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Reversing Declines in Grassland Bird Populations in Minnesota Through Restoration of the Northern Tall Grass Prairie

Lydia Dobrovolny

Introduction

The Homestead Act of 1862 coupled with technological innovations like the plow and railroad expansion facilitated deeper and more intrusive incursions into the North American prairies by settlers armed with an agrarian ethic. The resulting crop cultivation, overgrazing and suppression of natural processes that came with settlement of the Great Plains led to the degradation and fragmentation of grasslands which had extended out from the long rain shadow of the Rocky Mountains and covered most of the central United States. Declines in the total area of tall-grass prairie since 1830 are estimated to be between 82.6% to 99.9%; Minnesota's original 7.3 million ha of tall-grass prairie have been reduced by over 99%, leaving only 30-60,000 ha of presettlement prairie (Samson et al. 1998).

The destruction of the grassland ecosystem has been paralleled by a decline in grassland bird populations. Several species have experienced significant population declines, and "although global extinction may not be an immediate threat to these species, local or even regional extinctions are likely, especially if the loss and fragmentation of midwestern grassland habitat continues" (Herkert 1994).
Conservative estimates using state-level Breeding Bird Surveys (BBS) for the 40 states located at least partially east of the Rocky Mountains showed that 60% of grassland bird species exhibited declines between 1980 and 1998, and were attributed to changes in the availability of breeding habitats in the United States (Murphy 2003).

While the precise mechanisms of these declines have not been completely elucidated, researchers are beginning to better understand the processes driving interactions between grassland bird communities and tall-grass prairie ecosystems. The relationship between habitat loss and population declines is striking and a growing body of literature documenting this trend points to habitat restoration as one of the most promising ways to mitigate and potentially reverse the declines in grassland bird populations. The challenge to reverse this trend of population decline may yet be met through models that guide and creative policies that encourage restoration efforts. Technological innovations also offer the opportunity to couple utilization with conservation of restored grasslands.

The Northern Tall-Grass Prairie Ecosystem

The historic range of the tall-grass prairie extended from southern Alberta and Saskatchewan south through the Dakotas, Minnesota, Nebraska, Kansas and Oklahoma; prairie parkland typified by Oak savannah bordered the grasslands to the east across southeastern and central Minnesota (Knopf 1988). Lowland tall-grass prairie is associated with the grasses *Andropogon gerardii* (big bluestem), *Elymus canadensis* (Canadian wild rye), *Panicum virgatum* (switchgrass), *Sorghastrum nutans* (Indian grass), and *Spartina pectinata* (prairie cordgrass). Upland tall-grass prairie is associated with *Andropogon scoparius* (little bluestem), *Stipa spartea* (needle grass), *Agropyron smithii* (western wheatgrass), *Bouteloua* *curtipendula* (side-oats grama), *Koeleria cristata* (June grass), *Oryzopsis sp.* (Indian rice grass), and *Sporobolus heterolepsis* (prairie dropseed) (Peterson and Adler 1982). Precipitation in the tall-grass prairie region averages 50-100cm/year and occurs throughout the spring and summer; during the dry fall and winter, the native grasses are dormant (Knopf 1988). Grassland soils contain the bulk of the organic carbon found in the grassland ecosystem and there exists a direct correlation between plant productivity and soil organic matter (Samson et al. 1998).

Disturbance events are integral for the maintenance of diversity in the tall-grass prairie ecosystem. Fire maintains both diversity and productivity; total plant species in the tall-grass prairie is positively correlated with the number of times a site is burned (Samson et al. 1988). In addition to fires, disturbances such as flood, drought, frost, grazing and trampling serve to temporarily restrict the vigor and competitive capabilities of dominant plants. This allows an increase in the richness of subordinates and transients, which then contribute to carbon and nutrient uptake and may act as filters during recolonization (Grime 1998).

The tiny percentage of remaining tall-grass prairie remnants are severely fragmented and isolated in the landscape. As natural vegetation has been eliminated through agriculture and development, both dispersal and genetic diversity has declined, and the quality of remaining vegetation has been diminished by overgrazing, suppression of natural processes like fire events, and the invasion of alien and exotic species (Winter and Faaborg 1999). Agricultural processes deplete nutrients and organic carbons. Slow-forming prairie soils are further threatened by the fact that annually, three times as much topsoil is lost than is formed in the United States. Smaller, lighter nutrient rich organic soils are most at risk of erosion, particularly in areas that have already been destabilized (Samson et al. 1988).

Grassland Bird Species Interactions within the Tall-Grass Prairie Landscape

US Fish and Wildlife Service data indicates that 229 bird species breed in the Mississippi Headwaters/Tall-grass Prairie Ecosystem, which includes the majority of Minnesota and parts of Wisconsin and Iowa. Twenty-one of these species breed primarily within grassland habitat, including *Ammodramus henslowii* (Henslow's Sparrow), *Tympanuchus cupido* (Greater Prairie Chicken), *Calcarius ornatus* (Chestnut-collared Longspur), *Anthus spragueii* (Sprague's Pipit), *Spiza americana* (Dickcissel), *Circus cyaneus* (Northern Harrier) and *Athene cunicularia* (Burrowing Owl) (Koford 1997).

Patterns between grassland birds and habitat have been observed at both the field and the landscape level. Grassland birds respond to several ecological elements, and often it is a combination of these that best predict site selection. Vegetation composition and habitat patch characteristics were shown to significantly influence grassland species distribution patterns; 13 of the 15 most common species studied were influenced by vegetation features, and 8 of these were also influenced by area effects (Herkert 1994). Renfrew and Ribic (2002) cited influences of topography, pasture size and vegetation structure, including height, density and litter depth, on grassland passerine densities in southwestern Wisconsin. Differences in bird species and populations monitored at International Biological Program grassland sites across seven states were connected to local habitat factors like grazing intensity, standing biomass, and energy sources (Wiens 1973).

The particulars of the complex processes driving site selection on a regional scale have increasingly been elucidated. Walk and Warner (1999) considered area requirements for 12 species and concluded that a minimum of 60 ha of grassland area may be necessary to support nine breeding grassland species. Helzer and Jelinski (1999) studied a combination of habitat area and shape and found that a perimeter-area ratio of habitat patches was a more effective determinant of the presence and richness of grassland bird species than patch area alone. Cunningham (2001) studied the importance of surrounding landscape factors on the abundance and diversity of birds occupying grassland fragments in southern Minnesota and found that both local and large regional landscape variables, such as the amount of nearby grasslands and the extent of forest cover, contributed to the number of birds within a fragment. Ribic and Sample (2001) discovered that field and landscape-level factors are influential at least out to 800 meters, and possibly beyond.

The Effects of Tall-Grass Prairie Habitat Loss and Degradation on Grassland Bird Communities

In light of the complex vegetation and area habitat requirements of grassland birds, the relationship between grassland ecosystem destruction and diminishing grassland bird populations becomes apparent. Instrumental to the decline of grassland bird populations are habitat loss, the degradation of remaining grassland due to unsuitable management (including disruption of disturbance regimes and the encroachment of woody or exotic vegetation), and fragmentation (which includes size-effects, edge-effects and isolation effects) (Winter and Faaborg 1999, Johnson and Igl 2001). Study results clearly illustrate the association. All five of the bird species identified as area-sensitive (defined as species which were more likely to occur in large grasslands) by Herkert (1994) have also experienced significant population declines as indicated by the BBS data from 1966-1991: *Ammodramus savannarum* (Grasshopper Sparrow) declined 69%, *Ammodramus henslowii* (Henslow's Sparrow) declined 68%, *Sturnella magna* (Eastern Meadowlark) declined 43%, *Dolichonyx oryzivorus* (Bobolink) declined 38%, and *Passerculus sandwichensis* (Savannah Sparrow) declined 28% (adapted from BBS data in Herkert 1994).

The quantity of available habitat is integrally related to quality. Vegetation structure is an important indicator of nest-site suitability and resource availability for grassland birds. Exotic species threaten existing native plant diversity and the ecosystem processes related to that diversity. Grasslands infested by the exotic, invasive weed *Euphorbia esula* (leafy spurge) have been found to support lower densities of Grasshopper Sparrows and Savannah Sparrows than low and medium-spurge areas (Scheiman et al. 2003).

Intensification of land-use has also contributed to grassland bird population declines. In an investigation of the roles of different land-use types for conserving biodiversity in Minnesota, rarity or absence of several grassland birds was ascribed to three reasons: 1) little land remains in public reserves where high quality habitat can be maintained by fire management, 2) intensive management of some private grasslands kills young and destroys eggs, and 3) the size and number of grassland populations may be inadequate to maintain local populations (Chapman 2001). Concern over small and poorly managed habitat is due not only to the diminished available population "source" habitat, but also over findings that show these smaller, less suitable habitats may serve to function as reproductive "sinks" and depress population growth (Perkins et al. 2003).

Grassland bird populations are also threatened by diminishing reproductive capacity resulting from brood parasitism and nest predation. *Molothrus ater* (Brown-headed Cowbird) breeds in high concentrations in the Great Plains and the possibility exists that parasitism is contributing to population declines: half of all grassland birds in the Great Plains have brood parasitism rates above 30% (Koford et al. 2000). In western Minnesota, *Procyon lotor* (raccoons), *Vulpes vulpes* (red fox) and Cowbirds have increased in abundance and are common in prairie regions (Johnson and Temple 1990).

Implications of Tall-Grass Prairie Restorations for Grassland Birds

The grassland ecosystem, so widely and thoroughly degraded, will probably never exist as more than a shadow of its historic form. Its intrinsic value, however, is becoming better appreciated and conservation of remaining native fragments has been undertaken as a priority by both government and private organizations. In order for any original grassland ecosystem function to begin to be approximated, however, and related benefits regained, concerted restoration efforts will be required to reestablish suitable habitat and connectivity within the severely fragmented prairie landscape.

The Role of Grassland Bird Conservation in Prairie Restorations

Certainly an aesthetic and moral argument can be made for the preservation of grassland birds. The tradition of conservation in this country mandates action to mitigate human-related selection pressures on species populations whenever possible, even when not always practical. Because momentum is building behind grassland restoration efforts, and because modifications to accommodate grassland birds in restoration schemes do not deviate from, and more often enhance, restoration success, it is both possible and practical to incorporate bird species conservation efforts into restoration schemes. From a functional perspective, much is still unknown about the impacts of grassland birds on the grassland ecosystem. Research to elucidate the role of birds in tall-grass communities, however, has indicated potential important ecological effects in grasslands from seed predation by birds. Seed eating by birds reduced plant densities by 20-23% and grass biomass by 24-35% in restored prairie test plots in Illinois (Howe and Brown 1999). Richness was reduced without affecting diversity, which led researchers to speculate that suppression of grasses might release forbs and suppression of common forbs might encourage uncommon forbs and grasses: "Episodic seed eating by birds, in addition to chronic granivory by birds and rodents, may have substantial but unrecognized direct and indirect effects on established prairie vegetation, and will have a strong potential impact on restorations that employ broadcast seeding" (Howe and Brown 1999). The most important function of grassland birds in a restored ecosystem may not yet be fully realized; since the declines of grassland bird populations have been closely linked to the decline in grassland area and quality, a reversal of grassland bird population declines may become the most accurate indicator for the success of grassland restoration efforts.

Positively Impacting Grassland Birds Through Grassland Restoration Design and Implementation

The outcome of a grassland restoration is initiated at the onset through appropriate planning and application of restoration components relative to site constraints and goals. Special attention to certain aspects of the restoration process to benefit grassland bird populations will enhance the quality of the overall restoration. Ultimately, this will allow the restoration to most completely contribute to the support and sustainability of not only grassland birds, but other species which are dependent on the ecological functions of grasslands as well. Research has shown that a properly restored grassland is equally if not more capable than a native grassland of supporting bird populations. When tall-grass prairie plots and restored grasslands were compared, densities of common bird species were similar between habitat types except for Grasshopper Sparrows and Savannah Sparrows, which were respectively four and nine times more dense in restored grasslands, suggesting that restored grasslands provide habitat as suitable for most grassland birds as native habitat (Fletcher and Koford 2002).

Special attention to the factors most affecting grassland bird populations must be incorporated intentionally into restoration designs and management in order to ensure the provision of habitat suitable for supporting populations and eventually reversing declines. Consideration of these factors does not contradict restoration efforts, as they are generally already included in restoration schemes designed to establish quality grasslands. Several guidelines determined from the literature are highlighted in Figure 1.

Figure 1: Restoration components that positively impact grassland birds

Restoration Scale

Should be extended to the largest possible range to include landscape-level factors that combine to enhance and extend habitat suitability.
Cunningham 2001, Ribic and Sample 2001, Fletcher and Koford 2002

Management for Individual Species

Additional tailoring of landscape features to an individual species' needs may be required in the event that declines persist and species become endangered.
Ribic and Sample 2001
(In general, however, considerations should be broad-based and incorporate factors affecting all grassland bird populations to the greatest degree and magnitude that can be supported by the scope and resources of a particular restoration.)

Patch Area and Core Shape

Needs to be a prominent consideration in order to increase suitable habitat area for sensitive birds, reduce edge effects, and increase connectivity. In general, the larger the habitat area and more square or circular in shape, the better.
Herkert 1994, Helzer and Jelinski 1999, Winter and Johnson 1999, Johnson and Igl 2001, Perkins et al. 2003

Management of Aliens and Invasives

Should be continued to prevent declines in habitat quality which adversely affect plant diversity and grassland bird populations.
Scheiman et al. 2003

Management of Woody Vegetation

Increasing vegetative density, reducing wooded edge proximity, and focusing on removal of woody vegetation are options to reduce Cowbird parasitism frequencies and control predation effects.
Johnson and Temple 1990, Koford et al. 2000

Burning and Mowing Regimes

Protocols of burning and mowing to enhance plant diversity and control invasives and subsequently improve bird habitat are necessary and beneficial, but they should be timed so as not to interfere with nesting success and survival of young.
Chapman 2001

Soil Nutrients and Biota

Attention should be given to soil nutrient quality and associated soil biota to increase the likelihood of native plant success and diversity and the capacity of the restored ecosystem to support plan communities
De Deyn et al. 2003

The basic components that need to be considered when a grassland restoration is undertaken include appropriate species selection from local sources; site and seedbed preparation, including drainage and slope considerations, timing, and weed control measures; planting dates and rates; planting equipment and methods; and site management, including grazing and prescribed burn regimens (Duebbert et al. 1981). Managers involved in refuge and private grassland restorations with the US Fish and Wildlife Service have honed their techniques with experience and an increasingly systems-oriented approach that considers a host of species. Grasslands used to be seeded with cool grass and legume mixes. When native seed mixes were introduced, they were mainly composed of grass species in a 6 to 1 ratio. Now, seed mixes include a greater number of forbs because the flowers attract invertebrates which attract birds. Using seed sources from within 100 miles of the restoration site, mixes are created from 7 grass species, including big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), and side-oats grama (*Bouteloua curtipendula*), and up to 25 forb species, depending on funds. One to two applications of Round-up (glyphosate) are applied in the spring when weeds first come up, and then the seed mix is applied with a Truax seed drill at 10 lbs. pls/acre. Weed control is given priority in the first year. Since annual weeds grow faster than prairie grasses, managers run mowers 8-10 inches high to remove weed heads and inhibit seed production. Fields are generally mowed once or twice the first summer, and may be mown once or twice the second summer, but after two years, the prairie grasses are generally well-established and able to compete. Burns are conducted on a five-year rotation to mimic the natural fire regime for tall-grass prairies (Cooper, personal communication).

Ongoing research continues to refine restoration and management practices. Increasingly, patch scale and local variables are being scrutinized to determine how habitats within restored sites can be made most attractive to grassland birds. Working on a US Fish and Wildlife Service Refuge, Cooper (personal communication) is studying methods that would create micromosaics within large grassland patches to begin to approximate the different habitat requirements of different species. For example, some species like *Dolichonyx oryzivorus* (Bobolink) and *Cistothorus platensis* (Sedge Wren) prefer thicker vegetation within a patch. Cooper proposes a mixed disturbance burn/mow/idle rotation that would also be varied in its timing to create these micromosaics. Currently, burns are conducted in the spring, primarily because of staffing considerations. Spring burns favor big bluestem, switchgrass and Indian grass that push out forbs. Cooper believes a fall burn might favor a greater mosaic within the restored landscape rather than this triculture.

Merging Grassland Bird Conservation with Tall-Grass Prairie Restoration

Programs and Policies that Promote and Support Restoration Effects on Grassland Birds

Widespread restoration of the tall-grass prairie ecosystem is necessary to regain ecosystem function. Programs and policies that provide adequate incentives and technological assistance in a widespread manner are an integral element of the discussion surrounding the efficacy of framing conservation efforts of birds within the context of restoration efforts. The archetypal incentive program to alleviate landscape degradation is the Conservation Reserve Program (CRP), which Congress created as part of the 1985 farm bill. CRP provides annual payments to landowners who retire cropland and establish cover such as grass, legumes, trees and shrubs. Acceptance into the program is determined by criteria based on the potential for the covered land to offer, in order of importance, wildlife habitat benefits, water quality benefits, on-farm benefits, persistent benefits, air quality benefits, and cost (CRP Fact Sheet, USDA website). Variations of this program have appeared in subsequent farm bills: the 1990 bill created the Wetlands Reserve Program (WRP), and the new 2002 farm bill created the Grassland Reserve Program (GRP). GRP offers compensation in return for an easement or other long-term agreement to maintain native prairie or undertake prairie restoration. Options include permanent easements, thirty-year easements, and rental or restoration agreements. The GRP criteria are more stringent than those established for CRP, both in terms of qualification and prohibition of land use activities. Land must include at least 40 contiguous acres and include grassland or be located in an area that was historically grassland (GRP Fact Sheet, USDA website). The program has received an enthusiastic reception. Sign-ups began June 30, 2003, and as of September 24, 13,000 applications representing requests for more than $1.7 billion on approximately 9.5 million acres had been received, well in excess of the $49.7 million in funds that has been released to implement GRP (Westcott, USDA news release).

Policies built into these programs provide guidance for restoration that will positively impact grassland birds both intentionally and as a consequence of general good grassland restoration practices. Payment is highest for lands in which the landowner forfeits all land use rights for the entire easement period and decreases with each use retained by the landowner. Restrictions might still be imposed; for example, haying may only occur after July 15 to protect ground nesting wildlife. Weed control is generally the responsibility of the landowner, and may include woody encroachment control depending on the agreement established (Private Lands Restoration, USFWS website)

The new GRP program, with its specific focus on grasslands, offers great potential to advance efforts of linking bird population conservation to restoration. CRP lands, while not specifically targeted for grassland restoration, still demonstrated positive impacts on grassland bird populations. Evidence points to the success of the CRP lands for providing quality habitat that supports grassland birds (Johnson and Schwartz 1993, Koford 1999). In a study of landscape characteristics affecting grassland birds, CRP lands were found to support larger and more diverse populations of birds than public lands, which was attributed to both spatial and vegetation attributes (Cunningham 2001). Research has demonstrated the benefits of locating a CRP field near existing grassland or favoring the establishment of fewer large CRP fields over several smaller ones, particularly to benefit area-sensitive birds, and reiterates the necessity of collaboration between land managers and wildlife biologists (Johnson and Igl 2001, Weber et al. 2002).

Minnesota landowners interested in restoring grasslands may be eligible to participate in a number of cost-share programs. Wording for the new GRP program makes eligible all land that was historically grassland, which immediately qualifies most landowners in western Minnesota. All programs, however, are not created equal, and several offer conflicting outcomes, either from poorly defined management protocols or from directly conflicting goals. Where federal programs like GRP and Partners for Fish and Wildlife (USFWS web site) tend to target non-game habitat restoration and conservation efforts, state programs like the Pheasant Habitat Improvement Program (PHIP) and the Deer Habitat Improvement Program sponsored by the Minnesota Department of Natural Resources (UMN Extension web site) promote the cultivation of food crops and winter cover in direct contradiction to efforts to restore native plants and reverse encroachment by woody vegetation. Planning and collaboration among agencies and interest groups will allow the goals of various environmental initiatives to be complementary rather than conflicting. A model effort to increase collaboration in recognition that ecosystems are not constrained by political boundaries is exemplified by the North American Bird Conservation Initiative, which was launched in 1999 as a collaborative effort of US, Canadian and Mexican governments and private organizations and represents a major advance in the pooling of resources and research to target bird conservation (Kelly, 2003 presentation).

Use of the Grassland Bird Conservation Area Model to Inform Restoration Efforts

There needs to be a way to integrate restoration efforts and incorporate the growing body of research that points to a complex interaction of the variety of factors upon which grassland bird population success depends (Johnson and Winter 1999). The Grassland Bird Conservation Area (GBCA) model represent efforts to prioritize conservation areas for declining bird species based on assumptions drawn from the research, that 1) large patches are better than small ones, 2) patches that are square or round are better than linear or irregular patches due to a decreased edge effect, 3) trees are hostile habitat for grassland nesting birds because they favor predators, and 4) productivity within a patch is determined by habitat in the surrounding landscape (Kelly, power point presentation). This model was developed by Partner's in Flight, another collaborative effort aimed at reversing declining bird populations. The model is still in a development phase, but eventually might provide a framework upon which the myriad of interacting factors that dictate overall success of grassland bird populations might be structured to provide direction for grassland restoration efforts. Some of the parameters are understood while others are being developed based on the best available information. The model may eventually be used by planners to predict how large a grassland is needed for a self-sustaining population of non-game birds or to predict the population of a given area with given parameters that could be used to guide restoration prioritization.

Technological Development in Minnesota's Tall-Grass Prairie Region

While technological advances of the 19th century hastened the destruction of the prairie by enhancing the magnitude of human impacts on the landscape, technological advancements of the 21st century are increasingly being proposed to couple economic and ecological development, and may offer the best chance for wide-spread restorations. Land utilization strategies to aid failing rural economies are increasingly proposing crop diversification schemes that often would keep prairie in cover and maintain quality habitat. A consortium of academic institutions, private companies and organizations are currently investigating methods to diversify field use in rural Minnesota to increase economic and ecological benefits; if the needs of grassland birds are legislated by program designs and incentives, populations could experience positive benefits.

One alternative to traditional cultivation that has been proposed is the production of switchgrass for use as a biomass fuel. Switchgrass fields were found to create breeding habitat for some grassland birds, and because harvesting occurred in the fall and winter, nesting birds were not directly affected (Murray and Best 2003). Diversification of rural production and prairie restoration are already directly related. A farmer in Okabena, MN who converted 35 acres of corn to Indian grass and big bluestem harvests the seed and sells it for about $10 a pound to a prairie restoration company (Herwig 2002). Along with overt restoration efforts, as more ecologically sustainable farming methods are developed and adopted, secondary benefits in the landscape will result.

It is vital that monitoring and research accompany new technologies being incorporated into restoration plans to fully assess their impact on restoration outcomes. A study in southwest MN of wind turbines found that human disturbance, turbine noise and the physical movement of turbines may have disturbed nesting birds and recommendations were made that wind turbines be placed within habitats that support lower densities of grassland birds (Leddy et al. 1999). If restorations are to be carried out within the environmental and economic framework of a sustainable landscape setting, restorationists must be prepared to engage in policy developments to advocate for the options that are practical and do not create more harm than good.

Conclusion

Grassland birds are affected by a myriad of elements in the prairie ecosystem that are still being determined. The connection between habitat destruction and degradation with declining bird populations has been well established. Additional information to identify specific vegetation influences and more generalized landscape impacts as well as additional techniques to control invasives will assist future restoration projects. Restorations of the northern tall-grass prairie can be designed to accommodate grassland birds. Rather than an incidental outcome, conservation of grassland bird populations can be identified as a restoration goal, providing benefits to the entire grassland ecosystem with minimal deviations from the original scope of the restoration. Restoration of the northern tall-grass prairie in Minnesota is encouraged by numerous programs that provide incentives and technological assistance. A growing awareness of the need to conserve grassland birds through restoration efforts will increasingly link restoration incentives to factors which take into account the needs of grassland bird populations. Continued collaboration between restorationists, biologists and policy makers will assure that quality grassland restorations are undertaken that best accommodate the needs of grassland bird communities and ensure the overall success of the restoration outcome.

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