Notes

Delineating Grassland Bird Conservation Areas in the U.S. Prairie Pothole Region

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Abstract

Conservation of birds is increasingly focused on the importance of landscape characteristics to sustain populations. Implementing conservation on a landscape scale requires reliable spatial models that provide biological context for conservation actions. Before species-specific models relating grassland birds to their habitat at landscape scales existed, we created a conceptual model and applied it to spatial data to identify priority grassland habitats for the protection and restoration of populations of area sensitive grassland birds in the Prairie Pothole Region. Since that time, these Grassland Bird Conservation Areas have been widely used to guide conservation, and variations of these models have been adopted in other regions; however, the process used to delineate them (i.e., the conceptual models) is poorly understood by many users. We describe that process here and offer perspectives on the utility and limitations of conceptual models, especially on the value of making assumptions that commonly underlie management decisions explicitly, thereby making the assumptions testable, and hopefully increasing management transparency, credibility, and efficiency.

Keywords: grasslands; birds; strategy; Prairie Pothole Region; Grassland Bird Conservation Areas

Received: November 9, 2009; Accepted: March 29, 2010; Published: June 11, 2010 (delayed for inaugural issue)

Citation: Johnson RR, Granfors DA, Niemuth ND, Estey ME, Reynolds RE. 2010. Delineating Grassland Bird Conservation Areas in the U.S. Prairie Pothole Region. *Journal of Fish and Wildlife Management* 1(1):38–42; e1944-687X. doi: 10.3996/JFWM-022

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Introduction

Grassland bird populations declined more rapidly between the 1960s and 1990s than any other guild of North American birds (Peterjohn and Sauer 1999). Conversion of grasslands to agriculture across vast areas of the central United States has contributed significantly to these declines (Murphy 2003). Grassland loss is further exacerbated, particularly in the eastern Prairie Pothole Region (PPR), by tree planting and natural encroachment due to suppression of grazing and fire (Bakker 2003; Quamen 2007). Due to rising land values and cost of fee-title acquisition, easement, and agricultural set-aside programs that protect and restore grassland habitats, managers are under increasing pressure to apply treatments in the most cost-effective and least extensive manner. Spatially explicit decision support tools can aid in prioritizing areas for management practices for the conservation of grassland bird species (U.S. Fish and Wildlife Service [USFWS] 2008).

A conceptual model for Grassland Bird Conservation Areas (GBCAs) was first described by Sample and Mossman (1997) and adopted in the PPR by Partners-in-Flight (PIF) (Fitzgerald et al. 1998, 1999). Related models are discussed in Johnson et al. (2009) and Niemuth et al. (2009). A common feature of conceptual models is that they are usually used to predict apparent habitat suitability (Johnson et al. 2009) rather than abundance or demographic rates. Recently, empirical models that predict relative abundance have been developed for many priority species of grassland birds in the PPR (Quamen 2007); however, GBCAs are still widely used in a variety of agencies in their programmatic conservation strategies. The GBCA conceptual model, although biologically based, is poorly understood by many users. Here we describe the delineation of GBCAs and discuss the advantages and limitations of similar conceptual models (USFWS 2008).

Study Area

The PPR of the United States includes counties in Iowa, Minnesota, Montana, North Dakota, and South Dakota (Johnson and Higgins 1997) historically covered by tall- and mixed-grass glaciated prairies (Johnson and Higgins 1997). Tillage agriculture is the predominant land use and continues to expand throughout the region. Less than 1% of the historic native tallgrass prairies and <30% of the native mixed-grass prairies remain in the region (Samson et al. 1998). Federal conservation provisions, including the Bankhead–Jones Act of 1935, conser-

Table 1. Grassland Bird Conservation Area (GBCA) definitions and criteria.

Core	Consists of no neutral habitat and no habitat within 50 m of hostile habitat.
Type I core	At least 260 ha of compatible habitat ≥1.6 km wide. Compatible habitat includes all grassland and all National Wetland Inventory (NWI)-delineated temporary and seasonal wetlands. A maximum of 30% of the core area can be made up of semipermanent and permanent wetland.
Type II core	At least 65 ha of compatible habitat ≥0.8 km wide. Compatible habitat includes all grassland and all NWI-delineated temporary and seasonal wetlands. A maximum of 30% of the core area can be made up of semipermanent and permanent wetland.
Type III core	At least 22 ha of compatible habitat ≥0.45 km wide. Compatible habitat includes all grassland and all NWI-delineated temporary wetlands. A maximum of 30% of the core area can be made up of seasonal, semipermanent, and permanent wetland.
Matrix	All habitats falling within a 1.6-km buffer surrounding a core.
GBCA	A core and its associated matrix.
Type I GBCA	A Type I core and the associated matrix. At least 40% of the total area encompassed must be compatible habitat.
Type II GBCA	A Type II core and the associated matrix. A minimum of 30% of the total area encompassed must be compatible habitat.
Type III GBCA	A Type III core and the associated matrix. A minimum of 20% of the total area encompassed must be compatible habitat.

vation titles of ''Farm Bills'' enacted since 1985, and the USFWS's National Wildlife Refuge System and Partners for Fish and Wildlife Program have returned some of the historic grasslands of the PPR. Furthermore, approximately 450,000 ha of native prairie in the PPR have been conserved through the acquisition of USFWS perpetual grassland easements. Maps of GBCAs that we describe below were created to be decision support tools to be used by managers to target future conservation at the largest grassland patches with the smallest perimeter : area ratio (the greatest ''blockiness'') to efficiently benefit area sensitive grassland bird species.

Methods

Grassland Bird Conservation Area concepts were simplified from Sample and Mossman (1997), in developing PIF bird conservation plans that included measurable criteria for the habitat needs of area-sensitive grassland birds (e.g., Fitzgerald et al. 1998, 1999). The original PIF model recommended a minimum contiguous patch of 800 ha of grassland, including <40 ha of trees, surrounded by an additional 1,000 ha of grassland in at least 40-ha patches within a 1.6-km buffer around the core patch (e.g., Fitzgerald et al. 1998, 1999). Although useful, this model had several inherent limitations. The shape of contiguous patches of grassland was not explicitly described, resulting in delineation of long, linear grassland-like road ditches. Furthermore, the model did not account for wetlands embedded within grasslands.

The USFWS Habitat and Population Evaluation Teams (HAPETs), working with PIF and the Prairie Pothole Joint Venture (PPJV) Technical Committee, modified the model to address these limitations for the glaciated mixed-grass prairies. Nevertheless, criteria were still so restrictive that the GBCA models were of little use in providing guidance for conservation or restoration in the more disturbed areas of the PPR (i.e., the model did not account for patches or landscapes that may be important to priority species with less restrictive habitat requirements). Consequently, grassland bird researchers, managers, and biological planners (hereafter, the GBCA Working Group) met in January 2001 to develop GBCA models that could assist managers engaged in grassland protection and restoration across the entire PPR.

The GBCA Working Group concluded that a multitiered approach was needed to delineate GBCAs across a region as diverse as the PPR (Table 1). A multitiered approach enabled informed management in areas with extensive existing grasslands where protection was the preferred management alternative and also addressed highly fragmented landscapes where management objectives were protection of remnant grasslands complemented by grassland restoration. We assumed that if habitats were provided for area-sensitive species, the needs of other grassland birds that require similar, but less restrictive patch-level vegetation characteristics, also would be accommodated (Lambeck 1997).

GBCA Delineation

Grassland Bird Conservation Area delineation was based on the working hypothesis that some grassland bird species respond positively to patch size, landscape structure, or both and the following assumptions could be put forward with some confidence: 1) large patches support a greater array of species than small patches (Herkert 1994; Winter and Faaborg 1999; Ribic et al. 2009), 2) the amount of grassland in the landscape surrounding a patch affects the assemblage and productivity of bird species in that patch (Winter 1998), 3) woody vegetation is hostile habitat that reduces suitability or productivity of adjacent grasslands for at least some grassland bird species (Bollinger 1995; Delisle and Savidge 1996; Hughes et al. 1999; Hanowski et al. 2000; Winter et al. 2000; Coppedge et al. 2001; Bakker et al. 2002; Quamen 2007), and 4) patches that most closely approximate square or round shapes are superior to patches of other shapes of equivalent sizes due to their reduced edge.

Patches have traditionally been described in varying and arbitrary terms that are difficult to apply in ecoregional scale assessment projects. Delineation of GBCAs using remotely sensed satellite imagery and geographic information system technology required that vague definitions of patches be formalized in a standardized and measurable classification process. This presented several challenges. First, vegetative species cannot be reliably determined from classified satellite imagery (Gallant 2009), prohibiting patch delineation based on stand composition. However, landscape characteristics influence presence and reproductive success of grassland-nesting birds, regardless of stand composition, structure, or condition (Herkert 1994; Bakker et al. 2002; Herkert et al. 2003). Second, fine-scale site features such as fences and narrow windbreaks cannot be detected using

Table 2. Land cover classes grouped by their compatibility for grassland birds according to Partners-in-Flight classes for Grassland Bird Conservation Area (GBCA) delineation. See Table 1 for definitions of Types I, II, and III.

Land use	Type I	Type II	Type III
Grassland	C[a]	C	C
Hayland	N[b]	N	N
Cropland	N	N	N
Barren	N	N	N
Scrub and shrub	H[c]	H	H
Urban and developed	H	H	H
Trees	H	H	H
Wetland			
Temporary	C	C	C
Saturated	C	C	C
Seasonal, %	C	C	<30[d]
Semipermanent, %	<30	<30	<30
Permanent, %	<30	<30	<30
Forested	H	H	H
Scrub and shrub	H	H	H

[a] C = compatible—contributes to the area of grassland within a potential core or its matrix.
[b] N = neutral—does not count as grassland within a potential core or its matrix, nor does it cause adjacent grassland to be devalued as in hostile habitat below.
[c] H = hostile—habitats that reduce the value of adjacent grassland. Grasslands with 50 m of hostile habitat do not contribute to grassland making up a GBCA core or the area of grassland required in a GBCA matrix.
[d] The amount of wetland of this water regime that may occur within a GBCA core (i.e., if an area of grass included >30% of this type of wetland, it would not be delineated as a GBCA core).

Landsat satellite imagery. Anthropogenic features such as roads, which can influence presence of some species of grassland birds (Sutter et al. 2000), were not incorporated into this analysis unless they fragmented grasslands on the satellite imagery or the grass in the road ditches was detected. This generally limited the type of road affecting the analysis to interstate highways.

Instead of using a conventional arbitrary definition of a patch, we evaluated the land cover surrounding each 812-m^2 (28.5 × 28.5 m) pixel in the regional land cover geospatial data base. Because National Land Cover Database data had either insufficient or unknown accuracy standards, we created our own land cover data from circa 2001 (Minnesota and Iowa) and circa 1998 (North and South Dakota) Landsat imagery. More specific cover types were combined to create a general ''grassland,'' ''cropland,'' ''woody cover,'' etc. (Table 1) cover classes for these analyses. Using a focal sum analysis (ArcGIS version 8.0), we delineated GBCA cores made up of contiguous square blocks of grassland or compatible wetland habitat in three sizes and minimum widths (Table 1). Cores could be made up of single blocks or aggregates of the same or greater width. Cores were delimited by neutral or hostile habitats that were wide enough to be detected on classified satellite imagery (Table 2).

For each core size, we established expert-based thresholds for the percent grassland in the 1.6-km-wide landscape (matrix) surrounding and including the core (Table 1). Matrix thresholds diminished with block size because block size and percent grassland in the landscape are correlated. Each type of GBCA was expected to provide habitat for some priority grassland bird species, with blocks at least 260-ha in landscapes with ≥40% grassland expected to provide habitat for all priority species, and fewer species being supported by 22-ha blocks in landscapes with ≥20% grass. Assumptions inherent in using GBCAs to target conservation include the following:

1. Each hectare of grassland habitat is equivalent in terms of attractiveness and productivity regardless of stand composition and condition. Species exhibit multi-scalar habitat selection in their settling patterns, that is, selection occurs at the scale of range, landscape, patch, and stand. This modeling process ignores selection based on stand composition or condition. Different species may have incompatible responses to stand composition or condition. Thus, not all species predicted for a GBCA may actually occur there; however, the GBCA could provide habitat for each of the predicted species, depending on how it is managed.
2. Species assemblages and productivity occurring in different types of GBCAs may be reliably predicted within subregions of the PPR, conditional on stand composition and condition.
   a. Core size, block width, or both interact with percentage of grassland in the landscape to influence habitat use and productivity.
   b. Species assemblages may be predicted for different types of GBCAs.
3. ''Blocky'' cores that were large and wide (e.g., 260-ha blocks) support higher productivity and a larger assemblages of area-sensitive species than cores comprised of smaller blocks (e.g., 22-ha blocks).
4. Percentage of grassland in the landscape (matrix) influences bird habitat use and productivity.
   a. A 1.6-km band around a core is an appropriate landscape scale.
   b. 40% (Type I matrix), 30% (Type II matrix), and 20% (Type III matrix) are meaningful landscape-scale thresholds for assessing grassland abundance.
5. Trees constitute hostile habitats that affect habitat use and productivity within landscapes, and these effects occur primarily within 50 m of trees (Grant et al. 2004).
6. Adjacent croplands and other neutral adjacent habitats exert no edge effects on habitat use or productivity.
7. Wetlands are neutral habitats. Vegetation characteristic of temporary and seasonal wetlands are often grasses, and these wetlands are believed to function like grasslands in large grassland blocks (260- and 65-ha blocks) or have no effect on block use or productivity. Blocks may contain up to a total of 30% wetlands of without affecting their suitability for grassland bird species (Table 1).
8. Topography has no effect on bird species abundance in GBCAs (Frey et al. 2008).

Results

Type I, II, and III GBCAs were delineated for the entire PPR area, excluding the northeastern-most counties in Montana (Figure 1). Relative grassland restoration priorities also were identified in the course of delineating GBCAs. Relative restoration priority was defined as the amount of grassland that would need to be restored to create a Type I core (Figure 2).

Reynolds et al. (2006) described an empirically based decision support tool for targeting grassland protection and restoration for upland-nesting waterfowl. The tool is a map that depicts the relative number of upland nesting duck hens that can access a

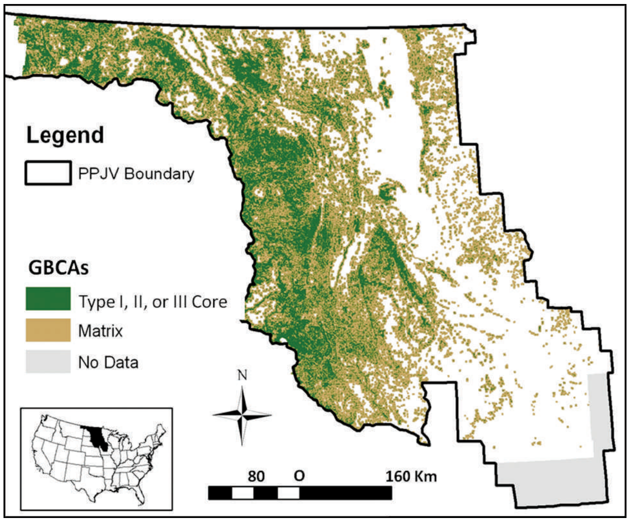

Figure 1. Grassland Bird Conservation Areas (GBCAs) of the U.S. Prairie Pothole Region. PPJV = Prairie Pothole Joint Venture. See Table 1 for definitions of Types I, II, and III.

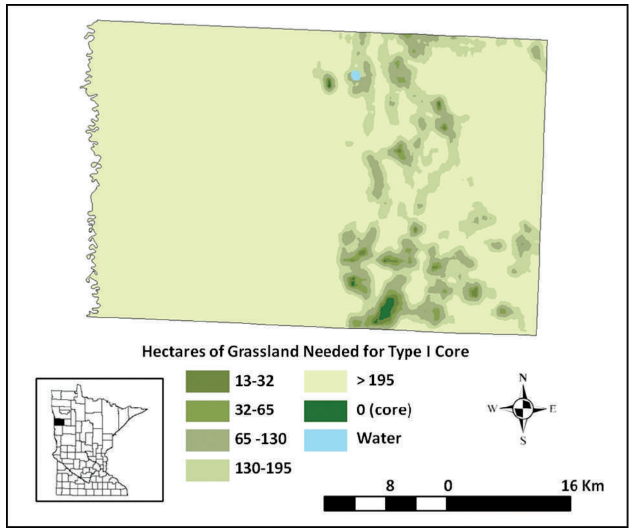

Figure 2. Amount of grassland restoration required to create a Type I Grassland Bird Conservation Area core in Clay County, Minnesota. See Table 1 for definition of Type I.

16-ha tract of grass based on regression estimates of the number of breeding pairs wetlands can support within the maximum home range radius of nesting hens. Because the map looks like a Doppler image of a thunderstorm, the map is commonly called a ''thunderstorm map'' and is used to target grassland conservation for ducks. Tools such as thunderstorm maps and GBCAs reflect management potential and priority areas for different guilds of species and may be combined to reflect relative management priorities of individual programs. The USFWS's HAPETs have integrated this waterfowl decision tool with GBCAs to identify priority grassland protection and restoration areas for an extensive suite of grassland birds. This integrated decision support tool is still being used by PPJV partners to target expenditure of Migratory Bird Conservation Funds for the Small Wetlands Acquisition Program, by applicants to the North American Wetland Conservation Act, for technical assessment for the USDA Wetland Reserve Program and Conservation Reserve Enhancement Program in Minnesota, and for various less well known state and nongovernmental programs.

Discussion

One advantage of using conceptual models, such as those for GBCAs, is that they require the assumptions managers routinely make about population–habitat relationships to be made explicit. This can have the effect of making management decisions more transparent and credible. These assumptions are candidate hypotheses for research and monitoring, depending on the potential impact of better information on management decisions and the uncertainty about each assumption. In fact, monitoring is essential to test the validity of assumptions in conceptual models such as those described here. Furthermore, the maps produced by applying the model to spatial data have proven to be effective communication tools for the public and elected officials. Encouragingly, many empirical models of individual species, derived from data collected at stops along Breeding Bird Survey routes, provide similar predictions to GBCAs about the distribution of area-sensitive grassland bird species that require large, contiguous blocks of grassland in grassland-rich landscapes (Figure 3; Niemuth et al. 2005; D. Granfors, USFWS, unpublished data; see examples at http://www.fws.gov/midwest/hapet/BreedingSurveyModel.htm). Despite the growing availability of empirical models, the more general GBCA models are still widely used for programmatic planning because general predictions of suitability for area-sensitive species seem to have intuitive appeal.

Although it may not be practical to develop empirical models (purely data driven or statistical models) for every species of interest, conceptual models such as GBCA models are a way to provide management decision support without large amounts of a priori data, provided that provisions are made to evaluate explicit assumptions in the models. However, models like the GBCA models described here provide few explicit predictions about species abundance or demographic rates (i.e., decision support is typically general and limited to apparent habitat suitability). For this reason, GBCAs are poorly suited for formal cost–benefit analysis of competing management alternatives.

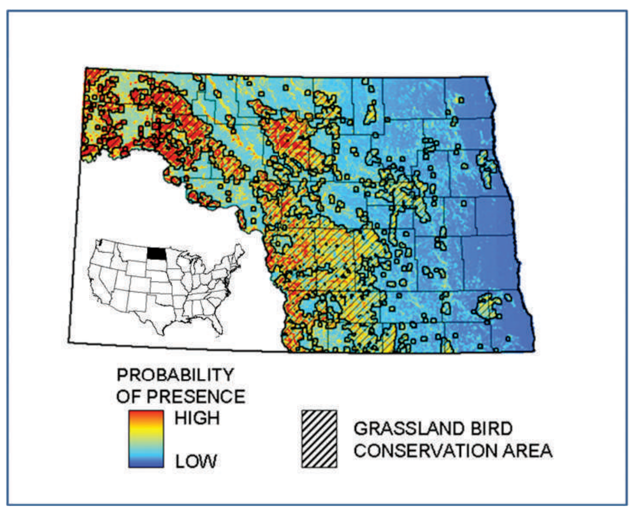

Figure 3. Grassland Bird Conservation Areas (GBCAs) overlain on output from a logistic model of probability of occurrence for northern harrier in the Prairie Pothole Region in North Dakota based on Breeding Bird Survey (BBS) data. Warmer colors indicate a higher probability of occurrence. Consistency between the GBCA and BBS-derived predictions are typical and lend credibility to the simple GBCA conceptual model.

Nevertheless, the explicit assumptions in a conceptual model like that for GBCAs may be a catalyst for discussions about critical ecological relationships such as the relative importance of site and area interactions, area sensitivity, patch perimeter : area ratio, or habitat structure and heterogeneity. Making these often unarticulated beliefs explicit should lead to research focused on assumptions that are critical to making reliable future management decisions. The HAPET offices created maps of GBCAs for the PPJV as draft decision support tools to be replaced by empirical models. These empirical models are now available and enable predictions of site suitability for individual grassland bird species, species assemblages, and strategic grassland restoration potential (Quamen 2007).

Acknowledgments

We thank the following individuals for assistance in developing GBCA delineation criteria: Dan Hertel, Stephanie Jones, Sean Kelly, Steve Lewis, Jim Mattsson, and Tom Will, USFWS; Todd Bishop, Iowa Department of Natural Resources; Kristel Bakker, Dakota State University; Julie DeJong, South Dakota State University; Tom Landwehr and Duane Pool, The Nature Conservancy; Larry Igl, Northern Prairie Wildlife Research Center, U.S. Geological Survey; Jamie Edwards and John Schladweiler, Minnesota Department of Natural Resources. Finally, comments provided by the subject editor and the three anonymous reviewers were very helpful and substantially improved this manuscript.

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