Research Article

Effects of Habitat Management for Ducks on Target and Nontarget Species

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Abstract

Habitat management for ducks has significant implications for the conservation of other species. We hypothesized that, because of their flagship and umbrella characteristics, upland-nesting ducks might be effective surrogate species for songbird and shorebird conservation in the dry mixed-grass prairie. We tested this by comparing effects of habitat management (cattle grazing deferments and field size), distance to other habitat (water, cropland/forage, roads), and vegetation, on the richness and density of ducks, songbirds, and shorebirds in southern Alberta, Canada. There were no consistently similar responses to these habitat characteristics among ducks, songbirds and shorebirds. Despite their conceptual appeal, ducks are, therefore, unlikely to be good surrogate species for avian conservation in the dry mixed-grass prairie. Habitat managers and conservation planners should empirically validate whether habitat management for ducks positively affects other species, if this is a management objective. Our results suggest that in dry mixed-grass prairie, deferring cattle grazing is likely to increase densities of only lesser scaup but that grazing, in general, can be used by managers to create a heterogeneous habitat that supports many species. (JOURNAL OF WILDLIFE MANAGEMENT 70(3):823–834; 2006)

Key words

Alberta, cattle grazing, dry mixed-grass prairie, ducks, edge effects, field size, shorebirds, songbirds, surrogate species.

Conservation of the northern prairies is of concern because grasslands have undergone significant habitat conversion and are the least protected of any biome (Hoekstra et al. 2005). Accordingly, declines of grassland birds across North America have been dramatic, where over 50% of grassland bird species in the midwestern United States declined by >50% between 1966 and 1993 (Herkert 1995). Habitat management for ducks has had a significant impact on these prairies (Hartley 1994). However, relatively little is known about the effects of habitat management for ducks on songbirds and shorebirds (Ball et al. 1994), particularly in the dry, mixed-grass prairie. The success and growth of collaborative organizations such as The North American Bird Conservation Initiative (NABCI), dedicated to conserving both game and nongame birds, illustrates the need and desire for integrating the conservation of all these avian species (Fitzpatrick 2002). The U.S. Fish and Wildlife Service formally promotes partnerships between organizations to encourage the conservation of multiple species, and it states that major conservation initiatives and joint ventures should benefit other avian species in addition to waterfowl (Fitzpatrick 2002; US Fish and Wildlife Service 2002, 2004). There is a clear need for more research to determine how effective concurrent management for ducks, songbirds, and shorebirds will be.

We hypothesized that management efforts targeted at ducks might benefit other taxa and that ducks might be effective surrogate species for avian conservation in the dry, mixed-grass prairie. The use of surrogate species to represent broader suites of species is common in conservation biology (Noss 1990), but their effectiveness has rarely been validated (Simberloff 1998, Fleishman et al. 2000), and it has been seriously questioned (e.g., Simberloff 1998, Lindenmayer et al. 2002). For example, niche theory suggests that different species are likely to respond to habitat management and ecological conditions in unique ways (Hutto 1998). In addition, umbrella species are typically assumed to have larger home ranges or body sizes than others (Caro and O'Doherty 1999), although large species might actually be less sensitive to fine-scale habitat fragmentation than species with lower dispersal abilities (Wiens 1989). Finally, numerous empirical studies have found surrogate species to be ineffective at encompassing the needs of other species (e.g., Andelman and Fagan 2000, Chase et al. 2000, Lindenmayer et al. 2002).

Despite these known limitations, the continued use of surrogate species in conservation is inevitable because it will never be practical to monitor all species to determine their conservation needs. Therefore, biologists should attempt to refine the application of surrogates to conservation as practically as possible. One means to achieve this may be to use suites of species as surrogates (e.g., Lambeck 1997). This may be particularly efficient where >1 species can be monitored using one sampling method (Hutto 1998, Fleishman 2000). Surrogates might also be relatively effective at conserving ecologically similar taxa. Finally, the potential effectiveness of surrogate species should be based on abundance or demographic data, rather than the more common presence/absence comparisons (e.g. Hutto 1998, Andelman and Fagan 2000), which may contradict detailed analyses (Bonn et al. 2002). Ducks may be good candidates for addressing these suggestions.

Ducks have characteristics of both flagship and umbrella surrogate species. Flagship species attract attention to conservation, whereas the conservation of umbrella species is assumed to conserve other species as well (Caro and O'Doherty 1999, Fleishman et al. 2000). Upland-nesting ducks have relatively large body- and home-range sizes when compared with songbirds and many shorebirds (e.g., Ehrlich et al. 1988, Hill and Gould 1997, Lowther et al. 2001, Mack 2003) and a well-known biology

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(Nudds 1992). Ducks also have low nest densities and success compared with upland songbirds (Greenwood et al. 1995, Prescott et al. 1998). These qualities suggest that the conservation needs of ducks may exceed those of songbirds and shorebirds, and strategies to maintain sufficient quantity and quality of habitat for ducks may, therefore, conserve other birds. Finally, a variety of duck species can be monitored and managed for concurrently, which may broaden habitat conservation goals sufficiently so that many nontarget species are also conserved (Hutto 1998, Lambeck 1997).

Duck management has influenced prairies in part through intensive management and alteration of wetlands to stabilize water depth and increase the number of wetlands containing water. This has been accompanied by the promotion of rotational grazing systems (Anderson et al. 1995). These prevent grazing of some fields early in the growing season, thereby minimizing disturbance to wetlands and nesting ducks and improving range condition (Clarke et al. 1943, Gjersing 1975, Ignatiuk and Duncan 2001). Effects of grazing may vary with field size, but the importance of size of management units, such as fields, is not well understood, for either ducks or non-game species (Weaver et al. 1996, Pasitschniak-Arts et al. 1998). Birds may perceive grassland patches that are separated into small fields as more fragmented than grassland patches containing few, large fields. Cattle may also graze large fields more heterogeneously than small fields (Walk and Warner 2000). Habitat use within fields may also be variable, as predation rates and species densities may vary with distance to habitat edges and roads (Reijnen et al. 1996, Pasitschniak-Arts et al. 1998, Johnson and Igl 2001).

Our objectives were to evaluate 1) whether upland-nesting ducks and songbirds had high richness and density at the same sites, which would suggest that these sites had high conservation value for these species; 2) whether ducks responded to similar habitat characteristics and management as songbirds and shorebirds; and 3) the effects of grazing and field size, including effects of distance to edge and vegetation structure on ducks, songbirds, and shorebirds. The wide range of field sizes around Brooks, Alberta, Canada, offers a unique opportunity to explore these effects, which have not been sufficiently addressed because large fields are so rare (Ball et al. 1994, Pasitschniak-Arts et al. 1998).

Study Area

Our study region encompassed 34 fields within a 111-km (NS) × 125 km (EW) area in southern Alberta, Canada (50°32′03″N, 111°54′57″W), where field was defined as a management unit surrounded by fences or roads. All fields (Table 1) consisted of native, dry mixed-grass prairie habitat. Upland prairie habitat was dominated by needle and thread (*Stipa comata*) and blue grama grass (*Bouteloua gracilis*), but it also included prickly pear (*Opuntia polyacantha*), ball cactus (*Coryphantha vivipara*), and sagebrush (*Artemisia cana*; Guyn and Clark 1999). All fields except one (Kinbrook) also contained wetland basins that had been enhanced between 1950 and 1995, and they were managed by Ducks Unlimited Canada (DUC). Basins contained water throughout the year, but water levels generally declined over the growing season. Kinbrook was adjacent to a reservoir and included similar wetland habitat to that found in other fields. The fringe of all wetlands was dominated by common cattail (*Typha latifolia*), spike rush (*Eleocharis palustris*), or great bulrush (*Scirpus acutus*). We collected data between 2000 and 2002. After our first field season using 24 fields, we used data to conduct a power analysis to determine adequate replication and power (approximately $\beta = 0.8$, $\alpha = 0.1$) for subsequent years of research (Faul and Erdfelder 1992). We subsequently measured songbird, shorebird, and duck density and species richness within 34 fields, up to 145 km apart (Table 1).

Fields ranged from 11 to 3,239 ha (Table 1), and they were located within larger patches of grassland. Fields were either idle, with no cattle grazing; had grazing deferred until after 15 July each year; or were grazed early in the season, between 31 May and 15 July. All grazed fields were managed to allow 50% carryover of vegetation. Because of variation in habitat, topography, soil conditions, etc., this resulted in there being a range of recommended stocking rates (Table 1). Fields were managed consistently for a minimum of 2 years before our study, usually much longer.

Methods

Avian Richness and Density

We used point-count plots (5 min, 100 m) to survey upland songbirds and shorebirds. We stratified samples by distance to wetland and road (Johnson 1999). We, therefore, located plots every 300 m along transects that radiated away from wetlands and roads, to a maximum of 1,100 m away from the wetland or road. In wetland point-count plots, we only surveyed wetland and pond habitats estimated to be within 100 m of the wetland point-count station, and in upland point-counts, we only surveyed upland habitats. Each field contained 1–20 upland plots and 1–4 wetland plots, depending on field size (Table 1). Upland point-count plots were located up to 1,855 m from water, 4,127 m from cropland/forage, and 2,250 m from roads. Wetland plots were located up to 3,941 m from cropland/forage and 2,350 m from roads. We conducted point counts between sunrise and 1000 hours on days with little or no precipitation, when winds were <20 km/hour. We repeated surveys 4–5 times annually in all fields, between 20 May and 5 July. We excluded from analyses birds observed flying high overhead and birds not using the habitat within the plot.

We developed an index of duck density to compare duck and songbird richness and density. We recognize that the presence of adult individuals may not indicate that habitats are productive (Van Horne 1983, Davis and Duncan 1999), and we address effects of habitat management on nest success elsewhere (Koper 2004). Although brood surveys are also useful for indicating habitat quality, we observed too few broods to analyze data statistically. The duck-density survey is intended to measure overall attractiveness of habitat and its suitability for purposes such as foraging, and it enabled us to compare habitat use by adult and subadult ducks, songbirds, and shorebirds using similar sampling methods. We used point counts to record ducks observed on ponds or wetlands, or within 200 m of wetlands. Because wetland point-count plots overlapped with the nearest upland point-count plot, data were not independent. We, therefore, used the maximum number of each duck species recorded in either the wetland or nearest upland point count as the density index for that location. We could not measure shorebird richness and density because we restricted our analyses on shorebirds to those species that could be monitored effectively

Table 1. Dry, mixed-grass prairie fields used to study ducks, songbirds, and shorebirds in southern Alta., Canada, 2000–2002. PC = point count, AUM = animal unit months, Def = deferred, and UNK = unknown.

Field name	Number of PC plots	Grazing	Years idle before[a]	Recommended stocking rate AUM/ha	Size (ha)	Years surveyed
ACHDA 4	10	Def		0.49	427	2000–2002
Bobby hale early	4	Early		0.74	89	2001
Bobby hale deferred	5	Def		0.74	100	2001
Cassils marsh	7	Early		0.74	136	2000–2002
Contra costa	20	Def		0.49	3,239	2000–2002
Edgewood	12	Early		0.49	939	2000–2001
Honess	3	Def		0.49	61	2000–2002
Ketchmark deferred	15	Def		0.59	325	2000–2002
Ketchmark early	12	Early		0.59	414	2001–2002
Ketchmark idle	4	Idle	3	0.00	65	2000–2002
Kinbrook	9	Early		UNK	128	2001
Kitsim deferred	15	Def		0.49	1,303	2001–2002
Kitsim early	16	Early		0.49	1,417	2001
Lake	16	Early		0.49	1,858	2000
Lomond canals	17	Early		0.62	960	2000–2002
Lore Lake	4	Def		1.65	23	2000–2002
Medicine Hat #2	1	Idle	6+	0.00	11	2001–2002
Murray Lake	4	Idle	7	0.00	59	2001–2002
Newell backflood	5	Idle	7	0.00	144	2000–2002
Newell main dam	2	Idle	7+	0.00	30	2000–2002
North Lake	14	Def		0.37	745	2000–2001
Oaklands 1	2	Idle	14+	0.00	12	2000–2002
Oaklands 2 early	15	Early		0.44	428	2000–2002
Oaklands 2 idle	1	Idle	2	0.00	24	2001–2002
Oaklands 3	7	Def		0.44	182	2000–2002
Pheasant Hatchery	2	Idle	6+	0.00	36	2000–2002
Prouty	2	Idle	14+	0.00	32	2000–2002
Reservoir H deferred	4	Def		0.37	55	2000–2002
Reservoir H early	5	Early		0.37	54	2001–2002
Rolling Hills spillway	6	Idle	5	0.00	95	2000–2001
San Diego	14	Def		0.49	858	2000–2002
Stonehill Lake	7	Idle	15	0.00	160	2000–2002
Tilley West	12	Early		0.49	1,162	2001–2002
Tilley O	15	Early		0.49	2,367	2000

[a] Number of years that field was idle before initiation of study. + indicates minimum number of years; previous data not available.

using our methods, such as willets (*Catoptrophorus semipalmatus*). Research methods were approved under the University of Alberta animal care protocol (2000-01C).

Vegetation

We collected structural data describing the upland habitat between 20 June and 15 July of each year, using methods developed by Wiens (1969). We took samples within each point-count plot, along each cardinal direction, at a randomly chosen distance from the center. We placed crossed meter sticks at each sample site, and at the end of each stick, we dropped a metal rod (Wiens pole) vertically. We estimated percentage of bare ground and litter cover for each quarter of the square created by crossing the meter sticks. We recorded the highest decimeter of vegetation and used it as an index of vegetation height because vegetation height was only measured directly in 2001 and 2002. Highest decimeter was correlated with vegetation height ($r = 0.859$). We used the total number of blades of live native grasses contacting the Wiens pole as an index of vegetation density. We also recorded the number of contacts with dead vegetation, but we could not use it in our analyses because it was correlated with litter depth (see below).

We sampled wetland vegetation along 3 transects perpendicular to each wetland. One transect started at the center of the wetland point-count plot, and we randomly selected remaining transects. Transects encompassed the riparian zone, from water's edge to the upland–wetland interface, defined as the boundary between shallow marsh zone and wet-meadow zone, based on vegetative characteristics (Stewart and Kantrud 1971). We measured contact with bare ground, vegetation height, average width of the wetland fringe, and contacts with dead vegetation, at every meter along the transect. We summarized bare ground as the percentage of the meters that contacted bare ground, and we described percentage of dead vegetation by counting contacts with dead vegetation. We calculated the latter index as [(number of contacts with dead vegetation)/(total number of contacts with vegetation)] × 100.

Geographic Information System (GIS) Analyses

We spatially referenced all point-count plots. We estimated the wetland edge length and total wetland area within each field using digitized aerial photographs and ArcGIS 8.2 (ESRI, Redlands, California). We calculated distance from the centers of the point-count plots to water, roads, and cropland/forage using Hawth's Analysis Tools (Beyer 2003) within ArcGIS 8.2. The digital land-use map was derived from Landsat Thematic Mapper (TM; U.S. Geological Survey, Center for Earth Resources Observation and Science, Sioux Falls, South Dakota) images collected between

1993 and 1995, georeferenced using ground control points, and processed using an unsupervised classification into 10 cover classes, including grassland (Prairie Farm Rehabilitation Administration 2002). Image resolution was 30 m. We improved classification accuracy within our study sites through ground-truthing. Updated Road Network (URN) maps indicated locations of roads, accurate within 10 m, at a confidence level of 90% (Centre for Topographic Information 2000). We manually added some wetlands and roads to the digital map.

Statistics

Data summary.—We averaged all data from each point-count plot across surveys within each year before analyses. We summarized and analyzed all data on a per-point-count plot basis. This yielded an index of species richness (per plot), and avian density (number of individuals per point-count plot). We only included species observed in $\geq$15 different point-count plots and $\geq$4 different fields in species-level analyses. Scatter plots of relationships between vegetation and distance to water, road, and cropland/forage showed no evidence of deviations from linear relationships. We, therefore, used only linear models to describe effects of distance to edge. We also examined a correlation matrix of variables included in the statistical models, and we rejected one of any pair of variables with $r > 0.6$. We examined residual plots to ensure assumptions of statistical tests were met (Draper and Smith 1981, Collett 1991). We logarithmically transformed some data to normalize them before analysis.

Index of field size.—Our objective was to evaluate the influence of management unit (field) size on species richness and densities, rather than explore effects of grassland amount. Linear regression indicated that $\log_e$ of field size was significantly related to amount of grassland in a 5-km-radius landscape centered on each field ($R^2 = 0.525$, $P \leq 0.001$). We did not want to incorrectly attribute an effect of amount of surrounding grassland to field size, so we used the residuals of the linear regression of $\log_e$ field size on amount of grassland as an index of field size. Examination of the residual plot suggested that the linear model was appropriate. This index ranged from -1.153 to 0.876 and represented the relative subdivision of existing grasslands into fields. We calculated absolute differences in response variables by comparing largest (least subdivided) to smallest (most subdivided) fields.

Correlations.—We used Pearson's coefficient to determine whether richness and density of ducks and songbirds (shorebirds could not be compared; see above) were correlated (Systat 7.0.1, SPSS Inc. 1997). We averaged data across fields to test whether fields with high duck richness and density had high songbird richness and density. We also used Pearson's coefficient to determine whether smaller fields contained relatively more wetland edge. We calculated the relative amount of wetland edge as (length of wetland edge)/($\log_e$ of field size).

Habitat use and model selection.—We used linear (lme) and generalized linear mixed-effects models (glme) to analyze point-count and vegetation data, depending on the observed distribution of the data, using S-plus 6.2 (Insightful 2001) and R 1.8.1 (R Foundation for Statistical Computing 2003). Mixed-effects models allowed us to analyze data on a per-point-count basis while statistically controlling for the lack of independence of point counts within the same fields, including samples repeated across years, $n = 34$ fields, 190 wetland point-count plots, and 547 upland point-count plots. We used treatment contrasts to compare the relative effects of the 3 grazing treatments. We compared idle and early grazed treatments against deferred fields. We treated field and year as random variables.

Goodness-of-fit tests for glme present a complex problem (Pendergast et al. 1996) and recently developed tests (Zheng 2000, Jiang 2001) are not yet available in standard statistical programs such as S-plus and R. However, the relative fit of different models can be compared (McCullagh and Nelder 1989:119). We, therefore, used Akaike's Information Criterion for small sample sizes (AIC*c*) to select best models (Burnham and Anderson 1998). We grouped variables into habitat management (grazing and field size), distance to other habitat (road, water, and cropland/forage), amount of wetland edge within fields, and local habitat characteristics (vegetation structure; Tables 2 and 3). We could not include recommended stocking rate in these models because it was correlated with grazing treatment (all idle fields had a recommended stocking rate of 0 AUM/ha, where AUM indicates Animal Unit Months, the amount of forage required to sustain a cow and a half for one month).

We presented data from the best model selected using AIC*c* criteria. We did not average model parameters because we were more interested in selecting the best model than in the parameter estimates themselves (Burnham and Anderson 1998). Although all variables in selected models are potentially important, we used P-value comparisons to help interpret relative importance of parameters within selected models on the assumption that parameters with lower P values ($<$0.1) and higher β were more likely to be influential than parameters with higher P values and lower β. This approach was necessary because we did not compare all possible model subsets (Burnham and Anderson 1998);

Table 2. Candidate models for describing vegetation characteristics in point-count plots in southern Alta., Canada, 2000–2002.

		Management		Distance to		
Model	Random field, year	Grazing	Field size	Water	Crop/forage	Road
1	Y[a]	Y	Y			
2	Y					
3	Y	IFS[b]	IG[c]			
4	Y		Y			
5	Y	Y				
6	Y	IFS	IG	Y	Y	Y
7	Y			Y	Y	Y
8	Y	IFS	IG	IG	Y	Y
9	Y	IFS	IG	IG, IFS	Y	Y
10	Y	IFS	IG	IG, IFS	IG	IG
11	Y	IFS	IG	IG, IFS	IFS	IFS
12	Y	IFS	IG	IG, IFS	IG, IFS	IG, IFS
13	Y	IFS	IG			
14	Y					
15	Y	IFS	IG			
16	Y	IFS	IG			
17	Y	IFS	IG			
18	Y	IFS	IG			
19	Y	IFS	IG			
20	Y	IFS	IG	IG, IFS	IG, IFS	IG, IFS

[a] Main effect of this parameter included in the model.

[b] IFS = main effect and interaction with field size included in the model.

[c] IG = main effect and interaction with grazing included in the model.

Table 3. Candidate models for describing duck, songbird, and shorebird density, and avian richness in southern Alta., Canada, 2000–2002. Models were also compared with and without the variable length of wetland edge.

							Local vegetation characteristics							
							Upland vegetation[a]				Wetland vegetation[b]			
		Habitat management		Distance to										
Model	**Random field, year**	**Grazing**	**Field size**	**Water**	**Crop/forage**	**Road**	**Height**	**Density**	**% bare**	**Litter depth**	**Height**	**% bare**	**% dead**	**Fringe width**
1	Y[c]	Y	Y											
2	Y													
3	Y	IFS	IG											
4	Y		Y											
5	Y	Y												
6	Y	IFS	IG	Y	Y	Y								
7	Y			Y	Y	Y								
8	Y	IFS	IG	IG	Y	Y								
9	Y	IFS	IG	IG, IFS	Y	Y								
10	Y	IFS	IG	IG, IFS	IG	IG								
11	Y	IFS	IG	IFS	IFS	IFS								
12	Y	IFS	IG	IG, IFS	IG, IFS	IG, IFS								
13	Y	IFS	IG				Y	Y	Y	Y	Y	Y	Y	Y
14	Y						Y	Y	Y	Y	Y	Y	Y	Y
15	Y	IFS	IG	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
16	Y	IFS	IG	IG, IFS	IG, IFS	IG, IFS	Y	Y	Y	Y	Y	Y	Y	Y
17	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

[a] Upland species only.
[b] Wetland species only.
[c] Abbreviations: Y = main effect, IG = main effect and interaction with grazing, and IFS = main effect and interaction with field size.

therefore, we could not always distinguish which variables resulted in improved model fit. For example, all candidate models that included distance to road also included distance to crop/forage, so distance to road might be incidentally included in a selected model if distance to crop/forage was influential. We, therefore, presented AIC*c*-selected models but emphasize parameters with low *P* values.

Results

We observed 112 species of ducks, shorebirds, and songbirds over 3 years of study. Our sampling years (2000–2002) included some of the driest and wettest on record for the study region. Although the average amount of precipitation (1971–2000) for Medicine Hat, at the east edge of our study area, was 333.8 mm (± SD 88.17), in 2000, it received 214.3 mm; in 2001, it received 148.0 mm; and in 2002, it received 523.8 mm (Environment Canada 2004). There were no consistent correlations between duck and songbird richness and density (Table 4), although wetland songbird richness was negatively correlated with duck richness in 2001 and when all years of data were combined.

Wetland area was highly correlated with wetland edge ($r = 0.977$), and it was, therefore, excluded from models. The density of dead grasses was excluded from the analysis because it was correlated with litter depth ($r = 0.727$). Litter depth, therefore, indicated effects of depth and density of litter and of standing dead vegetation. Recommended stocking rates did not differ between early and deferred fields ($P = 0.280$). Larger fields had proportionally more wetland edge than smaller fields ($r = 0.676$, $P < 0.001$).

Vegetation

Native grasses represented most of the vegetation surveyed. All measured characteristics and interactions had some influence on upland or wetland vegetation (Table 5). Grazing had few effects on wetland vegetation (Table 5). However, upland vegetation density was approximately 25% greater in deferred than early grazed fields (Table 5). Upland and wetland vegetation varied with distance to other habitats, and these effects were often influenced by field size or grazing treatment, particularly in the uplands (Table 5). Upland grass density was higher closer to cropland, decreasing by about 5% per km, with relatively greater effects in smaller fields. Litter depth increased by 0.465 mm, or 5%, per km away from roads, and this effect was greater in smaller and in deferred fields. Upland vegetation was 1 dm higher in the largest compared with the smallest fields. Wetland vegetation was influenced by distance to roads and distance to cropland, although these effects varied with field size and grazing treatment (Table 5). Wetland vegetation was higher closer to roads, by 0.32 cm per km, with this effect being greatest in smaller fields (Table 5).

Table 4. Pearson's correlations between duck and songbird richness and density in 34 dry mixed-grass prairie fields in southern Alta., Canada, 2000–2002.[a]

	Duck			
	Richness		Density	
Songbird guild	***r***	***P***	***r***	***P***
2000: U	0.523	0.009	0.552	0.005
2000: W	−0.274	0.195	−0.251	0.238
2001: U	0.111	0.547	0.084	0.649
2001: W	−0.350	0.049	−0.343	0.054
2002: U	0.310	0.140	0.173	0.418
2002: W	−0.329	0.116	0.109	0.612
All years: U	0.244	0.164	0.147	0.406
All years: W	−0.363	0.035	−0.260	0.137

[a] Abbreviations: U = upland songbirds, W = wetland songbirds.

Table 5. Generalized linear mixed-effects models and parameter estimates for Akaike's Information Criterion, corrected for small sample size AIC*c*-selected models describing vegetation in southern Alta., Canada, 2000–2002. Percent dead wetland vegetation and percent upland bare ground were independent of measured variables.[a]

Habitat	Metric	Family	Model	Parameters with $P < 0.1$	β	SE	*P*
Wetland vegetation	Height (cm)	Poisson	−E + I − FS + E*FS + I*FS − DCF − DR −DCF*E − DCF*I − DCF*FS + DR*FS + DR*E + DR*I	DR	−0.324	0.147	0.030
				DCF*FS	−0.464	0.216	0.034
				DCF*E	−0.225	0.125	0.074
				DR*FS	0.600	0.219	0.007
	% bare ground	Binomial	E − I				
	Fringe width (m)	Poisson	−E − I − FS + E*FS − I*FS − DCF − DR + DCF*E + DCF*I − DR*E + DR*I	DR*I	0.933	0.444	0.038
Upland vegetation	Grass density	Poisson	−E − I + FS + E*FS − I*FS − DW − DCF + DR − DW*FS + DW*E − DW*I + DCF*FS + DCF*E − DCF*I − DR*FS + DR*E − DR*I	E	−0.959	0.315	0.005
				I*FS	−1.769	0.602	0.007
				DCF	−0.263	0.136	0.055
				DW*FS	−0.830	0.366	0.024
				DCF*FS	0.735	0.266	0.006
				DR*E	0.477	0.162	0.003
				DR*FS	−1.097	0.236	<0.001
	Litter depth (mm)	Poisson	E + I − FS − E*FS − I*FS − DW − DCF + DW*FS − DW*E + DW*I + DCF*FS + DR + DCF*E − DCF*I − DR*FS − DR*E − DR*I	I*FS	−1.701	0.583	0.007
				DR	0.465	0.149	0.002
				DW*FS	0.947	0.411	0.022
				DCF*FS	0.908	0.282	0.001
				DR*FS	−0.620	0.267	0.021
				DR*E	−0.405	0.180	0.025
	Height (dm)	Poisson	−E + I + FS − E*FS − I*FS + DW − DCF − DR − DW*FS + DW*E − DW*I	FS	0.489	0.243	0.054
				E*FS	−0.564	0.313	0.082
				I*FS	−0.638	0.324	0.059
				DW*FS	−0.973	0.421	0.021
				DW*E	0.460	0.264	0.083

[a] Abbreviations: E = early grazed, I = idle, FS = field size $\log_e$ (ha), DCF = distance to crop/forage (km), DR = distance to road (km), DW = distance to water (km), * = interaction term.

Effects of Habitat Management and Characteristics

Field size and grazing had few impacts on bird distributions (Tables 6–9). Among species-specific models, only 6 of 31 included grazing and 7 of 31 included field size (Table 6). Grazing and field size influenced only 2 of 12 upland species, and these *P* values exceeded 0.1 (Table 6). However, interactions between field size or grazing, and distance to other habitats, indicated some indirect effects of these habitat management activities on upland

Table 6. Number of Akaike's Information Criterion, corrected for small sample size (AIC*c*)–selected models that included habitat characteristics influencing duck, wetland songbird and shorebird, and upland songbird and shorebird species in southern Alta., Canada, 2000–2002.[a]

	Ducks		Wetland birds		Upland birds	
	Number of selected models	Subset with $P < 0.1$	Number of selected models	Subset with $P < 0.1$	Number of selected models	Subset with $P < 0.1$
Number of species	6		13		12	
Grazing	1	1	3	2	2	0
Field size	1	0	4	2	2	0
Grazing*FS	0	0	3	1	2	1
Distance to water					10	5
Distance to crop/forage	0	0	3	0	10	5
Distance to road	0	0	3	2	10	5
DW*FS					2	2
DCF*FS	0	0	1	0	1	1
DR*FS	0	0	1	1	1	1
DW*grazing					2	1
DCF*grazing	0	0	0	0	2	1
DR*grazing	0	0	0	0	2	2
Width wetland fringe	1	0	10	3		
% dead vegetation	1	0	10	0		
% ground that is bare	1	0	10	3	5	1
Height	1	1	10	7	5	1
Vegetation density					5	2
Litter depth					5	5
Length wetland edge	3	2	3	3	2	2

[a] Abbreviations: FS = field size $\log_e$ (ha), DW = distance to water (km), DCF = distance to crop/forage (km), DR = distance to road (km), * = interaction term.

Table 7. Linear mixed-effects models and parameter estimates for Akaike's Information Criterion, corrected for small sample size (AIC*c*)–selected models describing duck richness and density in southern Alta., Canada, 2000–2002. No selected models included field size*grazing interactions or distance to other habitats. Duck density, mallard (*Anas platyrhynchos*) and northern pintail (*Anas acuta*) distributions were independent of measured variables.[a]

Metric	Transformation	Model	Parameters with $P < 0.1$	β	SE	P
Duck richness	None	−WF − PD − PB − H	H	−0.011	0.005	0.037
Blue-winged teal *Anas discors*	Log_e	WE	WE	0.050	0.028	0.078
Gadwall *Anas strepera*	Log_e	−FS + WE	WE	0.052	0.022	0.026
Lesser scaup *Aythya affinis*	Log_e	−E − I + WE	E	−0.774	0.338	0.029
Northern shoveler *Anas clypeata*	None	−WF + PD − PB − H	H	−0.012	0.004	0.003

[a] Abbreviations: WF = width wetland fringe (m), PD = percentage of dead vegetation, PB = percentage of bare ground, H = vegetation height (cm), WE = length wetland edge (km), FS = field size $\log_e$ (ha), E = early grazed, I = idle, * = interaction term

species (Table 9). Only soras (*Porzana carolina*) had higher densities, by 0.66 individuals per point count, in deferred than in idle fields (Table 8). Lesser scaup (*Aythya affinis*) had 0.77 more individuals per point count in deferred compared with early grazed fields (Table 7), and marsh wrens (*Cistothorus palustris*) had higher densities (0.7 individuals per point count) in early, compared with deferred, fields (Table 8). Only lesser scaup had significantly higher densities in deferred than early fields. Black terns (*Chlidonias niger*) had approximately 6 fewer individuals per point count in the largest, compared with the smallest, fields, whereas barn swallows (*Hirundo rustica*) had densities, on average, of 1.34 more individuals per point count in large fields (Table 8). Ducks did not show consistent responses to habitat characteristics (Table 7).

Distance to other habitats influenced 10 of 12 upland songbird species and influenced songbird abundance and richness (Tables 6 and 9). In contrast, distance to other habitats influenced no duck species and only 3 wetland bird species: black terns, common snipe (*Gallinago gallinago*), and marsh wrens (Tables 7 and 8). *P* values suggest that distance to road had a greater influence on the

Table 8. Linear mixed-effects models and parameter estimates for Akaike's Information Criterion, corrected for small sample size (AIC*c*)–selected models describing wetland bird richness and density in southern Alta., Canada, 2000–2002. No selected models included distance to other habitats*grazing interactions.[a]

Metric	Transformation	Model	Parameters with $P < 0.1$	β	SE	P
Songbird density	None	WF + PD + PB + H	H	0.108	0.026	≤0.001
Songbird richness	None	WF + PD − PB + H − WE	PD	0.006	0.003	0.046
			H	0.013	0.005	0.005
American avocet	Log_e	−WF − PD + PB − H	WF	−0.008	0.005	0.082
Recurvirostra americana			H	−0.028	0.009	0.002
Barn swallow	Log_e	FS − WE	FS	0.674	0.241	0.009
Hirundo rustica			WE	−0.036	0.015	0.025
Black tern	Log_e	E − I − FS − E*FS + I*FS + DCF −	FS	−2.988	0.834	0.001
Chlidonias niger		DR + DCF*FS + DR*FS	DR*FS	0.003	0.001	≤0.001
Brown-headed cowbird	None	WF + PD + PB + H				
Molothrus ater						
Common yellowthroat	Log_e	WF − PD − PB + H − WE	H	0.028	0.009	0.002
Geothlypis trichas			WE	−0.057	0.029	0.058
Common snipe	Log_e	DCF − DR	DR	−0.001	0.0003	0.031
Gallinago gallinago						
Killdeer	Log_e	WF − PD − PB − H	H	−0.037	0.009	≤0.001
Charadrius vociferus						
Marsh wren	None	E − I − FS − E*FS − I*FS + DCF + DR	E	0.700	0.214	0.003
Cistothorus palustris		− WF + PD − PB + H	I*FS	−0.899	0.417	0.040
			DR	0.001	0.0001	≤0.001
			WF	−0.003	0.002	0.096
			H	0.011	0.004	0.004
Red-winged blackbird	None	WF − PD − PB + H	WF	0.008	0.005	0.096
Agelaius phoeniceus			PB	−0.043	0.022	0.050
Sora	Log_e	E − I + FS − E*FS − I*FS + WF − PD + PB + H	E	0.723	0.379	0.066
Porzana carolina			I	−0.663	0.383	0.094
			H	0.031	0.008	≤0.001
Willet	None	WF − PD + PB − H + WE	PB	0.008	0.004	0.058
Catoptrophorus semipalmatus			WE	0.024	0.005	≤0.001
Wilson's phalarope	Log_e	−WF + PD − PB − H	H	−0.025	0.009	0.007
Phalaropus tricolor						
Yellow-headed blackbird	None	−WF − PD + PB + H	PB	0.088	0.040	0.030
Xanthocephalus xanthocephalus			H	0.073	0.020	≤0.001

[a] Abbreviations: WF = width wetland fringe (m), PD = percentage of dead vegetation, PB = percentage of bare ground, H = vegetation height (cm), WE = length wetland edge (km), FS = field size $\log_e$ (ha), E = early grazed, I = idle, DCF = distance to crop/forage (m), DR = distance to road (m), * = interaction term.

Table 9. Linear mixed-effects models parameter estimates for Akaike's Information Criterion, corrected for small sample size (AICc)–selected models describing upland bird richness and density in southern Alta., Canada, 2000–2002. Willet (*Catoptrophorus semipalmatus*) distributions were independent of measured variables.[a]

Metric	Transformation	Model	Parameters with $P < 0.1$	β	SE	P
Songbird density	None	DW + DCF + DR	DW	0.0004	0.0002	0.016
			DCF	0.0003	0.0001	0.001
			DR	0.0003	0.0001	0.020
Songbird richness	None	DW + DCF + DR	DCF	0.0001	0.00002	≤0.001
			DR	0.0001	0.00003	0.098
Baird's sparrow	Log$_e$	DW + DCF + DR	DCF	0.0003	0.0001	0.001
Ammodramus bairdii						
Brown-headed cowbird	Log$_e$	−DW − DCF − DR	DW	−0.0015	0.0002	≤0.001
Molothrus ater			DCF	−0.0002	0.0001	0.065
Chestnut-collared longspur	None	E − I − FS + E*FS + I*FS + DW +	I*FS	1.193	0.681	0.091
Calcarius ornatus		DCF + DR + DW*E + DW*I +	DCF	0.0004	0.0001	0.010
		DW*FS + DCF*E − DCF*I −	DR	0.0004	0.0002	0.019
		DCF*FS − DR*E + DR*I + DR*FS −	DW*FS	0.0012	0.0004	0.010
		D − PB − H − L + WE	DCF*FS	−0.0006	0.0003	−0.032
			DR*E	−0.0007	0.0002	≤0.001
			DR*FS	0.0007	0.0003	0.013
			L	−0.010	0.0039	0.013
	WE	0.027	0.015	0.083		
Clay-colored sparrow	Log$_e$	DW − DCF − DR + D + PB + H + L	DCF	−0.0002	0.0001	0.059
Spizella pallida			DR	−0.0003	0.0001	0.004
			L	0.017	0.006	0.002
Horned lark	None	DW − DCF + DR − D + PB − H − L	DW	0.0005	0.0001	≤0.001
Eremophila alpestris		+ WE	L	−0.012	0.004	≤0.001
			PB	0.005	0.003	0.063
			WE	0.019	0.011	0.077
Long-billed curlew	Log$_e$	−E − I + FS + E*FS + I*FS + DW −	DW	0.0004	0.0002	0.036
Numenius americanus		DCF − DR − DW*E + DW*I −	DW*I	0.0028	0.0007	≤0.001
		DW*FS + DCF*E + DCF*I + DR*E	DW*FS	−0.0006	0.0004	0.077
		− DR*I	DCF*I	0.0005	0.0003	0.085
	DR*I	−0.0008	0.0002	0.002		
Marbled godwit	None	−DW − DCF − DR	DR	−0.0001	0.00004	0.001
Limosa fedoa						
Savannah sparrow	None	D + PB + H + L	D	0.019	0.007	0.010
Passerculus sandwichensis			H	0.033	0.002	0.005
			L	0.011	0.003	≤0.001
Sprague's pipit	Log$_e$	DW + DCF − DR	DW	0.0006	0.0002	0.002
Anthus spragueii			DCF	0.0006	0.0001	≤0.001
Vesper sparrow	Log$_e$	−DW − DCF − DR	DR	−0.0004	0.0002	0.016
Pooecetes gramineus						
Western meadowlark	None	−DW + DCF − DR + D − PB + H + L	DW	−0.0002	0.00004	0.001
Sturnella neglecta			DR	−0.0001	0.00004	0.005
			D	0.019	0.004	0.008
			L	0.004	0.002	0.024

[a] Abbreviations: E = early grazed, I = idle, FS = field size log$_e$ (ha), DW = distance to water (m), DCF = distance to crop/forage (m), DR = distance to road (m), D = vegetation density, PB = percentage of bare ground, H = vegetation height (dm), L = litter depth (mm), WE = length wetland edge (km), * = interaction term.

distributions of these wetland species than distance to crop/forage (Table 8). Overall upland songbird density increased by at least 0.3 individuals per point count per km away from all other habitats, whereas the average number of species per point count increased by 0.1 per km away from cropland/forage and roads (Table 9). Baird's sparrows (*Ammodramus bairdii*), chestnut-collared longspurs (*Calcarius ornatus*), and Sprague's pipits (*Anthus spragueii*) had higher densities by at least 0.3 individuals per point count per km away from cropland/forage (Table 9). Distance to water had a similarly strong influence on upland species. The average number of individuals per point count increased by at least 0.4 per km away from water for Sprague's pipits, long-billed curlews (*Numenius americanus*), and horned larks (*Eremophila alpestris*; Table 9). However, species that select taller or shrubby vegetation, such as western meadowlarks (*Sturnella neglecta*), vesper sparrows (*Pooecetes gramineus*), brown-headed cowbirds (*Molothrus ater*), and clay-colored sparrows (*Spizella pallida*), had higher densities closer to nonprairie habitats (Table 9).

Duck richness decreased by 0.011 species per point count per cm of increase in vegetation height (Table 7), whereas, in contrast, wetland songbird richness increased by 0.013 species per cm of increase in vegetation height (Table 8). Wetland songbird densities were generally positively correlated (5 of 6 species), and shorebird densities were negatively correlated (4 of 6 species), with vegetation height (Table 8). Per 1 cm of increase in vegetation height, densities of common yellowthroats (*Geothlypis* *trichas*) and marsh wrens increased by at least 0.011 individuals per point count, whereas American avocet (*Recurvirostra americana*), killdeer (*Charadrius vociferus*), and Wilson's phalarope (*Phalaropus tricolor*) densities decreased by at least 0.025 individuals per point count. Vegetation structure influenced the distributions of 10 of 13 wetland and 5 of 12 upland species (Tables 6–9). *P* values suggest that, of the vegetation variables, height had the greatest influence on wetland bird (including duck) distributions, whereas litter depth had the greatest influence on upland species (Tables 8 and 9).

Densities of several upland and wetland species were influenced by length of wetland edge. All responses of ducks and upland species to length of wetland edge were positive, whereas other wetland species showed both positive and negative responses. Blue-winged teal (*Anas discors*), gadwall (*Anas strepera*), willet, horned lark, and chestnut-collared longspur densities were higher in fields with greater lengths of wetland edge (Tables 6–9). Barn swallow and common yellowthroat densities were lower in fields with more wetland edge (Table 8). The influence of length of wetland edge was subtle, however, resulting in changes in density of less than 0.057 individuals per point count per km increase.

Discussion

Ducks as Surrogates for Avian Conservation

We found few similarities in habitat use between ducks, songbirds, and shorebirds, and we found little evidence that ducks were more sensitive to habitat characteristics than songbirds or shorebirds. In addition, ducks, songbirds, and shorebirds did not have high densities in the same fields. Few studies have concurrently measured duck and songbird habitat use within the same sites. Naugle et al. (2001) found similar results to ours: ducks avoided wetlands with abundant vegetation whereas nongame species selected for them (see vegetation characteristics discussion, below). Shutler et al. (2000) found that many ducks avoided wetlands with woody margins that were important for some songbirds.

These results suggest that ducks are poor surrogates for upland or wetland songbirds and shorebirds in this system because of differences in habitat selection and use by these taxa. Although monitoring multiple species within a survey group (group of species surveyed concurrently), such as upland-nesting ducks, may indeed expand the focus of habitat management (e.g., Lambeck 1997, Hutto 1998), habitat needs were more similar within ducks as a group than between ducks, songbirds, and shorebirds, despite ecological similarities between these guilds. The habitat and management needs of ducks, therefore, should not be assumed to encompass the needs of coexisting species. Instead, the needs of each guild must be considered separately when designing multi-species management strategies.

Although there were some significant correlations between songbird and duck richness, and songbird and duck density, results were inconsistent across years, and correlation coefficients were small. There were no unusual environmental conditions that might explain the positive correlation between duck and upland songbird richness and density in 2000 only, so we suspect that this result was spurious. Negative correlations between duck richness and wetland songbird richness suggest that conservation plans to promote richness of duck communities will not similarly increase songbird richness. Wetland songbird populations are likely to benefit from wetland management for ducks through an increase in habitat availability, but it may not be possible to meet ideal vegetation conditions for both ducks and songbirds in the same wetlands.

It is likely that wetland-dependent shorebirds and songbirds would rarely inhabit this arid landscape if wetland management for waterfowl were not practiced because natural wetlands in the dry mixed-grass prairie of southern Alberta, Canada, do not hold water in years of average or less-than-average precipitation. In particular, wetland songbirds prefer the dense, tall wetland vegetation in these managed wetlands. These wetlands also play an important role in mitigating wetland loss across the prairies (Gibbs 2000). In addition, landscape-scale habitat management for ducks, such as conservation of native grasslands, almost certainly benefits a broad range of avian species. However, the local habitat needs of ducks, songbirds, and shorebirds are not sufficiently similar for ducks to function as strict surrogates for the others. Collaborative conservation efforts for these guilds of birds should be encouraged, but the needs of each group must be considered when designing management plans. Collaborative conservation for some ducks, Wilson's phalaropes, American avocets, and black terns, would be productive based on our current knowledge.

In general, protecting grassland from tillage should benefit conservation of prairie birds (e.g., Davis et al. 1999). Well-managed cattle rotations can benefit grassland birds because the physical activities of cattle emulate those of historical native ungulates (Vickery et al. 1999). Providing cattle ranchers with financial incentives for conserving grasslands can be especially beneficial. Although we identify limitations in the use of ducks as surrogates for local avian conservation programs, we stress that, in most instances, overall grassland and wetland conservation is a higher priority than local habitat management.

Effects of Habitat Management and Characteristics

Field size.—Our results suggest only a weak influence of field size on distributions of ducks, songbirds, and shorebirds. Those few species that did respond to field size showed both positive and negative responses, in contrast to previous research that found significant positive correlations between field size and population densities of most species (Henderson et al. 2000). Some species, such as long-billed curlew, which showed a trend toward higher densities in larger fields, may have done so because these fields had larger core areas, further from habitat edges and human disturbances, or because nest success was higher in larger fields (Koper 2004). Black terns, however, had higher densities in smaller fields, perhaps because low densities of wetland edge in smaller fields resulted in crowding. Wetland vegetation was similar in large and small fields, so vegetation conditions cannot explain this response.

Length of wetland edge, and therefore amount of wetland within each field, was a stronger determinant of species densities than field size. Ducks had higher densities in fields with greater lengths of wetland edge, whereas other wetland species showed both positive and negative correlations with length of wetland edge. Although upland habitat may influence some wetland species distributions (Naugle et al. 2001), local wetland conditions and densities are clearly critical to attracting ducks.

Grazing.—Local vegetation structure (which was heterogeneous within fields) and distance to nongrassland habitats had greater impacts on avian distributions than did grazing and field size. This suggests that management of local vegetation characteristics and distribution of roads and other habitats were more important than managing the timing of grazing or the subdivision of grassland patches into fields, within the parameter ranges addressed by our study. Only lesser scaup showed greater use of sites with deferred grazing. Scaup may have responded either to vegetation conditions (percentage of bare ground in wetlands or upland vegetation density), or to the absence of disturbance by cattle. In contrast to our results, many songbird species, including Savannah sparrows (*Passerculus sandwichensis*), Baird's sparrows, and Sprague's pipits have previously been shown to be sensitive to grazing (Bock et al. 1993, Milchunas et al. 1998, Davis and Duncan 1999). Grazing intensities in our study followed standard range management guidelines for the area, which resulted in moderate grazing intensities, which tends to produce a heterogeneous vegetation structure, particularly in large fields (Walk and Warner 2000). More intense grazing might have had a larger effect. It is possible that the duration of idling used here (2–15+ years) was not sufficient for recovery of vegetation from grazing pressure because of the aridity of the prairie (Bock et al. 1993, Dobkin et al. 1998). Significant interactions between grazing and field size indicate that indirect impacts of cattle grazing may be more significant than its direct impacts. We also note that in our study system, the same fields were deferred each year. This is common for duck conservation but different from most rotational-grazing systems.

Local vegetation characteristics.—The contrast between duck and wetland songbird habitat selection we observed is consistent with other research (Naugle et al. 2001). Ducks may have been more difficult to detect visually in wetlands with taller and denser wetland vegetation. However, other researchers have also observed that dabbling ducks have lower densities in wetlands with taller and denser vegetation (Payne 1992, Murkin et al. 1997), suggesting that our observation reflects duck habitat selection. Some shorebirds showed responses to local vegetation characteristics consistent with ducks, by avoiding tall, dense vegetation. Similarly, Taft et al. (2002) concluded that wetland vegetation could be managed via draw-downs to benefit both ducks and shorebirds. Upland vegetation had fewer and less-consistent effects on upland birds than wetland vegetation had on wetland birds.

Our vegetation indices represented conditions late in the breeding season, and they did not necessarily represent the vegetation conditions that attracted individuals to settle in a particular habitat. We cannot determine from our study whether early season vegetation structure, including residual vegetation from the previous growing season, influences habitat selection.

Distance to other habitats.—Densities of ducks were independent of distances to cropland/forage and to roads at the scales measured in our study. In contrast, these spatial habitat characteristics strongly influenced distributions of some wetlands and most upland songbirds. Because upland vegetation was only influenced by distance to water in small fields, and effects on vegetation were relatively weak compared with the strong effects of distance to water on bird distributions in all field sizes, songbirds responded to spatial habitat distribution rather than to vegetation only. Although some duck species had higher densities in fields with greater amounts of wetland edge, density of songbirds increased with distance to water, and most species-level responses by upland songbirds indicated avoidance of water. Higher densities of the brown-headed cowbird, a brood parasite, near wetlands may be a threat to the viability of coexisting songbird species, thus it may have contributed to this pattern (Robinson et al. 1992).

Although upland songbird richness and overall density was also higher farther from roads, several species in our study had higher densities near roads. Reijnen et al. (1996) found that most upland bird species avoid roads, but that study examined effects of roads with higher traffic densities than those in our study. The strong influence of distances to other habitats in explaining avian distributions highlights 2 issues: 1) differences existed between habitat requirements of upland-nesting ducks and other avian species, and 2) effects of local habitat management can be overwhelmed by characteristics of the surrounding landscape (e.g., Bakker et al. 2002).

Management Implications

Only lesser scaup are likely to benefit from deferred grazing under conditions similar to those in our study. We have little evidence that idling fields would benefit ducks, songbirds, or shorebirds. However, we recommend that a few idle fields be maintained on the landscape to benefit range-management science in the long term. Without idle fields, it would be difficult to measure the effects of cattle-grazing practices. Cattle may be indirectly influential through their impact on vegetation, but we recommend that management focus on vegetation conditions regardless of cattle presence. Sound range management practices are likely more important than timing of grazing, particularly as nest trampling rates were extremely low in this habitat (Koper 2004). We caution that stocking rates in the dry mixed-grass prairie are relatively low because of the aridity of the environment, and different effects may be observed in other regions.

Avoiding road development and maintaining large tracts of grasslands would benefit some species and increase upland songbird richness. Our study suggests that, in this system, subdivision of intact prairie into smaller fields is unlikely to negatively influence most species if range management practices consistent with those that we documented are applied and if additional access (i.e., road development) and habitat fragmentation is avoided.

Ducks are clearly effective as flagship species and may be used to promote habitat conservation. However, this does not justify their use as surrogates for more focused avian conservation efforts. If the intent of prairie management is to benefit all avian species, the needs of each group must be considered. Conservation strategies that benefit one group cannot be assumed to have similar effects on other species. Although other researchers have reached similar conclusions regarding the limitations of surrogate species for designing management strategies (e.g., Simberloff 1998, Andelman and Fagan 2000, Chase et al. 2000, Lindenmayer et al. 2002), this approach continues to be widely applied in conservation planning (Lambeck 1997, Thompson et al. 1999, Austin et al. 2001). Implementation of broad-scale conservation and monitoring plans should account for diverse species needs wherever possible.

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