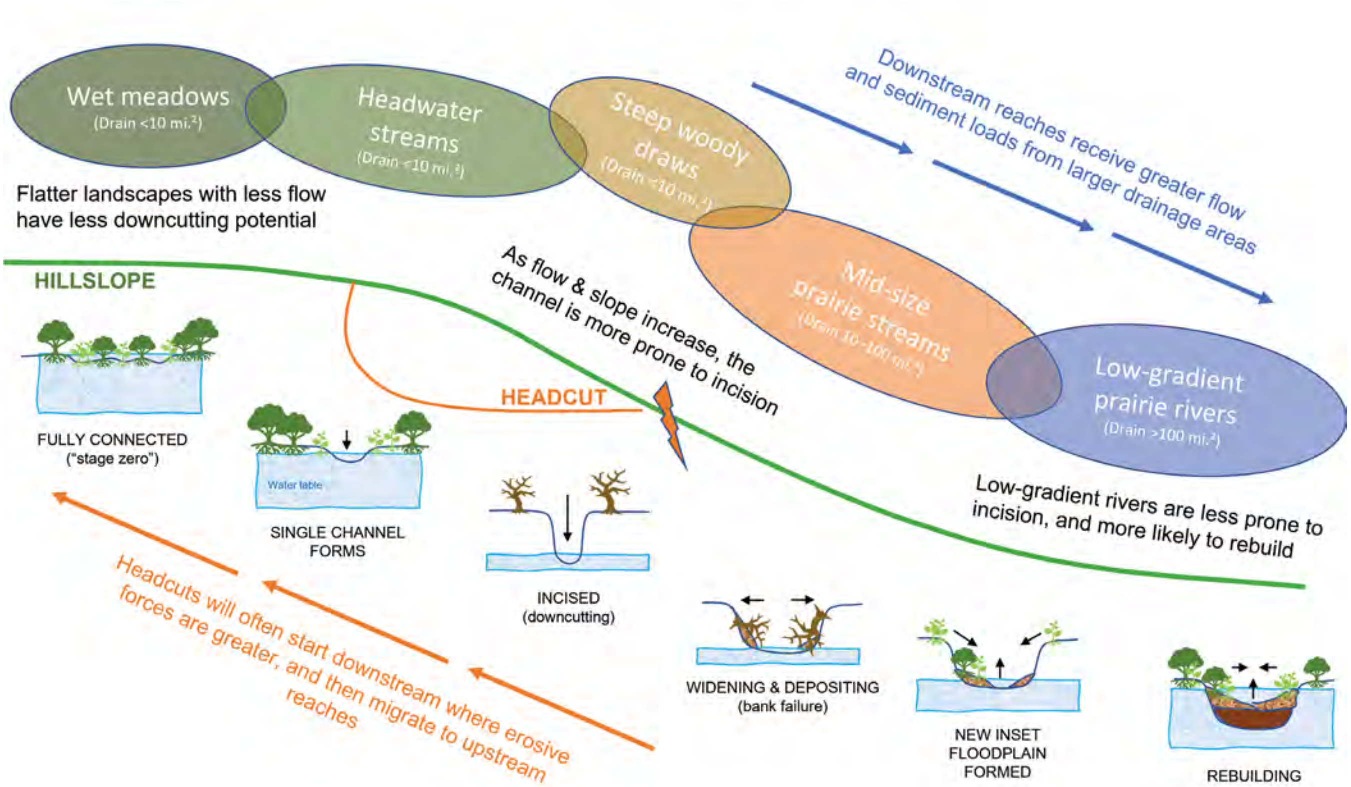


Figure 79: Drainage areas, stream size, and watershed position affect channel evolution processes, especially the formation of headcutting and downcutting, among stream types. Graphic © Christian Lenhart, Kristen Blann, and Corissa Busse, TNC

Table 2: Summary of Characteristics of Western South Dakota Prairie Streams

Stream Type and Characteristics	Headwater Streams and Wet Meadows	Steep Woody Draws	Mid-size Prairie Streams	Low-gradient Prairie Rivers
Watershed Position	High in watershed	High in watershed	Middle of watershed	Low in watershed
Drainage Area	<10 mi.^{2} (+5 mi.^{2})	<10 mi.^{2} (+5-10 mi.^{2})	10-100 mi.^{2} (+5-50 mi.^{2})	10-1000 mi.^{2} (+50-300 mi.^{2})
Slope	<1% Often closer to 0.1%	>1% May be up to 5-10%	<1% Often between 0.2-1%	<1% Often less than 0.1%
Common Channel Evolution Stages	> Connected ("staged zero") > Single Channel *More often stable ● ●	> Incising >Widening & Depositing *Prone to downcutting ● ●	> Incising >Widening & Depositing *Prone to downcutting ● ●	> Widening & Depositing > Forming new inset floodplain *Stabilizing and possibly reconnecting ● ●
Erosion and Deposition Processes	A zone of erosion; sediment carried downstream; can be incision-prone	Prone to incision; zone of sediment transport	Erosion from stream banks, deposition on point bars depending on stream	Sediment deposition is more frequent; lateral erosion and sandbar formation
Common Entrenchment Level	Slightly (>2.2) to Moderately (1.4-2.2); well-connected small floodplains ● ●	Moderately (1.4-2.2) to Highly Entrenched (<1.4); narrow floodprone width ● ●	Slightly (>2.2) to Highly Entrenched (<1.4); Variable ● ● ●	Slightly (>2.2) to Moderately (1.4-2.2); more floodprone width and connectivity ● ●
Sinuosity	Variable: Straight Sinuous Meandering Wet Meadow (*1.3+) ● ● ● ●	Straight Sinuous (*1.0-1.3) ● ●	Sinuous (*1.2-1.8) ●	Sinuous Meandering (*1.3-2.0+) ● ●
Flow	Ephemeral ● to intermittent ●	Ephemeral ● to intermittent ●	Intermittent ●	Perennial (some intermittent) ● ●
Dominant Plant Community	Vary from dry to wet, referred to as sub irrigated or overflow sites	Cedar/upland shrubs; mixed grass prairie species	Prairie cordgrass/ reedgrass with some shrubs, can vary dry to wet	Riparian shrubs and forest and/or wet meadow

- ● Most resilient
- ● Strong resilience
- ● Moderate resilience
- ● Functioning at risk
- ● Reduced function

Drought and Economic Conditions Challenge Ranch Conservation

> *"Heavy clay soils, decades of erosion, and drought conditions mean that it will take time and patience to rebuild soil and grass."*

In 2021, for the second year in a row, drought has affected the American West. The grass is short and the reservoirs are mostly dry. The conditions are exacerbated by economic woes that can force ranchers to make difficult decisions.

But West River ranchers like Robert Boylan have learned to work with nature and adjust herd size and pasture usage to keep improving the land even during these tough times.

Boylan, who grazes cattle and sheep in Butte County near Newell, South Dakota, is applying modern conservation practices to improve heavy clay rangeland that was abused and mismanaged when he took it over 10 years ago.

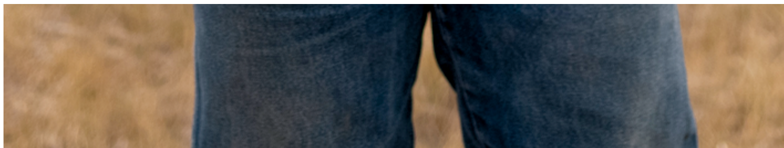
"They used the same pasture at the same time every year with the same amount of livestock without rotating, which leads to overgrazing and erosion," he says. "Rotational grazing is the best system ever developed. But we've learned in these heavy gumbo soils that small paddocks and high-density livestock don't work. So what works best for us is rotating in 1,000-acre pastures, mob grazing, then move them out. We hope to let each pasture rest for a whole year between moves—if it's feasible."

As he headed into the 2021 grazing season, Boylan knew he had to adjust to keep the pasture healthy. So he sold 30% of his cows and 40% of his sheep herd. "Very tough decisions had to be made, but it was the right call. Our grass is only 4–5 inches tall, and it's done growing," he explains.

Slowing water down

There are no springs on Boylan's ranch, but the North, South, and East Willow Creeks converge on the property, creating 10 to 15 miles of riparian areas. Although the

Robert Boylan, rancher
Butte County, SD



streams are nearly dry and highly eroded, they can run water year-round in a wet year like 2019. Boylan collects runoff water into 120 reservoirs that he built. He also installed more than 60 miles of pipeline to 60 water tanks.

"Our goal is to slow and pool the water so we can begin to grow vegetation to hold the soil better," he says. "I feel like we're gaining a bit, but it takes tough decisions on the economics and management of grass. We try to distribute water to keep cattle from trailing in different spots and causing further erosion."

Boylan faces an uphill battle due to the decades of overgrazing and erosion that occurred on the land before he bought the ranch. So far, he has installed four rock dikes to slow runoff, but he isn't confident that it's possible to stop erosion on heavy clay.

He is currently trying some different practices with the help of The Nature Conservancy, including beaver dam analogs and streambed rock structures to capture silt. (Beaver dam analogs are human-made structures designed to mimic the function of a natural beaver dam; their use can create the conditions that encourage beavers to return to an area.) "If we can pool some water and hold it, we'll hopefully see cattails and other vegetation growth to help stabilize the stream banks," he explains. "It's a never-ending battle, and we're trying to work with nature. You get a two-inch rain, water moves fast, and cattle can create a lot of compaction damage in heavy clay."

Later calving saves grass, water

By shifting calving dates to later in the year, Boylan can use and rest different pastures during different years, which he was unable to try earlier due to weather conditions. "More rest for pastures makes a world of difference, as the old grass funnels water down into the soil profile. The more grass we have covering up the ground, the more moisture we can conserve."

Boylan also notes that resting his grass provides benefits to wildlife and birds. For example, the grouse are thicker than they used to be because fewer nests get disturbed by livestock hoof action.

He hopes that someday his creeks will be lined entirely with cordgrass, there will be no more bare ground, and wildlife will abound everywhere on his ranch. "If you have a good environment for wildlife, your livestock will also thrive," he says.

When conditions were good, the ranch has supported up to 1,400 cows and 1,600 sheep. Right now, those numbers are down to 800 cows and 1,000 sheep. "If we had better economics, I'd rest more land," Boylan shares. "But when you're making land payments along with higher operating costs, it makes for tough decisions."

Figure 1. Several streams converge on Robert Boylan's ranch providing opportunity for 10-15 miles of riparian habitat. Photo © Joe Dickie, Generation Photography, Inc.

Figure 2. In drought years, these intermittent and ephemeral streams run dry. Photo © Joe Dickie, Generation Photography, Inc.

Figure 3. Boylan is working with organizations like The Nature Conservancy to install zeedyk rock structures in the stream beds to help slow down water, trap sediment, and reduce erosion. Photo © Joe Dickie, Generation Photography, Inc.

Figure 4. An example of a rock structure installation in one of the dry stream channels on Boylan's ranch. These structures will act like speed bumps for flowing water, slowing it down to reduce erosive energy and helping to trap sediment. Photo © Joe Dickie, Generation Photography, Inc.

Figure 5. A young cottonwood seeks to grow along the intermittent stream. Photo © Joe Dickie, Generation Photography, Inc.

Section 9: Common Management Challenges and Questions

While prairie streams may hold great potential, they also have experienced significant change and disturbance over hundreds of years. This section describes a few of the most common challenges seen in prairie streams across western South Dakota.

Overview of Common Riparian Management Challenges

A healthy, well-managed riparian area can provide many benefits to the landscape. These include water storage and retention high in the landscape, quality grazing forage production, flood protection during high flows, water quality protection, and habitat for wildlife (including game species, beneficial birds, insects, and pollinators). Loss of stream function however, either in terms of stream health or grazing value, is common across western South Dakota. Streams are affected by both upstream watershed conditions and local management practices.

For many landowners and managers, common stream and riparian management issues and challenges often center around the following issues (not in order of importance):

1) Active channel incision, bank erosion, and streambank instability
2) Overwidening
3) Inadequate low flows
4) Lack of adequate riparian vegetation, low-quality vegetation, and invasive plants
5) Poor water quality
6) Poor soil conditions, including **salinization** and sodification (an accumulation of water-soluble salts and/or sodium in the soil that leads to structural decline of soil)
7) Highly altered streams: impoundments, road crossings, and culverts

Due to the dynamic action of water in streams and riparian areas, these issues are often interrelated. This section will describe each of these challenges and possible causes in further detail. Later sections of the guide will then describe management options that can be used to help heal or recover prairie streams experiencing challenges such as these.

Active Channel Incision, Bank Erosion, and Streambank Instability

Active channel incision and headcutting are indicators of stream channel instability that leads to entrenchment. These downcutting sites often start with a single "knickpoint" (or headcut), as shown in Figures 80 and 81. Headcuts are commonly formed or originate at places of high disturbance, such as livestock trails, road crossings, etc. Culverts and road crossings can have particularly severe impacts on streams because they concentrate flow and contribute to downstream scouring. Headcutting and undersized or improperly designed culverts accelerate water and erode its channel. The downcutting of the stream channel causes vegetation to dry out, increasing erosion and sediment loss. This allows a headcut to migrate farther up the channel as well.

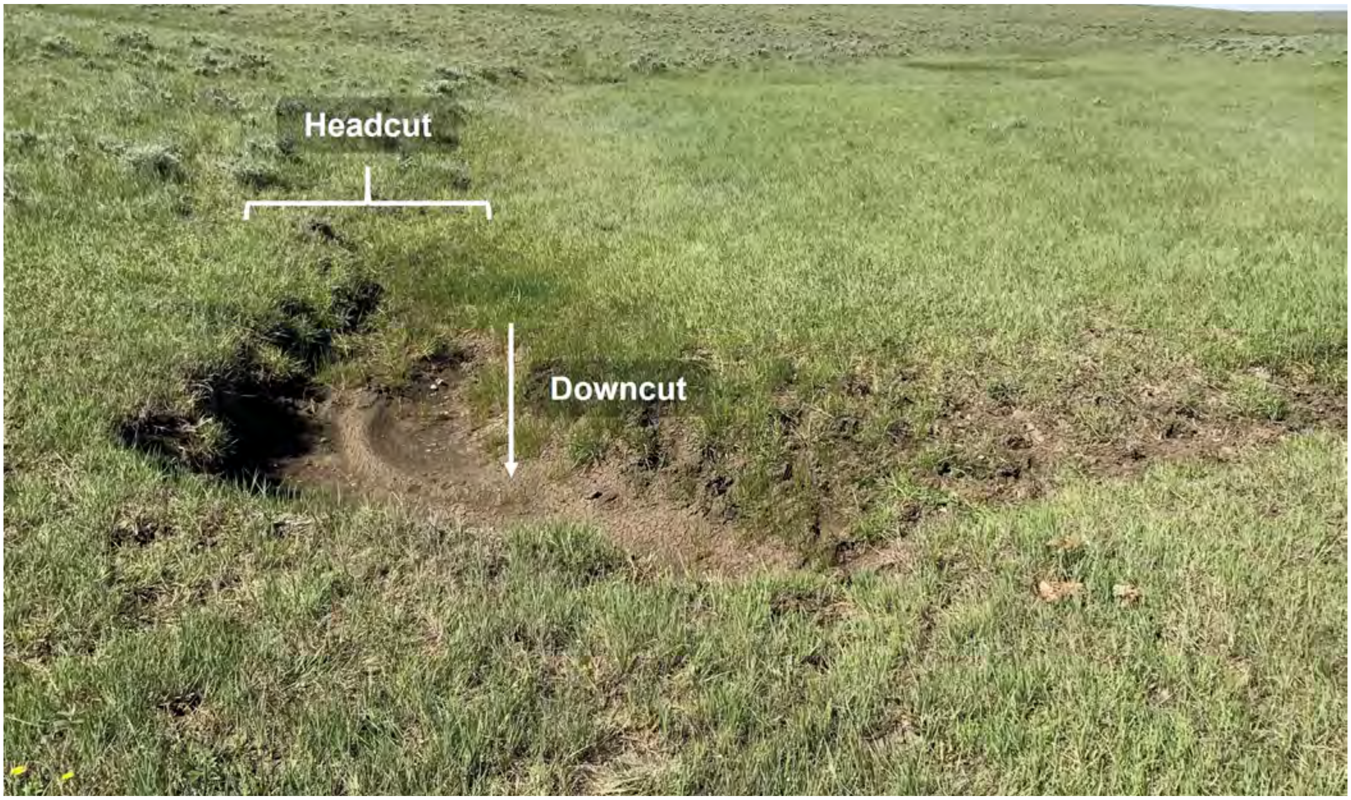


Figure 80: A headcut is forming in an upper headwater system. The area above this headcut is not incised. Below the headcut, the channel is downcutting and incising. Photo © Corissa Busse, TNC

Figure 81: When headcuts occur below water, they may not be easily visible—but they often can be heard. Here, the knickpoint where a headcut is forming underwater causes the water level to drop. The rush of water flowing down is audible. Photo © Corissa Busse, TNC

As downcutting and incision persist, a stream and its channel will begin to drop along with the water table below ground. This will create multiple management challenges, as shown in Figure 82, including difficulty accessing the water for livestock and wildlife, inability of managers to easily cross streams, and loss of riparian zones and the beneficial vegetation they provide.

Many of the problems associated with channel erosion, downcutting, or high bank instability are also caused by increased streamflow after large storm events, which erode and transport sediment. This problem has become more pronounced in western South Dakota in recent years due to the increased frequency of large precipitation and runoff events; it is not uncommon to now receive several inches of rainfall in under an hour. This has led to very high streamflow levels and flooding; accelerated erosion; and damage to roads, culverts, and other streamside infrastructure (Wienhold et al. 2018). These large rainfall events also trigger headcuts, which as noted can instigate problems both up and downstream.

Loss of infiltration and soil water-holding capacity across watershed areas frequently leads to excess runoff and creates increased peak flow and downstream flooding that can cause channel erosion problems. Altered hydrology and loss of infiltration across large portions of the watershed can be the result of recent changes in climate or land use, or they can be the cumulative effect of multiple changes in land use and management extending back many decades. If land-use or climate changes (such as new land conversion or increased precipitation in storm events) happened abruptly and recently, there may be an abrupt increase in channel erosion.

In more urbanized or intensive crop production regions of the United States, loss of water storage and infiltration is often related to draining wetlands and/or an increase in impervious surfaces, such as paved roads and parking lots. However, in western South Dakota, widespread soil compaction, reduced plant cover and loss of soil organic matter can occur across large areas due to extended drought, a long history of overutilization, and the loss of the historic plant community. Channel responses to these alterations may take many decades to adjust throughout the system, meaning that a stream that is currently actively downcutting or incising may be responding to management or environmental changes that occurred from historic events.

When the stream reach is at the downstream end of a relatively large watershed, and/or the landowner owns only a small portion of the overall watershed, an integrated approach of best management practices and tools will be needed to address stream health issues.

It is often possible, however, to heal or prevent the further spread of headcuts into a pasture at the local level by using site-specific management interventions. Similarly, it may be possible to rebuild a stream that has recently incised if the incision level is not too dramatic. Improved grazing management can positively impact riparian vegetation, which slows and traps sediment. In addition, in-stream installations such as Zeedyk structures and beaver dam analogs can be used to slow water and help trap sediment in the channel, which can then begin the stream's natural rebuilding process. These management interventions are described further in the following section.

Sensitivity to Downcutting

Certain stream types are more sensitive to disturbances, such as flood events, prolonged drought, channelization, and/or grazing pressure. As streams change over time, they often follow a pattern or cycle, as described in earlier sections. This cycle is influenced by the stream's position in the watershed, the slope, and the soil type. Many of the headwater streams and woody draws in western South Dakota are highly sensitive to disturbance because they run through soils composed of highly erodible fine sediments (clay and silt) and thus are prone to rapid channel adjustment. Streams with larger drainage areas are also sensitive to disturbance and likely to downcut because the larger volume of water exerts greater force on the banks.

The controlling influence of vegetation is very high in the slightly entrenched channel types. This means that if vegetation is removed by disturbance, streams are more likely to erode downward and/or widen, as shown in the Channel Evolution Cycle. Streams that are more entrenched have increased stream power and velocity, which will make restoration more challenging as the banks continue to erode.

Active channel incision is related to or plays a role in many of the challenges listed below in this section. It is the precursor event that contributes to bank erosion, degrading plant communities, and reduced flows.

Incision Leads to Excessive Bank Erosion and Streambank Instability

Streambank erosion is a natural process, but it is often accelerated by human activities that alter the plant community or increase flow and slope. Excessive bank erosion is a warning sign that a stream has limited ability to dissipate its energy and could result in additional riparian health problems. These issues tend to occur when there is a loss of deep-rooted plants. As streams lose bank stability, they become wider and water moves faster; over time their length shortens, and they become straighter as the water cuts through collapsing banks. Streambank instability is often closely related to channel incision. When channels are eroding laterally, it can cause problems for human structures such as fences and buildings. It also can make streams less accessible to livestock and more difficult to cross and may degrade water quality due to excess inputs of sediment.

Figure 82: This stream has incised nearly 10–15 feet. It is no longer easily crossed or accessible to livestock and wildlife. The surrounding meadow area will lose vegetation productivity due to the drop in the water table. Photo © Kristen Blann, TNC

Overwidening

Channel widening can occur when the stream bed hits a resistant soil layer such as claypan or bedrock, creating resistance to channel incision. In this case, bank erosion leads to channel widening rather than incision, and stream depth decreases. This can have significant impacts on the floodplain ecosystem and cause stream temperature to rise, drying out ephemeral or intermittent reaches earlier in the season. Typically, little water is retained in the streambanks for use by vegetation or delayed release back into the stream (Wyman et al. 2006).

Figure 83: This channel has widened considerably in recent years due to streambank collapse, leading to shallower flow with little vegetative overhang to provide shade and habitat for aquatic life. Photo © Corissa Busse, TNC

Inadequate Low Flows

Increased peak flows caused by excess runoff and reduced infiltration are frequently associated with extreme low flow periods. This indicates poor storage and capture of water in the watershed during wet periods and could be a warning sign of a falling water table as a stream downcuts and hydrology is lost. Low flow may create stressful conditions for the riparian plant community, wildlife, and aquatic life. While low-flow conditions are normal for streams in the region (by definition, intermittent streams go dry part of the year), channel incision and inadequate vegetation cover throughout the upland landscape contribute to excess runoff and poor soil infiltration. This worsens low-flow conditions because less water is being held in the soil profile throughout the watershed. Local flow and/or water levels can also be impacted by local impoundments and/or groundwater pumping, reducing baseflow and connectivity of streams during the late summer or fall, when water levels are typically at a low point for the year.

Figure 84: Many streams in western South Dakota struggle to hold water. This can be a result of loss of hydrology and connection to the water table. Photo © Joe Dickie, Generation Photography, Inc.

Lack of Adequate Riparian Vegetation, Low-quality Vegetation, and Invasive Plants

A common problem in riparian areas is poor quality or inadequate riparian vegetation, often associated with bare exposed soil in the channel and banks, leaving the stream vulnerable to water and wind erosion. The plants present in these degraded buffers are often weedy pioneer species, annuals, unpalatable salt-tolerant species, or invasive species that have little value as forage or wildlife habitat and that provide little streambank protection against high flows.

Poor quality riparian vegetation is often a vicious cycle. A period of high flows, drought, or other disturbance may trigger the original decline in vegetation. This decline can continue if disturbance continues, preventing plants from re-establishing. Scouring from high flows causes banks to dry out and the water table to lower as the channel begins to downcut. This lowering of the water table in the adjacent floodplain or terrace caused by channel incision is a subtle impact that dries out riparian soils and adjacent meadows (Chambers et al. 2004, 2016).

Drier conditions support less productive grasses and forbs and reduce the potential for desirable or woody riparian species to establish. As the riparian water table drops from ~3 inches in depth to greater than 60 inches in depth, the landscape changes. Channel incision greater than 3 feet can move the riparian zone from a wet meadow to a dry meadow or upland community. This is less desirable from both an ecological viewpoint and from a grazing standpoint, as there is less desirable forage and reduced water-holding capacity in the uplands.

Figure 85: As banks erode, the plant roots are exposed, which causes them to dry out and die. As the roots die, they are no longer able to hold soil. This creates a negative feedback loop of erosion and drying. This photo also demonstrates the lack of deep fibrous root systems in degraded areas that lack strong riparian vegetation. Photo © Joe Dickie, Generation Photography, Inc.

In comparison, strong riparian vegetation such as prairie cord grass and willow can help protect banks and capture sediment; they provide roughness that reduces stream velocity and its erosive power. As mentioned previously, some stream systems neither require nor have the potential to support woody vegetation, but a diverse herbaceous plant community can be equally effective at providing protection. Some systems need woody vegetation to function properly, but others do not. For that reason, it is important to understand the stream type that you are working with.

Figure 86: Small headwater streams, as shown in the photo on the left, may have some potential to support woody shrubs and small trees. The top right photo is an example of a mid-size prairie stream system that can support woody species, but because of loss of floodplain connectivity, trees are rare and struggling to survive. Larger systems like the one shown in the bottom right have more potential to support woody species. Photos © Joe Dickie, Generation Photography, Inc.

Larger prairie streams are more likely to support woody species than headwater meadow streams, which historically were subject to frequent fire and grazing. However, we surveyed many headwater streams in 2018–19 where infrequent, large mature cottonwoods were present, suggesting that riparian conditions even in these areas supported cottonwood establishment and persistence at some point in recent history. The presence of mature cottonwoods does not mean that the area is currently suitable for the establishment of young cottonwood seedlings. Cottonwood recruitment is influenced by access to shallow groundwater and sustained moist soil conditions throughout the growing season, as well as the occurrence of small flood events that deposit new sediment and seeds. As channel incision and dams have altered the hydrology of streams, favorable growing conditions are less likely to occur.

Poor Water Quality

Poor-quality water can have a negative effect on growth, reproduction, and general productivity of livestock and wildlife. In some cases, animals can die within days or hours after drinking low-quality water. Salinity is one of the most common water quality issues. Animals that have an increased requirement for water (e.g., during lactation or pregnancy) are the most susceptible to salinity. High salinity has been an increasingly common problem in South Dakota in past years. Limited snow run-off and dry conditions, along with evaporation, contribute to increased salinity concentration and should be a warning to producers that possible water problems may exist under these conditions. It is important to understand that limited run-off and drought increase the risk of poor-quality water; however, some water sources are "bad" regardless of environmental conditions.

The most widespread water quality issues for aquatic life in South Dakota streams are low dissolved oxygen, high temperature, and excessive nutrients (mainly nitrogen and phosphorus) from runoff. As stream levels recede and temperatures increase in the summer, low oxygen levels make it difficult for fish and aquatic life to survive (Dodds et al. 2004). Although these conditions are part of the natural pattern of intermittent prairie stream hydrology, they can be worsened by water withdrawals, farming practices, the alteration of riparian vegetation, and impoundments. Manure and/or farm runoff can add nutrients to streams and ponds, causing excessive algal growth that further worsens water quality in the form of blue-green algae (cyanobacteria) blooms.

Figure 87: Algae blooms and poor water quality may occur in heavily used, low-flowing streams. Photo © Corissa Busse, TNC

Poor Soil Conditions, Including Salinization and Sodification

Challenging soil characteristics occur across rangelands in the Northern Great Plains (Letey 2000). Typically, soils derived from marine sediments have high concentrations of sodium and other salts. Salts are leached out of soils into runoff and shallow groundwater seepage and tend to accumulate along the flowpaths of water at discharge points (as shown in Figure 88). Salts also accumulate where evaporation and evapotranspiration exceed inflows, such as in poorly drained footslope areas or along the margins of streams, wetlands, and impoundments (as shown in Figures 89 and 90). Frequently, evaporation and seepage from stock dam impoundments and even natural wetlands can exacerbate conditions that lead to saline and sodic conditions. Irrigation of hay, pasture, and cropland, both current and in the past, can also contribute to increased salts and overall changes in soil chemistry.

These soils are toxic to many plants and limit the growth of most species. The presence of salt-tolerant plants such as kochia *(Kochia scoparia)* and foxtail barley *(Hordeum jubatum)* indicate conditions where salt concentrations may be high. In extreme cases, there may be no vegetation. In the worst cases of soil salinization, streams contain barren exposed flats of varying sizes. Salinization can also lead to poor water quality for livestock in streams and stock ponds.

Salts and salinity are a natural component of the system in parts of western South Dakota, and plant communities have evolved to tolerate saline conditions. However, in some riparian areas or along the margins of stock dams and impoundments, salt accumulation exceeds the natural balance due to human-made disturbances of the landscape. Unlike historic beaver dams, which allowed slow but continuous flows of water through a system over greater areas, stock dams are designed to be impermeable and concentrate water, holding it in a confined area where it experiences greater stagnation and evaporation once inflows dry up. These water sources have an increased risk of salinity and other water quality issues.

At the time of this guide's publication, increasing attention is being given to salinity, and research is being conducted around how to address this difficult challenge, especially related to stock dams and impoundments. We recommend that you contact your local NRCS or SDSU Extension office for technical assistance and the most up-to-date guidance on how to address salinity issues.

Figure 88: Salinity accumulation causes loss of vegetation in riparian areas. Photo © Corissa Busse, TNC

Figure 89: At this poorly drained foot slope, intermittent/ephemeral hydrology has created salt accumulation due to evaporation. Photo © Lori Brown, TNC

Highly Altered Streams: Impoundments, Road Crossings, and Culverts

As mentioned earlier in the guide, many of our stream systems are highly altered. Some of the alternation is minor and has minimal effect on the overall health of the system; some alterations are drastic and directly impact the connectivity and integrity of a stream. We are just beginning to see and understand the full effect that alterations can have on stream health. The most common alterations to stream connectivity in our landscape are small impoundments, road crossings, and culverts.

Small impoundments and cattle stock ponds are intended to capture and store runoff, provide livestock with water later into the season, and attract wildlife. The storage of spring runoff water through the season is vital for livestock managers. Often, these stock dams and impoundments may be the only source of water available in large summer pastures to sustain livestock and other wildlife. However, impoundments can also create challenges on the landscape. In addition to capturing and storing water, they also capture and store sediment and, in some watersheds, accumulate salts. The sediment fills the ponds over time, which decreases the water storage capacity and starves the stream of sediment that would have helped build point bars and sinuosity. As a result, the erosive power of the water is increased and contributes to downcutting of the stream. The salts that are accumulated can cause water quality issues as they slowly leach out and concentrate downstream.

Furthermore, many riparian species like cottonwoods are dependent on natural flood events that deposit sediment, create scouring, and open soil for seeds to germinate, recruit, and establish (NRCS 2002). Unlike historic beaver dams, impoundments do not allow a continuous flow or trickle of water through them. We are still learning about how impoundments and dams influence and affect the landscape; more research is needed to help find solutions to balance the need for livestock water.

Figure 90: This small stock pond has a distinct ring of salt accumulation. In some situations, salt accumulation can create toxic conditions for livestock and wildlife. Photo © Lori Brown, TNC

Road and road berms can also function as impoundments, causing similar challenges and issues. Poorly designed water infrastructure such as perched or undersized culverts can create management issues and block movement of aquatic life, reducing connectivity of the aquatic habitat. This can permanently fragment populations and eventually eliminate those species from upstream reaches (Hernick et al. 2019). Undersized or poorly designed culverts may also be washed out or undermined during high flows, creating maintenance needs and raising costs for local government and ranch owners. Poorly designed road crossings can often trigger channel instability and headcuts that can migrate upstream or downstream. For example, during high flows, bridges or culverts that constrict the channel can cause a "fire hose" effect downstream or erode on the upstream side where flows are held back.

Figure 91: Culverts and road crossings can significantly constrict the flow of water in a stream during flood events. This constriction point can then intensify the force of waters, creating headcut and incision challenges, which not only create challenges for the stream but also compromise the road over time. Photo © Christian Lenhart, TNC

Holistic Plan Revives Ranch Springs and Soils

> *"A shift to bison, strategic grazing, and proper grass rest and recovery yields success in partnership with nature."*

The adage 'time heals all wounds' is appropriate for the 777 Bison Ranch, thanks to holistic management practices implemented by owner Mimi Hillenbrand over 30 years ago.

"By capturing water, controlling grazing to rest and recover grass, and building healthy soils, we have restored our prairie using bison, in partnership with nature," she says. "It's an ongoing journey that takes time, trial and error, and constant monitoring—but it works to produce more grass and increase water infiltration to feed the many springs this practice has created."

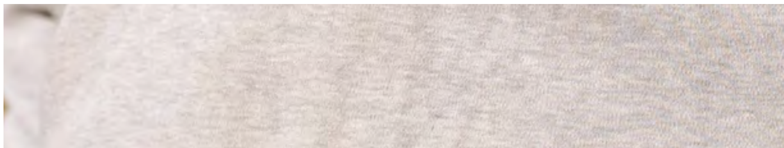
Her journey began in 1970, when she was a child and her family bought a ranch near Hermosa, east of Custer State Park in South Dakota. The ranch had a traditional, cow–calf Angus/Hereford herd and the family used the same pastures for calving, spring, summer, and winter. They also employed tillage and seeding of crested wheatgrass and smooth bromegrass—initially thought to be an ideal remedy for overgrazed rangeland.

An aha moment

Hillenbrand's passion for holistic practices was born during high school when she heard Allan Savory speak on the value of working with natural soil systems to graze and rest grass. "It just made sense to me and helped me determine what I wanted to do with my life," she shares.

She saw how previous pasture management had degraded the ground and eroded the creek beds, and how repeated grazing caused the creek areas to lose vital vegetation. "If we had a heavy rain back then, it would wash right through and be gone because the land was so degraded, so I knew we had to change," Hillenbrand says.

Mimi Hillenbrand, rancher
Custer County, SD



The ranch had very few seasonal springs, and Dry Creek, which ran through the ranch, lived up to its name. "I remember when we moved cattle, the creek was so dry you could easily drive a four-wheeler over it in certain parts where it wasn't steeply eroded."

Enter the bison

In the early 1980s, the ranch began incorporating bison into the beef herd. A nasty spring blizzard during calving season changed the ranch philosophy forever, prompting a shift away from beef to 100% bison.

"We were pulling calves from our beef cows and trying to keep them warm in the middle of a blizzard. Yet, all the bison waited to have their babies until after the storm had passed," Hillenbrand says. "It was the coolest thing to see how bison adapted to nature. They are survivalists."

That reevaluation helped spark a prairie regeneration journey for Hillenbrand. She adopted what was then known as the Savory System—wagon wheel paddock pastures around a central watering point. But the survivor characteristics of the bison also led to some teachable moments, including a disregard for electric fences, which made it difficult to contain them.

"We've learned a lot from the bison over the years," Hillenbrand laughs. "We've put up fence, added electric fence, taken down fence, taken out all electric fence, and redone pasture shape and size. At one point, we had 36 pastures, and now we're down to about 25 pastures, which seems to work for us."

Being flexible and writing spring and fall grazing plans in pencil are key to their grazing success. In addition, over the years, they have extended their two pasture recovery periods during the growing season. "It used to be between 40 and 100 days, but now we have more success with 60 to 120 days of rest and recovery."

To judge forage quality, quantity, and recovery, Hillenbrand must do daily monitoring. She and her team check the grass and herd daily to move the animals while maintaining healthy grass. "We move the bison anywhere from after a couple of days to after a week in a fast-growing smaller pasture. Or it can be seven days to three weeks in a larger pasture," she says. "It's daily decisions, and you have to be on the land all the time to know what's happening."

Dry Creek becomes a plant and wildlife haven

More than anything, Hillenbrand wanted to bring back native grasses and keep water on the land. During the past eight years, more sections of Dry Creek have had constant water, due to more springs running year-round.

"By planning our grazing, I've noticed over the years that our creek has more willows and young cottonwood trees, and more groups of prairie bulrush and other aquatic vegetation filling in, which is super exciting," she says. "And our bird and wildlife habitat increase every year, bringing in flocks of bobolinks and dickcissel, ducks, cranes, trumpeter swans, shorebirds, deer, mountain lions, coyotes and more."

When big rain events happen now, the water no longer runs fast and disappears. Instead, it soaks into the soil. A study conducted on the ranch confirmed that infiltration rates have vastly improved.

Research proves holistic benefits

Five years ago, Hillenbrand hired the company Applied Ecological Services to conduct an overall ranch health assessment. Over the course of a year, they mapped soils and plant species, examined water infiltration, and measured soil carbon, then compared these values with those of area ranches that were still practicing traditional grazing.

"We learned that we have two to three times more native grass species and fewer invasive species, and our water infiltration rates were dramatically higher," she says. "I'm so proud of my team, because achieving those two goals means we're doing things right."

Hillenbrand firmly believes that if you graze correctly and take care of the land, everything else falls into place. However, she describes her ranch as a work in progress, since there are always areas to improve. "That's why we're always learning, attending conferences, remaining open to new ideas, and doing things better—knowing that improvements take time."

Figure 1. Ranch owner Mimi Hillenbrand with ranch manager Moritz Espy. The 777 Bison Ranch team practices holistic grazing practices on the operation. Photos © Joe Dickie, Generation Photography, Inc.

Figure 2. The 777 Ranch works with bison as grazers, moving them rotationally over the land to mimic the historic movement of the herds. Photos © Joe Dickie, Generation Photography, Inc.

Figure 3. The 777 Ranch has seen many springs reappear across the ranch over the years as they continue to increase their soil profile. Photos © Joe Dickie, Generation Photography, Inc.

Figure 4. Willows, young cottonwood trees, and more groups of prairie bulrush and other aquatic vegetation are filling in along Dry Creek on the ranch. Photos © Joe Dickie, Generation Photography, Inc.

Section 10: Guide to Management Actions and Interventions

This section will explore several management practices that can help protect and restore riparian area resources and ecological health. This is not an exhaustive discussion of the options available but a starting point for riparian restoration planning and management.

A primary goal of restoration management is to proactively identify practices that are appropriate for each stream type to maintain, restore, or enhance its ecological services and values. Equally important is identifying practices that add value to landscapes for ranchers and landowners and that can restore streams and riparian areas toward their full potential.

Some challenges may be beyond the scope of the site-level management practices that a landowner or manager can implement. Addressing major channel erosion and instability, for example, may require advanced technical expertise. In addition, a coordinated effort at the watershed scale between land managers and technical experts may be necessary to address upstream or downstream causes of problems. For that reason, where possible, we indicate issues that may be beyond the scope of this guide and suggest where to obtain additional technical assistance.

A coordinated effort among government agencies, nonprofits, and landowners is invaluable to make watershed-scale improvements in soil health, water quality, and overall riparian condition. There are many actions, however, that individual landowners can take to improve riparian condition, accelerate recovery, and facilitate desired states and trajectories on their land. Full recovery of a stream system requires patience and continued active management over the course of years. The following section outlines opportunities and challenges to stream restoration and management on private lands.

Riparian Vegetation Restoration and Management

Riparian vegetation is critical in maintaining channel stability during high flows to allow a stream to maintain its proper shape, pattern, sinuosity, and gradient. Vegetation is vital in all stream types and can play a beneficial role in slowing flows and protecting against erosion. In addition to performing direct riparian area management, it is important to consider the condition and management of the associated uplands that directly affect conditions in the riparian area. Changes in the management of the uplands should not increase runoff or sediment delivery in a way that is detrimental to the riparian zone. The following section outlines several questions to ask when discussing vegetation management.

Managing Areas of Streambank Erosion Due to Poor Vegetative Cover

One of the key historic reasons to protect grasslands in the NGP was to address the high rates of soil loss that worsened in the Dust Bowl era of the 1930s and the following decades (Worster 2004). While many areas that were severely damaged by early attempts at crop production were revegetated through the National Grasslands and Conservation Reserve Program, many sensitive areas with fragile soils remain in a degraded state. Riparian areas that have less than 30–40% vegetation cover have significantly higher rates of soil loss, as soil erosion increases when it is less protected by plant cover. In these cases, grazing duration and timing can be adjusted to improve plant cover and reduce soil erosion.

Grazing management can be used to create conditions that enable riparian plant communities to recover from disturbance or maintain a healthy state. Sustainable riparian grazing is about managing the timing, duration, frequency, and intensity of use and allowing for recovery. This is described further in the grazing management portion of this section.

The percentage of bare soil is only one important factor to consider, however, when managing riparian vegetation. Managing for riparian plant community diversity is also important because a diverse community of plants is better able to maintain and enhance the stability of streams. Specifically, riparian species, especially plants with deep fibrous root systems, are six to ten times more effective at providing bank stability and resisting the force of water than are plant species adapted to drier environments (Micheli and Kirchner 2002). The roots of these plants have four basic characteristics that affect bank stability: root biomass, total root length, resistance to compressive force (hoof action), and linear or stretching strength.

Vegetation management can be used to address channel stability issues, especially on smaller streambanks. Once root depths decline to less than half of the bank height, the risk of bank collapse increases greatly. Vegetation has little effect on channel erosion once bank height exceeds six to eight feet because average plant root depths are only half a foot to three feet. Gravity-driven collapse of banks increases with high, poorly vegetated banks.

Ongoing and recurring monitoring and adaptive management are crucial to noting whether a stream is trending toward riparian diversity. We encourage users of this guide to note what riparian plants are seen at a stream site year after year. If diversity is increasing, continue management actions that have encouraged the diversity. If it seems to be decreasing, consider why this may be occurring and what management changes may have caused this to occur. Please consult the adaptive management section below on this topic as well.

Addressing Invasive or Undesirable Species Challenges

Non-native species that dominate a site may inhibit colonization by more desirable native species, including cottonwood and willow, along streams. Coverage by species such as Canada thistle, smooth brome grass, Kentucky bluegrass, or cheatgrass can be detrimental to biodiversity and forage quality for grazing animals.

Some control of invasive species can be achieved through targeted grazing or the use of different classes of livestock, while other situations may warrant a more intensive management approach. Treatment of invasive species with herbicides can be expensive and often requires multiple years of treatment to be successful. Treatment also needs to be selective enough to minimize harm to desirable native species. Control in riparian areas can be particularly challenging if upstream areas are not being treated. It is important to consult with local experts to develop an invasive species management plan. Managing for species diversity and controlling invasive species often go hand in hand because a more diverse plant community will be less susceptible to invasion by non-native species.

Managing to Promote Trees and Shrubs Along the Creek

Establishment or protection of woody plants in riparian areas is a frequent goal (or an open question) for many landowners and land managers in the region. The balance between stream health and access to shade and water for grazing animals is one of the key management issues for land managers in the western Dakotas. Trees and shrubs also provide streambank stability and critical habitat for fish and wildlife. However, cattle and sheep usage can decrease the abundance of woody riparian plants.

Not all grassland sites are appropriate for or have the potential to support riparian forests or woodlands. Historical evidence suggests that fire, grazing, and water availability strongly influenced and limited the extent of woody vegetation along riparian areas in the Great Plains. Riparian gallery forests of mature willow and cottonwood were common in the past along the larger rivers and floodplains, and still are today. They may have featured denser and more extensive tree cover than they do today, as these forests were heavily harvested and utilized for wood in the early days of European settlement (Hart and Hart 1997; Rumble et al. 1998; West and Ruark 2004).

The presence of mature trees without saplings is a strong indicator that seedling recruitment is not occurring and that natural processes are impaired. If trees are absent and if the site conditions justify planting, they may be re-established through a combination of grazing management, restoration of floodplain connectivity, and targeted planting of tree and shrub seedlings. Planting trees without first re-establishing hydrology to an area, however, is unlikely to succeed. For instance, trees along streams that have begun to downcut or incise are likely to die because they lack access to the water table. Replanting trees in this degraded system will not address the root cause of the issue: the hydrologic connectivity that the trees need to be supported. Further, once hydrology is restored, trees may naturally re-occur, even if they are not planted. We recommend, therefore, that efforts to restore woody cover focus on first restoring the stream system and riparian health.

Tree species typically do not occur in drainage areas less than 10 square miles unless there are springs or seeps feeding the system. Re-establishment of riparian woody plants in streams with a drainage area larger than 10 square miles can be accomplished through natural revegetation, as many of the seeds of key species (willow, cottonwood, boxelder) are dispersed by wind and wildlife. Seed sources may also be dormant in the seed bank on site, waiting for appropriate conditions to return; this experience is described in the ranching profile story of Al and Simone Wind earlier in this guide.

The recovery of woody species can depend a lot on initial conditions and the “first come, first served” effect. For example, if sedges and rushes are first to revegetate a recovering area, they can inhibit or delay woody species recruitment on sites that are fully capable of supporting woody vegetation. Meanwhile, if riparian woody and shrub species are among the first species to establish, there will be less competition to inhibit them from increasing in the riparian area (Winward 2000).

In some cases, seeding an area with a native seed mix may be beneficial, as the new seedlings will help cover bare soil and create favorable conditions for other seedlings. It can increase diversity and introduce species that would not naturally disperse to the site. Planting tree seedlings, however, can be expensive and they often do not succeed unless the hydrology issues have been addressed, as noted above. If streams are actively downcutting or have lost connection with the floodplain, the local water table will be too low for seedling roots to access.

Dense woody buffers may not be desirable in all situations. Managers should set suitable goals and follow an adaptive management process to achieve their desired balance of woody cover and forage production (see discussion on restoration planning and continuous adaptive management in section 11). Highly incised channels may take years to recover and require more intensive solutions, which is why it is important to have realistic expectations for woody plant recovery.

Figure 92: In the 1700s and 1800s, beaver and then trees were largely removed from western South Dakota prairies. As a result, many streams look dramatically different than they did historically, leaving many to wonder whether these systems can again support trees. This photo shows the Mortenson ranch, where trees only began to recruit and recover after the last homesteader moved on during the Dust Bowl era. Since the Mortensons implemented stream and grazing restoration practices, willow, ash, and cottonwood trees have made a dramatic comeback and now fill the draws. The trees provide valuable winter cover for their herd. Photo © Joe Dickie, Generation Photography, Inc.

Grazing Management

Many riparian objectives can be accomplished through grazing management alone. Riparian areas naturally attract livestock on the landscape, and even a few cows with prolonged access can have an impact. Often it is not possible to reach desired plant community goals by managing stocking rates alone, as it does not affect livestock usage of these areas. Riparian areas are sensitive and need to be managed with special attention; they are also incredibly resilient, adapted to periodic disturbance, and can respond more quickly to management changes than upland areas.

As mentioned in earlier sections, grazing management is about timing, duration, frequency, and intensity of use and recovery time. There is no one formula for grazing that will help riparian areas recover. These areas are complex and dynamic and require an adaptive management approach. All perennial plants can recover from grazing; some species are even more vigorous with moderate grazing. But when plants are excessively grazed, they are unable to replenish root reserves or grow new roots, which will negatively impact stream stability and erosion. Grazing management in riparian areas is a balance and is most effective when we understand site dynamics and have tools to address intensity of use. The following sections discuss common topics that influence livestock utilization of the landscape and can be tools for restoration.

Fencing, Off-site Water, and Mineral Use

The use of fencing and other temporary exclusion methods can encourage desirable plant species to recruit and re-establish and provides improved flexibility to a grazing rotation. Developing riparian pastures allows for very specific control of grazing pressure and has been effective at improving riparian function (Wyman et al. 2006). However, fencing and exclusion, even temporarily, is not always an available option and can encourage invasive grasses like Kentucky bluegrass and smooth brome. Totally excluding livestock is as detrimental to riparian communities as overutilization and should be avoided. Fencing is also very expensive to build and maintain and can restrict wildlife usage and movement.

Wildlife-friendly fencing near riparian areas is beneficial and can aid wildlife movements while reducing damage to fences in areas that are regularly used by deer, antelope, or elk. Practices that reduce the time livestock spend in bottoms and help draw them away from loafing near a stream can be a helpful alternative to fencing riparian areas. These practices include developing off-site water sources (including deep wells and pipeline development, or pumping surface water to an upland location), moving salt and mineral supplements off streams, and feeding livestock away from riparian areas. Additional livestock management practices such as regular herding of animals and selective culling of bottom-loafing cows have been used with some success in other western states, particularly on public land allotments and in steep rugged terrain where fencing is less feasible. These techniques are not common in western South Dakota. More information on these practices can be found in Practical Grazing Management to Maintain or Restore Riparian Functions and Values on Rangelands by Swanson et al. (2015).

Figure 93: Cattle prefer to graze along cooler, more vegetated areas like this streambank. Management can include fencing or rotational grazing to reduce the amount of time cattle linger in these areas. Photo © Julie Brazell, TNC

Season of Use

Managing season of grazing use and recovery can affect plant community composition and forage quality by controlling the timing of grazing to promote the expansion of desired native grasses. This can also promote streambank stability and reduce channel erosion. Season of use changes how livestock use upland and riparian areas and what plants they prefer. Many studies have found that cattle graze farther from the stream in the early growing season, when uplands are green, and concentrate along streams late in the summer (DelCurto et al. 2005). Season of use can also be used to set back undesirable species, such as Japanese brome or cheatgrass, that have little grazing value and support few ecological services. One example of a grazing management system that can be effective in changing plant communities is an intensive management system that creates high grazing disturbance over a short period of time. It can promote the growth of warm-season grasses, such as big bluestem and Indian grass, that are high in crude protein later in the growing season when cool-season grasses have entered dormancy. Every ranch operation is different, and intensive grazing is not a good fit for many situations and management operations. The goal in changing the season of use is ultimately about creating more diversity over time, which can be achieved with a variety of grazing systems.

Altering the timing of grazing from year to year provides recovery for different plant species at various plant growth stages and can maintain or improve riparian conditions. This is because plant needs for growth, seed production, vigor, carbohydrate storage, or root maintenance and development vary throughout the year and differ among species. There will always be benefits and drawbacks to consider when making a riparian grazing management plan. For example, keeping cattle off saturated banks helps prevent soil compaction, but disturbance can also help encourage more diversity. An effective riparian grazing strategy should be tailored to site conditions, objectives, and livestock management considerations and should focus on realistic desirable outcomes.

Livestock grazing that promotes and is compatible with healthy riparian vegetation contributes to sustainable levels of aboveground biomass, root growth, and root strength in streambanks. Overbank flows cause riparian vegetation to be naturally defoliated or buried by sediment deposition, which helps build soil structure and organic matter. The addition of properly timed grazing can help promote new green growth and root development. If the root strength of riparian vegetation and the surface roughness are sufficient, sediments will be deposited, rather than eroded away. One of the most common issues with grazing management is distribution, which is particularly true for riparian areas, where livestock tend to concentrate. Using riparian areas for winter grazing can reduce damage to streambanks, and plants are typically less stressed by dormant season grazing. In winter months, it may also be easier to draw livestock away from riparian areas by offering supplemental feeding away from the stream. Regardless of grazing season, manage for an adequate recovery/rest period and customize the grazing to site-specific needs.

Species and Classes of Livestock

The use of different species and classes of livestock can also influence riparian area health. Cow–calf pairs tend to concentrate, loaf, and forage in valleys, and they may impact riparian areas more than yearling cattle, which tend to range more widely and use more upland areas (Wyman et al. 2006). Sheep have different forage preferences and behaviors from cattle. Sheep can clip grass closer to the ground than do cattle, which typically graze using their tongues and graze farther above the soil surface. Because different animal species and classes have different plant and terrain preferences, integrating multiple grazing species may improve utilization and plant species composition (Launchbaugh and Walker 2006), but it is important to remember that with prolonged time on the land, any herbivore can graze close and damage vegetation. As with season of use, diversity in class of livestock can contribute to diversity in the plant community.

Bison ranching has grown in the Dakotas in recent years (O'Brien 2002). Bison impact plant community structure differently from cattle because they graze in different landscape positions, often have a lower impact on the riparian zone, and tend to graze more evenly across both upland and riparian areas (Miller 2003; Helzer 2009). The economics, overall feasibility, and long-term potential of bison ranching, particularly in the context of grassland maintenance and recovery, are beyond the scope of this guide, but more information is available from the National Bison Association (https://bisoncentral.com/raising-bison/).

Using Livestock to Repair Streambanks

When streams have entered a degraded phase of incision and downcutting, streambanks may become steep and separated from the uplands. This creates a challenge for both wildlife and livestock, as well as a lowering of the water table. To move out of an incision phase, the stream must widen and erode its banks until they eventually fall into the channel and help create a new inset floodplain (as described earlier in this guide).

There is a risk associated with fully excluding livestock and utilization during this phase. Exclusion of livestock can cause a stream to heavily revegetate along these incised banks, preventing the necessary erosion process that is needed to advance the stream out of its incised state. This is referred to as arrested degradation. The stream becomes stalled in its evolution process.

In some instances, it may make sense to use livestock to accelerate the channel evolution process through hoof action. As livestock and wildlife work to access the water, they put pressure on bank walls, causing weak areas to fall into the channel. This helps to lay back the steep banks of the incision phase and push the stream into widening and depositing. Extreme caution should be used, however, to ensure livestock safety in these situations and to manage for adequate plant recovery.

Comparing Grazing Management Options

The following table describes how a variety of grazing management practices may impact riparian and stream areas.

Table 3: Comparison of Grazing Management Tools (adapted from Swanson et al. 2015)

Grazing Management	Impacts
Hot season use	Livestock attracted to riparian area forage
Cool/early season use	Palatable upland vegetation and warmer temperatures attract livestock to upland areas; caution should be taken to ensure that adequate vegetation is left to dissipate spring flows
Season-long use/access	Plants experience repeated defoliation and decreases in plant vigor; this can be done selectively with adequate rest/recovery
Late/fall season use	Little time to regrow before dormancy; often not compatible where woody recruitment is goal; cooler temperatures will lead to less loafing time along stream
Consistent season of use	Use during same phenological stage decreases species diversity, leads to increase in less palatable species over time
Large pastures	Difficult to manage for riparian objectives
Occasional growing season use	Can be implemented with opportunity for plants to regrow before next defoliation and disturbance can improve diversity
Off-site water development	Improved pasture distribution, attracts livestock away from riparian bottoms
Moderate to light intensity utilization	Plants maintain leaf area and carbohydrate reserves needed for regrowth
Cleaned pastures/not leaving stragglers	Ensure recovery period and minimize continued riparian usage by animals
Exclusion of livestock	Can encourage invasion by non-native cool-season grasses, selectively applicable to support recovery

Evaluating Which Management Tools to Use to Address Stream Entrenchment

Two of the main problems discussed earlier in this section are channel incision and overwidening. If there are channel stability problems, is the area in a region that has naturally unstable channels, such as badlands, or in another area with poorly vegetated, erosion-prone soil? In addition, is the channel entrenched and/or at high risk of collapse?

The height of streambanks and the degree of downcutting in part determine what types of channel interventions are needed. Generally, if streambank heights exceed about 7 to 10 feet, vegetation alone cannot solve the problem. More intensive in-stream restoration may be required, but the cost and risk increase with increasing streambank height and flows. The following table helps describe how the level of entrenchment might respond to different management options.

Table 4: Sensitivity to Change and Response to Management of Streams Relative to Entrenchment (adapted from Rosgen and Silvey 1996)

Entrenchment level	Sensitivity to disturbance/flow change	Recovery potential	Controlling influence of vegetation	Suitability for stream restoration actions
Little or no entrenchment	High to very high	Very good	Very high	High
Moderate entrenchment	Moderate	Good	Moderate	Possible
Highly entrenched	High	Limited	Moderate or low	Limited

Direct Channel Interventions

Some channels require direct intervention to facilitate restoration and recovery or to protect valuable infrastructure. Stream restoration that involves installing large structures or earthmoving is typically expensive (Zedler and Callaway 1999; Bernhardt et al. 2005; Bernhardt and Palmer 2011), which limits its feasibility, and it is often designed for channel stability rather than for overall riparian system health. Where major channel instability threatens roads, bridges, culverts, or other infrastructure, stream restoration typically requires significant investments in design and engineering to address erosion, downcutting, and failing streambanks. Intensive stream channel alterations may be appropriate in certain situations but are typically beyond the scope and capacity of local landowners and land managers, and they are not covered in this guide. Instead, the following topics outline practical restoration techniques and tools that are feasible, effective, and self-sustaining. These do not constitute an exhaustive discussion of the options available, but instead serve as a starting point for riparian restoration planning and management.

Low-tech Process-based Restoration: "Let the Water Do the Work"

Landowners and resource managers have viable and affordable options for in-stream restoration practices. Strategies that use the stream's natural dynamic processes to accelerate recovery and address some of the root causes of degradation can be effective and low in cost. "Low-tech" process-based restoration is broadly applicable and consists of simple, cost-effective, often hand-built treatments that help repair degraded streams. Structures built with natural and local material like rock, wood, and even sod facilitate changes in flow. They help create a more physically diverse stream—and the more diverse a channel is, the more resilient it is to disturbance. Examples of these restoration approaches include low-profile rock or wood structures known as "Zeedyk" structures (after their originator Bill Zeedyk), as well as a suite of structures designed to mimic the complexity that would be found in healthy systems, such as beaver dam analogues (BDAs, covered in the next section) and woody debris structures. For more information about their specific application and design, see Let the Water Do the Work (Zeedyk and Clothier 2014) and Low-Tech Process-Based Restoration of Riverscapes Design Manual (Wheaton et al. 2019).

These approaches are intended to jump-start natural processes, not create permanent structural features. They help facilitate stream movement through the natural channel evolution process. They can be used in a variety of situations, including treating gully erosion, headcuts, and channel incision. The goal of many of these structures in this landscape is to slow the water, reducing its erosive power and allowing it to deposit sediment. Over time, this process will naturally build streams up and help them access disconnected floodplains and/or establish new ones. The structures are designed to be low profile and semi-permeable and to mimic natural processes.

Generally, stream restoration activities are most successful and cost-effective when the scale of restoration is matched to the scale of the degradation. Smaller streams will respond to site-specific intervention, while larger drainages will need many intervention sites. Smaller streams or stream reaches that are somewhat stable and not actively downcutting may be a higher priority for restoration, as they will likely respond quickly and with less direct input. Streams that are threatened by rapid incision or have only downcut a shallow depth may also be priority sites because they can be effectively protected from further incision using process-based restoration techniques. If the adjacent water table is not too far down, it may be raised back up and reconnected with its floodplain. The presence of water-loving plants like prairie cordgrass away from the streambank is an indicator that there may still be some water table connectivity or that the channel has only recently downcut. The presence of this type of vegetation, even in small amounts, will also help the channel recover more quickly. The restoration potential for truly ephemeral streams that lack groundwater connections will be different, and actions need to be tailored to the local setting.

Stream restoration is also more likely to succeed if streams have already downcut, stabilized, and established a new inset floodplain. Streams that have already undergone an incision event and are widening or restabilizing may respond quickly to vegetation management activities or practices that promote the development of the floodplain within the deeper channel. Streams that are actively incising or widening may be more challenging to recover. The best approach may be to accelerate the channel-forming process and help the stream widen, then stabilize. This can be achieved using wood or rock structures that encourage bank erosion and ultimately add more complexity into the channel.

Beaver Dam Analogues and Related Structures

Where beaver populations are unable to recolonize naturally, or where conditions do not yet support habitat for beavers, restoration practitioners are increasingly achieving success by using structures that are designed to mimic the role of beavers in riparian and wet meadow habitat. As mentioned in the earlier section on process-based restoration, beaver dam analogues (BDAs) can be used to mimic some of the physical and ecological benefits created by natural beaver dams, such as slowing and capturing runoff, thereby allowing it to infiltrate into the soil. This process helps raise the local water table in the riparian area and facilitates conditions for sustained recolonization. BDAs, rock structures, and woody debris structures can be used together at a site to help achieve multiple objectives. When implementing process-based restoration practices, there is strength in numbers. Beavers often build their dams in complexes, and when building analogue structures, it's helpful to follow a similar pattern; one or two BDAs may not produce the desired effect, but a complex of them can have compounding beneficial effects. It's important to remember that any type of restoration is a process and structures will require monitoring and maintenance over time to ensure that they are producing the desired results. At this time, research is being conducted to better understand the application of and best practices for process-based restoration in western South Dakota streams.

Examples of Zeedyk Structures

Figure 94: Zeedyk structures are used to prevent advancing headcuts and incision. These photos show a larger headcut that was "laid back" and covered with a Zeedyk rock structure. The rocks work to trap sediment from upstream. Root growth and vegetation will establish within crevices, allowing the site to heal. Photos © Joe Dickie, Generation Photography, Inc.

Figure 95: These photos show a rock Zeedyk structure used to prevent a headcut from advancing upstream. As shown in the lower photo, grass has already begun to grow through and revegetate the site, allowing the headcut to heal and preventing further erosion. Photos © Joe Dickie, Generation Photography, Inc.

Examples of Beaver Dam Analogues

Figure 96: Beaver dam analogues seek to mimic beaver activity to slow and hold water while also trapping sediment and rebuilding a stream bed from incision. These images show the same BDA from upstream or above the structure (top) and from downstream or below the structure (bottom). The BDA works to slow and hold water, trap sediment, and rebuild the stream bed. The lower photo demonstrates that nearly 18" of sediment and water above the dam were accumulated in just one season of use. Photos © Joe Dickie, Generation Photography, Inc.

Figure 97: These images show a side and top profile view of a beaver dam analogue. BDAs use local materials, including sod, grasses, or woody vegetation woven between and secured in place by untreated wood posts. Photos © Joe Dickie, Generation Photography, Inc.

The Potential for Beaver Restoration

Beavers once played an essential role as stream and wetland "landscape engineers" by slowing down stream flows and connecting the water table to the land surface, until they were nearly wiped out from the North American landscape during the fur trade. Beavers are increasingly being recognized and utilized as a potential low-cost restoration tool in many parts of the country, particularly in the intermountain West (UBMP 2010; Brown et al. 2011). For example, beaver dams have been demonstrated to influence local water table elevations (Westbrook et al. 2006), accelerate channel incision recovery (Pollock et al. 2007, 2012, 2014), decrease peak runoff and increase baseflows (Nyssen et al. 2011), promote sediment retention (Butler and Malanson 1995; Butler and Malanson 2005), increase species richness of the riparian zone (Westbrook et al. 2011) and at the landscape scale (Wright et al. 2002), and affect in-stream temperatures, influencing hydraulic conditions and surface water–groundwater interactions (Weber et al. 2017). These impacts often directly contribute to stream restoration goals. Perhaps the greatest advantage of employing beavers in restoration is that once installed, they provide low- or no-cost benefits for years or decades to come.

Beaver reintroduction to accelerate stream channel restoration and enhance landscape water capture and local recharge is an attractive opportunity in western South Dakota. However, at the time of writing, intentional restoration of beavers has not been widely practiced. Where beavers are present, having naturally found their way back into streams or ponds, they are often perceived to be a nuisance rather than being viewed as potentially beneficial, and they are often actively trapped or otherwise removed—though this paradigm is beginning to shift as the challenges of drought outweigh people's issues with beavers.

Often, individuals wish to remove beaver to protect the few remaining mature trees in a stream landscape. However, without beaver activity to help restore and ensure that a stream connects to its floodplain, removing beaver may be counterproductive to ensuring the long-term success of these trees. Without beaver to slow and hold water on the landscape, many of these mature trees are likely to fail in the years and decades ahead, should groundwater levels drop due to stream incision. Many of these tree species (cottonwood, willow, etc.) have also adapted to beaver activity and may even require it to succeed. For instance, these species will re-sprout from downed trees and cut branches that are placed in wet areas (as a beaver would do), producing significantly more woody vegetation and new re-growth to replace the individual tree(s) that were removed. In addition, it is possible to mitigate beaver cutting or removing valuable old-growth trees by fencing, caging, or painting these trees to prevent beaver from using them.

Reintroduction may not be immediately feasible if the landscape lacks suitable habitat to attract and sustain beaver (mainly enough streamflow, deep water habitat, and suitable woody species). It is not advisable to reintroduce beaver in locations that lack suitable habitat or where their presence will not be culturally accepted. BDAs (as described earlier) can be used to jump-start and prepare habitat for beaver to re-colonize an area.

Understanding the technical, social, and ecological feasibility of beaver reintroduction will require additional research and monitoring. We need to learn where in the NGP beavers represent an effective and appropriate component of riparian, stream, and ecosystem restoration and management, and where they may succeed at recolonizing and maintaining self-sustaining populations.

As noted, beavers are often regarded as a nuisance in many areas. People may have concerns about beaver tunneling in stock dam walls, plugging culverts, and raising water levels near structures such as homes and roads. Beavers are a very habitual species and will return repeatedly to areas that are suitable; trapping beavers is only a temporary solution to the undesirable effects of beaver presence. It is possible, however, to live with beaver and mitigate many of these concerns in most areas. There are non-lethal options and techniques for mitigating beaver challenges, including flow devices that control dam levels, such as "beaver deceivers" and fencing out priority trees. More information is available from https://www.beaversww.org/living-with-beavers/, The Beaver Institute https://www.beaverinstitute.org/, and The Beaver Restoration Guidebook by Pollock et al.

Photos of Beaver Activity in Northwest South Dakota

Figure 98: These beaver dams in northwest South Dakota are composed of sage, prairie cordgrass, and sod. Photos © Doug Shaw, Corissa Busse, TNC

Figure 99: This image shows how beavers can use primarily sod and prairie cordgrass to slow and hold water on the landscape. Trees and woody material are not requisites for beaver activity in western South Dakota, where beaver will also tunnel into the walls of streambanks to make their dens. Photo © Corissa Busse, TNC

Managing Streams at Watershed Scales

Many of the common riparian management challenges introduced in Section 9, from active channel incision to too much or too little streamflow, are caused or exacerbated by overall watershed conditions. In addition to following local and instream riparian restoration practices, landowners or managers may need to also target upland landscapes—both at the individual ranch level and at a watershed scale.

Stream health is directly influenced by the condition of surrounding uplands. Adequate ground cover of both living plants and litter and a diverse plant community composed of deep-rooted perennial plants are critical for watershed health. Often, stream system health and upland health have mutually beneficial goals and practices. For instance, improving grass cover in the uplands will help reduce runoff, slow the flow of waters, and prevent erosion and channel instability within the stream.

As noted earlier in the guide, the health and condition of all lands upstream in your watershed will affect the health and ability of your stream location—and similarly, the health of a stream and surrounding uplands at your location will affect all areas downstream and lower in the watershed. Every stream is affected not just by local ranch-level efforts, but by the broader landscape and watershed.

Management options depend on the scale and scope of the problem as well as the landowner's goals and resources. For example, in the case of active channel incision and headcutting in smaller systems, adaptive grazing management practices and low-cost, low-tech structures in riparian areas can help. However, in the case of excessive flooding, erosion, and severe incision, management will be most effective when it involves watershed-scale actions—and coordination with surrounding land managers and agencies. If peak flows have increased or the channel is still recovering from past disturbance, high-flow events will continue to result in significant erosion and deposition, upstream or downstream migration of the headcuts, and repeated bank failures, until the stream has re-established equilibrium with the new flow regime. In these cases, more active intervention may be needed. In very high-risk situations where infrastructure may be threatened by major channel erosion and instability, technical and engineering specialists must provide significant support to implement solutions, particularly in large stream systems where effective watershed management is not practical or feasible.

Collective efforts among many landowners in a watershed to restore stream health will have the most lasting, beneficial results. Local and state agencies, government, and nonprofit partners may be able to aid in building these collaborative projects, including possible funding opportunities for projects that benefit multiple operators. Watershed-scale projects can be time intensive, and it may take years to see the hydrologic benefits from them, but they often result in collective improvements in range condition and stream health that will far outweigh and outlast the improvements that occur at only a single site. Indeed, watershed-scale actions may be the only option to fully address the root cause of stream health problems.

Partnerships Help Rancher Improve Water and Save Soil

> *"Rotational grazing and investments in riparian stream health aim to build ranch resilience."*

In northern Butte County of South Dakota's semi-arid West River rangeland, Markus Erk continues to live by the 60-year conservation ethic of his father, George Erk. Their ranches, homesteaded by Markus's grandfather in 1912, offer a beautiful vista of Castle Rock.

His father helped grow their Hereford cattle and Rambouillet sheep herds by planting trees to offer livestock shelter and building dams with spreader dikes to channel water across the rangeland.

Fast forward to the current decade, Markus continues the investment in the land by focusing on slowing down and saving more water through riparian area improvements in the abundant creeks. By working with conservation groups like The Nature Conservancy and World Wildlife Fund, and through partnership with neighbors and NRCS, he hopes to reduce erosion, increase rotational grazing, and improve riparian areas.

The feast-or-famine rainfall in the region can shift from multiple-year droughts to overnight 4-inch, dam-breaking gully-washer events. "Our dams have been a lifesaver over the years for our livestock, but recent higher alkali levels in the water have many ranchers around here fencing them off to protect animal health," Erk explains.

Grant funding for riparian projects

The challenge of unpredictable water flows led Erk to join forces with five ranch neighbors in the same watershed and form the Castle Rock Ranch Water Corporation, which was awarded a Conservation Implementation Strategy grant from the NRCS. The grant will cost share drilling a well and piping fresh water to all the ranches—in exchange for the ranchers adopting more conservation practices.

"By working together with neighboring ranch owners, we're improving water quality for our livestock," he says.

Markus Erk, rancher
Butte County, SD

“We’re building soil health across a watershed by rotating cattle among more pastures with water to give the grass the longer rest it needs following grazing.”

Another project that excites Erk is The Nature Conservancy’s effort to help heal the riparian environments for healthy stream biodiversity. “The stream analysis by TNC targeted two creek areas where high water creates the most erosion damage,” Erk explains. “Last year, they installed 12 beaver dam analogs and Zeedyk rock structures to slow water, raise the water table, control erosion, and help nature begin to restore riparian biodiversity.”

Creating beaver dams

Beaver dam analogs (BDAs) are human-made structures that are designed to mimic the function of a natural beaver dam. TNC installed BDAs on the Erk ranch using wood-and-mud to hold creek water and stop erosion. As silt and water collect to expand the floodplain behind the BDA, more grass and vegetation grow and naturally slow water to create a slowly healing habitat for fish and wildlife, along with grazing animals.

These BDAs are installed using wood posts driven into a stream bed, with tree branches interlaced between the posts to hold them across the stream. Soil is packed onto the branches to contain the flow and create the face of a dam. “It’s very similar to how a beaver would construct a dam using sticks and mud,” Erk says.

In some highly erosive streambed areas, TNC installed a rock floor in the creek, called a Zeedyk structure, to reduce gully formation. Erk says, “It’s a similar technique to installing a stone patio with spaces in between to grow grass. When water flows over it, or a waterfall spills onto it, the structures hold soil in place and allow for vegetation growth between the rocks on the creek bed.”

After only one year, the riparian areas that received these creek structures are already showing signs of healing. “While we’re currently in the middle of several dry years, the beaver analogs and Zeedyks are working well to cut down on erosion and hold water to spread it out more. While it’s too early to tell, I’m excited for TNC to install more of these practices,” Erk shares.

More grassland, better rotational grazing

Related to ranch riparian health, Erk is also working with Burger King, Cargill and World Wildlife Fund (WWF) on their grassland restoration project to turn his last remaining fields of marginal cropland into grassland for his livestock.

“These new pastures, along with the addition of fresh water, will help improve our rotational grazing opportunities,” he explains. “By adding more fencing, we’re improving grazing efficiency, which will improve the grass and help deeper roots store more carbon to improve the soil and our ranch for the future.”

Proud of his conservation heritage, Erk hopes to spread his love of these practices to encourage their acceptance on more ranches throughout West River. “My lot in life follows my dad’s request to ‘be a good steward of our ranches, because if you take care of the land, the land takes care of you,’” Erk says. “Together, with my wife Candy and son Colton, we continue to improve the ranch and hopefully keep it in the family for future generations.”

Figure 1. Markus Erk and his son Colton. Photos © Joe Dickie, Generation Photography, Inc.

Figure 2. A Zeedyk rock structure installed to help prevent headcuts from eroding upstream reaches. Photos © Joe Dickie, Generation Photography, Inc.

Figure 3. The Zeedyk rock structure shown is trapping sediment behind it, healing a headcut that had formed by filling in with new grass. Photos © Joe Dickie, Generation Photography, Inc.

Figure 4. Beaver dam analogs work to slow and hold water in pools. Photos © Joe Dickie, Generation Photography, Inc.

Figure 5. A redwing blackbird uses a beaver dam analog post installed on a small headwater stream of the Erk ranch. Redwing blackbirds spend the breeding season along wet areas and near water. Photos © Joe Dickie, Generation Photography, Inc.

Section 11: Managing for Stream Health Now and into the Future

Prairie streams across western South Dakota have experienced major changes and loss of function—and yet, they continue to hold significant potential for beneficial restoration. We hope users of this guide will begin to see the connectedness of our systems. Healing in these systems is critical for the health of our prairie, its waters, and all who depend on them into the future.

Managing for Resilience

Throughout the guide, we have discussed many of the current common management challenges and opportunities for prairie streams of western South Dakota. Increasingly, landscapes are being looked at with resilience in mind to ensure that our lands and waters continue to thrive with changing land use and climate variability. Resilience in a stream system is the ability of a site to maintain diversity, productivity, and ecological function following a disturbance event such as flooding, drought, fire, or grazing. Stream systems in the Great Plains are naturally incredibly resilient because this landscape has been shaped by drought, grazing, and fire, and are uniquely adapted to variable moisture conditions and disturbance. Both droughts and floods, along with other extreme events, are a common occurrence in the region. However, much of this natural resilience has diminished over time, and many of our stream systems are struggling to function.

Streams rely on the relationship between the plant community, channel and landform characteristics, and hydrology to maintain resilience and support life. These are interconnected components of the system, and a stream's ability to recover from disturbance depends on these relationships. Managing streams and riparian corridors for flood, drought, and fire resilience means understanding the connections between the plant community, the stream channel, and the floodplain. Disconnected floodplains, lowered water tables, and reduced water storage capacity will make a system more sensitive to disturbance.

A stream with more channel diversity and complexity, such as one with beaver dams, wood accumulation, point bars, pools, and high sinuosity, will have variety in the flow pattern, water depth, and water velocity and will be more resilient to disturbances than simplified, homogeneous channels. Channel diversity can help increase the hydrologic connectivity both to the floodplain and to up- and downstream reaches, which can lead to increases in riparian vegetation resilience. A more connected system has improved water storage capacity and lessens the reliance of vegetation on rainfall to be productive. This allows the stream, riparian area, and overall system to function and remain intact during drought periods. Overall, as riparian areas and stream systems become more diverse and healthier, the stream can reach a new balance in which its productivity fluctuates very little with changes in rainfall, demonstrating greater resiliency against the impacts of drought or flooding.

Managing for resilience in the plant community and stream channel can decrease the sensitivity of the riparian area to climate variability over time. Incorporating resilience into stream management and restoration is fundamental for creating long-term conditions that best support both human use and ecosystems. Resiliency-based management helps to develop a system that can be self-sustaining under dynamic conditions.

The starting point in managing for resilience can vary and should fit the individual ranch needs and site conditions. Changes in grazing season of use or duration may be enough to trigger woody species recruitment, which can begin to make a site more diverse and complex. Incorporating resilience into ranch planning, grazing management, and restoration planning may seem like an abstract concept, but through adaptive management, monitoring, and clear goals, it can be implemented at a meaningful scale.

Restoration Planning and Continuous Adaptive Management: "Learn by Doing"

Adaptive management is a "systematic, and rigorous approach to learning from the outcomes of management actions, accommodating change, and improving management" (Holling 1978). It is basically a strategy of "learn by doing."

This model can be especially helpful and effective when working with novel techniques, understanding new systems, and discovering efficiencies. It is a system that is particularly well suited for stream and riparian restoration. The basis for implementing an adaptive management plan is focusing and responding to on-the-ground conditions and making management decisions to benefit long-term rangeland health and ranch economics. This system requires setting clear goals, and then monitoring and continuously evaluating to see if you are moving toward or away from the goals you have set. If you are moving toward the goals, great—keep going! However, if you are moving further away from your goals, evaluate what you may need to adjust to correct your course.

One of the challenges in assessing stream systems, particularly highly degraded systems, is discriminating between the potential of the system and the realistic interim management objectives. Restoring the system's potential will most likely involve continuous adaptive management to move toward more desired conditions, based on a full picture and understanding of the site's history and restoration options.

Successful restoration and management will therefore involve continuous and repeating cycles of site monitoring and an understanding of site condition and potential. Land managers will need to evaluate possible solutions, understand potential outcomes, and make changes based on the results. Figure 100 illustrates a decision model that may assist in the planning process. When working with this planning system you may not find the perfect "recipe," but the model can be an effective tool to evaluate decisions and adjust practices. Ultimately it will help you answer the question: "Am I heading in the right direction?" When planning restoration projects, land managers should consider the local and physical context as well as identifying financial, environmental, and social goals.

Due to variations in riparian landscapes, we may not fully know what these streams looked like pre-European settlement. A true "reference" stream (or ideal condition stream) may not exist—nor do we know the full potential that these streams may hold. On the positive side, this also means that the potential for improvement of these systems to provide habitat, slow and hold water, and regain resilience could potentially go beyond any expectations we can currently set. This is why we have not set a bar for what a healthy stream should look like, but instead encourage land managers to continuously work to improve the dynamic resilience of their stream systems. When discussing goals and objectives, it's important to think about ecological function, system resiliency, and management considerations.

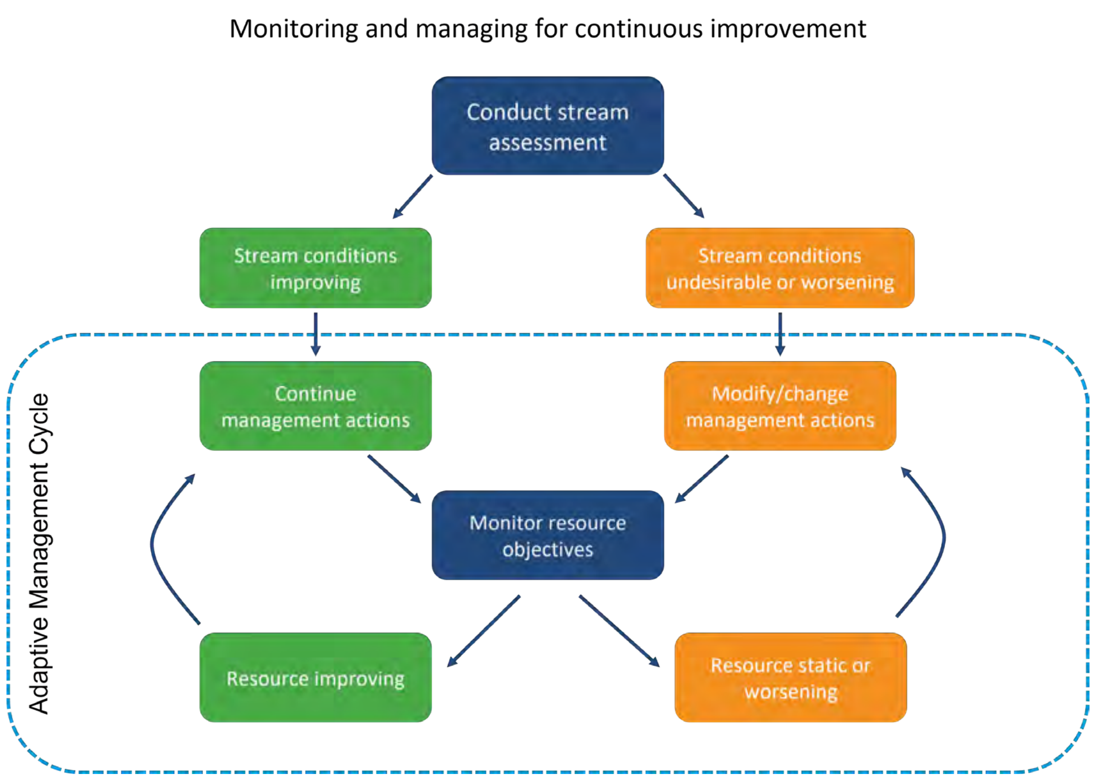


Figure 100: This monitoring and adaptive management framework shows how to work for continuous improvement. Graphic © Corissa Busse, TNC

To understand whether a grazing management system is encouraging riparian area recovery, for example, it is necessary to understand recovery rates and grazing impacts. The time scales required for recovery vary. Herbaceous and woody vegetation typically respond more quickly, whereas water quality and channel configuration may take 10–20 years to improve. Degradation rates show the same pattern: vegetation degrades first, followed by the channel and water quality.

Understanding expected recovery rates for specific riparian sites is necessary to develop achievable objectives that can be met within a designated timeframe. When you select indicators to monitor the effectiveness of management changes, keep in mind that there is often a lag between changes in management and the ecological response. Recovery of channel morphology and water quality can take time; therefore, it may be more appropriate to observe and monitor indicators based on vegetation response. Recovery times may also be highly variable due to the influences of climate, soils, available moisture, and streamflow.

Photo Point Monitoring

Photo point monitoring is an especially powerful way to track and observe changes over time. It is also quick, easy, and effective. It can be implemented to determine whether your management decisions are meeting your objectives and moving the riparian areas and/or uplands toward a desired future condition. Photo point monitoring can show trends over time by documenting effects of changes in the environment or effects of management actions. It requires no specialized expertise to take or interpret photo points, and they can stand alone as a record or be supplemented with additional data collection.

How to Conduct Photo Monitoring

As with any type of monitoring, it's important first to understand the goals or why you're beginning a monitoring program. Common goals of photo monitoring include:

- Documenting the current conditions
- Documenting change following a management practice or intervention
- Determining the effectiveness of management practices
- Documenting general change over time
- Document abnormal events like severe drought or wildfire

There is no one-size-fits-all, as monitoring is based on individual goals. It can be done once a year or throughout the year. The best method is the one that works for you. Below are some tips to help you develop an effective photo point monitoring program.

- **Equipment:** You can collect photos with digital cameras or cell phone cameras; just be sure the images are high enough resolution. Include a photo board; a sheet of paper with notes or an erasable board should appear in every picture. The photo board should include information about the date, location, or other details such as whether the photo is taken before or after grazing. A photo board will help you keep the photos organized.
- **Timing:** Take photos as close to the same time of year as possible. Usually, monitoring is done during the peak of the growing season, but this can vary depending on what you are trying to monitor.
- **Site selection:** Start by monitoring a site that is representative of the area. Don't be afraid to choose sites that are in poor condition, as these areas may end up being very responsive to management. Pick sites that are easy to get to, since you're more likely to take photos regularly if they're easily accessible. Use distinct landscape features to help you find your sites again and to help line up the photos each time they are taken. Distinct landscape features are those that are unlikely to change dramatically over time and can include rock formations, trees, and distinct topography (e.g., hills, swales, saddles). Take a minimum of two photos at each riparian site, one looking upstream and one looking downstream.

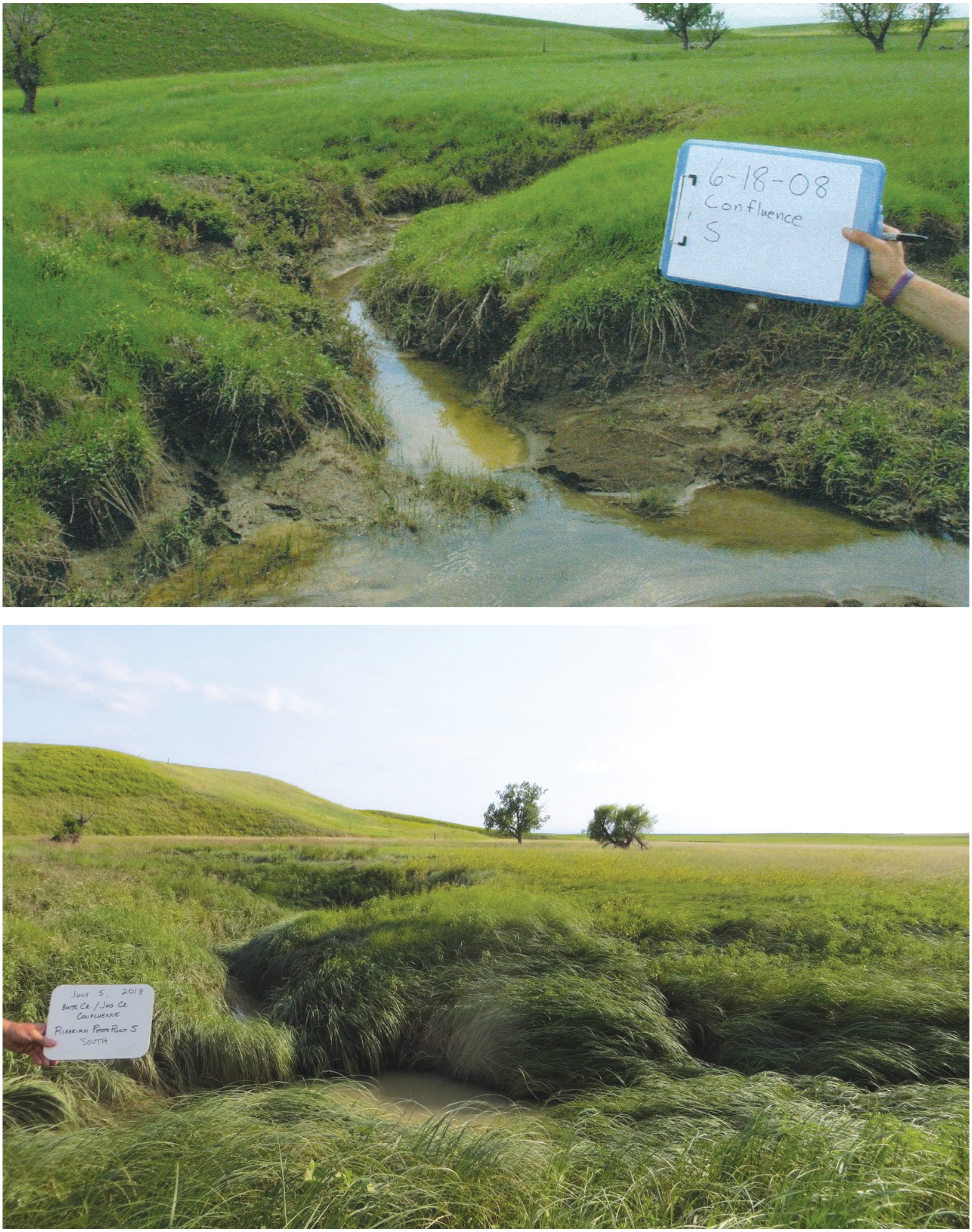


Figure 101: These photos show how repeated photo point monitoring has documented 10 years of stream recovery. The top photo is from 2008 and the bottom photo is from 2018. The photo board includes date, location, and direction. The lone trees and hillside in the background act as reference points. Photos © Al and Simone Wind

Questions and Techniques for Monitoring Stream Resilience Over Time

This following content outlines a monitoring protocol that can be used to better understand and "read" a stream, as well as to help notice trends and changes in the system over time. The monitoring questions outlined below can help indicate the current resilience of a stream reach, the processes at play, and whether there is potential for improvement.

Any stream within a given type can exhibit a wide range of conditions, from healthy and resilient to degraded and non-functioning. Since streams are dynamic, they are often actively transitioning either toward or away from a resilient state. The following monitoring tools are *not* intended to give a score to a stream nor compare its condition with that of other streams. Instead, this monitoring protocol is intended to help compare the condition of a stream to itself over time, and to notice how the stream is responding and adapting to management actions. In turn, this will help determine what management changes may be needed to help improve the stream's resilience. Management options to promote stream resilience are described in greater detail in Section 10.

Following the monitoring questions is a worksheet that you can use in the field to take notes and track your monitoring. Extra copies of the worksheet are also located in the appendices. In order to identify how a stream is changing over time—and whether it is trending toward or away from resilience—it is important to complete monitoring year after year. We also recommend monitoring at different times of the year and taking notes. A stream will change with the seasons, due to precipitation patterns, and from impacts that occur above and below your stream section. Above all, this process is primarily intended to help you get to know and listen to what the stream is telling you.

Key Monitoring Questions to Understand Stream Resilience

1. How often does the stream flow?

Why this matters: Wet meadows and streams that hold water for longer periods of time greatly benefit livestock and wildlife alike and can support more diverse vegetation and animal species. They are also more productive and likely to respond more quickly to changes in management. Determining how often your stream flows can help you understand its connection to the water table and its natural potential.

How to assess the stream flow:

The best method to determine your stream flow is to observe or monitor it multiple times throughout the year and note the differences in flow between years. If you are not familiar with the stream, it can help to ask someone who has managed the land previously or a neighbor who may know it well. If this is not possible, we recommend visiting your stream site in late summer, during a period without recent rainfall, to determine its flow. By August, most ephemeral and intermittent streams will have ceased flowing for the year.

Select the option that best describes your stream:

- ❑ **Ephemeral** (generally < 10 mi2 in drainage area): flows during < 10% of the year, for less than 30 consecutive days, and only in response to precipitation.
- ❑ **Intermittent** (generally 10–100 mi2 in drainage area): flows approximately 10–75% of the year. There is usually some connection to the groundwater table, which is generally within a few feet of the bottom of the stream bed, and there may be some permanent pools.
- ❑ **Perennial** (generally 100+ mi2 in drainage area): always flows, or flows for at least 75% of the year, even in dry years. Springs or seeps in the area often feed the stream.

Figure 102: A headwater ephemeral stream only holds water in its channel after a precipitation event. The area may still be marshy and wet if the adjacent floodplain is sub-irrigated and acting as a wet meadow. Photo © Joe Dickie, Generation Photography, Inc.

Figure 103: An intermittent stream holds water in its channel part or most of the year but goes dry seasonally, and may have disconnected pools of water, as shown in the photo above. Photo © Joe Dickie, Generation Photography, Inc.

Figure 104: A perennial stream holds water throughout the year. However, severe drought years may cause even these streams to go dry in pockets. Photo © Doug Shaw, TNC

2. Do you notice any springs or seeps feeding the stream?

Why this matters: Springs and seeps can influence the flow regime of a stream. Some small headwater streams that would otherwise be ephemeral can be perennial systems because of the presence of springs in the watershed. Springs also provide an important source of water for grazing livestock and critical habitat for aquatic life, waterfowl, frogs, and reptiles, because most streams in western South Dakota go dry for much of the year.

How to assess whether springs are present:

Look for aquatic plants or other indicators of permanent water in locations where the stream would otherwise go dry. The best time to observe is during low flow or drought periods, or in the winter when water levels are usually low.
Is there water or pooling on the channel during dry periods, or does water seem to disappear and reappear in the channel? This may be an indicator of subsurface flow from springs.

Based on your assessment, are springs or seeps present along your stream?

- ❑ No
- ❑ Yes

Figure 105: Seeps and springs are visible along the margin of the hills, making this headwater stream perennial even during dry periods. The tall wetland plants along the channel indicate that it holds water year-round. Photo © Lori Brown, TNC

3. What is the stream's sinuosity?

Why this matters: A stream's **sinuosity** describes how often it bends and curves over its course. Bends and curves help to slow down the water and remove energy from its flow. A slower flowing stream with less energy can benefit the land by holding water on the landscape longer, reducing erosive force, and allowing the water to seep into the surrounding riparian area, increasing vegetation cover. Imagine the speed and force you would have if you ran straight across a football field, versus if you ran while curving back and forth every five feet.

Unlike meandering streams, straight streams often provide fewer benefits to the land and can be in poorer health, particularly if they were naturally meandering streams that were straightened by people or forced to carry increased flow. Straight streams tend to pack more force and can erode the channel faster, causing it to separate from the floodplain and riparian vegetation. Many of the steep woody draws and river breaks in western South Dakota are naturally straight due to the higher velocity and in-stream forces within their steep, straight channels. You may hear of streams with straight channels referred to as "bowling alleys" because of the force that water can generate as it flows straight through them. Headwater streams may also be straight because they lack the stream power to produce meander bends.

How to assess sinuosity: Often, the sinuosity of a stream varies. A stream may be very curvy for 50 feet, then have a straighter section for the next 100 feet. For this assessment, describe the average sinuosity that you see over the entire area you are surveying.

Figure 106: This stream is an example of a straight channel. Streams can straighten over time as they downcut and disconnect from the floodplain. Photo © Joe Dickie, Generation Photography, Inc.

Figure 107: This moderately sinuous stream channel has noticeable bends but limited movement in the floodplain. Photo © Joe Dickie, Generation Photography, Inc.

Figure 108: This highly sinuous stream channel has large horseshoe bends. Photo © Joe Dickie, Generation Photography, Inc.

Figure 109: Some streams may not have a defined channel; the water course is actually a wet meadow system. Photo © Joe Dickie, Generation Photography, Inc.

Based on your assessment, which best describes the sinuosity of your stream?

- ❑ Straight (almost no bends in the channel)
- ❑ Moderately Sinuous (identifiable bends with limited movement in the floodplain)
- ❑ Highly Sinuous (stream with very winding path)
- ❑ Wet Meadow (no defined channel, wet sponge-like meadow)

4. How is the stream channel changing or evolving?

Why this matters: Determining the stage of the channel can help you identify whether your stream is stable and connected to your floodplain (or trending in that direction), or whether your stream is actively incising, entrenching, and separating from the floodplain. A stream that is connected to its floodplain can provide greater benefits for livestock and wildlife. When floods do occur, connected floodplains help to spread out or dissipate the force of the water, slowing it down. Streams with floodplain connections can produce greater amounts of riparian vegetation and store water longer.

In contrast, a stream that has incised has less access to its floodplain and is less able to slow down high flows. These streams often have greater in-stream force and higher rates of bank erosion. The force and erosion are not necessarily "bad," as they can also help the stream break down its banks and reach a new balance and inset floodplain. However, streams in this disconnected state provide fewer benefits for livestock and wildlife. They may also cause challenges for ranchers by making pastures inaccessible due to their high or unstable banks, threatening farm buildings and/or pastures located next to streams, and reducing meadow habitat due to a possible drop in the water table. (Note: Some steep woody draws and gullies have little or no floodplain, but may provide other benefits, such as shelter from the sun and snow.) Streams are dynamic and are usually evolving between stages as they seek balance and equilibrium after large disturbance events or management changes.

How to assess the stage of the channel evolution cycle:

Depending on your type of stream and on whether active headcuts are forming, different portions of your stream may be at different stages of channel evolution. The downstream areas may have undergone channel incision and are in later stages of channel evolution as they seek equilibrium after a disturbance event. Meanwhile, areas upstream of the headcut may not have undergone incision yet. Look for evidence along your stream like active headcutting, formation of point bars, and bank failure. Using Figure 110 below, estimate which stage represents what your stream is doing.

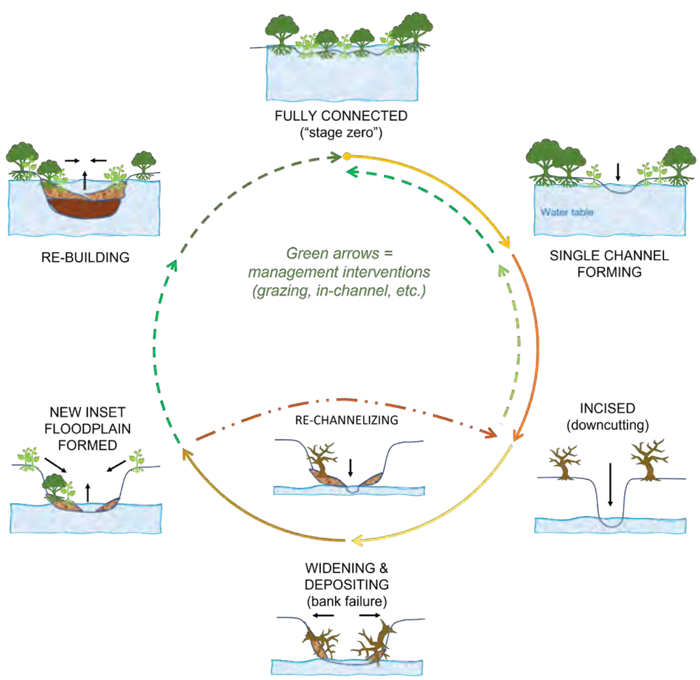


Figure 110: This figure can help to identify the stage of your stream. Streams that are highly connected to their floodplains (streams in the "stage zero," single channel, or recovery/rebuilding phases) are considered to be functioning at higher potential, or more "healthy," as they are able to accommodate and dissipate the energy of higher flows by spilling out over the floodplain. As the stream adjusts to change or disturbance by downcutting and widening, it is processing through more active erosional, unstable phases. As the stream begins to form a new inset floodplain and potentially move toward "recovery," it is attempting to reestablish equilibrium with the flow and sediment regime by rebuilding active floodplain features. Graphic © Corissa Busse, TNC

Based on your assessment, which option best describes how your stream is changing?

- ❑ **Fully Connected ("stage zero"):** For smaller stream systems, there is no visible channel, and the area usually resembles a moist or wet meadow; for larger stream systems, the channel is highly braided (multiple channels that intersect and weave together) and the stream readily overflows to its floodplain.
- ❑ **Single Channel Forming:** There is a stable single channel that is not excessively downcutting or eroding its banks, with a good connection to the floodplain and mature riparian vegetation (either trees or prairie grasses and forbs).
- ❑ **Incised (downcutting) or Rechannelizing:** The stream is eroding its bed and there are steep drops in elevation (cutting downward or headcutting); streambanks are getting steeper.
- ❑ **Widening and Depositing (bank failure):** The channel is widening and banks are slumping, and sediment is being deposited or laid down within the channel or on low benches next to the stream.
- ❑ **New Inset Floodplain Formed:** The channel has developed a new inset floodplain with benches laid down and point bars formed within the original channel boundaries.
- ❑ **Rebuilding / Recovery:** The channel is closing back in after heavy historic disturbance. The channel has rebuilt from the bottom up and potentially from the sides in and is now shallower and perhaps narrower than in the past.

5. How connected is the stream to the floodplain?

Why this matters: A stream that does not have frequent access to its floodplain fails to provide many benefits for both people and nature, such as reducing impacts of flooding and preventing erosion and damage to land alongside the stream. As flow becomes concentrated in the channel and cannot spread out onto the floodplain, its erosive force increases, leading to more channel erosion and sediment entering the stream.

How to assess your stream for floodplain connectivity:
Following periods or events of significant rainfall, visit the stream you are monitoring and note whether the flow of water has exited the stream's banks and is spilling out or flowing over and onto the adjacent floodplain. Document how often this flooding out of the streambanks occurs over time.

Based on your assessment, which of these descriptions best matches your stream's floodplain connectivity?

- ❑ Flooding out of banks occurs infrequently or never: stream channel is incised or confined within steep, narrow banks with no access to a floodplain except at the very highest, most infrequent flows (every 5–100 years at most)
- ❑ Flooding occurs occasionally: stream channel is confined or well-contained within the banks, but with access to a narrow floodplain at higher flows (may flood every 2–5 years)
- ❑ Flooding occurs frequently: stream can frequently access a wide or well-developed floodplain during typical bankfull floods occurring once or twice every couple of years

6. What is the condition of the riparian plant community area?

Why this matters: The condition of your riparian area is important for grazing animals, wildlife, and people. As mentioned in section 5, a health riparian plant community helps dissipate flood energy, stabilize soils, and improve water infiltration. Areas with low plant cover are more prone to erosion, provide less nutrition for grazing animals, and offer less habitat for fish and wildlife.

How to assess riparian condition:
There are many ways to measure riparian health, including amount and type of vegetation, distance that the greenbelt extends from the stream edge, presence of trees and woody plants, and diversity of plant species. This assessment piece is broken down into five components to generate a comprehensive picture of riparian condition.

6a. How much vegetative cover is there?

Why this matters: Plant cover prevents soil erosion, provides food for grazers, and supports wildlife.

How to assess amount of vegetative cover: You can estimate the percentage of plant cover visually. It is easiest and most accurate to focus on a small square or circle a few feet across (a square yard or meter). Compare your riparian area with the images in Figure 111.

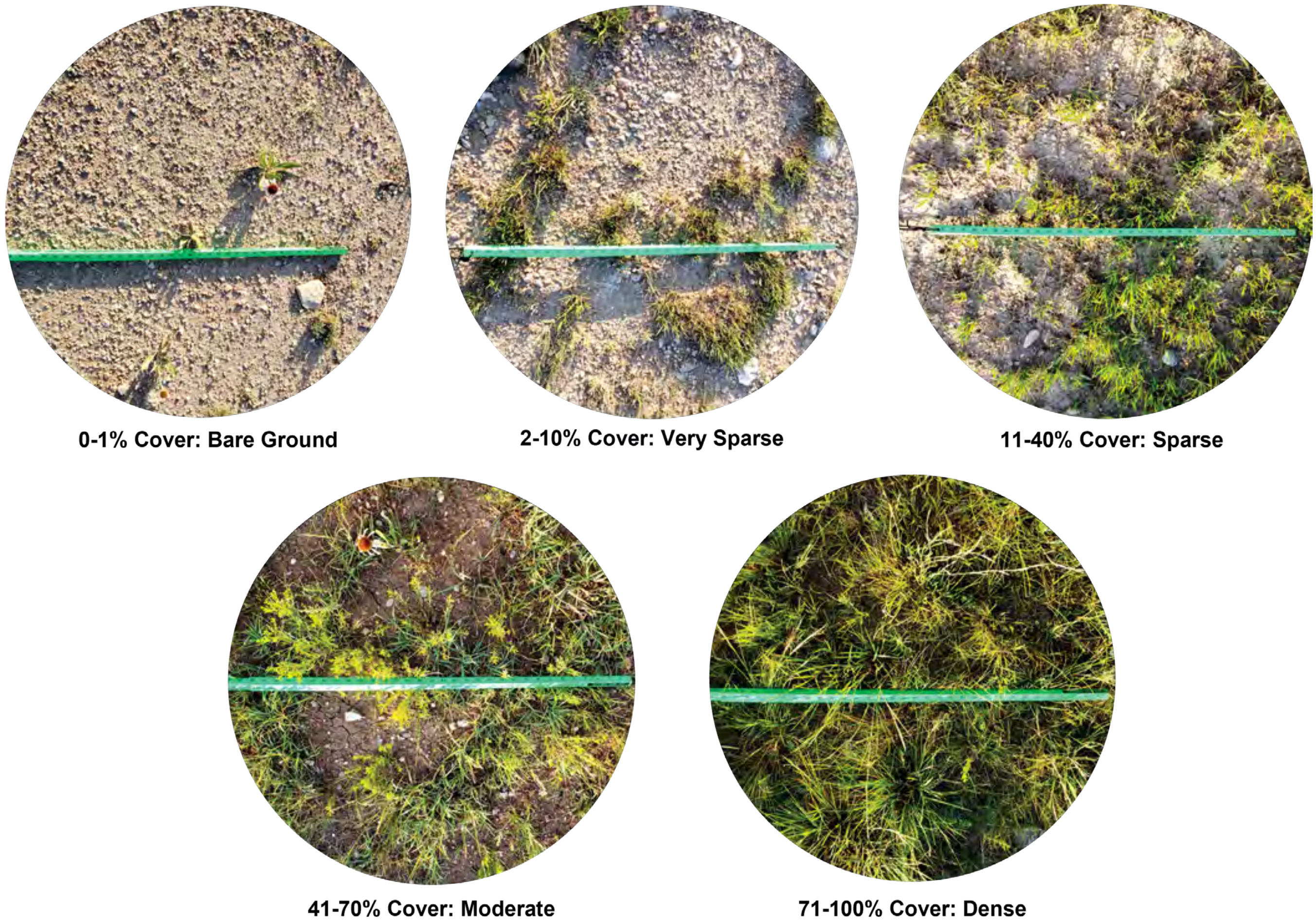


Figure 111: Different levels of plant cover, as seen from above. Photos © Julie Brazell, TNC

Based on your assessment, which option best describes the amount of vegetative cover?

- ❑ All bare ground, 0%–1% cover
- ❑ Very sparse, 2%–10% cover
- ❑ Sparse, 11%–40% cover
- ❑ Moderate, 41%–70% cover
- ❑ Dense, 71%–100% cover

6b. How far does your greenbelt extend from the stream edge?

Why this matters: The greenbelt is important for wildlife habitat, channel stability, and other stream functions. It is an indicator of subsurface moisture and can help you see how connected the stream is to the floodplain. An expansive greenbelt filling the majority of the valley bottom indicates that the site is well connected and holding water. A very narrow greenbelt that only exists along the stream channel indicates that there is little floodplain connection and water storage capacity.

Figure 112: This stream has little to no riparian vegetation. The banks are covered but are susceptible to erosion because they lack deep-rooted plants. Photo © Corissa Busse, TNC

Figure 113: This is an example of an expansive greenline along the valley bottom. The vegetation has helped to protect the channel and has minimized bank erosion. When this system floods, the stream has easy access to the floodplain and dense vegetation to dissipate energy. Photo © Chris Helzer, TNC

Figure 114: This stream has a very distinct greenline along the channel, but the adjacent areas are dominated by sagebrush, which indicates that the stream does not regularly access the valley bottom. Photo © Joe Dickie, Generation Photography, Inc.

How to assess the width of the greenbelt: Visually assess how far the greenbelt extends from your stream edge. Look for the line where denser, dark green vegetation stops and/or switches to more upland plants as the indication of the edge of the greenbelt.

Based on your assessment, which option best describes the greenbelt?

- ❑ No greenbelt present
- ❑ Greenbelt limited to the edge of the channel
- ❑ Greenbelt only occupying part of the valley bottom, limited to low-lying areas
- ❑ Valley bottom well vegetated with plants that are dependent on saturated or well-watered conditions

6c. What kind of vegetation is dominant within the greenbelt of your stream?

Why this matters: Vegetation type is important because some plants have more developed root systems, are more valuable for grazers, and can be indicators of a shallow water table, especially lush stands of native mesic grasses. Shrubs and trees typically do not provide much forage for livestock but do provide other benefits, such as shade, bank stabilization, and wildlife habitat.

How to assess the type of dominant vegetation: Walk next to your stream and through the stream valley bottom, and note the most common plant types. Are they species that typically occur in uplands or in wetlands? Note whether there are signs of wetness, such as ponded water or frequent flooding.

Figure 115: These photos show examples of dominant vegetation in a variety of western South Dakota streams. Top photos © Corissa Busse, TNC; Bottom photos © Joe Dickie, Generation Photography, Inc.

Based on your assessment, which best describes the type of vegetation?

- ❑ Mostly upland plants (sagebrush, western wheatgrass, needle-and-thread, cheatgrass)
- ❑ Mix of upland and some mesic plants (big bluestem, smooth brome, Kentucky bluegrass, snowberry, foxtail barley)
- ❑ Mostly wetland/mesic plants (prairie cordgrass, Canada wildrye, willow, rose)
- ❑ Wet meadow plants (cattails, sedges, bulrushes)

6d. Are trees and woody plants present?

Why this matters: Trees and shrubs help stabilize streambanks, provide habitat for birds, and offer shade for grazing animals. They can shelter wildlife movement along the stream corridor. (Note: Trees are not always native to a system. Russian olive and salt cedar can be particularly problematic, as they can take over stream areas and outcompete native species.)

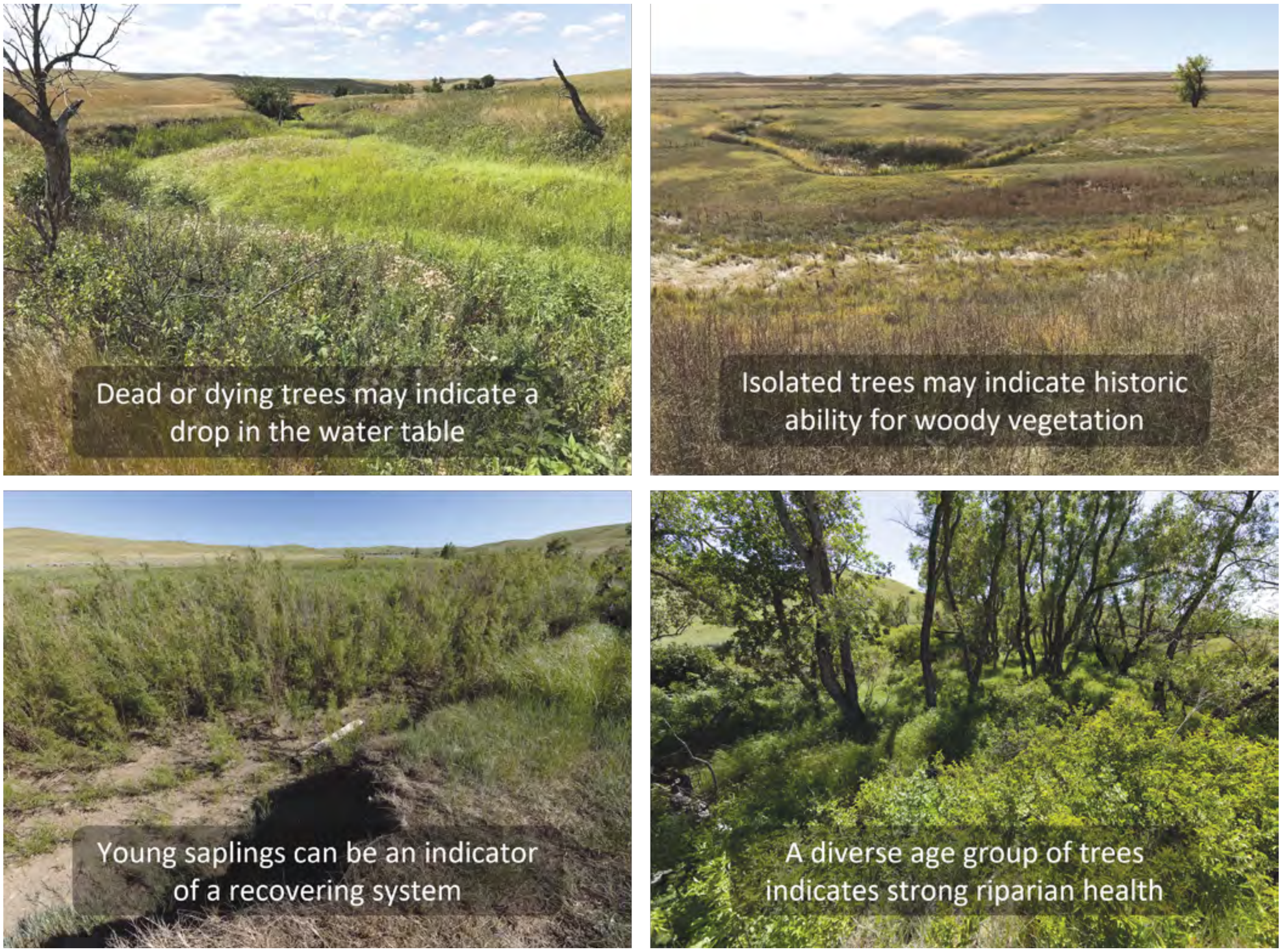


Figure 116: These images demonstrate how trees and woody vegetation can indicate stream health in some systems. Top photos © Kristen Blann and Corissa Busse, TNC; Bottom photos © Joe Dickie, Generation Photography, Inc.

How to assess the presence of trees:

Walk next to your stream and note whether trees such as cottonwood, willow, and ash are present. Remember, the trees you are looking for may be young saplings rather than fully mature trees.

Based on your assessment, which best describes the presence of trees in the portion of the stream you are monitoring?

- ❑ No trees or woody plants are present in this portion of the stream's riparian area
  OR
  Only invasive tree species and upland shrubs are present
- ❑ There are old, mature and/or dying trees high on banks away from the stream, but no new "recruits" (young trees)
- ❑ Young trees and mesic woody vegetation are beginning to re-establish in the riparian area
- ❑ There are mixed ages of trees and/or mesic woody plants and native perennial shrubs

6e. What is the diversity of plant species in your riparian zone?

Why this matters: The more diverse a plant community is, the more resilient it is to periodic disturbance. A site with high species diversity and richness will be more productive, as there are different species available to take advantage of changes in growing conditions. A variety of plants also helps support habitat for different birds, insects, and wildlife and provides forage for grazing animals throughout the year.

How to assess plant diversity:
Walk through the area next to the stream and note the number of different species you see.

Based on your assessment, which best describes the plant diversity?

- ❑ Low diversity, mostly invasive species and/or annual weedy species
- ❑ Low diversity, mostly perennial native species
- ❑ High diversity, mostly native species, and a mix of perennial grasses, forbs, and shrubs

7. Are indicators of salinity present?

Why this matters: Saline seeps prevent many plants from growing or stunt their growth. They are not as valuable for grazing and tend to support lower plant and animal diversity, though they are a natural feature on the landscape due to the parent material of our western South Dakota soils.

How to assess salinity:
Look for a white salt "pan" on the surface of the ground. You may also notice stunted growth in plants or notice that only salt-tolerant species are present (see Plant Guide for information on salt-tolerant plant species).

Figure 117: This area exhibits signs of salinity, including stunted plant growth and salt "pans" on the surface. Photo © Corissa Busse, TNC

Based on your assessment, is the presence of salts inhibiting plant growth and productivity?

- ❑ Saline conditions are affecting plant health, productivity, and vigor
- ❑ Salt indicators are visible but are not limiting plant growth
- ❑ Salts do not appear to be present

Section 12: Using the Stream Monitoring Worksheet

The stream monitoring worksheet on the next page is intended to be used regularly to identify trends in a stream's health and resilience over time. All streams—the good, the bad, and the ugly—are constantly in a dynamic state of change. Streams that appear to be in the worst of conditions may be changing toward health, and streams that appear to be healthy may be in the early stages of decline. A resilient stream can maintain or regain its function after changes and disturbance events (such as flood, fire, or drought) and rebound quickly to a healthy state. This worksheet is intended to help identify whether a stream is trending toward a healthy condition, or whether challenges are arising that could cause a condition to worsen.

We recommend that land managers use this worksheet to set a "baseline" report for a stream. Complete the worksheet questions and use the summary chart at the end to mark the box noting your stream's condition for each question. Then, continue to reuse the worksheet and monitor the stream over time, noting trends and changes. Get to know a stream at differing flows and conditions throughout the year—and use this worksheet as a tool to work toward continuous improvement.

Each of the elements that you monitor in this worksheet is capable of changing, either toward or away from a healthy condition. Many of the options trend from a low- to a high-resilience condition, as represented by a colored circle:

- Most resilient
- Strong resilience
- Moderate resilience
- Functioning at risk
- Reduced function

Please keep in mind that annual weather, including drought or wet years, may also impact your stream's condition. This is natural and reflects the power of prairie streams to adapt. These annual changes also speak to the need to better understand a stream over time. Appendix A includes an example of a completed worksheet, as well as multiple additional worksheets and note pages to use in future assessments.

Stream Monitoring Worksheet

Answer the following questions using the methods in section 11 of the stream guide.

1. **What is the stream flow type? Describe how the stream behaves during an average year's rainfall for your area.**
   - ❑ ● Ephemeral: stream only flows for a few hours or days after rain events
   - ❑ ● Intermittent: stream flows for part or most of the year, but does go dry in sections (note: intermittent streams may have unconnected pools of water year-round)
   - ❑ ● Perennial: stream flows year round

2. **Do you notice springs or seeps present?**
   - ❑ ● No
   - ❑ ● Yes

3. **What is your stream's sinuosity (or meandering)?**
   - ❑ ● Straight
   - ❑ ● Moderately Sinuous
   - ❑ ● Highly Sinuous
   - ❑ ● Wet Meadow (no defined channel)

4. **How is your stream channel changing or evolving?**
   - ❑ ● Fully Connected: no defined channel, "stage zero" or channel highly connected and continuous with an active floodplain
   - ❑ ● Single Channel Forming: small but clearly defined channel
   - ❑ ● Incised or Rechannelizing: channel actively incising/downcutting, headcuts may be present
   - ❑ ● Widening and Depositing: channel may be unstable, active cutting and widening
   - ❑ ● New Inset Floodplain Formed or Forming: unstable but recovering: bank slumping, sediment deposition, some point bars present
   - ❑ ● Rebuilding: channel is in recovery, is stabilizing again and developing new floodplain benches set down within the new floodplain—often with evidence of one or more older terraces

5. **How connected is your stream to the floodplain?**
   - ❑ ● Flooding out of banks occurs infrequently or never (every 5–100 years at most)
   - ❑ ● Flooding occurs occasionally: stream channel is confined or well-contained within the banks, but with access to a narrow floodplain at higher flows (every 2–5 years)
   - ❑ ● Flooding out of banks occurs frequently (once or twice every couple of years)

6. **What is the condition of your riparian area?**

   a. Vegetative cover
   - ❑ ● Bare Ground, 0–1% cover
   - ❑ ● Very sparse, 2–10% cover
   - ❑ ● Sparse, 11–40% cover
   - ❑ ● Moderate, 41–70% cover
   - ❑ ● Dense, 71–100% cover

   b. Width of greenbelt
   - ❑ ● No greenbelt present
   - ❑ ● Greenbelt limited to edge of channel
   - ❑ ● Greenbelt only occupying part of the valley bottom, limited to low-lying areas
   - ❑ ● Valley bottom well vegetated with plants that are dependent on saturated or well-watered conditions

c. Dominant vegetation
- ❑ 🟠 Mostly upland plants
- ❑ 🟡 Mix of upland and some mesic plants
- ❑ 🟢 Mostly wetland / mesic plants
- ❑ 🟢 Wet meadow plants

d. Based on your assessment, which best describes the presence of trees?
- ❑ 🟡 No trees or woody plants are present in the riparian area, OR only invasive tree species and upland shrubs are present
- ❑ 🟡 There are old, mature and/or dying trees high on banks away from the stream, but no new “recruits” (young trees)
- ❑ 🟢 Young trees and mesic woody vegetation are beginning to re-establish in the riparian area
- ❑ 🟢 There are mixed ages of trees and/or mesic woody plants and native perennial shrubs

e. Plant diversity
- ❑ 🟡 Low diversity, mostly invasive species and/or annual weedy species
- ❑ 🟢 Low diversity, mostly perennial native species
- ❑ 🟢 High diversity, mostly native species, with a mix of perennial grasses, forbs, and shrubs

7. Are indicators of salinity present?
- ❑ 🟡 Saline conditions are affecting plant health, productivity, and vigor
- ❑ 🟢 Salt indicators are visible but are not limiting plant growth
- ❑ 🟢 Salts do not appear to be present

Bringing It All Together

Using your answers from the worksheet above, fill in the chart below. Note areas that seem to be doing well, and others that need improvement.

Stream Type: ____________________ Stream Name or Location: ____________________

Date Monitoring Completed _____/_____/_____

Current Condition

For each question, mark the column that corresponds to the resilience color noted in the worksheet. Notice changes to condition over time by preserving this worksheet and your notes for future monitoring reference.

Question	Losing Function	Functioning But at Risk	Moderate Resilience	Strong Resilience	Most Resilient	Notes/comments: (wildlife observations, annual precipitation received, etc.)
	Less Resilient>>>>>>>>>>>>>>>>>>>>>>>>> More Resilient					
1. Stream Flow Type						
2. Springs and/or Seeps						
3. Sinuosity						
4. Stream Stage						
5. Entrenchment						
6a. Vegetation Cover						
6b. Width of Greenbelt						
6c. Dominant Vegetation						
6d. Trees and Shrubs						
6e. Plant Diversity						
7. Salinity						

Regenerative Bison Ranch Focuses on Riparian Future

> *"Bison and beavers are critical keystone species to restore riparian streambeds."*

In the vast open prairies between the Black Hills National Forest and the Buffalo Gap National Grasslands lies the Cheyenne River Ranch, where 1,000 head of buffalo roam to help regenerate more than 30,000 acres.

"We were doing regenerative agriculture before it was cool, for about 50 years," says Dan O'Brien, ranch owner and founder of the Wild Idea Buffalo Company. This ranching philosophy drove the wildlife biologist, rancher and carbon cowboy to bring buffalo back and revive degraded cropland with native grasses and grazing bison that heal the soil and capture carbon.

O'Brien has transformed many degraded pastures and cropland by planting and replanting native seeds and using regenerative practices that build healthy root systems and soil. On his ranch, he maintains a reasonable herd size that gives grass proper rest time, rather than expanding the size of the herd in good years.

Ranch manager and wildlife biologist Colton Jones shares O'Brien's passion for range management and his understanding of the role bison play in the ecosystem. Jones also works with like-minded ranchers from Montana to Nebraska who steward their land and manage their animals in the same manner. These partners provide the other half of the harvest needed to supply Wild Idea Buffalo Company customers.

Working to rebuild streams

Just as vital as rebuilding grass resources in this semi-arid, changing climate is restoration of the water resources. The Cheyenne River Ranch has two main riparian areas. The Cheyenne River runs through the south boundary of a deeded shared U.S. Forest Service allotment on the Buffalo Gap National Grasslands, and Lower Spring Creek flows from the Black Hills and crosses deeded ground in two areas on the ranch.

Dan O'Brien, Colton and Jilian Jones, ranchers Pennington/Meade County, SD

“My wife Jilian [general manager of Wild Idea Buffalo Company] and I have owned the land with Lower Spring Creek for five years now, and we’re beginning to see some early recovery of vegetation growth on the creek bottoms,” Jones says. “Since bison don’t camp in riparian areas like cattle, only visiting to drink, they’re helping to heal it from the years of cattle damage.”

The O’Brien and Jones families are passionate about rebuilding these riparian areas, as these creeks are a critical water source for the bison herd. “In a holistic view, if you’re not managing the water properly, you degrade your soil quality, which degrades the grass quality. Also, water is not in infinite supply. Water tables are dropping every year, so we must bring the ecosystem back to hold onto water longer,” Jones says.

Beavers vital to biodiversity

Jones has seen their creek run dry at times, given the wild weather swings brought about by climate change. “Since we don’t have plumbed water into those pastures, they could become useless unless we slow the water down and hold it, like what beavers can do.”

The Cheyenne River Ranch is working with The Nature Conservancy, which also holds conservation easements on the ranch’s deeded property, to incorporate beaver dam analogs to rehabilitate the stream habitat. Beaver dam analogs are human-made structures designed to mimic the function of a natural beaver dam to slow and hold water on the landscape. Their use can create the conditions that eventually attract these natural dam builders to return to an area.

“We consider beavers to be a keystone species to a prairie ecosystem, like the buffalo, and beaver reintroduction has been a short-term priority goal since we acquired this land,” Jones says. “Repairing these riparian areas will take time because beavers were trapped out of existence, and cattle distressed the habitat that was once here. We want to see more willow trees and other wetland species take root and build back the biodiversity.”

Both Colton and Jilian are beginning to see more wildlife on the creek bottoms, from turkeys to pronghorns. “I’ve seen turkey hens on that creek for the first time this spring, and we attribute that to the rest we give those areas and not overgrazing them,” he shares.

New ideas from partners

Jones travels to the different ranches in their network with a mobile harvest truck, which gives him the opportunity to get ideas for riparian restoration. Since the ranches he visits cover vast geographic distances and varied ecosystems—from Montana to Nebraska—he learns first-hand how other buffalo producers manage riparian areas in harmony with grazing to preserve the future of their ranches.

“On a ranch in Choteau, Montana, that has shifted to bison, their riparian areas now include beavers. As a result, they’re getting better water retention and starting to see willow trees popping up again,” Jones says. “Another affiliated rancher for our Wild Idea Buffalo Company in the Nebraska sandhills, near Atkinson, has brought beavers back successfully by focusing on riparian management.”

Seeing a ranch that is farther along in the riparian rehabilitation process gives him the incentive to keep going. “This insight into future riparian success is extremely encouraging, for the simple fact that these enterprises care more about putting value into the future than chasing today’s dollar,” he adds.

When the Joneses see tangible, measurable improvement in native biodiversity, it offers them hope for the ranch’s future that they will carry forward to the next generation. “We’re a family of outdoorsmen. Being down there on those creeks or the river with our children is part of how we enjoy life. The biodiversity, the different animals, the different fish that we catch out of those streams—that is what enhances our quality of life,” Jones shares.

Figure 1. Jilian and Colton Jones; © Joe Dickie, Generation Photography, Inc.

Figure 2. Spring Creek is a low-gradient stream, but can go dry in areas during hard drought years. Photo: © Joe Dickie, Generation Photography, Inc.

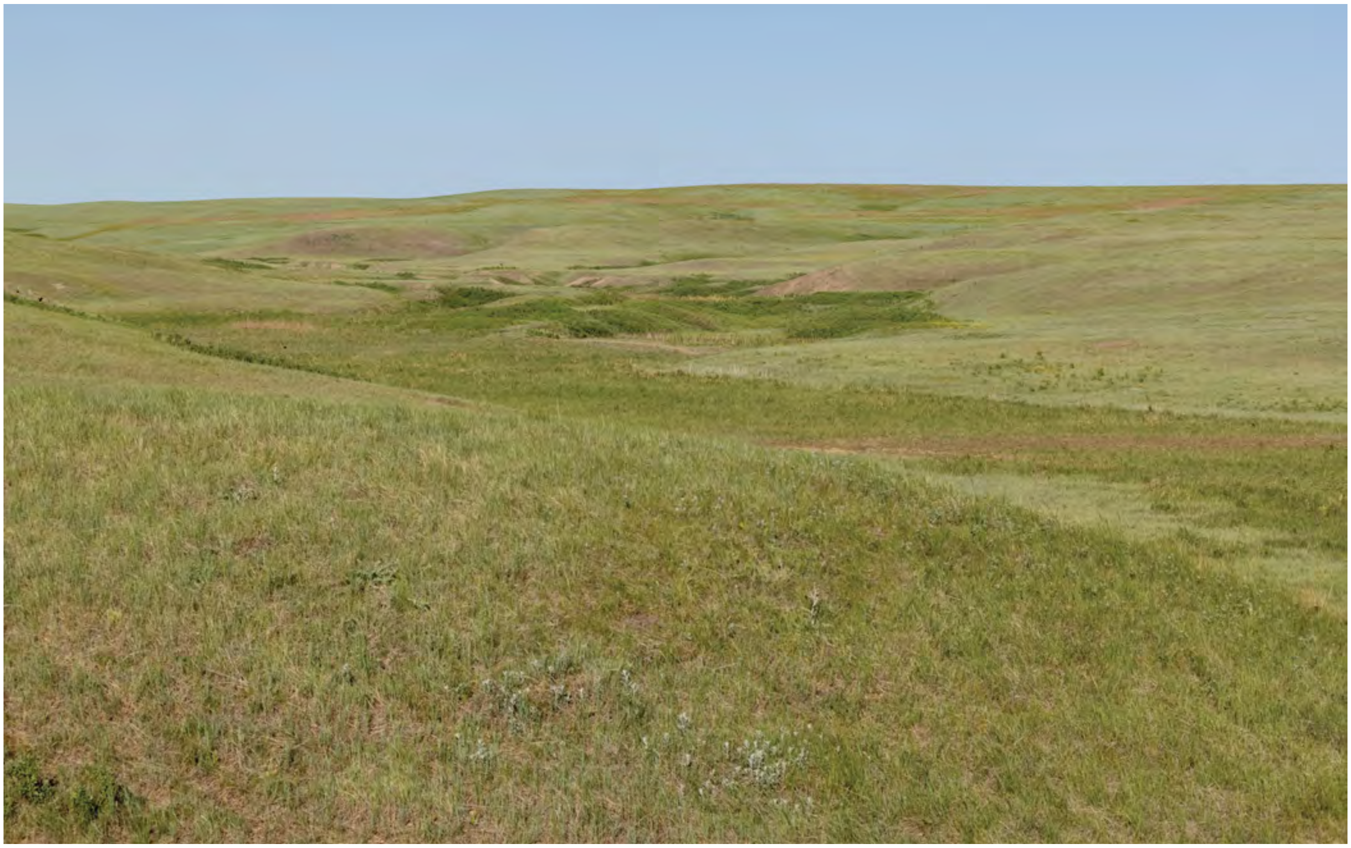


Figure 3. Holistic range management across the ranch and its uplands is important to the Jones and O'Brien families as they consider the health of their streams. Photo: © Joe Dickie, Generation Photography, Inc.

Figure 4. Bison are managed using holistic grazing practices at Wild Idea Buffalo Company. Photo: © Jill O'Brien

Figure 5. Streams are a critical water source for the bison herd. Photo: © Joe Dickie, Generation Photography, Inc.

Summary

Resource managers, landowners, and ranch operators share many management issues and concerns relating to riparian areas in western South Dakota. The primary issues involve water management (too much vs. too little), channel erosion and geomorphology, and riparian vegetation management. Most streams in the region are ephemeral or intermittent; therefore, slight changes in hydrology can have powerful impacts on local species. Geomorphologically, many of the streams are very sensitive to erosion and headcutting due to the nature of the climate, plant cover, soil, channel material, and historic land use.

Vegetation management to provide adequate forage for grazing animals, ensure healthy/stable stream channels, and create wildlife habitat is often a shared goal among partners. Each site has unique features and properties, so careful observation, discussion, and repeat adjustments are needed to choose the best stream management and restoration options. Vegetation management through grazing and process-based in-channel restoration practices are feasible for many land managers and can provide valuable returns.

With collaborative efforts and thoughtful, strategic planning, meaningful riparian restoration and management are achievable for western South Dakota. Healthy riparian areas provide tangible benefits, not just to the landowner but also to the greater community in the form of quality aquatic and wildlife habitat, flood protection, improved water quality, and sustained water storage. Riparian areas are unique features that require special and at times creative management; the better we understand these systems, the better we can manage them.

Nature is resilient, and our grassland systems are particularly remarkable in their ability to recover and heal. We are still learning about our prairie stream systems, but we already have many of the tools needed to support them; with proactive adaptive management, watershed-scale partnerships, and investment in nature-based low-tech solutions, we can build healthy self-sustaining streams and riparian areas that support both ranch economics and our diverse natural landscape.

Future Science and Management Information Needs

The success of riparian best management practices such as buffers, rotational grazing, and low-tech channel interventions is not well documented in the region. Therefore, there is a strong need for monitoring and peer-to-peer learning to better understand the effectiveness of these practices over time. Regarding beavers specifically, we lack significant information about their past range and where they could live and thrive today.As the climate changes and rainfall variability increases in western South Dakota, we need to record the effects of these changes and to collect case studies of how landscapes are being successfully managed. Restoring the connectivity and resiliency of riparian areas will help these systems adapt to climate change, and continued monitoring and assessment of management practices can help us achieve greater success.

Appendix A: Extra Copies of Stream Monitoring Worksheet

Example of Completed Stream Monitoring Worksheet

Answer the following questions using the methods in section 11 of the stream guide.

1. What is the stream flow type? Describe how the stream behaves during an average year's rainfall for your area.

- ☒ ● Ephemeral: stream only flows for a few hours or days after rain events
- ❑ ● Intermittent: stream flows for part or most of the year, but does go dry in sections (note: intermittent streams may have unconnected pools of water year-round)
- ❑ ● Perennial: stream flows year round

2. Do you notice springs or seeps present?

- ☒ ● No
- ❑ ● Yes

3. What is your stream's sinuosity (or meandering)?

- ❑ ● Straight
- ☒ ● Moderately Sinuous
- ❑ ● Highly Sinuous
- ❑ ● Wet Meadow (no defined channel)

4. How is your stream channel changing or evolving?

- ❑ ● Fully Connected: no defined channel, "stage zero" or channel highly connected and continuous with an active floodplain
- ☒ ● Single Channel Forming: small but clearly defined channel
- ❑ ● Incised or Rechannelizing: channel actively incising/downcutting, headcuts may be present
- ❑ ● Widening and Depositing: channel may be unstable, active cutting and widening
- ❑ ● New Inset Floodplain Formed or Forming: unstable but recovering: bank slumping, sediment deposition, some point bars present
- ❑ ● Rebuilding: channel is in recovery, is stabilizing again and developing new floodplain benches set down within the new floodplain—often with evidence of one or more older terraces

5. How connected is your stream to the floodplain?

- ❑ ● Flooding out of banks occurs infrequently or never (every 5–100 years at most)
- ❑ ● Flooding occurs occasionally: stream channel is confined or well-contained within the banks, but with access to a narrow floodplain at higher flows (every 2–5 years)
- ☒ ● Flooding out of banks occurs frequently (once or twice every couple of years)

6. What is the condition of your riparian area?

a. Vegetative cover

- ❑ ● Bare Ground, 0–1% cover
- ❑ ● Very sparse, 2–10% cover
- ❑ ● Sparse, 11–40% cover
- ☒ ● Moderate, 41–70% cover
- ❑ ● Dense, 71–100% cover

b. Width of greenbelt

- ☐ 🟠 No greenbelt present
- ☐ 🟡 Greenbelt limited to edge of channel
- ☒ 🟢 Greenbelt only occupying part of the valley bottom, limited to low-lying areas
- ☐ 🟢 Valley bottom well vegetated with plants that are dependent on saturated or well-watered conditions

c. Dominant vegetation

- ☒ 🟠 Mostly upland plants
- ☐ 🟡 Mix of upland and some mesic plants
- ☐ 🟢 Mostly wetland / mesic plants
- ☐ 🟢 Wet meadow plants

d. Based on your assessment, which best describes the presence of trees?

- ☒ 🟡 No trees or woody plants are present in the riparian area, OR only invasive tree species and upland shrubs are present
- ☐ 🟡 There are old, mature and/or dying trees high on banks away from the stream, but no new “recruits” (young trees)
- ☐ 🟢 Young trees and mesic woody vegetation are beginning to re-establish in the riparian area
- ☐ 🟢 There are mixed ages of trees and/or mesic woody plants and native perennial shrubs

e. Plant diversity

- ☐ 🟡 Low diversity, mostly invasive species and/or annual weedy species
- ☒ 🟢 Low diversity, mostly perennial native species
- ☐ 🟢 High diversity, mostly native species, with a mix of perennial grasses, forbs, and shrubs

7. Are indicators of salinity present?

- ☐ 🟡 Saline conditions are affecting plant health, productivity, and vigor
- ☐ 🟢 Salt indicators are visible but are not limiting plant growth
- ☒ 🟢 Salts do not appear to be present

Bringing It All Together

Using your answers from the worksheet above, fill in the chart below. Note areas that seem to be doing well, and others that need improvement.

Stream Type: ______________________________ Stream Name or Location: ______________________________

Date Monitoring Completed ______/______/______

Current Condition

For each question, mark the column that corresponds to the resilience color noted in the worksheet. Notice changes to condition over time by preserving this worksheet and your notes for future monitoring reference.

Question	Losing Function	Functioning But at Risk	Moderate Resilience	Strong Resilience	Most Resilient	Notes/comments: (wildlife observations, annual precipitation received, etc.)
	Less Resilient>>>>>>>>>>>>>>>>>>>>>>>>> More Resilient					
1. Stream Flow Type			x			Second year in moderate to severe drought. 4" precip received to date for 2021. Stream was running in May and early June after a few rain events. Damselfly and Great Plains toad seen along stream.
2. Springs and/or Seeps		x				
3. Sinuosity			x			
4. Stream Stage				x		
5. Entrenchment				x		
6a. Vegetation Cover				x		
6b. Width of Greenbelt		x				
6c. Dominant Vegetation	x					
6d. Trees and Shrubs	x					
6e. Plant Diversity				x		
7. Salinity					x	

Stream Monitoring Worksheet

Answer the following questions using the methods in section 11 of the stream guide.

1. **What is the stream flow type? Describe how the stream behaves during an average year's rainfall for your area.**
   - ❑ ● Ephemeral: stream only flows for a few hours or days after rain events
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   - ❑ ● Perennial: stream flows year round

2. **Do you notice springs or seeps present?**
   - ❑ ● No
   - ❑ ● Yes

3. **What is your stream's sinuosity (or meandering)?**
   - ❑ ● Straight
   - ❑ ● Moderately Sinuous
   - ❑ ● Highly Sinuous
   - ❑ ● Wet Meadow (no defined channel)

4. **How is your stream channel changing or evolving?**
   - ❑ ● Fully Connected: no defined channel, "stage zero" or channel highly connected and continuous with an active floodplain
   - ❑ ● Single Channel Forming: small but clearly defined channel
   - ❑ ● Incised or Rechannelizing: channel actively incising/downcutting, headcuts may be present
   - ❑ ● Widening and Depositing: channel may be unstable, active cutting and widening
   - ❑ ● New Inset Floodplain Formed or Forming: unstable but recovering: bank slumping, sediment deposition, some point bars present
   - ❑ ● Rebuilding: channel is in recovery, is stabilizing again and developing new floodplain benches set down within the new floodplain—often with evidence of one or more older terraces

5. **How connected is your stream to the floodplain?**
   - ❑ ● Flooding out of banks occurs infrequently or never (every 5–100 years at most)
   - ❑ ● Flooding occurs occasionally: stream channel is confined or well-contained within the banks, but with access to a narrow floodplain at higher flows (every 2–5 years)
   - ❑ ● Flooding out of banks occurs frequently (once or twice every couple of years)

6. **What is the condition of your riparian area?**

   a. Vegetative cover
   - ❑ ● Bare Ground, 0–1% cover
   - ❑ ● Very sparse, 2–10% cover
   - ❑ ● Sparse, 11–40% cover
   - ❑ ● Moderate, 41–70% cover
   - ❑ ● Dense, 71–100% cover

   b. Width of greenbelt
   - ❑ ● No greenbelt present
   - ❑ ● Greenbelt limited to edge of channel
   - ❑ ● Greenbelt only occupying part of the valley bottom, limited to low-lying areas
   - ❑ ● Valley bottom well vegetated with plants that are dependent on saturated or well-watered conditions

c. Dominant vegetation
- ❑ 🟠 Mostly upland plants
- ❑ 🟡 Mix of upland and some mesic plants
- ❑ 🟢 Mostly wetland / mesic plants
- ❑ 🟢 Wet meadow plants

d. **Based on your assessment, which best describes the presence of trees?**
- ❑ 🟠 No trees or woody plants are present in the riparian area, OR only invasive tree species and upland shrubs are present
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2. **Do you notice springs or seeps present?**
   - ❑ No
   - ❑ Yes

3. **What is your stream's sinuosity (or meandering)?**
   - ❑ Straight
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   - ❑ Highly Sinuous
   - ❑ Wet Meadow (no defined channel)

4. **How is your stream channel changing or evolving?**
   - ❑ Fully Connected: no defined channel, "stage zero" or channel highly connected and continuous with an active floodplain
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2. **Do you notice springs or seeps present?**
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   - ❑ Yes

3. **What is your stream's sinuosity (or meandering)?**
   - ❑ Straight
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Appendix B: Riparian Plant Guide

Keys to the Guide

Plant names:

- ***Green font*** represents species that are generally considered to be native.
- ***Brownish-tan*** font represents species that are generally considered to be exotic, non-native, introduced, or invasive.

Wetland Class:

- OBL stands for obligate wetland species; plants that do not occur outside these wet conditions.
- FACW stands for facultative wetland species; plants that usually occur in wetlands (~67-99% of the time) but are occasionally found in non-wetlands (1-33% of the time)
- FAC stands for facultative; plants that are equally likely to occur in wetlands and non-wetlands.
- FACU stands for facultative upland; species that occur in non-wetlands (~67%–99% of the time) but are occasionally found in wetlands (estimated 1%-33% of the time).
- UPL stands for upland plant species that occur in non-wetlands and upland habitats.

Arrows under the "Wetland Class":

- Arrows show to what extent a given species is likely to be associated with upland (dry) habitats versus riparian (wet) habitats, along a continuum. Some species are opportunistic and tolerate a range of moisture conditions; others are almost always dependent on wet or saturated soil conditions (and are called "hydrophytes," from the Latin for "water plant").
- Arrows also indicate a species preference for and/or tolerance of soil moisture conditions across a continuum throughout the year.
    - **Brown** shading on the left side of the arrow indicates a species that tolerates dry, upland conditions for at least a significant portion of the year.
    - **Dark green** shading on the right side of the arrow indicates a dependence on wet or saturated conditions for at least part of the year.
    - **Blue** shading on the right indicates a dependence, for the most part, on perennial aquatic habitat.
    - The breadth of the shading also indicates, roughly, the range of conditions where the plant might be observed, from wet to dry.

For example, the following arrows generally describe upland (UPL) or facultative upland (FACU) species that are not dependent on wetlands, riparian areas, or moisture conditions, but are included because they may often be observed in the study area on the uplands bordering streams and riparian areas.


(UPL)


(FACU)

The green arrows below indicate a facultative (FACW) or obligate wetland species (OBL), i.e. a species highly dependent on wet, saturated or moist conditions. Facultative wetland species usually occur in wetlands but are occasionally found in non-wetlands or areas that may dry out seasonally; obligates occur almost always under natural conditions in wetlands.


(FACW)


(OBL)

Big bluestem
Andropogon gerardii

© Matt Lavin, Montana State University

Growth: native, warm-season perennial

ID: 2–7 ft. tall, easy to ID, finger-like seed spikes in “turkey foot” shape; leaves < 18 in. and mostly lower; can create large clumps from short rhizomes; has purplish nodes on hairless stems; stems turn rusty red when mature

Community: short-, mixed-, and tallgrass prairie; plains, open woods, along railroads

Local Conditions: part shade to sun, average to dry soil, loamy overflow

Tolerances: grazing and mowing, decreases with frequent mowing or grazing

Wetland Class: FACU; dry, mesic

Notes: Tall, vigorous grass with distinct seed head. Occurs across a gradient of prairies and is iconic of lowland tallgrass communities. Recommended for summer pasture, seeded with other warm-season grasses. It is widespread in eastern South Dakota and found in western South Dakota on small protected areas with favorable soil moisture. Big bluestem has excellent quality, quantity, and palatability.

Little bluestem
Schizachyrium scoparium

© Matt Lavin, Montana State University and SDSU Extension

Growth: Native, warm-season perennial

ID: 1–4 ft. tall, clump-forming; pretty single spike, purplish; wispy white persists through winter; leaves up to 10 in; sheath forms a “V”; stems tan or reddish in fall

Community: short-, mixed-, and tallgrass prairie; plains, open woods, along railroads

Local Conditions: part shade to sun; average to dry, often sandy soil; also loamy, clayey soil

Tolerances: Drought; wide pH and texture range

Wetland Class: FACU; dry, mesic

Notes: Perennial bunchgrass that grows in distinct clumps with fuzzy white seedheads, often in nearly pure stands. Its Lakota name means “small red grass.” Seeded for erosion control with other native grasses. Valued as summer forage. Good nesting cover and forage for wildlife, host plant for several native butterfly species. Often on sand hill areas, associated with calcareous soils. When overgrazed, replaced with blue grama.

Western wheatgrass
Pascopyrum smithii

© TNC/KBlann and TNC/Brazell

Growth: cool-season perennial, native grass

ID: 12–30 in. single spike; stiff, ribbed leaves that roll up when dry; glaucous or bluish color

Community: mixed-grass prairie, major range grass of northern and central Great Plains

Local Conditions: sandy, clayey soils; <17 in. precipitation

Tolerances: saline, moderately alkali tolerant, moderate to drought, good to trample and mow

Wetland Class: UPL

Notes: Most abundant grass in South Dakota prairies. Rhizomatous, forming open sod. Commonly associated with grama and needlegrass. Decreases with long-term overgrazing; palatable and nutritious for livestock. Food source for a variety of wildlife (elk, antelope, deer, voles) and grouse use it for nesting. State grass of South Dakota, North Dakota, and Wyoming. Somewhat similar ryegrasses (*Lolium* spp.) also have flattened spikelets but they are rotated and aligned against the stem.

Blue grama
Bouteloa gracilis


© SDSU Extension and Matt Lavin, Montana State University

Growth: cool-season perennial, native grass

ID: 8–28 in. distinctive curved “eyebrow” seed head

Community: dry prairies, rock outcrops

Local Conditions: sun; dry, sandy, rocky, or clay soil

Tolerances: sun/shade, drought, freezing, grazing pressure

Wetland Class: UPL

Notes: Important forage species and popular ornamental due to its pretty, curved flower spikes and curly leaves. May look similar to hairy grama; however, blue grama is less hairy overall and shorter, with fewer spikelets.

Green needlegrass
Nasella viridula


© Matt Lavin, Montana State University and SDSU Extension

Growth: cool-season perennial, native grass

ID: 1–4 ft. long appressed panicle (tight to stem), black seed with spiraled awns 1 in. long

Community: dry short- to mixed-grass prairie, open woods, along railroads

Local Conditions: part shade to sun; often in sandy, loamy, clayey soils; prefers fine-textured soil

Tolerances: moderate to drought; fair to trampling, mowing

Wetland Class: UPL

Notes: Bunchgrass of moderate height and best in a mix with other cool-season grasses. Forms clumps, sometimes large tufts. Fringe of hairs on the edge of the sheath and collar. Distinct twisty or bent awns, and the ripe seeds are dark brown and shiny. The hairless leaves are found mostly on lower stems and appear rolled toward the tip. Green needlegrass decreases with overgrazing, and early season grazing is replaced by less productive mid- and shortgrass species. Most palatable of needlegrasses; nutritious to all livestock.

Needle-and-thread grass

Heterostipa comata

© Tony Fratesy

Growth: cool-season perennial, native grass

ID: 1–3 ft. tall, larger overall than related species; awns stout, 4–8 in. long, and bent (not curling). Leaves 8–12 in. long, mostly on lower stem, tips die back and blade rolls inward. Large spikelet with one floret with sharp-pointed, twisted awn 4–5 in. long that curls as it dries.

Community: prairie, grasslands, open woods

Local Conditions: sun; dry, sandy, and coarse-textured soils, shallow gravel, thin loamy soil

Tolerances: sun/shade, drought, freezing, grazing

Wetland Class: UPL

Notes: Initially increases with grazing, but eventually decreases with overgrazing, and is replaced by less productive mid- and shortgrass species. Very palatable to all livestock before maturity, after which seeds may cause injury to grazers.

Japanese brome
Bromus japonicus

© SDSU Extension

Growth: introduced grass, cool-season annual

ID: 14–28 in. drooping panicle with dangling seeds, long leaves twist at base upside-down

Community: dry short- to mixed-grass prairie; disturbed soil, waste areas, fields

Local Conditions: part shade, sun; disturbed soil, waste areas

Tolerances: sun/shade, drought, freezing, grazing pressure

Wetland Class: FACU

Notes: Also known as annual brome, it is an invader of dry soils in waste or disturbed areas and is generally considered a nuisance, though it is palatable to livestock as a green plant in autumn and in spring before flowering. Easily confused with downy brome.

Orchardgrass
Dactylis glomerata


© SDSU Extension and Matt Lavin, Montana State University

Growth: exotic, cool-season perennial grass

ID: 1–5 ft. tall, light green to blue-green panicle with erect, spreading branches

Community: fields, roadsides, trail edges, woodland edges, river banks

Local Conditions: part shade, sun; moist to dry disturbed soil

Tolerances: winter hardy; vulnerable to late summer drought

Wetland Class: FACU

Notes: Leaves glumes behind on stalk after shedding seeds. Pollen bad for hay fever. Used as a forage crop.

Crested wheatgrass
Agropyron cristatum


© Matt Lavin, Montana State University and TNC/Brazell

Growth: Exotic grass, cool-season perennial

ID: 1–3 ft. tall; packed 2-ranked seed spikes like teeth on comb, up to 4 in. long

Community: short- to mixed-grass prairie; fields, prairie, roadsides, gravel pits, waste

Local Conditions: sun; moist to dry disturbed soils of sandy, loamy, or clayey; 8–20 in. rain

Tolerances: cold, mowing; resilient to drought, grazing pressure, trampling; low to salty soil

Wetland Class: UPL

Notes: A common bunchgrass with early growing, extensive fibrous roots, introduced widely by federal agencies and soil conservationists as forage and soil stabilization after the Dust Bowl of the 1930s. Can form monocultures, not compatible with native grasses in seed mixes. Moderately coarse leaves, mostly basal and flat when growing but roll inward when dry. The spike is broader and shorter than in quackgrass. High silica content makes it a grazing increaser and less valued for forage.

Smooth bromegrass
Bromus inermis

© SDSU Extension and Matt Lavin, Montana State University

Growth: Exotic, cool-season perennial grass

ID: 20–50 in. flower panicle droops to side with dangling spikelets, longer leaves twist

Community: mixed-grass prairie; disturbed soil, roadsides, woodland edges, fencerows

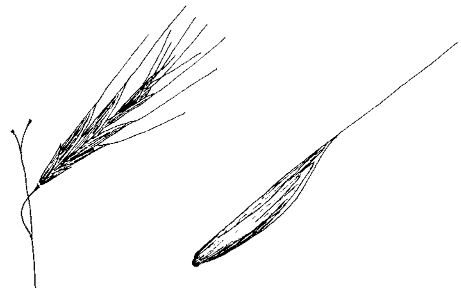
Local Conditions: part shade, sun; variety of soil conditions; often sandy or clayey soils

Tolerances: moderate tolerance to drought, good tolerance to trampling and mowing

Wetland Class: UPL; edge of dry

Notes: Widely introduced for forage, has become most abundant grass in South Dakota mixed-grass prairie; has become nuisance invader and pest in natural areas. Strong rhizomes; clump or sod-forming. Becomes dominant on idle fields. Leaf blades smooth, mostly basal, longer ones flipped upside-down, and “M” constriction like other bromegrass.

Downy brome, aka “cheatgrass”
Bromus tectorum



© SDSU Extension

Growth: introduced grass, cool-season annual

ID: 8–30 in. drooping panicle with dangling seeds, fewer than Japanese brome; 5–8 florets per spikelet; awns attached to florets 3/8 to 5/8 in. long, change from green to purple when mature, then brown or tan as the plant dries

Community: dry short- to mixed-grass prairie; disturbed areas, roadsides, fields

Local Conditions: deep, loamy soils; south-facing slopes; full sun; thrives across a wide range of annual precipitation that peaks in late winter or early spring

Tolerances: high tolerance to drought, temperature extremes

Wetland Class: UPL

Notes: Also known as annual brome or cheatgrass. An aggressive competitor with native grasses; invades both high-quality and disturbed areas. Clump-forming, often explodes after a burn. High protein and palatability for grazing livestock. In brome-legume pastures, allow legume to bud and grass to reach minimum height of 10 inches, before turning cattle in, to avoid bloat hazard. Easily confused with Japanese brome.

Kentucky bluegrass
Poa pratensis

© SDSU Extension and Matt Lavin, Montana State University

Growth: exotic, cool-season perennial grass

ID: sod-forming turf grass with numerous basal leaves and open, pyramid-shaped panicles up to 2 feet tall

Community: one of the most broadly distributed grasses, widely seeded in lawns and pasture

Local Conditions: widespread across all but the drier areas of South Dakota

Tolerances: grazing, sun/shade

Wetland Class: UPL

Notes: Extensive areas of tallgrass and mixed grass prairie have been replaced with Kentucky bluegrass; Eastern and central South Dakota are known for seed production. Desirable as a turf grass. The shallow root system of this plant will not form deep taproots and create areas vulnerable to soil erosion along banks.

American sloughgrass
Beckmannia syzigachne

© SDSU Extension and Matt Lavin, Montana State University

Growth: native grass, cool-season perennial

ID: 8–36 in. unique spikelet shape, branching 3–12 in. cluster with spikelets on one side. Leaves grow singly or as a few from the base in loose clumps, 3–8 in. long, wide, flat, hairless, and rough texture. Seed head resembles introduced barnyard grass, but growth form is more upright and less spreading.

Community: common grass in open wet places, wide distribution in cooler parts of North America

Local Conditions: marshes, pond and lake shores, streams, waterways and wet ditches

Tolerances: variety of soil types and wetness

Wetland Class: OBL

Notes: Rated high for palatability to livestock. The seeds provide important food for waterfowl, seed-eating birds, and small mammals. The species has been commonly sown for wetland wildlife habitat. Decreases under excessive grazing pressure. Readily reseeds itself.

Prairie cordgrass
Spartina pectinata

© Matt Lavin, Montana State University and SDSU Extension

Growth: native grass, warm-season perennial

ID: 3–8 ft. tall stature with erect flowering branches, leaves lower 8–36 in., rough edges

Community: wet prairies, swales, marshes, shores; confined in west to ditches, roadside, riparian areas

Local Conditions: sun; moist to dry sandy or loamy soils

Tolerances: variety of soil types and wetness, including dry and saline soils

Wetland Class: FACW

Notes: Common in wet soils, fast-growing, spreads vegetatively to form clonal colonies, often naturally dominates large open riparian swales. It is also planted to control erosion and as a biofuel. Distinctive curved seed heads with tightly packed two rows of stoutly awned spikelets. Coarse thick leaf blades up to 30 in. long, very abrasive with rough edges. Associated with switchgrass, Canada wildrye, sedges, and rushes. Not readily eaten by livestock except during spring or fall. Decreases with overgrazing, frequently replaced by spikerush and undesirable wetland sedges.

Canada wild rye
Elymus canadensis

© SDSU Extension

Growth: native grass, cool-season perennial

ID: 1–5 ft. tall, tufted, drooping spike; leaves wide and 4–10 in. long; glaucous; russet-tan late summer

Community: variety prairie, meadows, dunes, river and creek banks, jack pine, open woods

Local Conditions: part shade, sun

Tolerances: variety of soil types; generally confined to stream banks and shaded or otherwise relatively mesic areas in western South Dakota

Wetland Class: FACU; dry, mesic, wet

Notes: Common in restoration plantings. Several Elymus spp. look similar; this species has awns on seeds that bend, or curve outward as they mature, drop and leave papery glumes on stalk. Virginia wild rye, native to the East Coast, has a similar appearance but occurs on moister sites and is more shade tolerant; introduced into forage mixes, it may also naturalize along riparian areas in western South Dakota.

Inland saltgrass
Distichlis spicata var. stricta

© SDSU Extension and Matt Lavin, Montana State University

Growth: native grass, warm-season perennial

ID: 4–24 in. colonies from scaly rhizomes, short, compact

Community: ridges, dunes, salt marshes, roadsides, alkaline habitat

Local Conditions: sun; alkaline or saline soils

Tolerances: saline conditions, grazing

Wetland Class: FACW

Notes: Poor forage for livestock. Often associated with foxtail barley, alkali sacaton, prairie cordgrass, and western wheatgrass. Highly salt tolerant; often seen where white salt crystals encrust the soil. A Plains Indian name for inland saltgrass means “tough grass.”

Foxtail barley
Hordeum jubatum

© Matt Lavin, Montana State University

Growth: native grass, cool-season perennial

ID: 8–24 in. pretty, silky flowering spikes, blades, flowers, bunches

Community: fields, marsh edges, sloughs, roadside, waste places, seasonally wet areas

Local Conditions: sun; average to moist soil, saline soil, common in disturbed soils

Tolerances: sun/shade, drought, freezing, grazing pressure

Wetland Class: FACW

Notes: Salt-tolerant, often an indicator of saline soil conditions, such as when found along margins of intermittent/ ephemeral streams and stock ponds.

Swamp milkweed
Asclepias incarnata

© TNC/KBlann and SDSU Extension

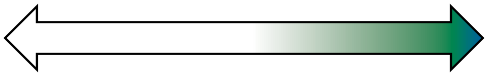
Growth: native perennial, flowering forb

ID: One to many upright, unbranched stems; smooth or with short hairs. Light to dark pink or rose-purple flowers bloom June to August.

Community: moist prairies, marshes, ditches, edges of ponds, lakes, streams

Local Conditions: silty to loamy or clayey; moist-wet, tolerates some mesic

Wetland Class: FACW, OBL



Notes: The iconic North American monarch butterfly (Danaus plexippus) cannot survive without milkweed plants (Asclepias spp.), a genus of plants known for their milky latex sap, which contains alkaloids and cardenolides that render them unpalatable to most animals. Milkweeds have fleshy, pod-like fruits that split when mature, releasing seeds that are attached to fluffy hairs (aka pappus, silk, or floss) that aid in wind dispersal. Swamp milkweed is the milkweed species that is most confined to wet, marshy areas.

Showy milkweed
Asclepias speciosa


© TNC/Brazell

Growth: native perennial, flowering forb

ID: Stout upright, unbranched, hairy stems; pink and cream or white flowers bloom June to August

Community: prairies, old fields, edges of rivers, ponds, disturbed areas

Local Conditions: sandy to loamy; dry to slightly wet, prefers moist soils

Wetland Class: FACW

Notes: A specific monarch butterfly food and habitat plant, it is also a host for several other moths and butterflies. Native Americans used the fiber in the stems for rope basketry and nets. Intensifying agriculture, development of rural lands, and the use of mowing and herbicides to control vegetation have all reduced the abundance of naturally occurring milkweeds. This has resulted in a substantial loss of critical resources available for monarchs throughout much of the United States. As a result, the North American Monarch Conservation Plan recommends planting native milkweed species to help restore breeding habitat.

Common milkweed
Asclepias syriaca

© *Karen Phelps*

Growth: native perennial, flowering forb

ID: One to many erect, stout, unbranched stems, usually with short dense hairs; leaves opposite; oval-shaped; hairy underneath. Pink flowers bloom June to August.

Community: prairies, old fields, railways, open woods, floodplains, disturbed areas

Local Conditions: sandy to loamy, clayey or rocky; dry to wet

Wetland Class: FACU

Notes: An important host plant for the monarch butterfly, this plant contains latex with large quantities of glycosides, making the leaves and follicles (often called "seed pods") toxic to sheep and other large mammals. Used historically by Native Americans for cordage and textiles, milkweed has been cultivated commercially for fiber and insulation in winter coats.

Plains Milkweed
Asclepias pumila

© SDSU Extension

Growth: native perennial, flowering forb

ID: Upright, unbranched to branched stems, up to 1 ft. long. Leaves alternate; thin and narrow. White to greenish white blooms July to August.

Community: prairies, plains, low hills, badlands, floodplains, woods

Local Conditions: dry, well-drained sandy to rocky soils

Wetland Class: FACU

Notes: Leafy stems have a bottlebrush appearance. Important food source for larval and mature monarchs and other moths and butterflies. Used as a medicinal plant by Native American peoples. Whorled milkweed (A. verticillate) is frequent in grasslands and similar in appearance to plains milkweed; however, whorled milkweed is taller and more robust with whorled leaves.

American licorice
Glycyrrhiza lepidota


© SDSU Extension and TNC/Brazell

Growth: native perennial, flowering forb

ID: 12–40 in. flowers, whitish cone spike 1–2 in. compound leaves, 11–19 leaflets 1–2 in. long

Community: prairies, fields, roadsides, creek banks, disturbed areas

Local Conditions: sun, average to moist soils

Tolerances: sun/shade, drought, freezing, grazing pressure

Wetland Class: FACU

Notes: Common widespread road and streamside native plant turned domesticated crop from 3000+ years of human selection. Listed in many states as noxious weed; hybridizes with several other species. Valued for beauty and wildlife food source. Underside of leaflets has glands; fruit is an oblong green pod 0.5 in. long that turns dark brown and persists through winter.

Especially outside the flowering season, may be confused with other species that have similar-looking compound leaves, such as milkvetches, leadplant (an upland prairie species with a purple or grayish-purple flowering head), or dwarf indigo (see section on woody shrubs and trees). This legume is important to prairie ecology because it is a good soil stabilizer and nitrogen fixer and is a native host plant for weevil, which keeps this species from aggressive spreading (unlike non-native legume species that spread unchecked).

Milkvetches, poisonvetches, and locoweed can often be confused with wild licorice, in part because of the leaf pattern. Important to correctly ID since there are many lookalikes between palatable species and those that are poisonous to livestock ("locoweeds").

Curly Dock
Rumex spp.

© TNC/K. Blann

Growth: common native herb/weed, genus includes ~200 species ranging from annual to perennial

ID: One of the most common species in disturbed riparian areas and dry channels, Rumex crispus plants begin from a large, basal rosette of smooth-edged, wavy ("crisped") alternate leaves; plants grow erect from a few branches to reach 12–55 in. tall. Flowers occur as a panicle of whorls on the upper 6–18 in. of the plant, becoming a small (<1/8 in.) heart-shaped fruit that becomes dark brown or rust-colored as the plant ages and dries.

Community: common widespread distribution in disturbed areas and fallow fields, often found in dry channels and wetland margins after water recedes

Wetland Class: FAC

Notes: Many species are considered nuisance weeds (and are sometimes called dockweed or dock weed), but some are grown for their edible leaves. Rumex species are used as food plants by the larvae of several moth and butterfly species, and are the only host plants of Lycaena rubidus. R. crispus is also known as "wild rhubarb."

Cocklebur
Xanthium strumarium

© SDSU Extension

Growth: annual weed

ID: Leaves alternate, large with wavy margins. Seeds are in burs that stick to animal coats.

Community: fields, streambeds, and stream banks; disturbed areas

Local Conditions: typically occur in mesic to wet areas

Tolerances: drought; some herbicide resistance

Wetland Class: FAC

Notes: Often found in dry beds of ephemeral or intermittent streams, after flows recede.

Common sunflower
Helianthus spp.

© SDSU Extension

Growth: native perennial, flowering forb

ID: 2–8 ft. tall; single, daisy-like flower 3–6 in. wide; stiff hairs on bracts; heart-shaped leaves

Community: prairies, fields, waste areas, roadsides

Tolerances: disturbed and dry soils

Wetland Class: FACU; dry, mesic

Notes: Common, widespread plant. Rough texture on stem and both sides of wide leaves. Strong taproot. First cultivated by Native American peoples 3,000+ years ago, the sunflower has been used for food, medicines, dyes, and fiber. Valued for beauty and wildlife food source. Highly palatable as forage early in season, reduced as matures; livestock and wildlife readily graze flower heads.

Fringed and green sageworts

Artemisia frigida, A. campestris, A. dracunculus

© SDSU Extension

Growth: native, warm-season perennial forbs

ID: Numerous, inconspicuous, yellowish cup-shaped heads borne on branches of a terminal panicle. Basal leaves numerous, smooth, with a pungent odor. Previous season's growth turns gray and can remain standing during the following growing season. Typically flowers by August.

Community: dry, open prairies

Local Conditions: favoring sandy or gravelly soils, these are often found on dry banks above bankfull

Tolerances: drought, grazing pressure

Wetland Class: UPL

Notes: The green sageworts (e.g., Western, false tarragon, prairie) are short-lived perennial forbs producing few to several closely grouped stems, normally 2 to 3 feet tall. Along with fringed sagewort, they have little forage value; however, they are commonly cropped (i.e., plant tops grazed) by cattle and sheep. Native American peoples used each species for multiple medicinal and other uses.

Cudweed sagewort (aka silver sagewort)
Artemisia ludoviciana

© SDSU Extension

Growth: native

ID: Herbaceous, white-woolly, rhizomatous forb with leafy stems 12–30 in. tall

Community: common across the West

Local Conditions: prairies, plains and roadsides; plants often form patches

Wetland Class: UPL

Notes: Aromatic herb with many ceremonial, medicinal, and other uses by Native Americans. Palatability is variable. Also known as silver sagewort.

Spreading dogbane
Apocynum androsaemifolium

© SDSU Extension

Growth: native perennial, flowering forb, herbaceous plant widespread across North America

ID: 1–5 ft. long branching reddish stem with milky white sap

Community: wooded areas, ditches, and hillsides, mainly near streams in shady or mesic habitats

Local Conditions: part shade, sun; gravelly or sandy soils

Tolerances: grazing, drought

Wetland Class: UPL

Notes: Often considered undesirable for grazing, as it is mildly poisonous to livestock. Native American peoples used it for several food and medicinal purposes.

Curlycup gumweed
Grindelia squarrosa

© SDSU Extension

Growth: warm-season, native, biennial or short-lived perennial

ID: Smooth with several stems 8–36 in.; contains a gummy “cup” that is the collection of bracts of the flower head as well as small, curved bracts that secrete a sticky resin. Flower heads are aster-like with yellow rays and disk flowers. Leaves are gland-dotted and also sticky.

Community: uplands and dry banks

Local Conditions: depleted soils

Tolerances: grazing, drought

Wetland Class: UPL

Notes: With a widespread distribution and tolerance of arid conditions, curlycup gumweed can become abundant after periods of dryness and grows on most soil types that are depleted of more desirable vegetation. An invader that has little value as forage and can form pure stands in long-term overgrazed pastures.

Creeping spikerush
Eleocharis palustris

© TNC/KBlann

Growth: native perennial, grass-like spikerush

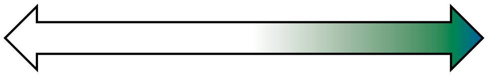
ID: 4–40 in. round stem, up to 5 mm wide with vertical ribs, single spike with brown cone

Community: lake, pond, and stream edges, ditches, fens, calcareous to brackish marshes

Local Conditions: sun; wet areas, shallow open water and seasonally flooded sites

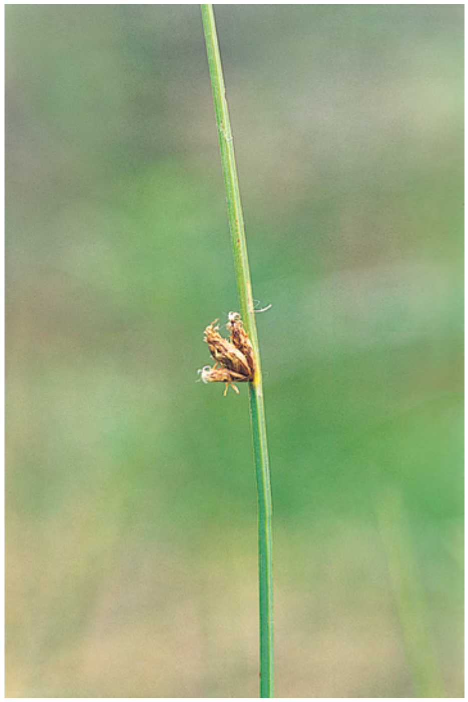
Tolerances: flooding, grazing

Wetland Class: OBL



Notes: Forms new stalks on long black rhizomes; also occurs as a solitary plant or in small clusters. Leaves reduced to papery green-red sheaths, black at tips. Can form extensive dark green matted colonies; good for wetland and riparian restorations, as rhizome matrix provides erosion control and bacteria act as water filter. Moderately high protein content in spring, good for grazing animals; provides nesting cover and seeds for waterfowl and amphibians.

Three-square bulrush
Schoenoplectus pungens

Growth: native perennial, grass-like sedge

ID: 1–4 ft. long 3-sided stem up to 6 mm wide, few spikelets midway; no leaves

Community: wet ditches, fens, marshes, lakeshores, ponds, slow-moving water margins along streams

Local Conditions: part shade, sun; wet, margins or seeps along intermittent stream channels in semi-arid South Dakota; often in shallow water up to 3 ft. deep

Wetland Class: OBL

Notes: Common indicator of perennial or mostly-perennial seeps along intermittent or ephemeral stream channels in western South Dakota.

Pale bulrush
Scirpus atrovirens

© SDSU Extension

Growth: native perennial, grass-like sedge

ID: 3–5 ft. long weakly 3-sided stem, shorter leaves; round flower clusters, dense spikelets

Community: lakes, ponds, sloughs, marshes, wet ditches

Local Conditions: part shade, sun; wet

Wetland Class: OBL

Notes: A common species in shallow water areas. Leaf-like bracts with flower are as long or longer than flower cluster. Lower stem leaf sheaths with conspicuous cross-partitions.

Hardstem bulrush
Schoenoplectus acutus

© Matt Lavin, Montana State University

Growth: native perennial, grass-like sedge

ID: 3–9 ft. tall, few or no leaves; terminal flower cluster with long erect stem-like bract

Community: lake and pond shores, ditches, fens, calcareous to brackish marshes

Local Conditions: sun; wet areas, shallow open water up to 5 ft deep

Wetland Class: OBL

Notes: Common plant in standing water, may form dense stands. Looks similar to other round bulrush species; this one has a long bract at top and firm stem not easily compressed.

Arrowhead
Sagittaria cuneata

Growth: native perennial, flowering aquatic plant

ID: 1–4 ft. long stem, distinct broad arrowhead shaped leaves; white 3-petal flowers on spike

Community: shallow open water of marshes, ponds up to 5 ft. deep, streams, wet ditches

Local Conditions: part shade, sun; wet

Wetland Class: OBL

Notes: May form dense stands. Leaves on long stalks that emerge above water. Several species of arrowhead look similar; this one is most common and generally has larger leaves. Also called duck potato, and provides a food source for waterfowl.

Water plantain
Alisma subcordata

© TNC/K. Blann

Growth: perennial aquatic plant in the perennial aquatic plant water-plantain family

ID: Lance- to oval-shaped leaves from bulbous corms / fibrous roots, up to 3 ft. tall; leaves that form underwater are weak and quick to rot, and rarely remain on adult plants. A branched inflorescence with white to pink 3-petaled flowers blooms from June to September.

Community: bogs, marshes, swamps, seeps, and perennial pools in rivers, ponds, and ditches

Local Conditions: grows in the mud of still to slow moving water, seeps, and wetlands

Wetland Class: OBL

Notes: Native to most of eastern and central United States and Canada. Seeds are eaten by waterfowl and upland birds; Native Americans dried and ate the starchy roots. The species name *subcordata* means "almost heart-shaped."

Common cattail
Typha latifolia


Growth: native perennial, wetland forb; aggressive colonizer in wetlands; commonly hybridizes with other cattail *(Typha)* species

ID: Tall (3–6 ft.), reed-like, emergent perennial, extensively colonial from fleshy rhizomes; simple stem, with alternate leaves, blue-ish green, blade-like, forming overlapping sheaths. Flower (June) in a stout terminal spike with numerous tiny flowers (resembling a corn dog).

Community: bogs, marshes, swamps, seeps, and perennial pools in rivers, ponds, and ditches

Local Conditions: wet areas, usually requires perennially wet habitat

Wetland Class: OBL

Notes: Often forms dense stands or monocultures in wetlands that can crowd out other wetland species. Tolerant of a wide range of water quality. Long valued as both a food source and a source of fiber by Indigenous peoples, the roots and inner stalks have been roasted for food; leaves and flower silks have been used for baskets, mats, clothing, storage bags, life preservers, and mattresses.

Watercress
Nasturtium officinale


© SDSU Extension

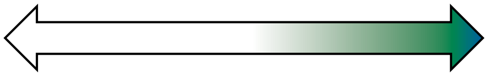
Growth: native perennial, flowering aquatic forb

ID: Floating, elongate, 12-24 in. stems, simple branched, rooting from nodes; leaves filiform (appearance like dill); flowers small (<1/4”), white, solitary on upper portion of stem

Community: springs and streams where water is fresh

Local Conditions: perennial aquatic habitat

Wetland Class: OBL



Notes: Edible; often used as a salad green for commercial pieces.

White water-crowfoot
Ranunculus longirostris

© SDSU Extension

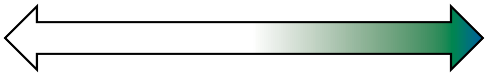
Growth: native perennial, flowering aquatic forb

ID: Floating, elongate, 3–8 in leaves, simple branched, rooting from nodes; leaves filiform (like dill); flowers are small, white, ¾ - 1 inch across, and solitary on upper portion of each stem

Community: slow streams, ponds, marshes, water-filled ditches, usually in calcareous water

Local Conditions: Perennial aquatic habitat

Wetland Class: OBL



Notes: Widespread distribution in western SD in aquatic habitats.

Marsh smartweed

Polygonum amphibium (syn. Persicaria amphibia)

© SDSU Extension

Growth: native, perennial forb

ID: Rhizomatous herb, variable in morphology, usu. submerged or floating in water bodies. Leaves lance-shaped; inflorescence is a dense terminal cluster of many five-lobed pink flowers. Stems are ribbed and may reach 10 ft. long in aquatic individuals.

Community: wet habitat, such as ponds, streams, and marshes

Local Conditions: aquatic, submerged or floating in water; growing in periodically inundated muddy and wet areas, or wet to moist meadows

Wetland Class: FACW

Notes: Marsh smartweed—also known as water smartweed, knotweed, and bistort - is part of a diverse genus of about 130 spp. of flowering plants in the buckwheat and knotweed families, ranging from herbaceous annuals to perennials and from upland to aquatic species. It is widespread throughout the world in aquatic habitats and is common in western South Dakota in a variety of wet habitats in perennial and intermittent stream settings. Native American peoples used various parts of the plant for medicinal purposes and sometimes food.

Floating-leaf pondweed
Potamogeton spp.

© TNC/Dave Stagliano

Growth: aquatic perennial plant

ID: Produces both floating (2–5 in.) and submersed leaves. Floating leaves are ovate to oblong-ovate, dark green, leathery, opaque with translucent longitudinal veins. Produces dense, cylindrical flower spikes, also 2–4 in. long.

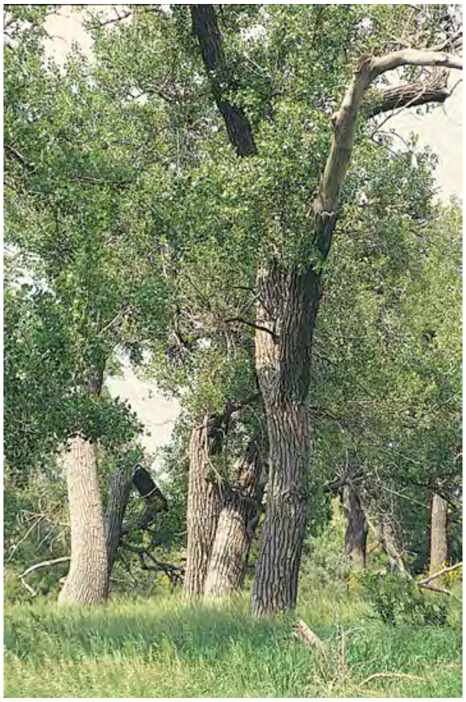
Community: native to quiet or slow-moving water; widely distributed in freshwater habitats

Local Conditions: marshes, ponds, stream margins and backwater pools

Wetland Class: OBL

Notes: Also known as floating pondweed and broad-leaved pondweed. One of many species of aquatic plants in the genus *Potamogeton*, *P. natans* is one of the more common, widespread, and easily identifiable species due to the distinctive shape of the floating leaf. It is indicative of perennial freshwater habitat. Photo is of *P. gramineus*, a closely related and similar species that is slightly less common.

Plains cottonwood
Populus deltoides




© SDSU Extension

Growth: large tree, native perennial

ID: 80–120 ft. tall, largest tree in region; leaves alternate, simple deltoid, taper to tip, shiny. Fast-growing tree adapted to moist, well-drained, fine sandy loams or silt loams. One large central trunk, crown 40–75 ft. wide, often marking major drainages and floodplains. Natural regeneration via seeds, becoming established where flood waters recede to expose bare soil. Bark gray with thick furrows. Leaves yellow in fall.

Community: wet lowland forests along lakes and streams, floodplains, moist woods, urban areas

Local Conditions: sun and part shade, where adequate subsurface moisture exists to get through drought

Tolerances: highly adapted to flood, dieback in drought causes distorted shape

Wetland Class: FAC; wet, mesic

Notes: Plains cottonwood is most common from the Midwest west of the Missouri River to the Rocky Mountains and Great Plains. In eastern South Dakota, Eastern cottonwood (also *P. deltoides*) is common, while Plains cottonwood dominates West River. As the largest native tree of the northern Great Plains, Plains cottonwood has always been an important resource for wildlife, Native Americans, and early European immigrants and can play an important role in riparian restoration and channel stabilization.

Green ash
Fraxinus pennsylvanica


© TNC/K. Blann

Growth: large tree, native perennial

ID: 35–110 ft. tall, leaves opposite, pinnately compound, fine tooth edges; bark diamonds

Community: riparian forest, floodplains, old fields and edges, regionally abundant

Local Conditions: average to moist soil; precipitation > 10 in.

Tolerances: highly adaptable tree for wide range of sites; including riparian and urban areas

Wetland Class: FAC; wet, mesic

Notes: Medium growth rate. Leaves 6–12 in. long with 5–7 leaflets 2.5–5 in. long tapered to point, dark green smooth upper surface and lower surface pale green with short hairs. Bark with woven diamond-shaped blocky ridges of deep furrows. Winged fruits called samaras form in clusters that persist until spring. Distinguished from black and white ash by short, winged stalks on leaflets. Turns brilliant yellow for short time in fall. Inexpensive and easily transplanted, but susceptible to emerald ash borer.

Sandbar willow
Salix interior

Growth: tall riparian shrub, native perennial

ID: 6–18 ft. tall, multi-stemmed in colonial stands, leaves same color both sides, long-blooming

Community: river banks, marshes, floodplains, wet fields, ditches, dunes, prairie swales, and stream banks

Local Conditions: sun; moist to wet places, sandy silty or loamy soil

Tolerances: low shade tolerance, minimum precipitation 18 in. or good soil moisture

Wetland Class: FACW, wet, mesic

Notes: Common sucker shrub, fast-growing, narrow stems up to 3.5 in. diameter. Called narrowleaf willow because it has the narrowest leaves of all South Dakota willows, 2–5 in. long and sharply toothed. Catkin blooms first out in early May but can ID from continuous blooming into July. Rhizomatous growth useful in streambank and shore stabilization. Recommended for deep wet lowland, overflow areas, and wet meadow sites. May become weedy and displace other species.

Peachleaf willow
Salix amygdaloides

© SDSU Extension

Growth: tree-like tall riparian shrub, native

ID: 10–65 ft. tall, often several straight trunks, leaves lustrous, 1–3 in. long, tapered into tail

Community: riverbanks, marshes, swales, moist ravines, around ponds and potholes

Local Conditions: sun; moist to wet; areas prone to seasonal flooding

Tolerances: will reduce in vigor with long-duration grazing

Wetland Class: FACW; wet, mesic

Notes: Small to medium-sized tree up to 40 ft. tall. Leaves alternate, 2–5 inches long and finely toothed, light yellow-green on upper and whitened on undersurface. The only native tree willow in region, it is the overstory dominant species in many riparian systems in the West and Midwest. The dense matrix of roots serves as an effective filter, trapping sediment and pollutants. Can be propagated from rooted cane cuttings. Some tribes used tea made from bark to treat headache and fever.

Dwarf indigo
Amorpha fruticosa

© *SDSU Extension*

Growth: native perennial, short shrub

ID: 3–12 ft. tall, alternate compound leaves, 11–25 oval leaflets; purple-red flower spikes < 6 in.

Community: along shores, edges of woods

Local Conditions: part shade, sun; moist soils

Tolerances: sun/shade, drought, freezing, grazing

Wetland Class: FACW

Notes: Also called desert false indigo. Cultivated in parts of the country. One plant can have numerous flower spikes, main stem is woody and hairless. Flowers look similar to leadplant, but dwarf indigo grows taller and typically is found in more mesic habitats (i.e., along stream banks); leaflets are also larger and less crowded.

Golden currant
Ribes aureum



Growth: native perennial, short shrub

ID: 3–7 ft. tall, distinct 3-in. wide 3-lobed leaves; large yellow flowers; round smooth berry

Community: upland prairies; rocky slopes, bluffs, stream banks, fencerows, open woods

Local Conditions: part shade, sun; average to moist soils

Tolerances: sun/shade, drought grazing

Wetland Class: FACU

Notes: Also called buffalo currant or flowering currant. Unlike related gooseberry species, does not have thorns or spines and has more (5–6) flowers within clusters (gooseberry has 1–4 flowers); flowers turn from yellow to orange-dark red. Widely planted ornamental. Older lower stems are gray and smooth with raised bumps called lenticels.

Common chokecherry
Prunus virginiana

© SDSU Extension

Growth: native perennial, tree

ID: 10–25 ft. tall; flowers in bottlebrush clusters, forms berries that ripen to purple

Community: open woods, forest edges and openings, fencerows, riverbanks, roadsides

Local Conditions: in northern plains, may form thickets along fence rows, valley bottoms, or riparian areas; a common understory tree in woodlands

Wetland Class: FACU

Notes: One of most common and ubiquitous trees in North America; found in many habitats. Fruits are favored by birds and wildlife that spread seeds. Several food and medicinal uses, as well as ceremonial importance, for Indigenous peoples. Susceptible to fungal disease causing lumpy, disfigured branches.

Russian olive
Elaeagnus angustifolia

© SDSU Extension

Growth: exotic, small to medium deciduous tree

ID: Freely branched, irregularly shaped. Leaves are alternate, silvery-green, and lanceolate; branches often end in sharp thorns. Small yellow flowers are sweetly fragrant and borne in racemes. Edible but mealy fruit (August to October) is olive-shaped, 0.5 in. long, and yellow-gray with a striped pit.

Community: Introduced as an ornamental, often promoted as a shelterbelt species, it has naturalized throughout Canada, the central and western United States, and Mexico, and is invasive in low rangelands, pastures, and especially floodplains.

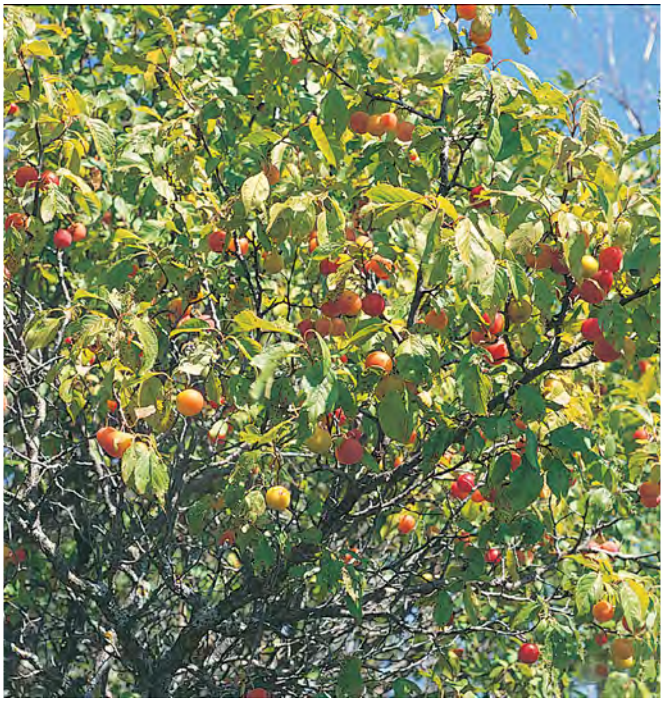
Local Conditions: wide range of sandy, silty or loamy soils with low fertility in floodplains and riparian areas

Tolerances: alkali or moderately saline conditions; tolerant to very tolerant of salt injury

Wetland Class: FACU

Notes: Russian olive is increasingly considered a nuisance along streams in South Dakota, where it often chokes out native vegetation and uses scarce water. Fruit is preferred by small mammals and numerous birds, including pheasants and sharp-tailed grouse. Provides winter roosting for upland birds and summer nest sites for mourning doves and other songbirds; some viable seed passes through their digestive tracts, accounting for its spread. Fox squirrels also eat the young branches.

Wild plum
Prunus americana



© SDSU Extension

Growth: native perennial, tall shrub

ID: 10–25 ft. tall, reddish brown twigs, gray older bark; white 5-petaled flower; toothed leaves

Community: prairies, woodlands, forest edges, roadsides, along shores and stream banks

Local Conditions: part shade, sun

Wetland Class: UPL

Notes: Common throughout prairie and central hardwood region. Historically this species was suppressed by fire, but now it has expanded its range into prairie, sometimes forming dense thickets with suckering roots. Fruit is purple-red drupe with waxy bloom about 1 in. diameter.

Silver buffaloberry
Shepherdia argentea

© SDSU Extension

Growth: native perennial, tall shrub

ID: 6–16 ft. tall thorny thicket; leaves simple, opp. ~2 in. long, toothless, silver; fruit bright red

Community: open prairie, plains, river bottom along shores

Local Conditions: sun, stream banks, wood edges

Tolerances: poor soils, grazing

Wetland Class: UPL

Notes: Shrub of arid western plains. Rhizomatous roots form dense thickets, providing cover for wildlife, and berries are also used by a variety of wildlife, including birds and bears. Looks similar to another small tree with silvery leaves, Russian olive. Buffaloberry has a single thorn at tips of short branches.

Eastern red cedar
Juniperus virginiana

Growth: shrub, small tree, native perennial

ID: 10–50 ft. tall conical-shaped evergreen; scaly, prickly leaves; gray bark, peels in vertical strips

Community: prairies, old fields, roads, open woods, limestone ledges, drainages

Local Conditions: part shade, sun; sandy or rocky soil

Tolerances: extremely drought tolerant; intolerant of shade, fire

Wetland Class: UPL

Notes: Historically restricted by fire, now readily invades abandoned fields, even high-quality native prairie, crowding and shading other species. Prescribed fire is successful to remove young plants, older plants require mechanical removal. Has male and female cone-like flowers. Fruit is a round pea-sized, blue berry-like cone. Conical shape distinguishes it from the more freeform-shaped Rocky Mountain juniper. Eastern red cedar and Rocky Mountain juniper do hybridize.

Rocky Mountain juniper
Juniperus scopularum


Growth: evergreen

ID: Highly variable in size (10 to 30 ft. tall), shape, and color; bark dark reddish-gray

Community: found on drier slopes, along butte edges, and in upper draws (“woody draws”)

Local Conditions: part shade, sun; sandy or rocky soil

Tolerances: dry conditions, sandy soils, and badlands

Wetland Class: UPL

Notes: Freely hybridizes with eastern red cedar, a common species in the eastern United States that is known for invading prairies in the Midwest. In western South Dakota, Rocky Mountain juniper forms the most common woodland, occurring on drier slopes along butte edges and in upper draws. Especially in badlands areas, Eastern red cedar and Rocky Mountain juniper often colonize areas following the creation of “side-slope slumps” or landslides, where additional moisture can collect. Juniper trees are often felled or knocked sideways during these small landslides and may sometimes root along the trunk, with each major branch becoming a new tree.

Western (common) snowberry
Symphoricarpus occidentalis

Growth: native perennial, short shrub

ID: 1–3 ft. tall; opposite oval-egg leaves; tight clusters pink-white flowers; round white fruit

Community: open forest, forest edges, bluffs, barrens, outcrops, upper edges of river banks

Local Conditions: part shade, sun; average to dry soil; primarily sandy or rocky soil

Tolerances: intermediate shade tolerant; drought, grazing; not resistant to fire

Wetland Class: UPL; dry

Notes: Also known as buckbrush. Common, slow-growing shrub, mature height 1–5 ft., but rarely gets above knee-high. Can form large stands. Flowers with petals hiding stamens, bright white fruit 0.5 in diameter (brighter and larger than similar wolfberry) persists through winter. Wildlife use for food and cover, especially berries in winter for grouse and prairie chickens. Beneficial to butterflies. Snowberry may be expanding in prairie/grassland areas of western South Dakota with the absence of fire.

Silver sagebrush
Artemisia cana

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Growth: native perennial, short shrub

ID: 1–3 ft. erect woody shrub, spreading branched stems, shredding bark, gray leaves

Community: commonly occur with other sagebrushes, which are the dominant shrub of the western and northern Great Plains

Local Conditions: well-drained deep loam to sandy soils of valley terraces, erodible lands; along with snowberry, this species and other sagebrushes often mark the transition to drier uplands when found along the upper banks of riparian areas and stream channels

Tolerances: grazing, alkali soils, fire

Wetland Class: UPL; dry, mesic

Notes: Widespread, abundant. Linear leaves are gray with numerous small flower heads in clusters appearing in September. Often spread by root sprouting rhizomes, particularly after mowing or fire. Often associated with other sagebrushes, yarrow, rabbitbrush, blue grama, buffalograss, needlegrasses, and wheatgrasses. Good to excellent browse in fall and winter for livestock and pronghorn as well as for sage grouse.

Big sagebrush
Artemisia tridentata


Growth: native perennial, long-lived evergreen shrub

ID: Stout, highly branched, pale-gray shrub, 8 in.-10 ft. tall. Leaves .66 to 1.3 in. long and mostly 3-lobed at the leaf tips and wedge-shaped at the base.

Community: arid and semi-arid conditions; the "steppe" region of the Intermountain West (areas that receive 7.1–15.7 in. of annual precipitation)

Local Conditions: in the western Dakotas, confined to upland plains and valley floors; in riparian areas, typically occurs on high banks, well above the water table and bankfull elevations; a deep taproot allows sagebrush to access the water table below it

Tolerances: prefers deep, basic soils (arable land)

Wetland Class: UPL; dry, mesic

Notes: This is the characteristic sagebrush of the "West," known for its fragrant odor, due to the presence of camphor and other volatile oils. Range includes the Great Basin, all 17 western states except Kansas, and south into Baja, including western portions of the northern Great Plains in eastern Wyoming, Montana, and the western Dakotas. Some upland birds, notably sage grouse, and many large grazers, such as pronghorn and mule deer, depend heavily on big sagebrush forage. An important plant that Native American peoples used ceremonially, medicinally, as a source of yellow dye, for fuelwood, and for other uses.

Rubber rabbitbrush
Chrysothamnus nauseosus

© SDSU Extension

Growth: native perennial, shrub

ID: Highly branched shrub with rounded crown, 12–60 in. tall, formed from multiple, straight stems that can be yellowish-green or mostly whitish due to a dense covering of felt-like matter hairs. Leaves dark green (sometimes white-woolly), alternate, linear; abundant autumn yellow flower heads; distinctive odor when crushed.

Community: drier rangelands and shrublands; commonly associated with sagebrush, greasewood, and wheatgrasses.

Local Conditions: in the Dakotas, found from the Missouri River westward

Tolerances: soils with moderate amounts of alkali

Wetland Class: UPL; dry, mesic

Notes: Many varieties of rubber rabbitbrush in North America. Most have low palatability for domestic livestock, although they are eaten by pronghorn, jackrabbits, mountain sheep, mule deer, elk, and chipmunks, and provide considerable cover for plains birds and small mammals. Rabbitbrushes have been used by Native Americans to make yellow dye, tea, medicines, and chewing gum.

Appendix C: Glossary and Guide to Acronyms

Alluvial – deposits of sand, silt, clay, gravel, or other matter derived from flowing water, as in a riverbed, floodplain, or delta; generally young landforms in terms of geologic time.

Alluvial fan – a landscape feature that forms when eroded gravels, sediments, and silts are carried down through steeper water courses and begin to spread out (usually in the shape of a fan) when they reach flatter and slower surface areas. These areas tend to be where water and sediment that has flowed down from uplands will accumulate in a valley bottom.

Anastomosis – the interconnectedness of streams and rivers in a local floodplain, allowing heavy waterflows from rainfall events to easily spill out into the floodplain area; connectivity of the channel to its floodplain.

Aquatic / Wetland Plants – plants that are adapted to tolerate having their roots inundated with water and that are typically intolerant of drought conditions.

Arrested degradation – a channel evolution state in which incision has occurred but then halted. This may be caused by the stream encountering harder bedrock materials, or by the removal of disturbances, resulting in re-vegetation that locks the stream into a degraded state, preventing erosive processes necessary to widen the stream channel and advance the channel evolution process.

Arroyo – also called a wash. A dry creek, stream bed, or gulch that flows only temporarily or seasonally.

Badlands – area of southwest South Dakota that typically has some extreme temperatures, lack of water, rugged terrain, and sparse vegetation. Geologically, "badlands" are formed when soft sedimentary rock is extensively eroded in a dry climate, exposing sharp spires, gullies and ridges.

Bankfull discharge – measurement of when floodwaters fill to the banks of a stream and are at the point to spill over into the floodplain. In stable streams this occurs every year or two, or every few years in drought situations.

Bankfull stage – the point at which the flow of water just begins to enter the active floodplain.

Bankfull width – the surface width of the stream measured at bankfull stage, which occurs at the bankfull discharge.

Baseflow – the portion of streamflow that is sustained between precipitation events, typically fed by delayed pathways such as shallow or deep subsurface flow of water through watershed soils.

Biotic/abiotic – biotic relates to or results from living organisms, their activities, and interactions, while abiotic refers to aspects of habitat or environment that are not derived from living organisms, such as bedrock, geology, or physical shape of habitats.

Bottomlands – lowlands of river valley floodplains, typically located along riparian areas and consisting of alluvial deposits.

Catchment – an area of the landscape in which water (precipitation) falling on or flowing across the land surface drains into a particular stream or river and flows, ultimately, through a single point or outlet. It is a synonym for drainage basin, or watershed, but the term often has the connotation of a smaller area than that of a drainage basin (a sub-basin).

Channel evolution – the natural process and progression of a stream's channel formation, change, and development over time; how the landscape responds to changing volumes of water in an effort to reach equilibrium between sediment load and erosion.

Channel-forming – the stable, dominant water flow that has the greatest impact on shaping a stream channel.

Channel incision – see downcutting – a process that reduces the connectivity of the channel to its floodplain.

Channel morphology – the process and/or outcome by which a river channel is formed into a particular shape.

Depressional wetlands – confined to topographic basins or hollows that are either too small or too shallow to form lakes and reservoirs. The source of water can be precipitation and groundwater discharge.

Discharge – the volume of flow per unit time. In equations used by scientists and practitioners, it is generally represented as a variable by the letter "Q."

Downcutting – downward or vertical erosion of a stream due to water removing material from the stream bed. This results in steep embankments.

Drainage area – the total surface area of a watershed upstream from a point on the creek to which all water will flow.

Ecological site – an area of the landscape that has specific soil and physical characteristics that differ from other areas in terms of its potential to produce a distinctive kind and amount of vegetation and its ability to respond similarly to management actions and natural disturbances (NRCS definition).

Ecological site description (ESD) – reports developed by NRCS and other partners, intended to provide detailed information about a particular, distinct ecological site.

Ecological region, or ecoregion – an ecologically and geographically defined area that shares characteristic flora, fauna, and abiotic conditions (such as soil, landforms, and climate). Typically, ecoregions can be described hierarchically across multiple spatial scales. For example, an ecoregion may contain many land types and ecological sites, but is smaller than a bioregion, which in turn is smaller than an ecozone. The U.S. EPA, The Nature Conservancy, and NRCS each use slightly different ecoregional classification systems that serve slightly different management purposes.

Ecosystem – a community of living organisms in conjunction with the nonliving components of their environment, interacting as a system. These biotic and abiotic components are linked together through nutrient cycles, climate, and energy flows.

Ecotone – a transition area between two biological or ecological communities, where two communities meet. The transition might be abrupt or gradual, if two communities overlap as they begin to blend or integrate.

Entrenchment – the vertical containment of a river that is quantitatively defined as the width of the floodprone area divided by the bankfull width.

Ephemeral – referring to a stream or wetland that contains water only briefly during and immediately following a rainfall or snowmelt event.

Evapotranspiration – the process in which water goes back into the air either through evaporation or transpiration. Evaporation is water drying from a surface as it returns to the air in vapor form. Transpiration is the water vapor that plants release from their leaves as they transpire or "breathe."

Facultative (FAC) plant species – plant species that are equally likely to occur in wetlands and non-wetlands. FAC species include trees such as green ash and cottonwood.

Facultative upland (FACU) plant species – plant species that usually occur in non-wetlands (estimated 67%–99% of the time) but that are occasionally found in wetlands (estimated 1%–33% of the time). FACU plants include common sunflower and big bluestem.

Facultative wetland (FACW) plant species – plant species that usually occur in wetlands (>2/3 of the time) but are also occasionally found in non-wetlands (up to 1/3 of the time). FACW plants include several willow species and prairie cordgrass.

Floodplain – a relatively flat area adjacent to a stream channel that tends to flood when flowing water exceeds the capacity of the channel.

Floodprone width – the area within the channel associated with the elevation that corresponds generally to about twice the maximum bankfull depth. It includes the floodplain of the river and often the low terrace of alluvial streams.

Floodprone elevation – typically defined as the elevation that is approximately twice the maximum depth elevation of water at bankfull stage.

Fluvial – from the Latin word fluvius for river. Refers to or pertains to streams, including fluvial processes (stream processes), fluvial landforms such as fluvial islands and bars, and fluvial biota living in and near stream channels. Common usage is often extended by geomorphologists to hydrologic processes on hillslopes.

Fluvial activity – the action of moving water in riparian ecosystems.

Fluvial processes – the physical interactions between flowing water and the landscape across which it moves; the work that water does as it moves across a landscape, including erosion, transportation, and deposition of sediment.

Fluvial surfaces – the floodplains and terraces associated with a stream.

Forb – an herbaceous (non-woody) flowering plant that is not a grass, rush, or sedge.

Geomorphic processes – any processes that influence channel form, primarily erosion and deposition.

Geomorphology – the study of the physical features of the surface of the earth and their relation to its geological structures.

Great Plains – the broad expanse of prairie, steppe, and grassland that lies across the central United States and western Canada.

Groundwater – water present beneath the land surface in soil pore spaces and in the fractures of rock formations.

Gully – a small hollow or channel worn in earth or unconsolidated material by running water, as on a hillside, and through which water runs only after a rain or the melting of ice or snow; it is larger than a rill and smaller than a stream channel.

Headcut – an identifiable point of active incision in the stream channel that creates a vertical or near-vertical face, or drop, on the bed of a stream channel. This headcut (or knickpoint) interrupts the channel gradient and, through processes of channel erosion, will continue to migrate or progressively move up-channel.

Headcutting – the active phase of a channel incision or headcut migrating upstream.

Headwater streams and wet meadows – a stream type describing systems that are typically located at the "top" of the drainage network where channels have just started to form, generally smaller streams with small drainage areas. Although in mountainous regions headwater streams typically have higher slopes, in western South Dakota, these streams typically have low to intermediate slope of < 1%. Headwater stream channels typically arise at the bottom of wet meadows where water flowing down and across gentle slopes begins to form a channel.

Hillslope – a landscape feature where the topography begins to rise up from a valley bottom, typically as a hillside or butte (or as mountains in areas further to the west).

Hydraulic – in the study of open channel fluid dynamics, the hydraulics are characterized by depth (a scalar quantity) and velocity (a vector quantity with direction and magnitude). Thus, hydraulics characterize the forces of moving water (the nature of flow; denoting, relating to, or operated by a liquid moving in a confined space under pressure).

Hydrogeomorphic / Hydrogeomorphology – relating to the interaction of hydrology (the action and work of water) with geology and land morphology (= shape).

Hydrologic Unit Code (HUC) – a watershed naming system that reflects the nested nature of watersheds and can be used to identify specific areas by their watershed (somewhat similar to a postal code).

Hydrology – the study of water on the Earth's surface and beneath the surface of the Earth, the occurrence and movement of water, the physical and chemical properties of water, and its relationship with the living (biotic) and physical (abiotic) components of the environment.

Incision – a process relating to abandonment of an active floodplain and the lowering of the local base level.

Intermittent – refers to a stream that flows only part of the year, or seasonally, during years of normal precipitation. Intermittent streams typically have a well-defined channel but contain water for only part of the year, typically during winter and spring when the aquatic bed is below the water table.

Knickpoint – part of a river or channel where there is a sharp change in channel slope, such as a headcut or incision point. Knickpoints reflect different conditions and processes on the river and are often initiated by a disturbance event.

Landform – a feature of the land surface that makes up the terrain; the arrangement of landforms in the landscape is known as topography.

Lentic – pertaining to an ecosystem that contains standing water, such as a lake, pond, or wetland.

Lotic – pertaining to an ecosystem that has flowing water, such as a river or stream.

Low-gradient prairie river – a stream type describing systems that are located low in the watershed, with wider valleys and sandy soil, drain an area of 100–1,000 square miles, and have a slope of less than 1%. Includes the lower reaches of mid-size prairie streams.

Major Land Resource Area (MLRA) – a classification developed by the USDA NRCS to identify geographically aggregated areas with similar land use, elevation, topography, climate, water resources, potential natural vegetation, and soils, designed to be useful for land and water resource planning and management.

Mesic – refers to areas with a balanced supply of moisture throughout the growing season.

Mid-size prairie stream – a stream type describing systems that are located in the middle of the watershed, below headwater streams and upstream of large, low-gradient rivers, drain an area of 10–100 square miles, and have a slope of less than 1%.

Northern Great Plains (NGP) – a region in the north-central United States that was historically open prairie or plains.

Natural Resources Conservation Service (NRCS) – formerly known as the Soil Conservation Service, NRCS is an agency of the U.S. Department of Agriculture (USDA) that supports farmers, ranchers, and land managers by providing technical assistance to conservation of land, water, soil, and other natural resources.

Obligate upland (UPL) plant species – plant species that almost always occur in non-wetlands under natural conditions. UPL plants include big sagebrush and blue grama.

Obligate wetland (OBL) plant species – plant species that almost always occur in wetlands under natural conditions and are strong indicators of wet soil conditions during the growing season. OBL plants include the common cattail and many species of bulrush.

Overbank zone – the area extending away from a stream channel, where sediment has been deposited on the floodplain of a river or stream by flood waters that have broken through or overtopped the banks, known as alluvial geological deposits.

Perennial – a stream or river that has constant flow throughout the year through parts of its streambed during years of normal rainfall.

Potential evapotranspiration – the amount of evaporation that would occur if sufficient water were available.

Proper Functioning Condition (PFC) – a qualitative method used by BLM and other natural resource managers for assessing the condition of riparian wetland areas. The PFC assessment provides a consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian wetland areas.

Recurrence interval – also called a return period or repeat interval. An average time or an estimated average time between events such as earthquakes, floods, landslides, or river discharge flows to occur.

Riparian Complex Ecological Sites (RCES) – refers to the description of ecological sites in riparian areas and complexes.

Riparian – the interface between land and a river or stream. Generally, the riparian zone is the floodplain portion of the valley bottom, which supports vegetation with higher water tolerances and/or needs.

Riparian area – within ecology, biota and other characteristics of alluvial bottomlands.

Riparian complex – the unique ecosystem associated the unique combination of biotic and abiotic factors producing distinct riparian complex and plant communities along a stream and its riparian area.

Riparian gallery forests – located along riparian areas that support tree growth. Usually the surrounding landscape is barren of trees due to the lack of water, supportive soil, etc.

Resilience – the capacity of a system to recover after stress or disturbance.

River Breaks – a local geographic term describing the rugged valleys, badlands, and bluffs of the upper Missouri River system (also “coulees”); these are typically the higher gradient stream types of the West River.

Riverine sites – locations along rivers or streams; riparian.

Riverscapes – composed of connected floodplain and channel habitats that together make up the valley bottom; indicates a holistic perspective of the broad-scale patterns and processes associated with fluvial systems.

Salinization – an accumulation of water-soluble salts in the soil that leads to structural decline in a system.

Seep – an area where water percolates slowly to the land surface (see also spring).

Semi-arid – refers to the climate of a region that receives precipitation below potential evapotranspiration, but not low enough to qualify as a desert.

Sinuosity – the degree to which a stream or river meanders back and forth across its floodplain, in an S-shaped pattern (curviness); the degree to which the stream deviates from a straight line.

Sodic, or sodicity – containing higher amounts of sodium attached to clay soil. The soil may be saturated below the surface, but dry and cracked on top.

Sodification – the accumulation of water-soluble sodiums in the soil.

Spring – a water resource that is formed when the side of a hill, a valley bottom, or other excavation intersects a flowing body of groundwater at or below the local water table. It is the result of an aquifer being filled to the point that the water overflows onto the land surface.

Steep woody draw – a stream type located high in a watershed, usually draining an area of less than 10 square miles, and with a steeper slope.

Streambank – the vertical portions (or sides) of a stream channel.

Stream bed – the lateral portion (or bottom) of a stream channel.

Stream channel – the zone where flowing water is contained when a stream is not flooding.

Stream order – a measure of the relative position of a stream in a watershed; the smallest tributaries are referred to as first-order streams.

Stream type – a way of classifying or grouping streams based on similarities and differences to facilitate discussion of ecological patterns, functions and processes, and management potential.

Stream Visual Assessment Protocol (SVAP) – a national protocol developed by the USDA NRCS designed to provide an initial evaluation of the overall condition of wadeable streams, their riparian zones, and their instream habitats.

Terrace – in riparian areas, landforms that are remnants of the former floodplain of a stream or river, formed by the downcutting of a river or stream, eventually to the point where they are no longer connected to the floodplain.

Toeslope – a landscape feature where a hillslope (the side of a hill or butte) becomes more gradual (less steep) as it transitions down to the valley bottom. This area is typically where sediment and erosion from hillslopes tend to slow down and accumulate.

Tributary inflow – a river or stream flowing into a larger river or lake.

Turbidity – a measure of the suspended material in a stream, related to suspended sediment levels. Although it is natural, high turbidity is often detrimental to aquatic life.

Uplands – areas and landforms that are elevated above the level where water flows or where flooding occurs; generally refers to areas that rarely, if ever, flood.

Valley – a low area between upland areas often with a stream channel running through it. In geology, a valley or dale is a depression that is longer than it is wide. The terms U-shaped and V-shaped are descriptive terms of geography to characterize the types and forms of valleys.

Valley bottom – a low area in the landscape generally located between hillsides or mountains, to which water will flow and collect, typically resulting in the formation of a stream.

Water table – an underground boundary between the soil surface and the area where groundwater saturates spaces between sediments and cracks in rocks.

Wet meadows – See "headwater streams and wet meadows"

Wetland – a distinct ecosystem that is flooded by water, either permanently or seasonally. Wetlands are distinguished from other land forms or water bodies by their characteristic aquatic vegetation, adapted to the unique hydric soil (i.e., soil frequently characterized by very wet or saturated conditions), where oxygen-free processes often prevail.

Watershed – a drainage basin area contributing water to a network of stream channels, a lake, or other topographic lows where water can collect. Formerly used to refer to drainage divide or a "water parting." Synonyms: drainage basin, catchment.

Appendix D: List of Additional Resources

Stream and Riparian Assessments

Reference	Description
U.S. Department of the Interior. 2015. Riparian area management: Proper functioning condition assessment for lotic areas. Technical Reference 1737-15. Bureau of Land Management, National Operations Center, Denver, CO. https://www.blm.gov/documents/national-office/blm-library/technical-reference/riparian-area-management	An assessment method and a defined, on-the-ground condition of a riparian area based on hydrology, vegetation, and erosion/deposition. Commonly used by Federal land management agencies. Note: PFC is not intended to be used on ephemeral systems.
U.S. Department of the Interior. 2011. Riparian area management: Multiple indicator monitoring (MIM) of stream channels and streamside vegetation. Technical Reference 1737-23. Bureau of Land Management, National Operations Center, Denver, CO. https://www.blm.gov/documents/national-office/blm-library/technical-reference/multiple-indicator-monitoring-mim-stream	Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation was developed to aid adaptive management. Indicators and procedures in this protocol were selected to monitor impacts of livestock. Commonly used by Federal land management agencies.

Beavers

Reference	Description
Pollock, M. M., Lewallen, G., Woodruff, K., Jordan, C. E., and Castro, J. M. 2018. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.0. United States Fish and Wildlife Service, Portland, OR. https://www.fws.gov/oregonfwo/Documents/BRGv.2.0_6.30.17_forpublicationcomp.pdf	A practical synthesis of the best available science for using beaver to improve ecosystem functions. Provides guidance on beaver translocation, beaver habitat needs, and beaver restoration practices.
http://www.martinezbeavers.org/	An informational website with beaver educational materials and tools for living with beaver in urban areas.
https://www.beaverinstitute.org/	A source for technical assistance to public land management staff and private landowners experiencing beaver conflicts. The Beaver Institute provides trainings and information to support cost-effective methods to resolve conflicts with beavers.

Stream Health and Restoration

Reference	Description
Macfarlane, W.W., J.M. Wheaton, N. Bouwes, M. Jensen, J.T. Gilbert, N. Hough-Snee, and J. Shivick. 2015. Modeling the capacity of riverscapes to support beaver dams. Geomorphology. DOI: 10.1016/j.geomorph.2015.11.019. https://www.umt.edu/spatial-analysis-lab/projects/current-work/montana-brat/default.php	Beaver Restoration Assessment Tool (BRAT) is a decision support and planning tool intended to help researchers, restoration practitioners, and resource managers assess the potential for beaver as a stream conservation and restoration agent over large regions and watersheds. Note: Website contains interactive map tool but is more applicable as a downloaded ArcMap layer file.
Shahverdian, S., Wheaton, J.M., Bennett, S.N., Bouwes, N. and Maestas, J.D., 2019. Low-Tech Process-Based Restoration of Riverscapes: Design Manual. Utah State University Wheaton Restoration Consortium, Logan, Utah. https://lowtechpbr.restoration.usu.edu/	A manual that provides guidelines for low-tech process-based restoration. The goals of this manual are to: i) define the principles that guide low-tech process-based restoration; ii) detail how low-tech restoration principles underlie and inform all steps of the restoration process from planning to design and implementation, to expectation management and long-term management and monitoring; and iii) describe the form, function, and design of two low-tech restoration structures.
2018. Maestas, J. D., Conner, S., Zeedyk, B., Neely, B., Rondeau, R., N. Seward, Chapman, T., With, L., and Murph, R.: Hand-built structures for restoring degraded meadows in sagebrush rangelands: Examples and lessons learned from the Upper Gunnison River Basin, Colorado, USDA, Natural Resources Conservation Service, Denver, CO	A technical note that explains how to use relatively simple, cost-effective structures to improve riparian areas and wet meadows. This document is geared toward resource managers looking for relatively simple solutions for addressing shallow headcuts or small gullies impacting meadows and drainages using "Zeedyk structures."
https://www.missouriheadwaterstool.org/	A web-based support tool for collaboration and conservation at watershed scale. It includes an analysis of mesic resources, priority grassland bird habitat and rangeland productivity to help individuals and conservation partners better understand watershed health and landscape connectivity.
https://quiviracoalition.org/	Quivira is a nonprofit organization dedicated to building economic and ecological resilience on western working landscapes. The Quivira Coalition produces educational webinars and free technical guides, and hosts in-person trainings about holistic management and regenerative agriculture.
NRCS. 2017. Mesic Habitat Conservation Planning Guide. https://www.sagegrouseinitiative.com/wp-content/uploads/2017/04/Mesic_Habitat_Conservation_Planning_Guide1.pdf	This guide is an overview of conservation practices with help to enhance and restore mesic resources. It provides information about relevant decision support tools, conservation options from the NRCS, and how to monitor project success.

Grazing Management

Reference	Description
https://jornada.nmsu.edu/	An online hub for monitoring manuals, journal articles, presentations, and rangeland research. The Jornada Experimental Research Range is a collaboration between New Mexico State University, USDA and BLM. They have been conducting range science work since the early 1900s.
https://grasscast.unl.edu/	An innovative Grassland Productivity Forecast for producers in the Great Plains. Grass-Cast uses almost 40 years of historical data on weather and vegetation growth—combined with seasonal precipitation forecasts—to predict if rangelands are likely to produce above-normal, near-normal, or below-normal amounts of vegetation.
https://rangelands.app/	The Rangeland Analysis Platform combines satellite imagery with thousands of on-the-ground vegetation measurements collected by BLM, NPS, and NRCS and allows the RAP to easily map vegetation across the western United States. RAP provides biomass and vegetation cover data and identifies changes over time such as transition to woody cover or cheatgrass.
Smart, A., Bauman, P. J., & Lefer, J. 2017. Healthy Grasslands. 2nd Edition of South Dakota Grassland Coalition Publication "Greener Pastures." Brookings, South Dakota. https://sdgrass.org/wp-content/uploads/2017/10/healthy_grasslands.pdf	This document produced by the South Dakota Grassland Coalition provides technical resources and information about grassland ecology, grazing management, drought planning, monitoring and many other topics relevant in rangeland and pasture management.

Other Resources

Reference	Description
https://streamstats.usgs.gov/ss/	Stream Stats provides access to spatial analytical tools that are useful for water-resources planning and management, and for restoration design purposes. The map-based user interface can be used to delineate drainage areas, get basin characteristics and estimates of flow statistics, and more.
South Dakota Department of Game, Fish and Parks. 2014. South Dakota Wildlife Action Plan. Wildlife Division Report 2014-03. South Dakota Department of Game, Fish and Parks, Pierre. https://apps.sd.gov/gf43wap/Default.aspx	The South Dakota Wildlife Action Plan assesses the health of fish and wildlife and their associated habitats. The website also provides information on species of concern habitat extent, including interactive maps on aquatic and terrestrial species.
https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm	Web Soil Survey provides soil data and information produced by the National Cooperative Soil Survey. Soil surveys can be used for general farm, local, and wider area planning. Information provided includes site suitability, rangeland productivity, and erosion potential.
https://www.ag.ndsu.edu/publications/environment-natural-resources/riparian-complex-ecological-sites-of-north-dakota-a-pictorial-guide-of-riparian-complex-ecological-sites-common-in-north-dakota	This publication is a pictorial guide of the valley, streams, and plant communities common in riparian complex ecological sites in North Dakota. This guide is intended to aid in the interpretation of riparian ecological site descriptions and assist in identification of riparian complex ecological sites when developing management plans for riparian ecosystems.
https://edit.jornada.nmsu.edu/	An interactive tool for cataloging information about how ecosystems respond to different land uses, management practices, and natural phenomena. EDIT serves as the primary repository of Ecological Site information produced by the USDA NRCS.

Local Resources

Reference	Description
Natural Resource Conservation Service (NRCS) 200 Fourth Street SW, Room 203 Huron, SD 57350 Phone: 605-352-1200 https://www.nrcs.usda.gov/wps/portal/nrcs/site/sd/home/	USDA-NRCS collaborates with farmers, ranchers, communities, and other individuals and groups to protect natural resources on private lands. They provide technical and cost-share assistance for implementing conservation practices.
SDSU Extension https://extension.sdstate.edu/	SDSU Extension provides education and learning opportunities. It emphasizes knowledge gained through research to support local communities and natural resource industries.
South Dakota Grassland Coalition https://sdgrass.org/	South Dakota Grassland Coalition works to promote good stewardship of grasslands through sustainable and profitable management. The Coalition presents workshops, field tours, and technical assistance.
South Dakota Soil Health Coalition https://www.sdsoilhealthcoalition.org/	South Dakota Soil Health Coalition provides education and technical resources to help producers increase sustainable ag production through diversification and improved soil health.
Northern Great Plains Joint Venture https://ngpjv.org/	The mission of the Northern Great Plains Joint Venture is to support and implement protection, enhancement, and restoration of prairie grassland, shrub-steppe, wetland, and riparian ecosystems. The website provides conservation planning tools and resources.
The Association of Conservation Districts Phone: 605-895-4099 116 N Euclid Avenue Pierre, SD 57501 https://www.sdconservation.org/	Almost every county has its own Conservation District. They work directly with landowners to conserve and promote healthy soils, water, forests, and wildlife. They coordinate assistance from all available sources—public and private, local, state, and federal—to develop locally driven solutions to natural resources concerns.

Climate Change and Resilience

Reference	Description
Resilient and Connected Landscapes Network https://www.conservationgateway.org/ConservationPractices/ClimateChange/Pages/Climate-Resilience.aspx	This site provides downloadable datasets and maps as well as web-based interactive features. This project identifies a conservation network of representative climate-resilient sites designed to sustain biodiversity and ecological functions into the future under a changing climate. The network was identified and mapped over a 10-year period by Nature Conservancy scientists using public data available at the state and national scale. The data can be a starting point for conversations with local communities, indigenous tribes, land trusts, agencies, corporations, and funders on how to coordinate conservation efforts to increase our collective impact and sustain nature.
Northern Great Plains Climate Hub https://www.climatehubs.usda.gov/hubs/northern-plains	The Northern Plains Hub serves Montana, Wyoming, Colorado, Nebraska, South Dakota, and North Dakota. The Hub delivers science-based knowledge, practical information, management and conservation strategies, and decision tools to farmers, ranchers, and forest landowners with the goal of helping them adapt to weather variability and changing climatic conditions.

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