SRM Society for Range Management

Evolving Management Paradigms on U.S. Fish and Wildlife Service Lands in the Prairie Pothole Region

By Cami Dixon, Sara Vacek, and Todd Grant

On the Ground

- The US Fish and Wildlife Service manages nearly 1 million acres of wetlands and grasslands in the Prairie Pothole Region.
- Initial management paradigms focused on nesting cover for waterfowl and other birds, which led to idling prairies, and seeding former croplands to non-native plants.
- Current paradigms encompass a broader focus on ecological integrity and biological diversity, resulting in increased defoliation of prairies and seeding former croplands to native plants.

Keywords: U.S. Fish and Wildlife Service, Prairie Pothole Region, land management, waterfowl, fire, grazing.

Rangelands 41(1):36–43
doi 10.1016/j.rala.2018.12.004

The Prairie Pothole Region (PPR) of the United States (Fig. 1) stretches from the tallgrass prairies of northern Iowa and western Minnesota, across the mixed-grass prairies of North Dakota and South Dakota, and northwest toward the dry mixed-grass prairies of Montana. This region received its name for the millions of depressional wetlands, or "potholes," created by retreating glaciers following the end of the Wisconsin glacial period about 10,000 years ago.[1] Historically, wetlands and grasslands of the PPR supported a plethora of biota, but are most notable for producing a significant portion of North America's waterfowl. The PPR occupies only about 10% of the waterfowl breeding range, yet accounts for approximately 50–80% of annual production.[2,3] Grasslands and wetlands of the PPR also provide significant habitat for other grassland-dependent wildlife, particularly grassland songbirds, of which several species are endemic to the region, and most species have shown steep population declines in recent decades.[4] The PPR grasslands and wetlands are among the most altered and least protected major habitats in North America.[5]

The US Fish and Wildlife Service, National Wildlife Refuge System (USFWS) manages nearly 1 million acres within the PPR of Montana, North Dakota, South Dakota, Minnesota, and Iowa (Table 1). Management paradigms have changed in the more than 80 years since land acquisition began in the PPR, and the relationship between USFWS land management and the region's significance to waterfowl are critical to understanding that evolution. The progression from land acquisition, to manipulating natural systems for the benefit of a few species, to managing for ecological integrity is an intriguing grassland management story.

Starting in the 1930s––Land Acquisition

In 1934, the Duck Stamp Act was passed, creating a way for waterfowl hunters to actively participate in protecting habitats necessary to maintain waterfowl populations.[3] Concurrently, many national wildlife refuges (NWR) in the PPR were established in response to extreme drought and a perceived need to protect important waterfowl habitat, especially wetlands. In many cases, water control structures were installed, primarily on riverine systems, to provide for consistent, stable water levels to mitigate effects of future droughts. NWR management plans developed at that time listed the primary wildlife management objective "to improve the potential for carrying capacity for migrating waterfowl."[6] At the time, these actions were a logical response to extreme drought experienced in the 1930s. However, this approach has had unintended negative consequences for long-term productivity of the very wetland systems intended for protection or enhancement.[7–10] Hindsight suggests that many anthropogenic changes implemented during this period have had complex and long-term ecological implications.

The Small Wetlands Acquisition Program was initiated in the 1950s to create wetland management districts (WMD),

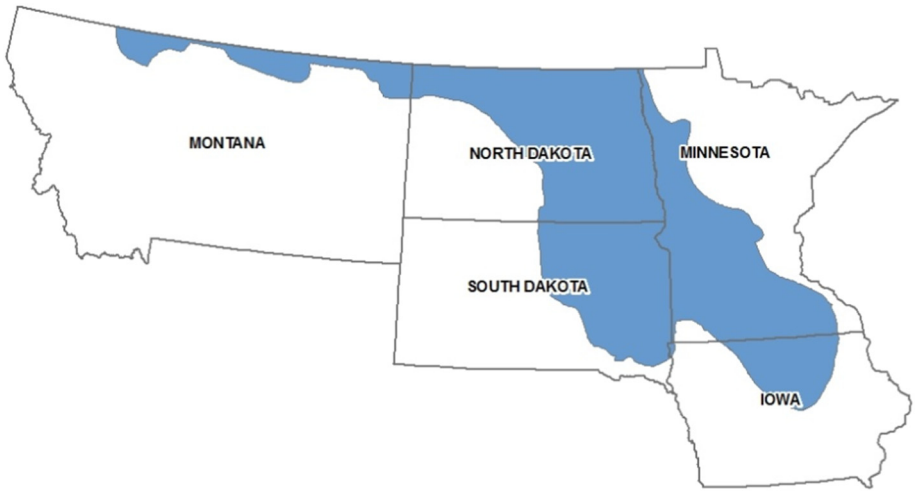

Figure 1. The boundary (in blue) of the Prairie Pothole Region of the United States.

allowing the purchase of waterfowl production areas (WPA) under the amended Duck Stamp Act of 1958. Each WMD encompasses a multicounty area that includes many noncontiguous WPA tracts ranging in size from <40 acres to >3,000 acres. USFWS manages WPAs for the benefit of waterfowl, other migratory birds, threatened and endangered species, and resident wildlife. Most WPAs are open to public hunting. WPAs were initially purchased to save wetlands from various threats, particularly drainage. Ironically, during the 1950s to1960s, drainage of prairie pothole wetlands was subsidized by the US Department of Agriculture to increase cropland production.[3,11] Although millions of acres of grassland were converted to cropland following Euro-American settlement of the region, significant grassland acres remained on the landscape, mostly as private rangeland and hayland. As such, initiatives aimed at acquiring and protecting wetlands appeared reasonable, at least in terms of promoting waterfowl conservation. Little emphasis was placed on management of the uplands that were purchased adjacent to wetlands on WPAs.

Table 1. Number of units and area of national wildlife refuges and waterfowl production areas managed by the USFWS, by state, in the Prairie Pothole Region

State	Number of units	Acres
Iowa	181	34,858
Minnesota	1,151	254,741
Montana	95	94,547
North Dakota	1,448	408,214
South Dakota	794	186,804
Total	**3,669**	**979,164**

The vast majority of WPAs were acquired during the 1960s and early 1970s. Simultaneously, private land contracts that were enrolled in the Soil Conservation Service's (now the Natural Resources Conservation Service) Soil Bank Program (precursor to the Conservation Reserve Program) were expiring. This provided the impetus for USFWS to also acquire expiring Soil Bank era grasslands to prevent conversion back to cropland. Land acquisition consumed the time and attention of USFWS employees at the time, leaving little opportunity to think about grassland management on these WPAs.

Starting in the 1960s–Dense Nesting Cover and Rest are Best

Managers desired to make waterfowl habitat more productive and sustainable over the long term, which required an increased knowledge of waterfowl ecology for implementation. In the 1960s, Northern Prairie Wildlife Research Center (NPWRC; Jamestown, North Dakota) was created, where research efforts focused on waterfowl ecology in the PPR, especially on increasing waterfowl production on NWRs and WPAs.[11] A significant body of waterfowl literature both on waterfowl breeding biology and habitat relationships was produced between the 1960s and 1980s by NPWRC researchers. Many of these researchers received notoriety for their expertise and study findings, so much so that wildlife managers sometimes utilized the information before more substantive evidence could be developed or broader implications could be considered. This may have limited the ability of USFWS managers to recognize and develop a broader ecological-based focus for managing grasslands and wetlands.

NPWRC researchers documented several associations between upland nesting birds and vegetation structure, especially for waterfowl; grasslands that were tall and dense had significantly higher nest densities than those composed of

short and sparse cover (reviewed in Naugle et al.[12]). Early research strove to identify an optimal seed mixture useful both for reclaiming former cropland tracts and for increasing waterfowl production on lands enrolled in farm programs (e.g., Soil Bank Program, Cropland Adjustment Program) and on NWRs and WPAs. Duebbert and Lokemoen[13] and Duebbert and Kantrud[14] determined that an easily established vegetative cover of cool-season introduced grasses (e.g., smooth brome [*Bromis inermis*])] and legumes (e.g., alfalfa [*Medicago sativa*])] provided an attractive and relatively secure nesting cover for upland nesting ducks in the PPR. Waterfowl nest densities were higher in this tall, dense cover compared with other covers such as native prairie (no previous cropping history; shorter cover) and smooth brome monocultures (stands become short and sparse with age).[13] The intent was to provide for quick vegetative establishment, with early spring green-up concurrent with the duck nest initiation period. Most of the lands included in farm programs were seeded to these mixtures and were idled for the contract duration (i.e., 10 years). This seed mix became known as "Dense Nesting Cover" (DNC). USFWS managers in the PPR seeded many thousands of acres of this cover across the landscape. By the 1980s the principal species planted as part of this seed mixture were introduced plants including: tall wheatgrass (*Thinopyrum ponticum*), intermediate wheatgrass (*Thinopyrum intermedium*), alfalfa, and yellow sweet clover (*Melilotus officinalis*).[15] These DNC stands remained primarily idle (i.e., little to no grazing, burning, or haying), except during drought periods when they were released as emergency forage for livestock operations.

USFWS managers embraced the information generated from DNC studies, which supported idling grasslands to produce consistently taller and denser cover attractive to nesting ducks, prairie grouse, and other game species.[13,14] This idling paradigm gradually was applied to all grassland types including native prairies. Similar to DNC, native prairies that were deferred from defoliation practices such as grazing and haying had higher nest densities than recently grazed or hayed tracts.[16,17] Managers believed that idle prairies would provide attractive early nesting cover via tall and dense vegetation structure during nest initiation in early spring. Kirsch[18] was among the first to advocate discontinuation of practices that removed grassland plant cover because duck nesting was expected to be lower compared with grasslands that were idled. This rest-dominated management philosophy lasted into the 1990s, echoed at that time by Kruse and Bowen,[17] who stated that, "manipulations (grazing, fire, or grazing and fire) we studied were detrimental to most species of upland-nesting waterfowl, at least in some years."

Historically, managers had clear perceptions regarding cattle grazing and haying and the effects on waterfowl and other game species. Annual, season-long grazing or yearly haying occurred regularly on NWRs acquired in the 1930s. These grasslands did not provide optimal habitat for many wildlife species, and concerns were particularly noteworthy when idle grasslands were contrasted with overgrazed pastures common on private land. During the droughts of the 1930s, Bossenmaier[19] noted that excessive grazing negatively affected waterfowl breeding areas, and overgrazed pastures were less beneficial to waterfowl than idled cover. On Benson WMD (now part of the Morris WMD, Minnesota), managers observed, "extreme over-grazing of the land prior to the Government's purchase has been the rule. This makes it necessary to defer grazing until the pasture land is rehabilitated."[20] Kirsch et al.[16] noted that on Arrowwood NWR (Pingree, North Dakota), prairie chickens no longer occurred because of "unsuitable habitat brought on by fire protections and annual grazing." Grant and Murphy[21] documented some efforts beginning in the 1950s to reduce cattle presence on NWRs in North Dakota, noting that by the mid-1980s, total acreage annually grazed on J. Clark Salyer NWR (Upham, North Dakota) was 85–90% less than what was grazed during the 1960s.

Annual or inappropriately timed haying operations were also deemed detrimental to wildlife production. Annual haying persistently reduces each following season's standing dead vegetation and litter that are attractive to waterfowl. Grasslands that attract waterfowl and other nesting birds can become ecological traps when early haying (i.e., before 1 August) occurs, due to substantial (upwards of 100%) nest losses and hen mortality.[19] Recommendations at the time were that managers should avoid annual grazing or haying treatments in order to meet wildlife management objectives. Although the emphasis was on annual, most USFWS managers adopted long-term rest as the de facto management practice. Ironically, multiple earlier sources indicated that native grasslands devoid of periodic grazing and fire begin deteriorating quickly; however, this message did not take hold until many years later.[22,23]

Starting in the 1970s and 1980s–Rest is Death and Native Plants are Best

Up to this point in time, the trends on USFWS lands were to manage vegetation structure for the benefit of waterfowl and other game species, which was accomplished primarily by deferring defoliation on both seeded grasslands and native prairies, and by planting former cropland to nonnative plant cover. Despite the paradigm of rest-dominated management, new research at NPWRC in the 1980s indicated that managing grasslands is a "never-ending" task, and that periodic prescribed fire and planned grazing systems are acceptable tools for renovating grassland structure.[15] Rest-dominated management was clearly at odds with the concept that grasslands in the PPR evolved with climate, fire, and grazing[24]; removing the latter two processes altered the plant communities in ways beyond the ability of managers to grasp at the time.

Beginning with Euro-American settlement of the region, fires were viewed as detrimental and were quickly suppressed. During the 1930s to 1980s, naturally occurring fires on NWRs and WPAs were also suppressed and use of prescribed fire was uncommon. In the mid-1980s, NPWRC researchers began to document the historical role of fire in shaping grasslands of the Northern Great Plains.[25–27] Higgins et al.[25]

established practical guidelines for implementing prescribed fire in grasslands. Prescribed fire gradually gained favor, especially as a tool for removing dead vegetation and stimulating grassland vigor. WMD managers in Minnesota began using prescribed fire in the mid-1970s using technical advice from NPWRC and others, and by the 1980s fire was a widely accepted management practice in the eastern part of the PPR. Karen Smith, Manager of Lostwood NWR (Kenmare, North Dakota), was among the first to use fire to manipulate plant species composition in grasslands. Smith demonstrated the utility of using fire to reduce and eventually reverse woody vegetation encroachment into grasslands. She also recognized the potential for using fire to address invasion of cool-season introduced plant species, while documenting fire effects on grassland songbirds and waterfowl.[17,28] Beginning in the 1990s, USFWS hired staff dedicated to prescribed fire (and in some situations wildfire suppression). Common objectives for burns on USFWS grasslands included increasing vigor of native plants and reducing invasive plants, woody plants, and litter.[25]

Grazing by bison and other wildlife prior to Euro-American settlement was a major driver of grassland function in the PPR.[24] As previously described, grazing on USFWS lands evolved from annual, season-long grazing at varying, but often light, stocking rates (1930–1960s) to limited prescribed grazing rates that were greatly reduced in scope and scale, used primarily to increase vegetation height and density for waterfowl and game production (1960–1990s). Idle USFWS lands also were seen as landscape-level mitigation for often severely overgrazed pastures widely occurring on private land. At the USFWS agency level, grazing and other practices (e.g., crop production, lumbering) were scrutinized because of compatibility concerns with the intended purposes of WPAs and NWRs. Overgrazing (especially on riparian habitats) and wildlife mortality due to collisions with fences were documented as primary concerns with grazing.[29–31] Because there was no comparable effort to research grazing management on public lands in the PPR as there was for prescribed fire, alleviating such concerns proved challenging. During this period, USFWS managers remained cautious about grazing.

In their discussion of the waterfowl productivity values of DNC, Duebbert and Kantrud[14] also noted that maintaining such cover requires periodic (i.e., 5–6 year intervals) manipulation (e.g., burning) and reseeding. If not maintained at appropriate intervals, DNC loses vigor, develops a thick litter layer, and becomes weed infested. The most productive stands of DNC are those that are reseeded approximately every 10 to 15 years.[15] By the mid-1970s interest grew in using native grasses as an alternative for reseeding former cropland. Duebbert et al.[15] provided instructions on seeding native grasses, and noted that once established, this mixture remains viable for waterfowl longer than DNC. Further, rejuvenating native mixtures can be accomplished through prescribed burning as opposed to the reseeding required for DNC. Typically, seed mixes consisted of 3 to 5 species of native grass cultivars. By the end of the 1990s, many managers in the eastern part of the PPR were striving to harvest their own local grass seed for these mixes.

Starting in the 1990s–Ecological Integrity

Periodic and frequently reoccurring defoliation of USFWS-owned prairies did not become an accepted management philosophy until the 1990s and beyond. By the end of the 1990s the scientific community seemed to agree that continuously idling grasslands without periodic defoliation failed to address overall grassland integrity.[12] Also, legislation was added to formally note that ecosystem integrity and biological diversity are important goals for managing lands held in public trust.[32,33] The USFWS started hiring more biologists to advance science-based management on NWRs and WPAs. The USFWS biological staff officially began documenting the floristic composition of native prairies beginning in the early 2000s. Multiple studies documented changes in prairie plant and wildlife communities resulting from tree and shrub encroachment, cool-season introduced grass invasion (mainly smooth brome and Kentucky bluegrass [*Poa pratensis*]), and the reintroduction of fire and grazing. Researchers specifically noted the pitfalls of managing disturbance-dependent grasslands as relatively static, late-successional systems over the long-term.[21,34] The synchrony of these studies and numerous anecdotal observations heightened the concern about invasion of cool-season introduced grasses on USFWS prairies, ultimately prompting a Smooth Brome Summit in 2006 that was attended by USFWS staff, experts from other state and federal agencies, and university researchers. One outcome of the meeting was a project to survey all USFWS-owned native prairies across parts of Montana, North Dakota, and South Dakota. This "prairie inventory" documented significant invasions of smooth brome and Kentucky bluegrass on USFWS prairies (Fig. 2). Out of the more than 220,000 acres of prairies

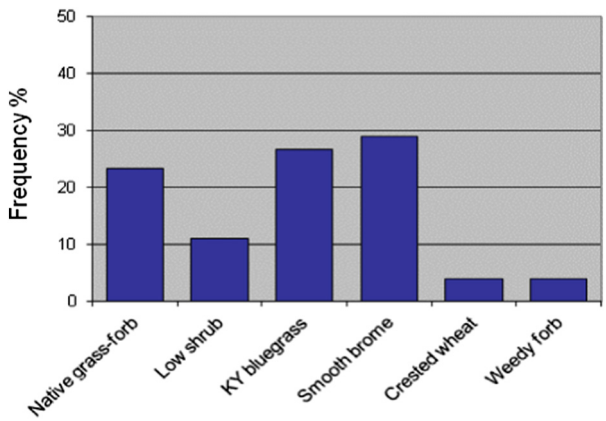

Figure 2. Composition of U.S. Fish and Wildlife Service-owned native prairies (no cropping history) across northeastern Montana, North Dakota, and South Dakota. Over 220,000 acres were surveyed between 2004 and 2010. Native plants (native grass-forb) dominate less than 25%, whereas Kentucky bluegrass and smooth brome grass combined dominate greater than 50% of surveyed prairies (Todd Grant, U.S. Fish and Wildlife Service, J. Clark Salyer National Wildlife Refuge, unpublished data).

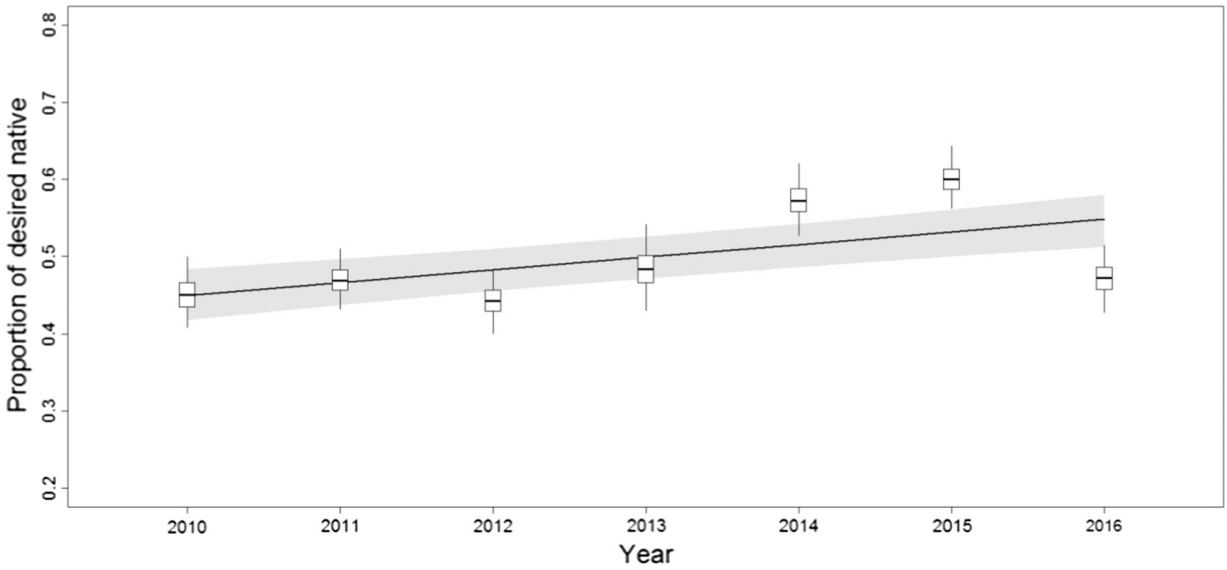

Figure 3. Annual means and trend in native plant composition across the Native Prairie Adaptive Management program area, after adjustment for other model parameters (climate, prior-year precipitation, treatment, and prior-year native prairie percentage). The average annual increase in the percent native prairie cover was 6.1%, with a 95% confidence interval (indicated by the gray shading in the figure) of 3.1-8.9% (Clint Moore, U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit, unpublished data.).

surveyed, native plants dominated less than 25% of prairie composition, whereas smooth brome and Kentucky bluegrass dominated more than 50% of the composition (Todd Grant, unpublished data, August 2018). Although many factors contributed to this invasion, it is likely that long-term rest and, in some cases, season-long light grazing were two contributing factors.[34] Prompted by outcomes from this inventory, as well as other studies that noted potential compositional benefits achieved from grazing,[35] perspectives on defoliation were changing. In a comparison of privately owned prairies to USFWS managed prairies, both Kentucky bluegrass and smooth brome were present; however, Kentucky bluegrass was the dominant invader on private lands (annual, season-long grazing), and smooth brome was the dominant invader on USFWS lands (rest-dominated). These data support the notion that smooth brome has some grazing sensitivity, lending to the concept that grazing could be a tool for reducing smooth brome.[34]

Results from the prairie inventory conducted on USFWS lands provided metrics relative to the scope and scale of cool-season introduced grass invasions and prompted USFWS staff to begin addressing this loss of natural biological diversity on USFWS prairies. The Native Prairie Adaptive Management initiative (NPAM) emerged as a comprehensive, long-term effort to evaluate strategies (e.g., burning and grazing) intended to reduce smooth brome and Kentucky bluegrass occurrences in USFWS native prairies. Participation in NPAM occurs throughout the PPR of Montana, North Dakota, South Dakota, and Minnesota, providing for an evaluation of management across a broad spectrum of physiographic and climatic gradients.[36] NPAM participants seek to maintain examples of high-quality prairies using strategies that are reasonable and cost effective. Intended to serve as a model for managing all USFWS prairies in the region, NPAM may also benefit prairies held in private or other public ownership. Managers acknowledge that traditional prairie management has been neither issue driven nor process oriented. Using an adaptive management approach, NPAM seeks to address several primary questions about prairie management including: 1) what type and frequency of management to employ (e.g., rest, grazing, fire); 2) is restoration success affected by the dominant invader species (smooth brome or Kentucky bluegrass); 3) what is the influence of recent management (years since treatment and frequency of management); and 4) is the effectiveness of restoration modified by a threshold level of invasion? NPAM has been operational for 9 years, averaging about 120 management units per year. Prairies enrolled in NPAM show a slight increase in native plant composition as indicated in Figure 3. NPAM provided the impetus for USFWS staff to shift the paradigm to focus more on ecological integrity of prairies, primarily by utilizing fire and grazing to better recreate environmental disturbances from which native prairies evolved.

USFWS managers and biologists are also managing more ecologically when reseeding former croplands. Beginning in the late 1990s, there has been a shift away from nonnative plantings or native plantings composed of only a few grass species to planting more diverse, multiple species mixtures of native grasses, forbs, and small shrubs. Morris WMD (Morris, Minnesota), for example, first included forbs in their seed mixes in 1997, which were a combination of hand-harvested purple prairie clover (*Dalea purpurea*) and about 10 species of purchased native forb seed. Planting such a mixture (often called a "reconstruction") provides for a resilient grassland cover that reduces soil erosion and invasive species

while creating habitat more suitable to a wider array of wildlife species. Prairie reconstructions do a better job of reestablishing important ecological processes such as the water cycle, energy flow, and nutrient cycling characteristic of grasslands.[37] Developing practices that best produce successful reconstructions is a relatively new area of study for USFWS lands in the PPR. Recent studies provide insights into reducing invasions by noxious weeds and cool-season introduced grasses.[38–40] The Prairie Reconstruction Initiative (PRI) was recently formed to explore ways to collaboratively collect and analyze reconstruction data across the Midwest. This group developed a database for land managers (USFWS and others) to record the steps being used to establish reconstructions (e.g., seedbed preparation methods, seeding mixes, seeding methods, etc.).[41] Eventually this collective information will be evaluated to ascertain which practices produce the most successful outcomes. Currently, nonnative plant mixtures such as DNC are rarely used by land managers, except where there might be concerns with salinity or excessively weedy areas that will require intensive herbicide use.

2000s and Beyond–Ecological Processes

USFWS land management perspectives in the PPR continue to evolve, primarily by better recognizing formative ecological processes that historically shaped the region's ecology. Managing for waterfowl will always be a priority for NWRs and WPAs in the PPR. Our management goals have evolved, to incorporate an explicit recognition of biological diversity and ecological integrity as opposed to managing habitats primarily to benefit a few wildlife species. A broader focus provides opportunities to not only improve waterfowl productivity over the long-term, but also to improve habitats for grassland songbirds, pollinators, and other native wildlife. As an example, where feasible, water control structures that were installed decades ago on NWRs are being removed to better allow for improved ecological functioning of certain wetland complexes. Also, a better understanding of biological diversity and ecological integrity is demonstrated by a recent study of grassland pollinators across USFWS lands in North Dakota and northeastern South Dakota. Kentucky bluegrass cover decreased the diversity of the butterfly community, primarily by reducing abundance of obligate grassland butterfly species.[42] This study also noted that grassland obligate butterflies (e.g., skippers) focused more on native forbs for nectaring as opposed to nonnative forbs such as yellow sweet clover and Canada thistle (*Cirsium arvense*).[42] As privately owned native prairies continue to be converted to cropland or degraded by invasive plants, fragmentation, energy development, and climate change, USFWS and other publicly owned grasslands will remain critically important not only for wildlife use, but also for ecosystem services at the landscape level.

Effective science-based management of an ecologically diverse and disturbance-dependent ecosystem will continue to challenge USFWS managers well into the future. Declining budgets and staff, especially considering the large and widely scattered land base, will be an ongoing limitation for effective implementation of management that is based on biological diversity and ecological integrity. Collaborative, landscape-scale programs like NPAM and PRI offer useful models to address the challenge, as they provide efficient frameworks for implementing science-based management. No matter how successful these programs become, cool-season introduced grass invasions will persist into the future. There are no silver bullets to bring back the pristine prairies that were commonplace 200 years ago, and land managers are uncertain about the level of success that can be achieved in reducing or reversing invasion of cool-season introduced grasses. Beyond ecological integrity, science is likely to focus more efforts into understanding ecological processes such as hydrology, nutrient cycling, and energy capture because changes in these processes are ultimately what drive changes in plant and animal populations documented on USFWS lands. Thus, the current goal of increasing native plant composition on USFWS grasslands becomes a natural byproduct of refined ecological process-oriented management. For example, an objective might be developed to reduce nitrogen in the soil by implementing multiple burn treatments. The overall management goal is to increase native plants, but under an ecological processes paradigm, the focus would be on the incremental steps to allow these processes to function as naturally as possible. This paradigm is completely dependent on a deeper understanding of the ecology of prairies, thereby enabling USFWS managers to tailor their expectations throughout the lengthy, intensive (frequent burning and grazing), and often uncertain restoration process.

Acknowledgments

We would like to thank former and current USFWS staff for taking on the challenges of protecting and managing lands over the years in the Prairie Pothole Region. We specifically want to thank former USFWS employees, Harris Hoistad, Mike McEnroe, and William Schultze for providing background information relative to this manuscript.

The views expressed in this article are the authors' own and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

References

1. Bluemle, J.P. 2000. The face of North Dakota. 3rd ed. Bismarck, ND, USA: North Dakota Geological Survey Educational Series 26, 210 p.
2. Batt, B.D., M.G. Anderson, C.D. Anderson, and F.D. Caswell. 1989. The use of prairie potholes by North American ducks. In: & van der Valk A, editor. Northern prairie wetlands. Ames, IA, USA: Iowa State University Press. p. 204-227.
3. Smith, A.G., J.H. Stoudt, and J.B. Gollop. 1964. Prairie potholes and marshes. In: & Linduska JP, editor. Waterfowl tomorrow. Washington, DC, USA: U.S. Government Printing Office. p. 39-50.
4. Sauer, J.R., J.E. Hines, J.E. Fallon, K.L. Pardieck, D.J. Ziolkowski, and W.A. Link. 2014. The North American breeding bird survey, results and analysis 1966–2013. Version 01.30.2015. Laurel, Maryland, USA: U.S. Geological Survey, Patuxent Wildlife Research Center. Available at: http://www.mbr-pwrc.usgs.gov/bbs/bbs.html. Accessed 20 August 2018.

5. Sampson, F.B., F.L. Knopf, and W.R. Ostlie. 2004. Great Plains ecosystems: past, present, and future. *Wildlife Society Bulletin* 32:6-15.
6. U.S. Fish and Wildlife Service, 1962. Tewaukon National Wildlife Refuge Development Plan 1962-1971. Cayuga, ND, USA: U.S. Fish and Wildlife Service. 15 p.
7. Gleason, R.A., N.H. Euliss, and C.W. Holmes. 2003. Sedimentation rates in the marshes of Sand Lake National Wildlife Refuge. Jamestown, ND, USA: U.S. Geological Survey Quick Response Report to the U.S. Fish and Wildlife Service. QR-F6-00-07. 27 p.
8. Johnson, W.C., B.V. Millett, T. Gilmanov, R.A. Voldseth, G.R. Guntenspergen, and D.E. Naugle. 2005. Vulnerability of northern prairie wetlands to climate change. *BioScience* 55 (10):863-872.
9. Kantrud, H.A., J.B. Millar, and A.G. van der Valk. 1989. Vegetation of wetlands of the prairie pothole region. In: & van der Valk A, editor. Northern Prairie wetlands. Ames, IA, USA: Iowa State University Press. p. 132-187.
10. Tangen, B.A., M.K. Laubhan, and R.A. Gleason. 2014. Assessment of sediments in the riverine impoundments of national wildlife refuges in the Souris River Basin, North Dakota. U.S. Geological Survey Scientific Investigations Report 2014-5018. p. 37. Available at: https://pubs.usgs.gov/sir/2014/5018/pdf/sir2014-5018.pdf. Accessed 20 August 2018.
11. Austin, J.E., T.L. Shaffer, L.D. Igl, D.H. Johnson, G.L. Krapu, D.L. Larson, L.D. Mech, D.M. Mushet, and M.A. Sovada. 2017. Northern Prairie Wildlife Research Center—celebrating 50 years of science. U.S. Geological Survey Circular 1434. 27 p. Available at: https://doi.org/10.3133/cir1434. Accessed 20 August 2018.
12. Naugle, D.E., K.F. Higgins, and K.K. Bakker. 2000. A synthesis of the effects of upland management practices on waterfowl and other birds in the northern Great Plains of the U. S. and Canada. Wildlife Technical Report 1. Stevens Point, WI, USA: College of Natural Resources, University of Wisconsin-Stevens Point. 28 p.
13. Duebbert, H.F., and J.T. Lokemoen. 1976. Duck nesting in fields of undisturbed grass-legume cover. *Journal of Wildlife Management* 40(1):39-49.
14. Duebbert, H.F., and H.A. Kantrud. 1974. Upland duck nesting related to land use and predator reduction. *Journal of Wildlife Management* 38(2):257-265.
15. Duebbert, H.F., E.T. Jacobson, K.F. Higgins, and E.B. Podoll. 1981. Establishment of seeded grasslands for wildlife habitat in the prairie pothole region. Jamestown, ND, USA: U.S. Fish and Wildlife Service. Special Scientific Report No. 234 21 p.
16. Kirsch, L.M., A.T. Klett, and H.W. Miller. 1973. Land use and prairie grouse population relationships in North Dakota. *Journal of Wildlife Management* 37(4):449-453.
17. Kruse, A.D., and B.S. Bowen. 1996. Effects of grazing and burning on densities and habitats of breeding ducks in North Dakota. *Journal of Wildlife Management* 60(2):233-246.
18. Kirsch, L.M. 1969. Waterfowl production in relation to grazing. *Journal of Wildlife Management* 33:821-828.
19. Bossenmaier, E.F. 1964. Cows and cutter bars. In: & Linduska JP, editor. Waterfowl tomorrow. Washington, DC, USA: U.S. Government Printing Office. p. 627-634.
20. U.S. Fish and Wildlife Service, 1967. Annual narrative report, Benson Wetland Management District, January–December 1966. Benson, MN, USA: U.S. Fish and Wildlife Service. 53 p.
21. Grant, T.A., and R.K. Murphy. 2005. Changes in woodland cover on prairie refuges in North Dakot, USA. *Natural Areas Journal* 25:359-368.
22. Anderson, K.L., C.E. Owensby, and E.F. Smith. 1970. Burning bluestem range. *Journal of Range Management* 12:81-92.
23. Kirsch, L.M., and A.D. Kruse. 1973. Prairie fires and wildlife. Proceedings Tall Timbers Fire Ecology Conference, 12. . p. 289-303.
24. Severson, K.E., and C.H. Sieg. 2006. The nature of eastern North Dakota: pre-1880 historical ecology. Fargo, ND, USA: North Dakota State University, North Dakota Institute for Regional Studies. 308 p.
25. Higgins, K.F., A.D. Kruse, and J.L. Piehl. 1989. Prescribed burning guidelines in the northern great plains. Brookings, SD, USA: U.S. Fish and Wildlife Service and South Dakota State University Cooperative Extension Service. 38 p.
26. Higgins, K.F. 1984. Lightning fires in North Dakota grasslands and the pine-savanna lands of South Dakota and Montana. *Journal of Range Management* 37:100-103.
27. Higgins, K.F. 1986. Interpretation and compendium of historical fire accounts in the northern Great Plains. Jamestown, ND, USA: U.S. Fish and Wildlife Service Resource Publication. 86 p.
28. Madden, E.M., A.J. Hansen, and R.K. Murphy. 1999. Influence of prescribed fire history on habitat and abundance of passerine birds in northern mixed-grass prairie. *Canadian Field-Naturalist* 113:627-640.
29. Coleman, R.A., N. Fuller, J.P. Marzzoni, R. Berry, J. Davis, D. Adams, D.G. Young, R. Fires, and T. Huer. 1990. Report to the Director: a review of secondary uses occurring on national wildlife refuges. Washington, DC, USA: US Fish and Wildlife Service. 232 p.
30. Kirby, R.E., J.K. Ringelman, and R.S. Sojda. 1992. Grazing on national wildlife refuges: do the needs outweigh the problems? *Transactions of the North American Wildlife and Natural Resources Conference* 57. p. 613-626.
31. Strassmann, B.I. 1987. Effects of cattle grazing and haying on wildlife conservation at National Wildlife Refuges in the United States. *Environmental Management* 11:35-44.
32. Gergely, K., J.M. Scott, and D. Goble. 2000. A new direction for the U.S. National Wildlife Refuges: the National Wildlife Refuge System Improvement Act of 1997. *Natural Areas Journal* 20:107-118.
33. U.S. Fish and Wildlife Service, 2001. Policy on maintaining the biological integrity, diversity, and environmental health of the National Wildlife Refuge System. Washington DC, USA: Division of Natural Resource Planning. 601 FW3. Available at: https://www.fws.gov/policy/601fw3.html. Accessed 20 August 2018.
34. Murphy, R.K., and T.A. Grant. 2005. Land management history and floristics in mixed-grass prairie, North Dakota, USA. *Natural Areas Journal* 25:351-358.
35. Brown, D. 1997. Smooth brome (*Bromus inermis* Leyss.) in the foothills fescue grassland: stand characterization and the effects of cattle, sheep, mowing, glyphosate, and fire [M.S. thesis]. Edmonton, Alberta, Canada: University of Alberta, Edmonton, 136 p.
36. Grant, T.A., B. Flanders-Wanner, T.L. Shaffer, R.K. Murphy, and G.A. Knutsen. 2009. An emerging crisis across the northern prairie refuges: prevalence of invasive plants and a plan for adaptive management. *Ecological Restoration* 27(1):58-65.
37. Dixon, C., P. Comeau, K. Askerooth, J. Norland, and K. Sedivec. 2017. Prairie reconstruction guidebook for North Dakota. Fargo, ND, USA: North Dakota State University Extension Report (1840). 32 p. Available at: https://www.ag.ndsu.edu/publications/environment-natural-resources/prairie-reconstruction-guidebook-for-north-dakota/r1840.pdf. Accessed 20 August 2018.
38. Larson, D.L., J.B. Bright, P. Drobney, J.L. Larson, and S. Vacek. 2017. Persistence of native and exotic plants 10 years after prairie reconstruction. *Restoration Ecology* 25(6):953-961.

39. Norland, J., S. Fasching, C. Dixon, K. Askerooth, K. Kelsey, and G. Wang. 2013. Reduced establishment of Canada thistle (*Cirsium arvense*) using functionally similar native forbs. *Ecological Restoration* 31(2):143-146.
40. Norland, J., T. Larson, C. Dixon, and K. Askerooth. 2015. Outcomes of past grassland reconstructions in eastern North Dakota and northwestern Minnesota: analysis of practices. *Ecological Restoration* 33(4):409-417.
41. Walker, B.A., C. Dixon, P. Drobney, S. Jacobi, V.M. Hunt, A. McColpin, K. Viste-Sparkman, and L. Straw. 2018. The prairie reconstruction initiative database: promoting standardized documentation of reconstructions. *Ecological Restoration* 36(1):3-5.
42. Kral, K.C. 2018. Method selection and estimating densities for grassland butterflies in the mixed-grass prairie [PhD dissertation]. Fargo, ND, USA: North Dakota State University.

Authors are Wildlife Biologist, U.S. Fish and Wildlife Service, Chase Lake National Wildlife Refuge, Woodworth, ND 58496, USA, cami_dixon@fws.gov (Dixon); Wildlife Biologist, U.S. Fish and Wildlife Service, Morris Wetland Management District, Morris, MN 56267, USA (Vacek); and Wildlife Biologist, U.S. Fish and Wildlife Service, J. Clark Salyer National Wildlife Refuge, Upham, ND 58789, USA (Grant).