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AN EVALUATION OF CANADA'S PERMANENT COVER PROGRAM: HABITAT FOR GRASSLAND BIRDS?

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Abstract.—In the early 1990s Agriculture Canada's Permanent Cover Program (PCP) converted over 445,000 ha of cropland to perennial vegetative cover. The wildlife benefits of the PCP have not been the subject of previous research. We conducted grassland bird surveys on 629 PCP sites and 564 cropland sites across Alberta, Saskatchewan, and Manitoba between 25 May and 3 July 1998. PCP sites showed higher avian species richness than cropland, and nine of 10 commonly detected grassland bird species occurred at higher frequencies in PCP than cropland. PCP sites were characterized by taller, denser vegetation and less bare ground than cropland sites. Hayed and grazed PCP sites differed significantly in their vegetative structure and avian community composition, but did not differ in species richness or evenness. Mean bird species richness at both cropland and PCP sites was significantly lower in the aspen parkland ecoregion than in the mixed and moist-mixed grassland ecoregions. Logistic regression identified 18 geographic and vegetative variables that significantly influenced the occurrence of individual species, but models for only two species predicted both presence and absence with greater than 50% accuracy. Avian productivity on PCP lands must be determined to appraise definitively the quality of this habitat for grassland birds.

UNA EVALUACIÓN DE EL PROGRAMA DE CUBIERTA PERMANENTE DE CANADÁ: ¿ HABITAT PARA AVES DE VERBAZALES?

Sinopsis.—El Programa de Cubierta Permanente (PCP) de Agricultura en Canadá cambió sobre 445,000 ha de terreno cosechado en cubierta vegetativa perenne a principios de la década de 1990. Los beneficios del PCP para la vida silvestre no han sido estudiados previamente. Conducimos censos de aves en yerbazales en 629 sitios del PCP y en 564 lugares de terrenos cosechados a través de Alberta, Saskatchewan y Manitoba entre el 25 de mayo y el 3 de julio del 1998. Los sitios del PCP mostraron una mayor riqueza en especies de aves que los cosechos, y nueve de las diez especies de aves comúnmente detectables en yerbazales, ocurrieron a mayores frecuencias en PCP que en terrenos cosechados. Los lugares de PCP se caracterizaron por vegetación más alta, más densa y con menos tierra desnuda que sitios cosechados. Lugares del PCP con heno y de pastoreo difirieron significativamente en su estructura vegetativa y en la composición de la comunidad de aves, pero no difirieron en la riqueza de especies o en uniformidad. La riqueza de especies de aves promedio tanto en cosechos como en sitios del PCP, fué significativamente mayor en parques en terrenos en la ecoregión de *Populus tremuloides* que en las ecoregiones de herbáceas mezcladas y húmedo-mezcladas. Las regresiones logísticas identificaron 18 variables geográficas y vegetativas que influenciaron significativamente la ocurrencia de especies individuales, pero solo los modelos para dos especies predijeron tanto la presencia como la ausencia con precisión de sobre el

50%. La productividad de las aves en terrenos del PCP debe ser determinada para evaluar definitivamente la calidad de este habitat para aves de yerbazales.

Loss and degradation of native and tame grasslands have caused grassland bird populations to decline more consistently and sharply than any other group of North American bird species (Knopf 1994; Peterjohn and Sauer 1993; Herkert 1994; Sauer et al. 1999). In the three Canadian prairie provinces, only 23% of the historic native grassland remains, and in some areas well suited for crop production less than 0.1% of native grassland persists (Samson and Knopf 1994; Riemer et al. 1997). The Conservation Reserve Program (CRP) in the United States provides habitat for many grassland bird species and has been suggested as one of the factors contributing to the population recovery of some species (Johnson and Schwartz 1993; Reynolds et al. 1994). In Canada, Agriculture and Agrifood Canada's Permanent Cover Program (PCP) created additional grassland habitat in the prairie provinces and British Columbia in the early 1990s by converting cultivated land into perennial vegetative cover through a one-time financial incentive to landowners. Landowners committed to maintain the land in permanent cover for a 10- or 21-year period and, unlike CRP, used the forage produced annually on their fields for pasture or hay. Nearly 13,000 sites totalling over 445,148 ha were enrolled in PCP at the cost of 67 million Canadian dollars (Vaisey et al. 2000). While PCP reduced soil degradation on marginal cultivated lands with high erosion risk (Perlich 1992), the wildlife benefits of this program have not been evaluated. We evaluated the apparent quality of PCP fields in southwestern Manitoba, and southern Saskatchewan and Alberta by comparing the frequency of occurrence of grassland birds on PCP and cropland sites.

METHODS

We conducted grassland bird surveys throughout the mixed grassland, moist-mixed grassland, and aspen parkland ecoregions (hereafter mixed grassland, moist grassland, and parkland, respectively) of the Prairie Ecozone of Alberta, Saskatchewan and Manitoba (Fig. 1). Across the Prairie Ecozone, temperature decreases from south to north, and precipitation increases from south to north and from west to east. As a result, trees, shrubs, and wetlands occur more frequently in the moist than mixed grasslands, while the aspen parkland is characterized by a mosaic of trembling aspen (*Populus tremuloides*) groves surrounding numerous wetlands (Acton et al. 1998). A smaller proportion of native mixed grassland has been lost to cultivation (50%) than moist grassland or parkland (80%; Acton et al. 1998).

Eighty-one clusters of 10 PCP sites each were randomly selected to be surveyed (Fig. 1). Because the number of PCP sites available was not equal among ecoregions, sampling effort (number of clusters) varied among ecoregions in approximate proportion to the ratio of PCP sites to ecoregion area. Only PCP sites accessible by road and separated by a dry-

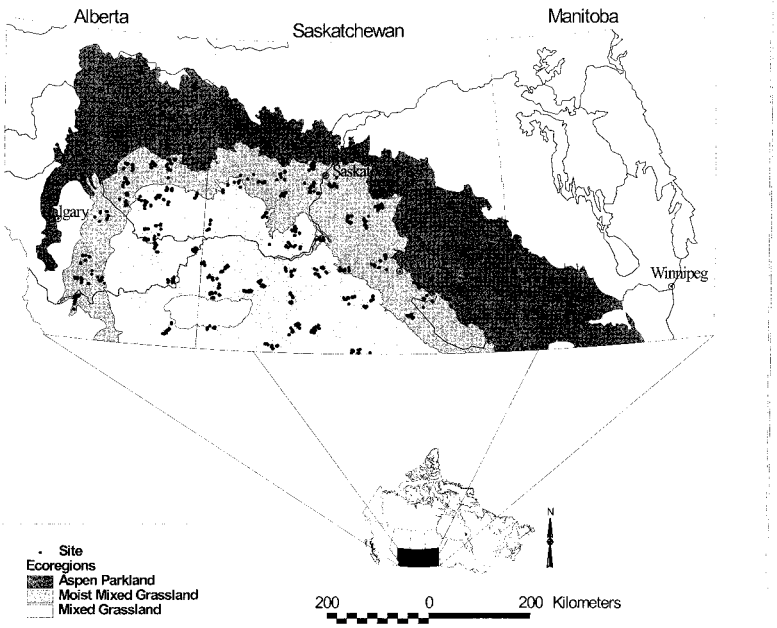

FIGURE 1. Location of Permanent Cover Program clusters across the prairie provinces.

weather road or 800 m (to ensure independence) were included in the study. Within each cluster of PCP sites, cropland sites to be surveyed were identified by both landowner contacts and by field staff. Land-use at PCP sites was classified as hay, pasture, hay and pasture, or idle. PCP sites classified as ''hay and pasture'' were hayed in summer and subsequently grazed by cattle in the fall. PCP sites classified as ''idle'' had not been hayed or grazed for several years. Cropland sites consisted of annually cultivated fields, mainly for production of grain.

PCP vegetation commonly was comprised of some combination of wheatgrass (*Agropryon* spp.), bromegrass (*Bromus* spp.), alfalfa (*Medicago* spp.), and crested wheatgrass (*Agropyron cristatum*). The preponderance of alfalfa on hayed PCP sites resulted in a mix of forbs and grasses, whereas alfalfa comprised a small percentage of the grass-dominated community in grazed PCP sites. Cropland vegetation was dominated by wheat (*Triticum aestivum*), although some sites consisted of canola (*Brassica* spp.), summer fallow, or summer fallow strips interspersed among wheat. The percent area of summer fallow cropland is higher in southwestern Saskatchewan than in other regions of the province (Acton et al. 1998).

A single point count (Ralph et al. 1993) was conducted at each PCP and cropland site between 25 May and 13 June, and then repeated between 14 June–3 July 1998. At most sites both surveys were performed by

the same observer, and most observers surveyed sites in two or three ecoregions. Vegetation measurements were made at eight random locations within the 100-m radius point count circle using the techniques of Rotenberry and Wiens (1980). We recorded the number of contacts in each of the first six decimeters above ground for standing dead (dead 1–6), narrow-leaf grass (<6 mm wide, narrow 1–6), broad-leaf grass (>6 mm wide, broad 1–6), rhizomatous grass (rhizomatous 1–6), clumped grass (clump 1–6), shrubs (shrub 1–6), dwarf shrubs (club-moss *Selaginella* spp. less than 15 cm tall, dwarf 1–6), and forbs (forb 1–6). We also recorded the percent bare ground within 1 m^2, maximum vegetation height (cm), and litter depth (mm) at each site. Area (ha) of each PCP field was estimated using PFRA statistics and Geographic Information System products. Due to small sample sizes, we (1) combined the number of vegetation contacts within the fifth and sixth dm intervals, (2) considered only contacts in the first dm for the shrub and dwarf shrub variables, and (3) included data for idle sites (n = 20) only in analyses comparing total PCP to cropland.

Bird species were considered common over the entire study area if they were detected within more than 5% of the point counts in either PCP or cropland. Because more than one individual was rarely detected for most species ($\bar{x}$ = 4.9 and 9.0% of cases in cropland and PCP, respectively), for most analyses we converted bird abundance data for each species to presence or absence. Species richness, and Shannon diversity and evenness indices (using natural logarithms base e) were calculated using the abundance of individuals of each species and species richness within the circle at each site. Because species richness and Shannon diversity index values showed identical trends between habitat types and ecoregions, we present only species richness values here.

We used parametric tests for all analyses despite most data being not normally distributed (Johnson 1995). Tests for differences between two or more categories were made using t-tests (for either equal or unequal variance) and one-way ANOVA, respectively. When F-statistics indicated a significant difference among groups, we used Tukey's honestly-significant-difference test to compare groups. Chi-square contingency analyses were used to test for differences in proportions.

We used logistic regression to identify variables predicting the occurrence of each of the common bird species in PCP fields. Prior to the analysis, we checked for significant Spearman rank correlations (r_s > 0.60) between variables. Significant correlations were identified between longitude and elevation, and numerous vegetation contact variables. Of the correlated variables, only longitude and the vegetation contact variable in the lowest decimeter was considered for inclusion in the model. In turn, only variables that differed significantly (using t-tests) between sites where each species was present or absent were retained for consideration in each species model. The list of variables considered for inclusion in the logistic regression models for all species included vegetative (litter depth, % bare ground, vegetation height, dwarf shrub 1, clump 1,

2, 3, 4, 5/6, forb 1, 2, 5/6, dead 1, 2, 3, 4, narrow 1, 2, 3, 4, 5/6, broad 1, and shrub 1), geographic (area, ecoregion, latitude, and longitude), and anthropogenic (land-use) variables. Latitude, longitude, and ecoregion were considered for inclusion in all species models. Interaction terms between ecoregion and latitude, longitude, and all vegetation variables were also considered for inclusion in each species model.

RESULTS

We surveyed 629 and 564 PCP and cropland sites, respectively (Fig. 1). We recorded totals of 43 and 37 bird species on PCP and cropland, respectively. Ten bird species were common to PCP sites, whereas only three species were common to cropland sites (Table 1). Nine of the 10 species were detected significantly more frequently at PCP sites than cropland, whereas only the Horned Lark occurred significantly more frequently in cropland (Table 1). Bird species richness was significantly higher in PCP than cropland, but evenness indices did not differ significantly (Table 2). Interestingly, bird species richness in both cropland and PCP tended to be higher in mixed and moist grassland than aspen parkland (Table 3). Land-use significantly influenced the frequency of occurrence of seven species (Table 1). Within PCP grasslands, four species occurred significantly more frequently in hayland, three species in pasture, and three species did not differ in their frequency of occurrence between the two types of land-use (Table 1). Species richness and evenness did not differ between hayed and grazed sites (Table 2). Species occurrence data generally fell along a gradient of the inverse relationship between bare ground and vegetation height (Fig. 2).

PCP sites were characterized by significantly deeper litter, taller vegetation, and significantly less bare ground than cropland sites (Table 4). Vegetation was significantly more dense on PCP than cropland sites (Table 4). The majority of the PCP sites were either hayed ($n = 262$) or grazed ($n = 270$), while other sites were both hayed and grazed ($n = 77$) or idle ($n = 20$). Hayed sites had significantly less bare ground and significantly taller vegetation than grazed sites (Table 4). However, the mean difference in bare ground between pasture and hayland was quite small. Overall, vegetation density of total broad and forb contacts differed significantly between hayed and grazed sites (Table 4).

We developed a significant logistic regression model that predicted occurrence for each species, but only the models for Horned Lark and Savannah Sparrow correctly predicted both presence and absence in more than 50% of cases (see Table 5). Geographic variables were important determinants of occurrence; ecoregion, longitude, or latitude were included singly or as an interaction term in the model for each species (Table 6). Area of the PCP field had a weak, but positive influence on the occurrence of Baird's and Grasshopper Sparrows, while land-use significantly influenced the occurrence of Clay-colored Sparrows, Horned Larks, and Savannah Sparrows (Table 6). A number of vegetation variables also significantly influenced species presence. Broad contacts were

TABLE 1. Frequency of occurrence of the 10 common bird species compared between cropland and PCP, and hay and pasture PCP sites.

Species	Proportion of sites detected					
	Crop (n = 564)	PCP (n = 629)	χ^2 (P)	Hay (n = 262)	Pasture (n = 270)	χ^2 (P)
Horned Lark (*Eremophila alpestris*)	0.587	0.318	87.1 (<0.001)	0.211	0.415	24.9 (<0.001)
Clay-colored Sparrow (*Spizella pallida*)	0.01	0.128	63.9 (<0.001)	0.195	0.063	21.6 (<0.001)
Vesper Sparrow (*Pooecetes gramineus*)	0.119	0.405	124.0 (<0.001)	0.41	0.39	0.21 (0.65)
Savannah Sparrow (*Passerculus sandwichensis*)	0.287	0.604	120.5 (<0.001)	0.729	0.515	24.9 (<0.001)
Grasshopper Sparrow (*Ammodramus savannarum*)	0	0.119	65.9 (<0.001)	0.086	0.141	3.7 (0.06)
Baird's Sparrow (*A. bairdii*)	0.019	0.181	82.9 (<0.001)	0.218	0.148	4.3 (0.04)
Le Conte's Sparrow (*A. leconteii*)	0	0.084	49.7 (<0.001)	0.113	0.052	6.9 (0.009)
Chestnut-collared Longspur (*Calcarius ornatus*)	0.021	0.097	29.7 (<0.001)	0.06	0.119	5.3 (0.02)
Brown-headed Cowbird (*Molothrus ater*)	0.027	0.059	7.4 (0.006)	0.053	0.048	0.08 (0.78)
Western Meadowlark (*Sturnella neglecta*)	0.043	0.275	116.6 (<0.001)	0.286	0.26	0.49 (0.48)

TABLE 2. Species richness and Shannon evenness indices compared between cropland and PCP, and hay and pasture PCP sites.

Variable	Mean ± SE (n)		t (P)	Difference (95% C.I.)	Mean ± SE (n)		t (P)	Difference (95% C.I.)
	Crop	PCP			Hay	Pasture		
Species richness	1.34 ± 0.05 (564)	2.50 ± 0.06 (629)	15.1 (<0.001)	−1.16 (−1.3, −1.0)	2.57 ± 0.1 (262)	2.38 ± 0.1 (270)	1.4 (0.16)	0.19 (−0.07, 0.46)
Shannon evenness	0.93 ± 0.01 (220)	0.93 ± 0.00 (449)	0.28 (0.8)	0.001 (−0.01, 0.014)	0.93 ± 0.01 (186)	0.93 ± 0.01 (190)	0.25 (0.80)	−0.002 (−0.17, 0.012)

TABLE 3. Species richness and Shannon evenness indices compared between ecoregions for both cropland and PCP. Different letters denote significant difference as indicated by Tukey's test.

Variable	Mean ± SE			F (P)
	Mixed	Moist	Parkland	
Crop				
Species richness	1.55 ± 0.08[a]	1.46 ± 0.08[a]	0.93 ± 0.07[b]	18.6 (<0.001)
Shannon evenness	0.93 ± 0.01	0.94 ± 0.01	0.93 ± 0.01	0.20 (0.82)
PCP				
Species richness	2.75 ± 0.1[a]	2.54 ± 0.1	2.18 ± 0.1[b]	7.5 (0.001)
Shannon evenness	0.95 ± 0.004[a]	0.92 ± 0.01[b]	0.92 ± 0.01[b]	6.0 (0.003)

negatively associated with the occurrence of four species, while clump contacts were positively associated with the occurrence of three species (Table 6). Dead contacts, forb contacts, and vegetation height were both positively and negatively associated with occurrence, depending on the species (Table 6).

DISCUSSION

Grassland bird habitat associations are driven more by vegetation structure than plant species composition (Wiens 1974; King and Savidge 1995; Sutter et al. 1995; Davis and Duncan 1999). PCP sites were characterized by denser and more structurally heterogeneous vegetation than cropland sites. PCP sites had higher mean species richness, but not evenness, of birds than cropland, and nine of the 10 common species occurred more frequently in PCP. These results are consistent with those of studies comparing bird abundance and diversity in dense nesting cover or CRP with seeded cropland (Johnson and Schwartz 1993; Hartley 1994; King and Savidge 1995; Patterson and Best 1996; Best et al. 1997). Soil, temperature, and precipitation vary among ecoregions, resulting in concomitant variation in vegetation structure and plant species composition in native habitats (Acton et al. 1998). The richness of the bird community in both PCP and cropland sites also differed significantly among ecoregions. As aspen parkland had lower species richness, cropland conversion programs delivered in the Canadian mixed and moist grasslands will likely provide habitat for more grassland birds.

Grassland bird species may respond either positively, negatively, or neutrally to grazing intensity and haying, depending upon the characteristics of vegetative structure they are associated with (Owens and Myres 1973; Kantrud 1981; Bock et al. 1993; Sutter et al. 1995). In this study, vegetation structure differed significantly between hayland and pasture sites. Hayland sites had denser and taller vegetation, whereas pasture had shorter vegetation with more bare ground. Seven of the 10 common bird species were detected more frequently in either hayland or pasture than cropland, and the remaining three species showed no detectable response

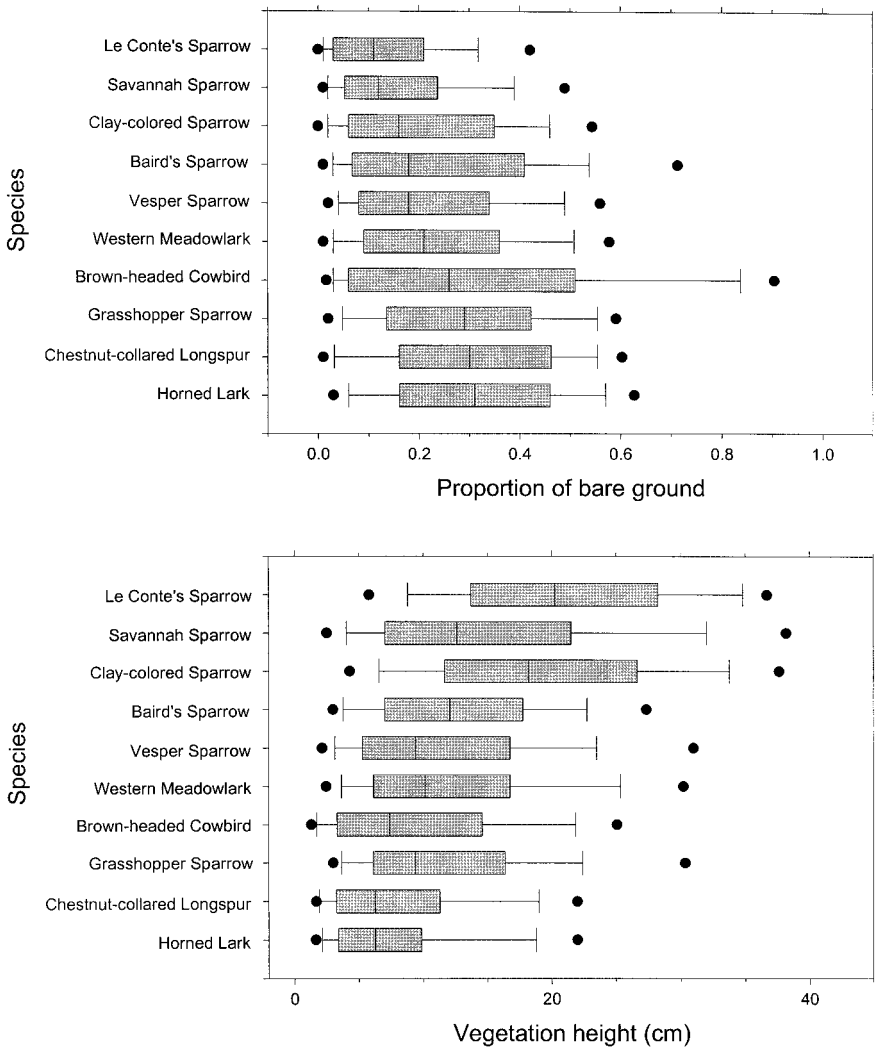

FIGURE 2. Median (and 5, 10, 25, 75, 90 and 95th percentiles) proportion of bare ground (upper panel) and vegetation height (lower panel) plotted for each of the 10 commonly detected species using all PCP sites where each species occurred.

to land-use. Species richness and evenness did not differ between land-uses, likely because species were replaced, rather than added, along the gradient from open to dense vegetation.

As shown in previous studies, geography, vegetation (Johnson and Schwartz 1993; Knapton 1994), land-use, and the area of habitat available (Herkert 1994; Vickery et al. 1994; Swengel 1996) predicted species occurrence in converted cropland, although the predictive ability of logistic

TABLE 4. Vegetative characteristics and density compared between cropland and PCP, and hayland and pasture PCP sites.

Variable	Mean ± SE Crop (n = 560)	Mean ± SE PCP (n = 623)	t (P)	Difference (95% C.I.)	Mean ± SE Hay (n = 260)	Mean ± SE Pasture (n = 269)	t (P)	Difference (95% C.I.)
Percent bare ground	0.75	0.22	42.7 (<0.001)	0.53 (0.50, 0.55)	0.2 ± 0.01	0.24 ± 0.01	2.1 (0.03)	−0.04 (−0.06, 0.00)
Litter depth (mm)	2.3 ± 0.2	4.0 ± 0.2	6.4 (<0.001)	−1.74 (−2.18, −1.16)	3.82 ± 0.2	4.0 ± 0.3	1.0 (0.32)	−0.4 (−1.2, 0.4)
Vegetation height (cm)	4.1 ± 0.3	14.7 ± 0.5	18.7 (<0.001)	−10.6 (−11.7, −9.5)	16.5 ± 0.6	12.5 ± 0.8	3.9 (<0.001)	4.1 (2.0, 6.2)
Broad contacts	0.2 ± 0.02	0.26 ± 0.02	1.7 (0.09)	−0.06 (−0.12, −0.01)	0.31 ± 0.05	0.21 ± 0.03	2.0 (0.05)	0.10 (0.02, 0.21)
Clump contacts	0.1 ± 0.02	0.41 ± 0.03	7.7 (<0.001)	−0.27 (−0.34, −0.20)	0.43 ± 0.06	0.37 ± 0.04	0.7 (0.45)	0.06 (−0.09, 0.19)
Dead contacts	0.1 ± 0.01	1.22 ± 0.06	17.9 (<0.001)	−1.12 (−1.2, −1.0)	1.18 ± 0.08	1.13 ± 0.09	0.4 (0.68)	0.05 (−0.18, 0.28)
Forb contacts	0.1 ± 0.01	0.8 ± 0.05	14.3 (<0.001)	−0.69 (−0.79, −0.60)	1.29 ± 0.09	0.34 ± 0.04	9.9 (<0.001)	0.95 (0.75, 1.13)
Narrow contacts	0.3 ± 0.02	0.8 ± 0.03	14.1 (<0.001)	−0.56 (−0.64, −0.48)	0.76 ± 0.05	0.82 ± 0.04	0.9 (0.39)	−0.06 (−0.2, 0.07)
Rhizomatous contacts	0.2 ± 0.03	0.5 ± 0.03	6.9 (<0.001)	−0.28 (−0.35, −0.19)	0.52 ± 0.05	0.47 ± 0.04	0.8 (0.46)	0.05 (−0.08, 0.18)

TABLE 5. Logistic regression model statistics and percentage of observations correctly classified for each of the 10 common species.

Species	Wald χ^2 (P)	Percent correctly classified (n)	
		Present	Absent
Baird's Sparrow	98.9 (<0.001)	21.7 (106)	97.4 (497)
Brown-headed Cowbird	35.7 (<0.001)	0.0 (33)	100.0 (570)
Chestnut-collared Longspur	116.8 (<0.001)	14.0 (57)	99.1 (546)
Clay-colored Sparrow	83.4 (<0.001)	10.3 (78)	98.9 (525)
Grasshopper Sparrow	105.2 (<0.001)	17.4 (69)	98.3 (534)
Horned Lark	244.2 (<0.001)	62.7 (193)	88.8 (410)
Le Conte's Sparrow	102.8 (<0.001)	27.1 (48)	99.5 (555)
Savannah Sparrow	183.4 (<0.001)	83.9 (367)	57.9 (236)
Vesper Sparrow	51.9 (<0.001)	35.8 (246)	81.2 (357)
Western Meadowlark	83.6 (<0.001)	21.1 (166)	93.4 (437)

regression models was often low. In some cases poor predictive ability likely resulted from the imbalance in sample sizes between presence and absence data (Capen et al. 1986). Species such as Western Meadowlarks and Brown-headed Cowbirds, however, generally showed few correlations with vegetative parameters, possibly because they respond to cues at different spatial scales or are not tied to a nesting territory (Sadler and Maher 1974 *in* Sutter and Brigham 1998; this study).

Cropland conversion programs do not restore either native prairie or their avian communities, but they do offer breeding habitat for a wide array of grassland bird species (Johnson and Schwartz 1993; Davis and Duncan 1999). Breeding Bird Survey data indicate seven of the 10 common species in this study currently show significant population declines from 1966 to 1998 either survey-wide or within Canada (Sauer et al. 1999). Therefore, PCP and other cropland conversion programs have the potential to ameliorate habitat availability for these species, as has CRP for some grassland birds in the United States (Reynolds et al. 1994). Seeded grassland may provide limited benefits for native grassland specialists such as Sprague's Pipit (*Anthus spragueii*; Wilson and Belcher 1989; Dale et al. 1997; Sutter and Brigham 1998; Davis and Duncan 1999), given the low detection frequency (3%) of this species in PCP. Conversely, the benefits of cropland conversion programs may extend beyond the seeded cover itself if bird nests become more dispersed in the landscape (Reynolds et al. 1994), or if the condition of other native and tame grasslands in the vicinity improve as a result of deferred grazing.

Grassland birds undoubtedly breed in PCP, but the reproductive consequences of selecting this habitat must be determined to accurately assess habitat quality (Van Horne 1983; Johnson and Temple 1986; Vickery et al. 1992). Haying of PCP sites likely represents a major source of mortality in some years, and may create local sink populations (Pulliam 1988; Bollinger et al. 1990; Frawley and Best 1991; Dale et al. 1997). Of the four species more frequently associated with hayland than pasture in this study,

TABLE 6. Multiple correlation coefficients of discriminating variables included in significant logistic regression models for each of the ten common species. Those coefficients shown are significant at $P < 0.05$.

	Multiple correlation coefficient[a] (R)									
Discriminating variable	Baird's Sparrow	Brown-headed Cowbird	Chestnut-collared Longspur	Clay-colored Sparrow	Grass-hopper Sparrow	Horned Lark	Le Conte's Sparrow	Savannah Sparrow	Vesper Sparrow	Western Meadow-lark
Continuous variables										
Field area	0.18				0.17					
Bare ground							−0.19	−0.18		
Broad 1		−0.09	−0.01		−0.10	−0.07				
Clump 1					0.06					
Clump 2	0.08									
Clump 3								0.06		
Dead 1		−0.18							−0.15	
Dead 3	0.07				0.15	−0.05				
Forb 1					−0.14	−0.13			0.07	
Forb 2				0.08				0.13		
Latitude			−0.07		−0.20	−0.25		−0.05	−0.07	−0.04
Litter depth								0.12		
Longitude	−0.21	−0.09	−0.19	−0.17			−0.32			−0.10
Narrow 1							−0.14			
Narrow 3				0.09						
Vegetation height			−0.09	0.11		−0.20				−0.09
Categorical Variables										
Ecoregion				0.12				0.13		
Ecoregion × Bare ground						0.12				
Ecoregion × Clump 2				0.10	0.09					
Ecoregion × Dead 1		0.13								0.06
Ecoregion × Forb 56						0.03				
Ecoregion × Narrow 1			0.09					0.05		
Ecoregion × Latitude	0.14									0.09

TABLE 6. Continued.

Discriminating variable	Multiple correlation coefficient[a] (R)									
	Baird's Sparrow	Brown-headed Cowbird	Chestnut-collared Longspur	Clay-colored Sparrow	Grass-hopper Sparrow	Horned Lark	Le Conte's Sparrow	Savannah Sparrow	Vesper Sparrow	Western Meadow-lark
Categorical Variables										
Ecoregion × Longitude	0.14									
Ecoregion × Latitude × Longitude			0.15							0.08
Ecoregion × Vegetation height							0.14			0.07
Landuse				0.07				0.09		

[a] For continuous variables, the sign of R indicates whether species presence is related positively or negatively to the discriminating variable.

Clay-colored Sparrow and Savannah Sparrow are experiencing significant population declines (Sauer et al. 1999). While species associated with pasture are not vulnerable to direct threats such as haying (but see Paine et al. 1996), heavily grazed pastures likely do not provide habitat for species that prefer intermediate or tall vegetation height and density. The influence of vegetation on bird community composition shown in this study and others, indicates habitat maintained in a mosaic of successional stages will provide habitat for the richest diversity of grassland species.

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