Ecosystem Services Provided by Prairie Wetlands in Northern Rangelands

By W. Carter Johnson

On the Ground

- Wetlands add significant ecosystem services to rangeland. These services include: sediment capture; groundwater recharge and discharge; stock water processing and purification; habitat and forage for plants and animals, including livestock; and climate protection via carbon storage. Services from wetlands occur at multiple scales, from local to global.
- These services are lost when wetlands are permanently drained. Strategic management of wetlands in rangeland can sustain most services, diversify and improve ranch income, lower the costs of livestock production, and provide benefits to society beyond the ranch boundary.

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The American people have been divided for centuries on the value of wetlands.[1] Legitimate fears of contracting mosquito-borne diseases, such as malaria, and the presence of animals dangerous to humans, such as alligators and poisonous snakes, led to repeated but often unsuccessful attempts to permanently drain the nation's great southern swamps, including the Dismal, Okefenokee, and Everglades, even though many "swampers" were making a living from hunting, fishing, and fur trapping in these and other expansive wetlands. Once the soils in drained wetlands of glacial origin in the western corn belt (Dakotas north and east of the Missouri River; extreme western Minnesota; most of Iowa) were found to produce high crop yields in most years, a majority of the millions of preagricultural wetlands were drained using ditches and tile. Initially, draining wet soils was culturally considered a praiseworthy activity; however, a "battleground" soon formed between farmers and wildlife conservationists over wetland drainage, a conflict that remains today.

This division has softened over time. The initial, negative reaction by the public to the words "swamp," "marsh," or "slough" (the term "wetland" came into use only recently) attached to those "infectious wastelands" are now considered more positively because of societal values ascribed to them through scientific research, the writings of conservationists, and government policies. Added to this was the novel perspective toward the human use of land and nature proposed by Aldo Leopold midway through the 20th century[2]: "We abuse land because we regard it as a community belonging to us. When we see land as a community to which we belong, we may use it with love and respect." Paul Errington, a Leopold colleague, exposed the public to the complexities and wonder of prairie wetlands through his exhaustive field studies of muskrats, mink, and waterfowl, and in his many popular writings.[3]

Growing public concern over continued wetland drainage led to protective federal legislation; the most significant were the Federal Duck Stamp Program in 1934, the Clean Water Act of 1972 and 1977, and the Conservation Compliance Provision of the 1985 Food Security Act (referred to as Swampbuster). Federal agencies including the US Fish and Wildlife Service, the Natural Resource Conservation Service, and nongovernmental organizations (e.g., Ducks Unlimited, The Nature Conservancy) also protect wetlands from drainage through easements with landowners, particularly in the Prairie Pothole Region where the majority of ducks are produced in North America. While laws and private easements have kept millions of prairie wetlands from being drained, the number of functional wetlands in this region continues to decline.[4]

The contrast between grain farmers and cattle ranchers regarding the value of wetlands is distinct. Farm operators without livestock or rangeland often view wetlands negatively for several reasons, including being impediments to the passage of large farm equipment, the flooding of cropland during wet years, and the lack of income from wetland acres. During dry years, however, wetlands are often the most productive lands for farmers. To ranchers, however, natural wetlands provide water for livestock at little to no expense (Fig. 1). Deeper wetlands provide water for entire growing seasons. Shallow wetlands that dry out by late summer provide high yields of palatable forage.

Figure 1. Livestock utilizing seasonal wetland in western South Dakota rangeland. Photo courtesy of Joe Nichols.

Dense wetland vegetation shelters livestock during inclement weather. In short, these services provided by wetlands are generally seen by producers to profit ranching, but not farming, operations. However, as discussed below, society benefits from wetlands even though cropland farmers may not.

Ecosystem Services

Ecologists have devoted considerable effort in recent decades to identifying and monetizing ecosystem services, defined simply as benefits provided to humanity free of charge by the living natural environment.[5] Numerous services are provided by wetlands, and the benefits range widely, from local to global scales.[6] Some benefit private individuals and businesses, or society, or both. Efforts to protect and restore wetlands have increased as the awareness of the importance of public services has spread.[7]

Wetland ecosystem services and values include the retention and purification of water, regulation of climate, the formation of soil, the cycling of nutrients, detoxification and reuse of wastes, pollination of crops and wild food plants, and the production of forage, lumber, and biofuels, among others.[8] When valued services are lost, they have to be replaced at considerable financial cost to society. Examples are farm-raised seafood, plantation forestry, and the raising and stocking of game birds. The global economic value of ecosystem services has been estimated at about $35 trillion, twice that of the global Gross National Product (GNP). Ecosystem services that benefit the public include:

- **Flood and flow control**—all wetlands capture surface runoff, and many receive groundwater discharge. Holding more water longer on the land reduces flooding in streams and rivers. Captured water in wetlands serves as a natural stock tank for livestock. Major wetland drainage in the upstream watershed contributed to the massive flooding in 1993 and 1995 on the lower Missouri River and the more frequent floods along the Red River in North Dakota and Minnesota.
- **Sediment retention**—sediment captured by wetlands improves the quality of water that flows from wetlands to streams and rivers. Excessive sediment influx to wetlands, however, reduces storage capacity and shortens their functional life.
- **Groundwater recharge and discharge**—many wetlands are leaky, and thereby recharge groundwater that can be accessed, often some distance away, from wells by farmers or ranchers and rural and urban citizens. Other types of wetlands capture groundwater discharge, making it accessible to livestock and wildlife.
- **Water processing**—microorganisms such as bacteria and fungi promote denitrification (converting potentially toxic nitrate to inert nitrogen gas) and removal of many other chemicals from water. Nutrients released by decomposers are rapidly taken up by the highly productive wetland plants, exported in hay or in the flesh of livestock, or buried in sediments when ungrazed plants die. Nutrients filtered from runoff and processed in wetlands improve the water quality of receiving streams, rivers, and lakes.
- **Habitat and nursery for plants and animals**—wetlands support high biodiversity; most wetland species are found nowhere else in the landscape. Income from wetland plants and animals includes the harvest of hay and native plant seed,[9] livestock production, fee hunting and fishing, fur

trapping, sale of bait, and activities such as bird watching, recreational hunting and fishing, and canoeing or kayaking.
- **Carbon storage**—wetlands store large quantities of carbon per unit area compared with most types of grassland. However, when wetlands dry down or are burned, some of the carbon stored is released back to the atmosphere. Still, much more carbon is stored in functional wetlands than in drained and farmed wetlands.

Prairie Wetland Types and Characteristics

Wetlands are transitional between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered at times by shallow water. Wetlands are sometimes wet and at other times dry. Wetlands occur midway along a landscape's environmental gradient, with lakes on one end and dry uplands on the other. The presence of water alone does not make a wetland. To be defined by the USDA as a wetland [16 U.S.C. Section 3801(a)(18)] with potential legal protection, a site must have three attributes: 1) a predominance of hydric soils, 2) inundation or saturation by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, and 3) it supports a prevalence of such vegetation under normal circumstances.

Prairie wetlands occur in a wide range of shapes, sizes, and depths (an indicator of permanence). The wetland classification system used most often by specialists is based primarily on wetland permanence because so many other wetland characteristics correlate with it, especially vegetation, animal use, and value for livestock.[10] Five types or classes of wetlands are commonly found in prairie landscapes; four are of natural origin (temporary, seasonal, semipermanent, fens) and one is a created wetland type (impounded basins [dams built on drainages] and dugouts [stock ponds] in low-lying areas to expose shallow groundwater).

Natural pothole wetlands dominate numerically in northern prairies. Temporary wetlands are the least permanent, recharging from snow melt and spring rains on frozen ground but rapidly drying out by late spring or early summer. Standing water in seasonal wetlands persists longer, until mid- to late-summer in most years. Semipermanent wetlands retain surface water in most years. Fens, also called springs, support a very distinct and often rare flora found predominantly in rugged terrain where a relatively steady supply of groundwater comes to the surface and saturates the ground. In unglaciated prairies with few natural wetlands, wetlands have been created. Even though they are not "natural," they provide abundant services: provide the only reliable water source for livestock, support wetland vegetation, and attract a surprisingly rich diversity of native organisms, including waterfowl.[11]

A distinct feature of wetlands with relatively fresh water is the presence of nested, concentric vegetation zones associated with water depth contours that follow the physical structure of the basin. The wetland zones occur in unique combinations in each class. Each zone has a distinct assemblage of dominant plant species that vary in quality as wildlife habitat and forage value for livestock. Plants in semipermanent wetlands are tallest (cattails [*Typha* spp.] and bulrushes [*Schoenoplectus* spp.]); shorter in seasonal wetlands (river bulrush [*Bulboschoenus fluviatilis*], bur reed [*Sparganium eurycarpum*], and slough sedge [*Carex atherodes*]); and shortest in temporary wetlands (sedges [*Carex* spp.] and mixed forbs). Deeper water zones are often populated with submerged aquatic plants.

Alkaline or brackish wetlands are more common in western, drier parts of the northern prairies where surface drainage networks (i.e., intermittent stream channels) are poorly developed. These closed-basin wetlands retain salts because they rarely overflow or leak into the groundwater, as do nonalkaline wetlands. In general, biodiversity is much lower in alkaline wetlands because the large majority of the wetland flora is intolerant of significant salt concentrations. In very salty wetlands, only one higher plant species may be present, the submergent plant wigeon grass. Saline wetlands usually lack well-developed emergent cover and forage for livestock.

Wetlands of different classes naturally occur nearby in groups or complexes. Wetland complexes, including temporary, seasonal, and semipermanent basins, are necessary to obtain maximum production of ecosystem services, especially biodiversity. Temporary wetlands supply invertebrate foods for dabbling ducks and other water birds at the start of the breeding season when the more permanent wetland types are still frozen. Temporary wetlands are usually dry in late summer and fall when haying and livestock grazing can be carried out. Seasonal wetlands with longer hydroperiods are a major source of invertebrate protein for female ducks laying eggs early in the breeding season. Their longer hydroperiod, when compared with temporary wetlands, also makes them attractive as brood and molting habitat. Seasonal wetlands are usually dry in the fall and provide producers with hay and grazing opportunities. Finally, as the shorter hydroperiod wetlands are nearly or completely dry in late summer, semipermanent wetlands are usually wet for water birds to complete their life cycles. Wetland services are provided to waterfowl and upland bird hunters via semipermanent wetlands since they are usually the only wetlands in the complex with standing water in the fall and have tall and dense cattail cover where pheasants and other resident vertebrates can survive harsh winters.

In addition to water birds, many other groups of important vertebrates live in and near prairie wetlands. Muskrats are wetland engineers that restructure the surface of semipermanent wetlands by clearing emergent cover to make lodges. Muskrat lodges can be as large as 6 feet high and 15 feet across; lodge density can be as high as 20 lodges per acre. The muskrat "eat outs" create habitat heterogeneity, also known as cover interspersion, favorable for many other wetland species. Trapping muskrats has generated pocket money for many farm and ranch kids. About a dozen species of amphibians also depend on wetlands. The most common is the leopard frog that requires about 90 days of ponded water to develop from egg to adult. It often performs courtship in temporary wetlands but deposits its eggs in wetlands with longer hydroperiods. The tiger salamander occupies seasonal and semipermanent wetlands

Figure 2. Livestock thinning tall emergent cover in semipermanent wetland in northeastern South Dakota. Photo courtesy of Kurt Forman.

where its larvae can exceed 2,000 per acre. Larval salamanders grow rapidly, reaching an average weight of 12 ounces by summer.

Wetland Management

Grazing, mowing, and burning are the major disturbances to wetlands that affect their delivery of ecosystem services. To maximize the yield of ecosystem services, wetlands should be managed to avoid damaging desirable plant cover.[12] Prairie wetlands evolved under episodic grazing pressure by highly mobile large herbivores. Season-long grazing of wetlands by livestock often favors unpalatable species, reduces plant heights, reduces biomass production, and increases plant diversity (including more weedy species). Where wetland grazing is controlled by fences, the "take half, leave half" principle can be implemented to minimize any negative effects of grazing but to increase the positives. One benefit to greatly improve duck nesting and foraging is to use livestock to break up parts of monotypic stands of cattails (Fig. 2). This practice creates openings that allow for colonization by shorter hydrophytic plants, many of which are palatable and nutritious. Contemporary grazing practices of rapid pasture rotation are compatible with the goal to maximize ecosystem services from wetlands in rangeland.

Mowing is another land use practice affecting wetlands. It is practiced most often in temporary and seasonal wetland basins that are usually dry late in the growing season. The drier, upper slope zones of semipermanent wetlands also are commonly hayed. During droughts when the deep marsh zones of semipermanent wetlands are dry, they also may be hayed. Mowing once a year has minimal effect on plant composition, although some species benefit from mowing.

Seasonal wetlands produce more hay per acre, if cut once a year, than adjacent upland grassland; however, the forage is less digestible than that in the uplands. [13,14] Wetland species vary considerably in quality. White top (*Scolochloa festucacea*) and slough sedge have comparable quality to upland tame grasses. Bur reed, another dominant, is relatively unpalatable. Forage quality overall is highest in spring, as it is in upland grassland. The nutritive quality of cattails with few flowering shoots in semipermanent wetlands is comparable to that of common cool-season grasses. If cattails are grazed exclusively as fresh forage, supplemental feed may be needed to counterbalance their high moisture content.

Most wetland services would disappear if wetlands were to be drained and cropped. Accepting slightly lower forage quality but higher biomass would still provide good forage at minimal cost, while retaining services desirable to the public. In dry and drought years, wetland forage should greatly exceed that of the uplands. Many producers have reported that wetland grasses, including cattails, got them through the Dust Bowl and other droughts when they desperately needed emergency hay reserves.

A number of invasive, hydrophytic plants outcompete native plants and lower wetland biodiversity. These include creeping foxtail (*Alopecurus arundinaceus*), reed canary grass (*Phalaris arundinacea*), and narrow-leaved (*Typha angustifolia*) and hybrid cattail (*T. glauca*). Narrow-leaved cattail is more aggressive than the native broad-leaved cattail; however, hybrid cattail has had the most negative effect on biodiversity and use of wetlands by wildlife. It is a natural cross between broad-leaved cattail and narrow-leaved cattail that expanded its range into the Northern Plains during the 20th century. The hybrid tolerates deeper water than either of its parents, therefore enabling it to persist and form dense, monotypic stands until being drowned out by occasional periods of chronic flooding. Many wetlands undisturbed by extreme weather events, grazing, haying, or fire persist for long periods as near biological deserts. Using

cattle as ecological engineers would improve wetland biodiversity and function; however, fewer and fewer farms in the Western Corn Belt have livestock to use for this purpose.

Historically, fires caused by lightning and Native Americans commonly occurred in prairie wetlands. The frequency and intensity of fire must have influenced wetland biodiversity and function; however, it is uncommonly used today to manage wetlands. Positive effects of moderate levels of burning include higher productivity from the release of nutrients from senescent vegetation, opening up of the competitive vegetation canopy, and earlier warming of wetlands in spring. Fire removes standing dead material, but cattails usually grow back from rhizomes. Fear of fire and the risk that a prescribed fire would escape and damage neighboring property are often reasons why fire is not included in wetland management plans. If fire were to be used in management, it would need to be integrated with grazing and haying to provide maximum ecosystem services from wetlands.

Conclusions

The more that wetlands are studied, the longer is the list of ecosystem services found to benefit rangeland and other landscape ecosystems. Owners of wetlands and the general public lose free services when wetlands are degraded or destroyed. Benefits of wetlands accrue at local, regional, and global scales. Maximum societal benefits from wetlands can be achieved by controlling erosion and sedimentation in wetland watersheds; using livestock strategically to maintain or to recover high wetland biodiversity; grazing and haying wetlands at appropriate seasons and duration; acknowledging that wetlands range widely in permanence and plant composition, hence cannot be managed uniformly; using fire cautiously as a management tool when a different disturbance is needed; and developing new income streams for wetland products, especially high-value native grass seed.

References

1. Prince, H. 1997. Wetlands of the American Midwest. Chicago, IL, USA and London, UK: University of Chicago Press. 395 p.
2. Leopold, A. 1949. A Sand County almanac and sketches here and there. London: Oxford University Press. 226 p.
3. Errington, P.L. 1957. Of men and marshes. Iowa City, IA, USA: University of Iowa Press. 150 p.
4. Dahl, T.E. 2014. Status and trends of prairie wetlands in the United States 1987 to 2009. Washington, DC, USA: U.S. Department of the Interior, Fish and Wildlife Service. 67 p.
5. Costanza, R., R. D'arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 38:253-260.
6. van der Valk, A.G. 2012. The biology of freshwater wetlands. 2nd ed. New York: Oxford University Press. 280 p.
7. Gleason, R.A., M.K. Laubhan, and N.H. Euliss. 2017. Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region with an emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs, 1745 Washington, D.C.: U.S. Geological Survey Professional paper. 58 p.
8. Mitsch, W.J., and J.G. Gosselink. 2000. Wetlands. 3rd ed. New York: John Wiley and Sons Inc. 920 p.
9. Zilverberg, C.J., W.C. Johnson, A. Boe, V. Owens, D.W. Archer, C. Novotny, M. Volke, and B. Werner. 2014. Growing *Spartina pectinata* in previously farmed prairie wetlands for economic and ecological benefits. *Wetlands* 34(5):855-864.
10. Stewart, R., and H. Kantrud. 1981. Classification of natural ponds and lakes in the glaciated prairie region. Washington, D. C.: Resource Publ. 92. Bureau of Sport Fisheries and Wildlife Service, Fish and Wildlife Service. 57 p.
11. Rieger, B.A., K.F. Higgins, J.A. Jenks, and M.L. Kjellsen. 2006. Demographics of western South Dakota wetlands and basins. Brookings, SD: South Dakota State University. 124 p.
12. Kantrud, H., G.L. Krapu, and G.A. Swanson. 1989. Prairie basin wetlands of the Dakotas: a community profile. Washington, DC, USA: U.S. Fish and Wildlife Service. Biological Report 85(7.28). 111 p.
13. Hubbard, D. 1988. Forage potential of seasonal wetlands. [dissertation]. Brookings, SD: South Dakota State University. 165 p.
14. Hubbard, D.E., D.A. Beck, and B.D. Schultz. 1988. Chemical constituents and IVDDM of hybrid cattail from a South Dakota prairie pothole. *Wetlands* 8:179-192.

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