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Research Papers

Relationships between Duck and Grassland Bird Relative Abundance and Species Richness in Southern Saskatchewan

Relations entre l'abondance relative et la richesse spécifique des canards et d'autres oiseaux de prairie dans le sud de la Saskatchewan

Susan P. Skinner [1] *and Robert G. Clark* [2]

ABSTRACT. Digital map products that integrate long-term duck population and land-use data are currently being used to guide conservation program delivery on the Canadian Prairies. However, understanding the inter-relationships between ducks and other grassland bird species would greatly enhance program planning and delivery. We hypothesized that ducks, and Northern Pintail (*Anas acuta*) in particular, may function as an umbrella guild for the overall breeding habitat quality for other grassland bird species. We compared grassland bird species richness and relative abundance among areas of low, moderate, and high predicted waterfowl breeding densities (i.e., duck density strata) in the southern Missouri Coteau, Saskatchewan. We conducted roadside point counts and delineated habitats within a 400 m radius of each point. The duck high-density stratum supported greater avian species richness and abundance than did the duck low-density stratum. Overall, duck and other grassland bird species richness and abundance were moderately correlated, with all r between 0.37 and 0.69 (all $P < 0.05$). Although the habitat requirements of Northern Pintail may overlap with those of other grassland endemics, priority grassland bird species richness was only moderately correlated with total pintail abundance in both years, and the abundances of pintail and grassland songbirds listed by the Committee on the Status of Endangered Wildlife in Canada were not correlated. No differences in the mean number of priority grassland species were detected among the strata. Adequate critical habitat for several priority species may not be protected if conservation is focused only in areas of moderate to high wetland density because large tracts of contiguous, dry grassland habitat (e.g., pasture) occur infrequently in high-quality duck habitat.

RÉSUMÉ. Les produits de cartographie numérique qui intègrent des données à long terme sur les populations de canards et l'utilisation du sol sont actuellement utilisés pour orienter les programmes de conservation dans les Prairies canadiennes. Toutefois, la compréhension des relations entre les canards et les autres espèces d'oiseaux de prairie améliorerait grandement la planification et la mise en œuvre de ces programmes. Nous avons supposé que les canards, le Canard pilet (*Anas acuta*) en particulier, pouvaient représenter une guilde parapluie en ce qui concerne la qualité de l'habitat de reproduction pour d'autres espèces d'oiseaux de prairie. Nous avons comparé la richesse spécifique et l'abondance relative d'espèces d'oiseaux de prairie à des endroits où la densité prédite de sauvagine nicheuse (c.-à-d. la strate de densité de canards) était faible, moyenne ou élevée, dans le sud du Missouri Coteau, en Saskatchewan. Nous avons effectué des points d'écoute le long de routes et avons décrit les habitats dans un rayon de 400 m à chaque point d'écoute. La strate de densité élevée de canards avait une richesse spécifique et une abondance relative de l'avifaune plus grandes que celle de densité faible de canards. Dans l'ensemble, la richesse spécifique et l'abondance des canards étaient corrélées moyennement à celles des autres oiseaux de prairie, avec toutes les valeurs de r comprises entre 0,37 et 0,69 (tous les $P < 0,05$). Même si les besoins du Canard pilet en termes d'habitat peuvent chevaucher ceux d'autres espèces de prairie endémiques, la richesse spécifique

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d'oiseaux de prairie prioritaires était seulement corrélée moyennement à l'abondance du Canard pilet au cours des deux années; de plus, l'abondance du Canard pilet et celle des passereaux de prairie listés par le Comité sur la situation des espèces en péril au Canada n'étaient pas corrélées. Aucune différence dans le nombre moyen d'espèces de prairie prioritaires n'a été détectée entre les strates. L'habitat essentiel de plusieurs espèces prioritaires pourrait ne pas être protégé si la conservation vise uniquement les endroits où la densité de milieux humides est de moyenne à élevée, parce que de grandes parcelles d'habitat de prairie sèche contigüe (p. ex. pâturage) sont peu fréquentes dans ce qui est l'habitat de grande qualité pour les canards.

Key Words: *abundance; Bird Conservation Region 11; Canadian Prairies; conservation; ducks; grassland birds; grassland habitat; predicted waterfowl breeding distribution; Saskatchewan; species richness; umbrella guild.*

INTRODUCTION

Many grassland bird species of North America are declining at a greater rate than avifauna associated with other habitats, even though many share common wintering areas (Herkert 1995, Peterjohn and Sauer 1999, Downes and Collins 2007). Most apparent and steep declines have occurred within Bird Conservation Region (BCR) 11, an area that includes the prairie pothole region of Alberta, Saskatchewan, Manitoba, and the northcentral United States and provides critical breeding and migration habitat for many waterfowl and priority grassland bird populations (Canadian Prairie Partners in Flight 2004). Canadian Breeding Bird Survey trend data indicate that grassland bird populations in BCR 11 have declined at an average rate of 1.5% per year (1968–2006; Downes and Collins 2007). These long-term population declines have been attributed to the loss and degradation of natural grassland habitats (Houston and Schmutz 1999, Vickery et al. 1999, Smith and Radenbaugh 2000).

North American bird conservation programs have typically been aimed at individual taxonomic groups such as shorebirds, neotropical migrant land birds, or waterbirds, each with separate objectives. For example, effort in the Canadian prairie-parkland region has focused primarily on increasing waterfowl populations to the average levels recorded in the 1970s through the North American Waterfowl Management Plan (NAWMP), which was established in 1986 (Anderson et al. 1995, Williams et al. 1999). More recently, the development of the North American Bird Conservation Initiative has fostered greater awareness for grassland bird conservation, specifically for birds listed as species of conservation concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and Canadian Prairie Partners in Flight. BCRs provide a common geographic basis for the development of plans by conservation agencies and for the delivery of integrated conservation initiatives for all bird species (Canadian Prairie Partners in Flight 2004).

Currently, predictive waterfowl distribution models and digital land cover map products are tools that are used by waterfowl researchers and managers to target management to areas of greatest waterfowl potential within the prairie pothole region (Ducks Unlimited Canada and Institute for Wetland and Waterfowl Research 1999, Ducks Unlimited Canada 2000). However, similar large-scale predictive models are lacking for most grassland bird species. Because many populations of these species are apparently declining throughout BRC 11, it is timely to determine the extent to which habitat planning and activity in areas of high priority for ducks contribute to habitat and conservation goals for other grassland species.

Therefore, our objective was to describe grassland bird community composition and abundance in relation to landscape-level habitat characteristics among areas of differing predicted duck densities in southern Saskatchewan. Few studies have examined the relationship between the grassland bird community and landscape structure across an agricultural mosaic within the mixed-grass prairie; the value of the remaining grassland habitat to grassland birds is not well known (Coppedge et al.

2001, Bakker et al. 2002, Fletcher and Koford 2002). Because the duck community that breeds in this area has diverse habitat and large area requirements, we hypothesized that ducks could function as an umbrella guild of overall breeding habitat quality for other grassland bird species (Simberloff 1998, Chase et al. 2000, Suter et al. 2002, Koper and Schmiegelow 2006*a*). More specifically, we assessed whether Northern Pintail (*Anas acuta*) may be a reliable indicator for other grassland endemics, given that its habitat requirement for open grassland may overlap with those of other grassland bird species (Landres et al. 1988, Noss 1990, Chase et al. 2000). Northern Pintail recovery in the prairie region is currently a primary goal of several agencies, with the focus of habitat conservation efforts in key areas because continental populations have failed to reach levels set by NAWMP (Miller and Duncan 1999, Podruzny et al. 2002).

The landscapes that we examined were typically dominated by dry-land agriculture (i.e., cropland) interspersed with small wetlands and remnant patches of grassland and other natural habitats, e.g., trees and shrubs. The extent to which waterfowl and other grassland bird species co-occur may be strongly influenced by the amount and configuration of suitable habitat (Coppedge et al. 2001, Fletcher and Koford 2002). Therefore, waterfowl and other grassland bird species that share common habitats may be affected in similar ways by processes such as habitat fragmentation, resulting in covariation in patterns of bird abundance and species richness. Alternatively, it is possible that duck habitat quality does not adequately account for the specialized habitat requirements of some COSEWIC-listed grassland songbirds (Koper and Schmiegelow 2006*a*). We determined the strength of correlations between ducks and other grassland birds and examined how the species richness and abundance of three grassland bird groups differed among various duck density strata.

METHODS

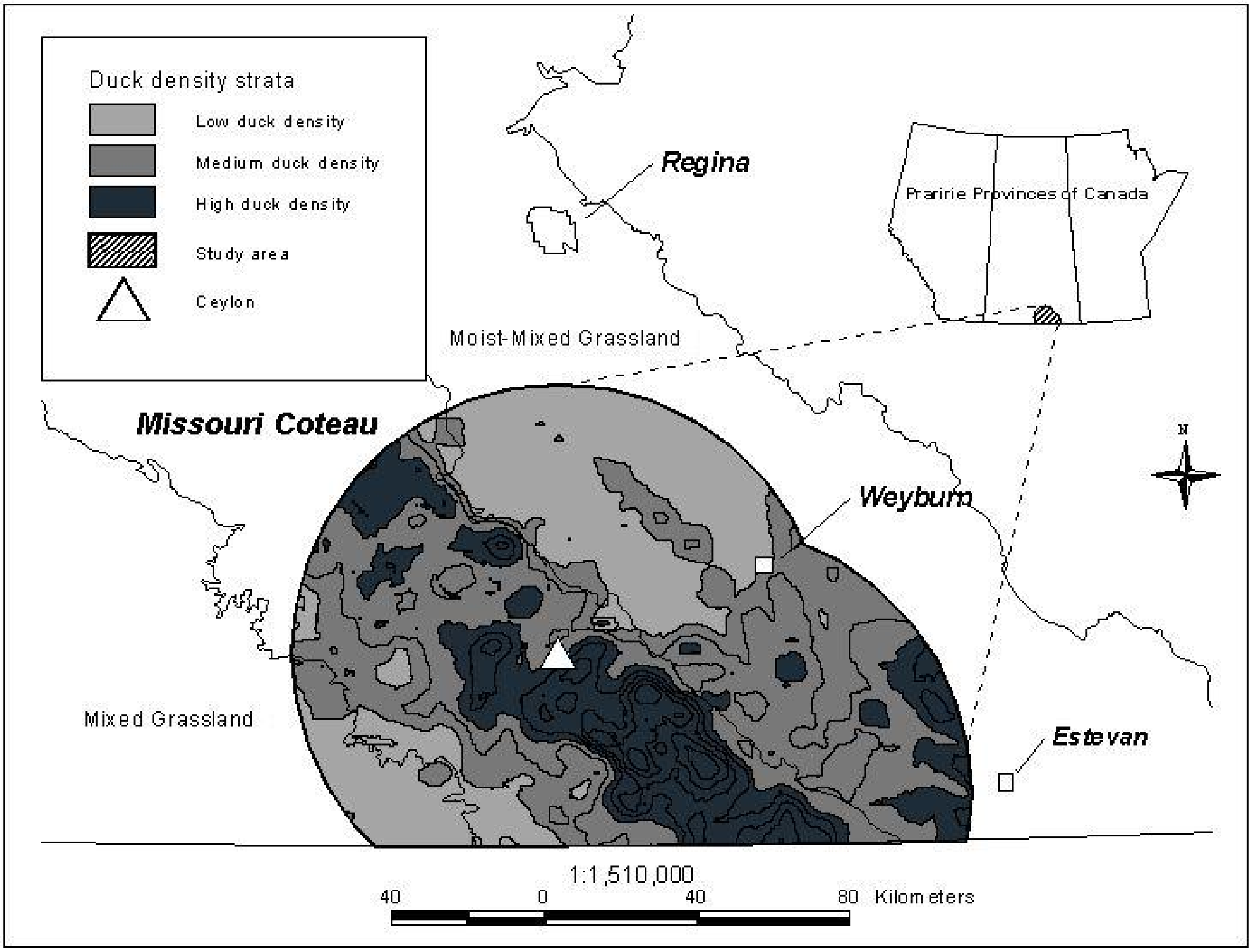
The study was conducted approximately 100 km south of Regina and overlapped the southeastern portion of the Missouri Coteau in southcentral Saskatchewan (49º23’ N, 104º39’ W; Fig. 1). The area is located between the moist-mixed and mixed grassland ecoregions of the prairie ecozone (Acton et al. 1998) and includes a wide range of predicted waterfowl breeding densities, i.e., from < 8 to > 40 pairs/km²). The study area encompasses approximately 16,500 km² and consists mainly of cropland (65%). Native grassland (23%), water bodies (5%), and low percentages of tame pasture, shrubs, trees, and farmland make up the remaining area. A detailed description of the study area is given by Skinner (2004).

Bird surveys

We used the Predicted Waterfowl Breeding Distribution for the Canadian prairie pothole region (Ducks Unlimited Canada and Institute for Wetland and Waterfowl Research 1999) as a basis to compare grassland bird community composition and coarse-level habitat characteristics among areas of differing predicted duck density. This color-coded GIS-based regional conservation map product was created in 1999 and displays the spatial distribution of 10 classes of predicted waterfowl pair density ranging from < 4 to > 38 pairs/km² across the prairie and parkland ecoregions of Alberta, Saskatchewan, and Manitoba. The abundances of five dabbling duck species, i.e., Mallard (*Anas platyrhynchos*), Blue-winged Teal (*Anas discors*), Northern Pintail, Northern Shoveler (*Anas clypeata*), and Gadwall (*Anas strepera*), and two diving duck species, i.e., Canvasback (*Aythya valisineria*) and Redhead (*Aythya americana*), were modeled as a function of the total number of wetlands, Canadian Land Inventory Capability for Waterfowl, and open marsh area based on long-term United States Fish and Wildlife Service and Canadian Wildlife Service air-ground waterfowl survey data. The predicted densities derived from survey segment-level information were assigned to each quarter-section (2.59 km²) within a 46-km² land-surface window and then interpolated over the entire region.

To survey grassland songbirds, we conducted point count transects from the last week in May to the second week in July in 2001 and 2002, following standard Breeding Bird Survey (BBS) protocols (Peterjohn 1994). To allow for simple comparisons of bird and habitat data across contrasting predicted duck densities, BBS-style transects (hereafter, routes) were distributed according to a random stratified design at three levels of predicted waterfowl breeding density: low (< 8 pairs/km²), medium (> 8 to < 15 pairs/km²) and high (> 15 pairs/

Fig. 1. Location of the study area, overlapping the southeastern portion of the Missouri Coteau in southern Saskatchewan, Canada. Duck density: low, < 8 pairs/km²; medium, 8–15 pairs/km²; high, > 15 pairs/km².



km²) duck density strata within the study area (Fig. 1). We surveyed 41 routes in 2001 (low: 11; medium: 15; high: 15) and 33 routes in 2002 (low: 12; medium: 10; high: 11). To reduce systematic biases, route allocation was assigned randomly, with two observers surveying roughly the same number of routes in each density stratum each week. Surveys began 0.5 h before and ended 4 h after sunrise (0830 to 0900) on days with light to moderate winds (< 30 km/h) and little precipitation. Transects were 32 km long, with 40 stops at 800-m intervals. Each observer recorded all birds seen and heard within a 400 m radius plot for 3 min so that the bird abundance data were consistent with local BBS route data.

Bird abundance data were reduced to a core group each year by excluding rare species (i.e., species that occurred on < 20% of all survey routes each year), species that are sampled poorly using roadside survey techniques (e.g., gulls, grouse, owls), and colonial species. We classified all core species into three key grassland bird categories to compare grassland bird communities among the duck density strata: all core duck species encountered; all core species other than those included in the duck and priority species groups, categorized as "common," and; endemic species identified by the Committee On the Status of Endangered Wildlife in Canada or Canadian Prairie Partners in Flight as species of concern within Bird Conservation Region 11, classed as "priority" (Table 1).

Distance sampling

Abundance estimates based on a fixed radius > 100 m are not reliable for most priority species, e.g., Baird's Sparrow (*Ammodramus bairdii*), because of low detection rates, e.g., subtle songs and cryptic colouration and behavior. Differences in detection probabilities among species may affect priority-species–habitat associations (Buckland et al. 2001, Diefenbach et al. 2003, Skinner 2004). Therefore, distances to visually detected birds from observers were estimated with aid of a Bushnell Yardage Pro 500® laser range finder (accuracy of ± 1 m up to 500 m distance) for all prairie breeding shorebirds and all passerines except blackbirds and corvids to improve abundance estimates for priority species (Table 2). Distances estimated for birds that were detected aurally proved unreliable and were not included in subsequent analyses.

We collected insufficient visual distance estimates to calculate species-specific detection probabilities (P_a) because the numbers of most priority species were low compared to common grassland bird species; for example, Nelson's Sharp-tailed Sparrow (*Ammodramus nelsoni*) was not expected in the study area (Skinner 2004). Consequently, visual detections based on the level of contrast in plumage coloration or pattern, body size, or display behavior were used to estimate P_a using DISTANCE version 3.5 software (Thomas et al. 1998) for nine conspicuous species, e.g., Lark Bunting (*Calamospiza melanocorys*) and Western Meadowlark (*Sturnella neglecta*), and six inconspicuous species, e.g., Baird's Sparrow and Grasshopper Sparrow (*Ammodramus savannarum*). The maximum radial distance within which inconspicuous species were detected visually after data truncation was 90 m. The P_a of conspicuous species within 90 m was ~0.45 and that of inconspicuous species was ~0.36 (Skinner 2004). Accordingly, all priority species counts were classed as conspicuous or inconspicuous and adjusted by a correction factor of 2.25 or 2.75, respectively (Table 2). Counts of Swainson's Hawk (*Buteo swainsoni*) and Northern Harrier (*Circus cyaneus*) were not adjusted.

Landscape composition and configuration

We quantified the landscape composition and spatial configuration (i.e., landscape structure) using 10 land-cover classes within a 400 m radius from the center of each stop on each route (i.e., landscape scale) surveyed in 2001 and 2002. Digital land-cover information along all routes was based on classified Landsat Thematic Mapper-7 satellite images collected from 1993 to 1995 and was verified and manually updated during visits to all stops each year. Digital land-cover grid images were converted to vector polygons using Spatial Analysis version 2.0. The area (nearest 1 ha) of all land-cover classes, total number of patches, mean patch size, total edge length, and mean core area were calculated using Patch Analyst version 2.2 (Elkie et al. 1999) of ArcView 3.2 desktop GIS (Environmental Systems Research Institute, Redlands, California, USA). We defined a habitat patch as a discrete area of contiguous land cover characterized by a distinct polygon boundary (i.e., habitat edge), with a minimum resolution (i.e., patch grain) of 0.09 ha within the 400 m radius around each point count stop (McGarigal et al. 2002). Typically, measures of landscape fragmentation are the number of habitat patches and mean patch size, although they are negatively correlated. Larger patch size reflects a more homogeneous landscape (Coppedge et al. 2001). However, we could not reliably separate true grassland fragmentation effects from habitat heterogeneity; in landscapes with greater occurrence of wetland or shrubby areas, these habitat patches dissected larger patches of native grassland, producing higher apparent fragmentation than in landscapes with fewer wetland or shrubby areas. The mean core area is defined as the area within a given habitat patch located > 100 m from a polygon edge within each 400-m buffer (Helzer and Jelinski 1999, Saab 1999, Coppedge et al. 2001). Core area is considered relatively free from edge effects and is associated with the population viability of area-sensitive species (Andrén 1994, Gustafson 1998, McGarigal et al. 2002). The total edge length reflects patch shape; greater edge length indicates patches that have a higher edge-to-interior ratio and a more

Table 1. Status and expected occurrence of 12 endemic grassland bird species of high conservation priority that were present in all three predicted waterfowl breeding density strata (low, < 8 pairs/km²; medium, 8–15 pairs/km²; high, > 15 pairs/km²) and detected on > 20% of survey routes in southern Saskatchewan in 2001 and 2002.

		Priority		
Common name	Scientific name	CPPIF[†]	Primary endemic[‡]	Expected in study area[§]
Baird's Sparrow[¦]	*Ammodramus bairdii*	X	X	X
Bobolink[¶]	*Dolichonyx oryzivorus*	X		X
Chestnut-collared Longspur[¦]	*Calcarius ornatus*	X	X	X
Grasshopper Sparrow[¦]	*Ammodramus savannarum*	X		X
Lark Bunting[¶]	*Calamospiza melanocorys*	X	X	X
Le Conte's Sparrow[#]	*Ammodramus leconteii*	X		X
Marbled Godwit[¶]	*Limosa fedoa*		X	X
Nelson's Sharp-tailed Sparrow[¦]	*Ammodramus nelsoni*	X		Uncommon
Northern Harrier[††]	*Circus cyaneus*	X		X
Sprague's Pipit[¦,‡‡]	*Anthus spragueii*	X	X	X
Swainson's Hawk[††]	*Buteo swainsoni*	X	X	X
Wilson's Phalarope[¶]	*Phalaropus tricolor*		X	X

[†]Priority species as identified by Canadian Prairie Partners In Flight (CPPIF) based on national supervisory responsibility rank, population trends, and species vulnerability.
[‡]Primary endemic grassland bird species as identified by Mengel (1970). These species have narrow environmental tolerances and are historically restricted to the prairie grassland ecoregion.
[§] Core range overlaps with the study area.
[¦]Inconspicuous species: counts were multiplied by detection correction factor of 2.75.
[¶]Conspicuous species: counts multiplied by detection correction factor of 2.25.
[#]Le Conte's Sparrow was not included in analyses for 2002 because it was encountered on < 20% of survey routes.
[††]Original count data were used.
[‡‡]Listed as a threatened species by the Committee On the Status of Endangered Wildlife in Canada.

Table 2. Parameter estimates and SEs derived from linear mixed models for the species richness and abundance of three key grassland bird groups encountered at point count stations along transects in southern Saskatchewan in 2001 and 2002.

	Duck density stratum†					
	Low		Medium		High	
Parameter	Estimate	SE	Estimate	SE	Estimate	SE
Duck species richness	0.14	0.09	0.51	0.08	1.20	0.08
Duck species abundance	0.40	0.50	1.97	0.48	4.99	0.48
Priority species richness	0.76	0.09	0.62	0.08	0.69	0.08
Priority species abundance	3.33	0.45	2.71	0.43	3.06	0.42
Common species richness	4.43	0.20	5.72	0.19	6.15	0.19
Common species abundance	9.42	0.62	13.08	0.59	13.48	0.59

Note: Estimates account for random effects of route.

†Predicted waterfowl breeding densities were classified into three strata: low, < 8 pairs/km²; medium, 8–15 pairs/km²; high, > 15 pairs/km². The numbers of routes per stratum are provided in Table 3.

convoluted shape (McGarigal et al. 2002). The proportion of edge habitat may affect reproductive success or bird behavior (i.e., attract or repel individuals; Helzer and Jelinski 1999, Graham and Blake 2001).

We also calculated the Shannon-Wiener (H') diversity index to describe the diversity or heterogeneity of habitat patches within a 400 m radius of each stop point (Flather and Sauer 1996, Gustafson 1998, Lichstein et al. 2002). Stops or routes with fewer, more contiguous habitat patches have a low habitat diversity index, whereas stops or routes with multiple habitat types within the delineated boundaries have a high habitat diversity index. We did not report patterns at finer scales (e.g., 200 m radius) because of strong correlation among habitat variables at scales up to 400 m in radius (Browder et al. 2002, Fletcher and Koford 2002). Detailed habitat descriptions are given by Skinner (2004).

Statistical analysis

Associations between total abundance and total species richness of other grassland bird species (i.e., priority and common core species) and the seven duck species that were used to create the model for the predicted waterfowl breeding distribution were assessed using Pearson's product-moment correlation and linear regression for each year. To improve the normality and homogeneity of variance, duck count data were square-root transformed (Zar 1999). We also investigated whether total pintail abundance was correlated with total priority species abundance and richness. Lastly, we conducted correlation analyses within each duck density stratum to determine whether associations between duck species and other grassland bird species were consistent among the strata.

Stratum-level species richness for all core ducks, priority, and common species encountered along stops in both years were estimated using rarefaction procedures, using the computer program EstimateS (Colwell 1997). Rarefaction is a statistical method that estimates expected species richness based on multiple random sampling from the complete data set (James and Rathbun 1981). Count data from each duck density stratum in each year were resampled 100 times without replacement, and expected richness was plotted. We also used this technique to determine the minimum sample effort (i.e., number of stops) required to estimate species richness to within 5% of the maximum number of species detected per stratum for each key bird group.

We used linear mixed models (PROC MIXED; SAS Institute 2004) to account for the hierarchical structure in the data (i.e., variation among routes within strata) and to test for random nested effects. We tested whether species richness and total abundance (stop level) of each bird group differed among duck density strata and year, and whether patterns of variation among strata were consistent between years. Counts of zero ducks and priority species were frequent; square-root transformation and multinomial classification did not improve normality, so raw count data were used. The Bonferroni pairwise comparison was used to perform a posteriori contrasts of stratum-level marginal means when mixed models indicated significant stratum-level effects; this method adjusts the observed significance level to account for multiple comparisons (Rice 1989, SAS Institute 2004).

Finally, we conducted full-factorial multiple analysis of variance (MANOVA) with 2001 and 2002 route-level habitat variables to determine if the percent habitat composition and landscape structure differed among duck density strata. All correlations and MANOVAs were performed using SPSS version 11.0.1 (SPSS 2001).

RESULTS

Duck and grassland bird associations

In total, we recorded 63 core species on 74 routes (2797 stops) in 2001 and 2002. In general, moderate, positive route-level correlations were found between total duck and total grassland bird (i.e., common and priority groups) species abundance and richness across all duck density strata in both 2001 and 2002 (species richness: 2001: $r = 0.57$, $n = 41$, $P < 0.001$; 2002: $r = 0.69$, $n = 33$, $P < 0.001$; abundance: 2001: $r = 0.41$, $n = 41$, $P = 0.008$; 2002: $r = 0.37$, $n = 33$, $P = 0.032$; Fig. 2). In all cases, the explained variation among these associations was low to moderate, with r^2 between 0.14 and 0.48 (all $P < 0.03$). Total priority bird species richness was moderately correlated with total pintail abundance in both years (2001: $r = 0.34$, $n = 40$, $P = 0.033$; 2002: $r = 0.42$, $n = 33$, $P = 0.016$). However, there was no relationship between the abundances of pintails and priority grassland species (2001: $r = 0.14$, $n = 40$, $P = 0.34$; 2002: $r = 0.039$, $n = 33$, $P = 0.83$).

Overall, ducks and other grassland bird species tended to be positively correlated at the route level in the duck low- and high-density strata, but there was little route-level correlation in the medium-density stratum. Positive correlations between duck and other grassland bird species richness were found in the low-density stratum in both years (2001: $r = 0.70$, $n = 11$, $P = 0.017$; 2002: $r = 0.69$, $n = 12$, $P = 0.013$) and in the high-density stratum in 2001 ($r = 0.52$, $n = 15$, $P = 0.047$). Similarly, the abundances of duck and other grassland bird species were correlated in the high-density stratum in both years (2001: $r = 0.56$, $n = 15$, $P = 0.031$; 2002: $r = 0.67$, $n = 11$, $P = 0.024$). In 2001, only total priority species richness and abundance were positively correlated with pintail abundance in the low-density stratum (species richness: $r = 0.61$, $n = 12$, $P = 0.045$; abundance: $r = 0.73$, $n = 11$, $P = 0.011$).

Relationships between duck density strata and key bird groups

In both years, the estimated core duck species richness was greater in the duck medium- and high-density strata than in the low-density stratum (Fig. 3A and Table 2; PROC MIXED, Bonferroni comparisons, all $P < 0.002$). In all cases, the number of stops needed to adequately estimate duck species richness was exceeded. The total duck abundance varied among and within the duck density strata (PROC MIXED, $F_{1, 2720} = 41.21$, $P < 0.001$). More ducks were encountered in the high- than in the medium-density stratum and in the medium- than the low-density stratum, regardless of year (Bonferroni comparisons, all $P < 0.022$). Interaction effects between stratum and year were not detected in these or the analyses described next (PROC MIXED, all $P > 0.07$).

Fig. 2. Route-level relationships between the seven duck species used to create the model for the predicted waterfowl breeding distribution and all other grassland bird species encountered along point transect routes in southern Saskatchewan in 2001 (49 species) and 2002 (45 species). (A) Total number of common and priority species per route as a function of total duck species per route. (B) Total abundance of common and priority species per route as a function of total duck abundance per route. Symbols indicate predicted waterfowl breeding density.

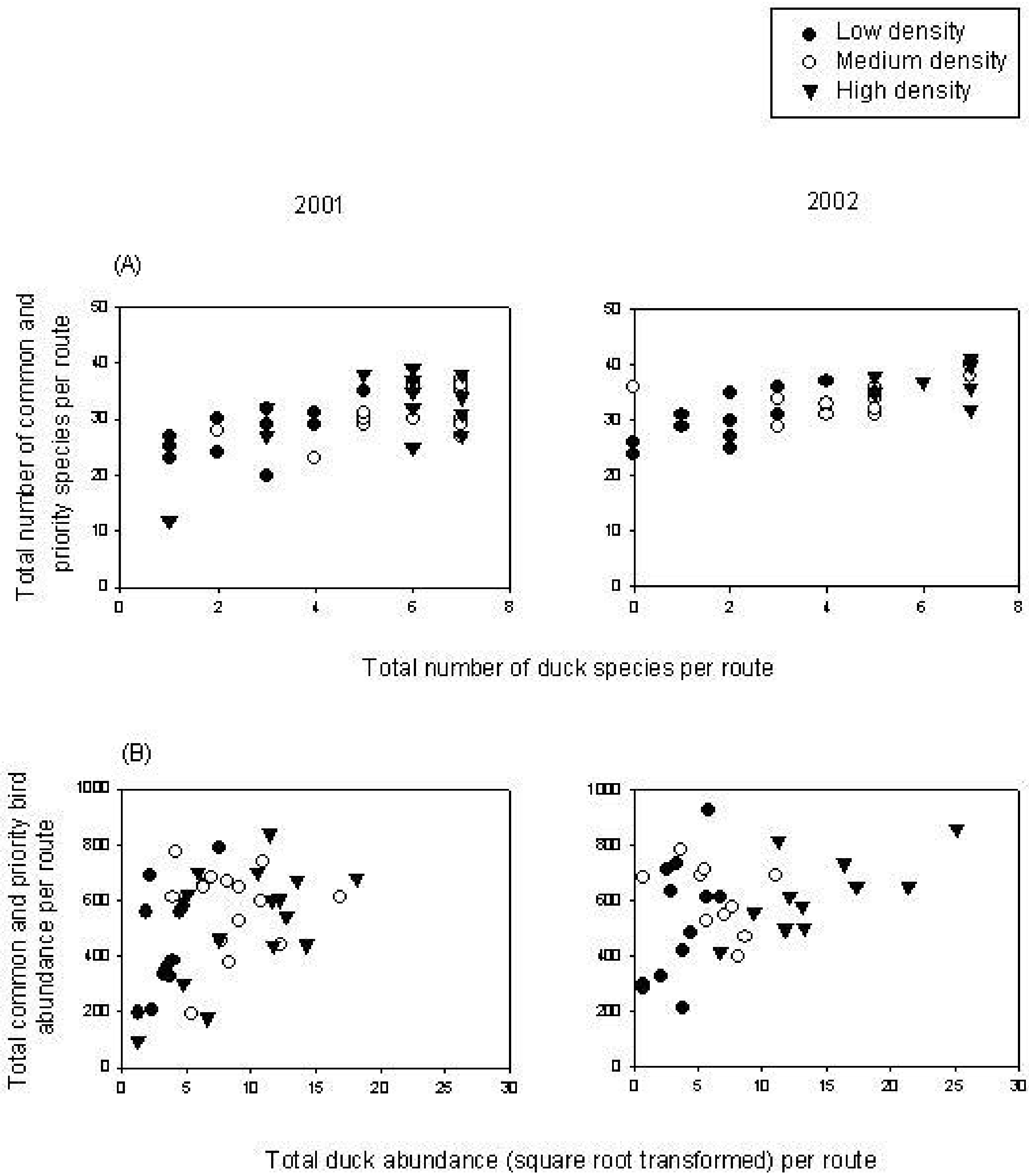
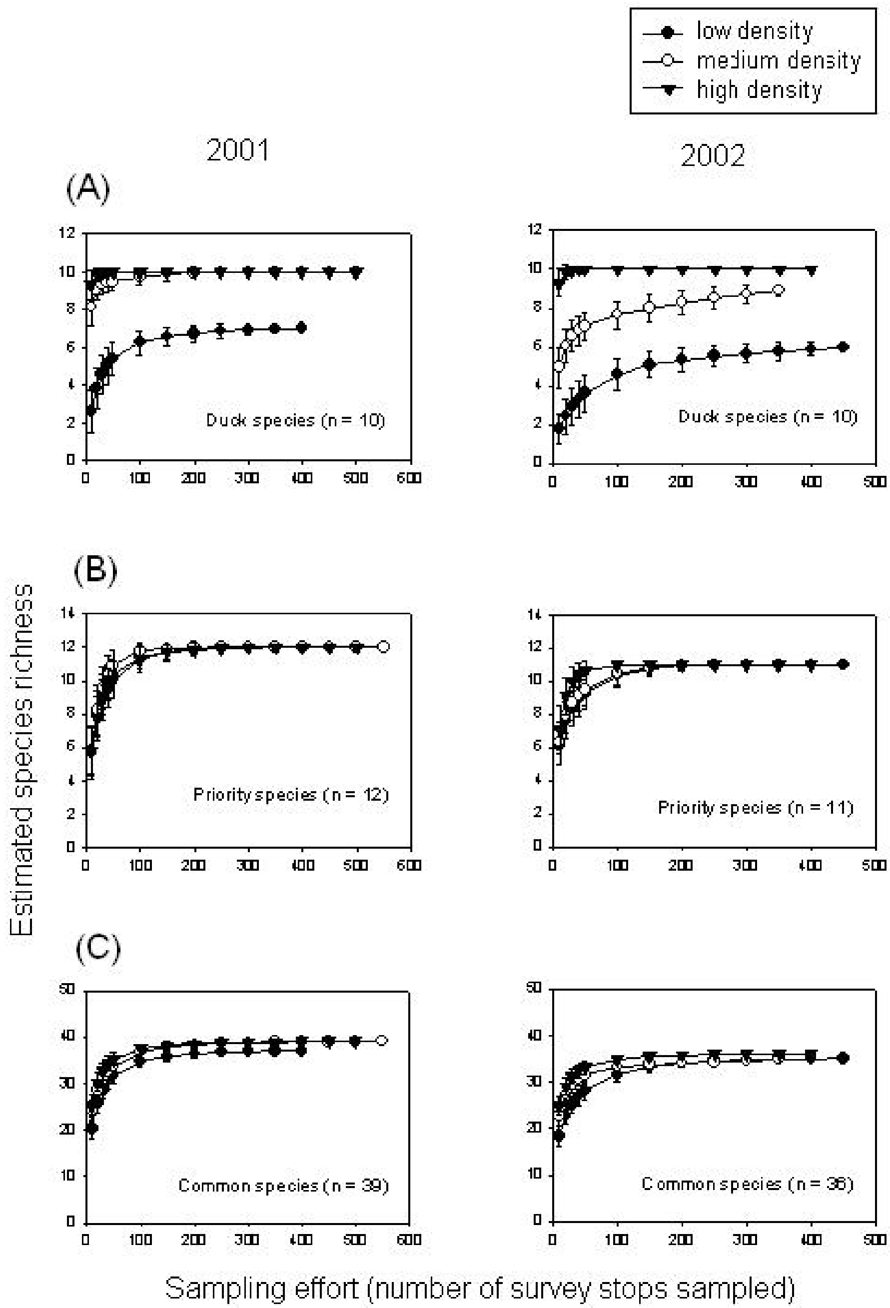


Fig. 3. Rarefaction curves for three key groups of grassland bird species encountered along point transect routes in southern Saskatchewan in 2001 and 2002: (A) duck species, (B) priority grassland bird species, and (C) common grassland bird species. Curves indicate the estimated sample species richness (± SD) detected with increasing numbers of survey stop points along routes in low (< 8 pairs/km²), medium (8–15 pairs/km²), and high (> 15 pairs/km²) predicted waterfowl density strata, indicated by symbols. Note that the scale of the y-axis differs among bird groups.



Sampled areas of differing duck density supported approximately equal numbers of priority species in 2001 and 2002. A minimum of 115 stops was required to obtain reliable estimates of species richness (95% of the maximum) in all duck density strata both years (Fig. 3B). Priority species abundance (corrected for detection differences) among routes within strata was higher in 2002 than in 2001 (PROC MIXED, $F_{1, 2723} = 4.75$, $P = 0.029$). In both years, total priority species abundance was similar among and within strata.

The richness of common species was greatest in the high- and medium-density strata compared to the low-density stratum, regardless of year, but more common species were recorded in 2001 than in 2002 (stratum-level Bonferroni comparisons, all $P < 0.001$; PROC MIXED, year-level $F_{1, 2723} = 8.16$, $P = 0.004$; Fig. 3C). Greater sampling effort was required in the duck low-density stratum than in the medium- or high-density strata in both years, but < 200 stops were required to reach 5% of the maximum species in all three strata each year. In both years, more birds of common species were encountered in the high-density than in the low-density stratum (Bonferroni comparisons, all $P < 0.001$), and within-stratum variation was evident (PROC MIXED, $F_{1, 2723} = 13.43$, $P < 0.001$).

Habitat composition and configuration

The duck density strata differed with respect to the 10 habitat variables (MANOVA, Wilk's Lambda = 0.11, $df = 34$, $P < 0.001$; Table 3). Specifically, the landscape within the duck high-density stratum was more heterogeneous and contained a greater number of smaller, irregular-shaped habitat patches (i.e., greater total edge and lower mean core area), greater areas of perennial forage (for hay or silage production; predominantly alfalfa), shrub (e.g., snowberry, saskatoon, buffaloberry, and willow), wetland (intermittent water bodies, areas that have semi-permanent or permanent wetland vegetation, including marshes), and open water (lakes, rivers, streams, ponds, and dug-outs) compared to the low- and medium-density strata (Bonferroni comparisons, all $P < 0.016$). In contrast, the low-density stratum contained larger, more uniformly shaped habitat patches and a greater proportion of cropland (seeded annually for crops or in summer fallow) compared to the medium- and high-density strata (Bonferroni comparisons, all $P < 0.015$).

DISCUSSION

Ducks were moderately successful as an indicator or umbrella guild for the abundance and species richness of other grassland bird species; this approach may facilitate the initial selection of areas of high conservation value for multiple grassland bird species, but will not directly benefit the development of priority species conservation plans (Kerr 1997, Poiani et al. 2001, Koper and Schmiegelow 2006*a*). This conclusion stems from two main lines of evidence. First, there was moderate covariation in patterns of measured duck and other grassland species (i.e., priority and common species) richness and abundance, but > 50% of the variation between grassland bird and duck species was not explained (Fig. 2) at the route-level spatial scale. One plausible explanation is that habitat features other than wetland area, which is a good predictor of duck density, affect the distribution of common and priority grassland bird species. Koper and Schmiegelow (2006*a*) attributed the low correlation between duck and upland songbird richness in grasslands of southern Alberta to differences in habitat selection and use by both groups. They found that upland songbirds generally avoid cropland, wetland edges, and roads, whereas the amount of wetland edge positively influenced duck densities.

Likewise, associations between the abundances of pintails and other priority grassland species were generally weak because the occurrence of most endemic grassland species is not related to wetland habitat or cropland. Rather, native grassland or other perennial cover and patch size are stronger determinants of endemic grassland bird abundance and nest success (Ribic and Sample 2001, Herkert et al. 2003, Skinner 2004, but see Koper and Schmiegelow 2006*b*).

Overall, stronger positive correlations in abundance and species richness between duck and other grassland bird species were observed within duck high- and low-density strata compared to associations in areas of moderate duck density. These stratum-specific trends may reflect differences in the habitat composition and configuration among duck density strata. In the low-density stratum, habitat other than large expanses of dry cropland or native pasture (native dominant grasslands that may contain tame pasture) was limited; consequently, the grassland bird community tended to coexist in the remaining suitable habitat,

Table 3. Route-level summary statistics (mean ± 1 SE) for landscape attributes measured along each transect in southern Saskatchewan in 2001 and 2002.

		Duck density stratum[†]		
Landscape attribute	Variable	Low (*n* = 23 routes)	Medium (*n* = 25 routes)	High (*n* = 26 routes)
Land cover class (%)	Cropland	74.7 ± 4.4	73.8 ± 2.9	59.9 ± 3.0
	Forage	2.5 ± 0.6	4.65 ± 0.7	7.0 ± 0.8
	Native dominant grassland	17.0 ± 3.7	11.9 ± 2.2	18.2 ± 2.5
	Pasture	2.0 ± 0.4	2.6 ± 0.4	2.7 ± 0.4
	Shrub	0.8 ± 0.2	0.8 ± 0.1	2.2 ± 0.3
	Tree	0.2 ± 0.1	0.1 ± 0.0	0.2 ± 0.0
	Wetland	1.2 ± 0.2	3.4 ± 0.2	6.2 ± 0.4
	Open waterbody	0.3 ± 0.1	0.7± 0.2	1.7 ± 0.3
	Other land	1.1 ± 0.2	1.5 ± 0.2	1.2 ± 0.1
	Mud/sand/saline	0.2 ± 0.1	0.5 ± 0.2	0.7 ± 0.1
Landscape structure	Heterogeneity index	0.7± 0.1	0.9 ± 0.1	1.2 ± 0.1
	Number of habitat patches	213 ± 27	361 ± 38	720 ± 87
	Mean patch size (ha)	12.2 ± 1.7	6.5 ± 0.6	3.3 ± 0.3
	Total edge length (m)	199,013 ± 12,338	261,432 ± 11,285	375,685 ± 27,478
	Mean core area (ha)	13.6 ± 1.0	9.2 ± 0.5	4.9 ± 0.3
	Number of native patches	44.4 ± 7.2	50.3 ± 10.7	93.0 ± 12.8
	Mean native patch size (ha)	7.0 ± 1.4	6.1 ± 1.0	4.0 ± 0.4
	Mean native core area (ha)	5.3 ± 0.9	3.9 ± 0.9	1.6 ± 0.3

Note: Landscape attributes were calculated from a 400 m radius buffer around each point count station.

[†]Predicted waterfowl breeding densities were classified into three strata: low, < 8 pairs/km²; medium, 8–15 pairs/km²; high, > 15 pairs/km².

which contained more diverse habitat, including wetlands and perennial cover. In contrast, habitats within the duck high-density stratum were structurally more heterogeneous (i.e., higher beta diversity; Samson and Knopf 1993); thus, ducks and other grassland species may coexist because suitable habitat characteristics are locally available (Skinner 2004).

A second line of evidence is that although the duck high-density stratum generally supported more ducks and common grassland bird species than did the other strata, priority species richness and abundance were similar among and within the strata (Fig. 3B). This suggests that, as expected, local habitat features for nesting and breeding were important determinants of community composition for this bird group (Koper and Schmiegelow 2006*a*, *b*). Within each duck density stratum, priority species most likely inhabited suitable habitat patches. However, we did not examine this association. Annual variation in water levels and weather patterns (Agriculture and Agri-Food Canada 2002, Environment Canada 2007) likely contributed to between-year differences in common species richness and priority species abundance (Skinner 2004).

CONCLUSION

Digital map products designed for duck conservation will only be useful for multispecies grassland bird conservation planning in a general sense, and pintail conservation efforts will not directly benefit several priority species. In the absence of reliable grassland bird abundance or species richness data, conservation actions targeted to areas that support higher duck species richness will likely support greater grassland bird diversity (species richness or abundance). However, adequate essential habitat for a majority of priority upland species of conservation concern such as Sprague's Pipit (*Anthus spragueii*), Chestnut-collared Longspur (*Calcarius ornatus*), and Lark Bunting may not be protected if conservation is focused only in areas of moderate to high wetland density without the consideration of the surrounding landscape composition or configuration. An improved understanding of the effects of habitat structure (i.e., composition and spatial configuration of habitat patches), social interactions, and local predator communities on the distribution, abundance, and breeding success of grassland birds at multiple spatial scales would help to guide future conservation planning efforts.

Responses to this article can be read online at:
http://www.ace-eco.org/vol3/iss1/art1/responses/

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