Studies in Avian Biology No. 19:211–218, 1999.

GRASSLAND SONGBIRD OCCURRENCE IN NATIVE AND CRESTED WHEATGRASS PASTURES OF SOUTHERN SASKATCHEWAN

STEPHEN K. DAVIS AND DAVID C. DUNCAN

Abstract. We examined grassland songbird occurrence in native pasture and in seeded pastures comprising pure crested wheatgrass (*Agropyron cristatum*), crested wheatgrass/grass mix, and crested wheatgrass/legume mix in southern Saskatchewan, Canada, to determine (1) if grassland songbirds are equally attracted to native and crested wheatgrass pastures; (2) if grassland songbirds are equally attracted to different types of crested wheatgrass pastures; and (3) what habitat variables are important in predicting the occurrence of grassland songbirds. Bird occurrence was quantified using 100-meter fixed-radius point counts. Sprague's Pipit (*Anthus spragueii*), Chestnut-collared Longspur (*Calcarius ornatus*), and Clay-colored Sparrow (*Spizella pallida*) occurred more frequently in native pasture than in any of the crested wheatgrass pastures. Baird's Sparrow (*Ammodramus bairdii*), Savannah Sparrow (*Passerculus sandwichensis*), Vesper Sparrow (*Pooecetes gramineus*), Horned Lark (*Eremophila alpestris*), and Western Meadowlark (*Sturnella neglecta*) were recorded as frequently in each of the crested wheatgrass pasture types as in native pasture. Grasshopper Sparrow (*Ammodramus savannarum*) was the only species detected more often in one or more of the crested wheatgrass pasture types than in native pasture. Among the various types of crested wheatgrass pasture examined, Sprague's Pipit and Grasshopper Sparrow were recorded more often in pure crested wheatgrass than in crested wheatgrass/legume-mix pastures. Habitat variables associated with songbird occurrence differed among species and generally supported findings in other studies. Our results show that vegetative structure is more important than plant-species composition in grassland bird habitat selection, as crested wheatgrass pastures were as attractive as native pastures to many of the species studied. Because previous studies have shown that most grassland songbirds rarely inhabit cropland, the conversion of cropland to pure crested wheatgrass pastures in southern Saskatchewan would likely benefit this avian community.

LA INCIDENCIA DE AVES PASERIFORMES DE PASTIZAL EN LOS PASTOS NATIVOS Y EN LOS PASTOS DE *AGROPYRON CRISTATUM* DEL SUR DE SASKATCHEWAN

Sinopsis. Examinamos la incidencia de aves paseriformes de pastizal en pasto nativo y en pastos sembrados que comprenden *Agropyron cristatum* puro, una mezcla de *Agropyron cristatum* y hierba, y una mezcla de *Agropyron cristatum* y legumbres en el sur de Saskatchewan, Canadá, para determinar (1) si los pastos nativos y los pastos de *Agropyron cristatum* atraen en igual medida a las aves paseriformes de pastizal; (2) si los diferentes tipos de pastos de *Agropyron cristatum* atraen en igual medida a las aves paseriformes de pastizal; y (3) cuáles son las variables importantes de hábitat para predecir la incidencia de aves paseriformes de pastizal. Se cuantificó la incidencia de aves aplicando conteos desde un punto y por un radio fijo de 100 metros. La Bisbita de Sprague (*Anthus spragueii*), el Escribano Cuellicastaño (*Calcarius ornatus*) y el Gorrión Pálido (*Spizella pallida*) se encontraron más frecuentemente en el pasto nativo que en ninguno de los pastos de *Agropyron cristatum.* El Gorrión de Baird (*Ammodramus bairdii*), el Gorrión Sabanero (*Passerculus sandwichensis*), el Gorrión Coliblanco (*Pooecetes gramineus*), la Alondra Cornuda (*Eremophila alpestris*) y el Pradero Occidental (*Sturnella neglecta*) se registraron en cada uno de los tipos de pasto de *Agropyron cristatum* con la misma frecuencia que en los pastos nativos. El Gorrión Chapulín (*Ammodramus savannarum*) fue la única especie detectada con más frecuencia en uno o más de los tipos de pasto de *Agropyron cristatum* que en pasto nativo. Entre los distintos tipos de pasto de *Agropyron cristatum* que examinamos, se registraron la Bisbita de Sprague y el Gorrión Chapulín con más frecuencia en *Agropyron cristatum* puro que en pastos de una mezcla de *Agropyron cristatum* y legumbres. Las variables de hábitat asociadas con la incidencia de aves paseriformes difirieron entre especies y generalmente ratificaron las conclusiones de otros estudios. Nuestros resultados revelan que la estructura vegetativa es más importante que la composición de plantas y especies en la selección de hábitat de las aves de pastizal, ya que los pastos de *Agropyron cristatum* fueron tan atrayentes como los pastos nativos para muchas de las especies estudiadas. Dado que estudios anteriores han comprobado que la mayoría de las aves paseriformes de pastizal habita raramente en terreno cultivado, la conversión de terreno cultivado a pastos de *Agropyron cristatum* puro en el sur de Saskatchewan probablemente beneficiaría a esta comunidad de aves.

Key Words: crested wheatgrass; grassland songbirds; habitat selection; native pasture.

The loss and degradation of native prairie in North America have been cited as primary factors in the decline of many grassland songbird species (Peterjohn and Sauer 1993, Herkert 1994, Knopf 1994). In Saskatchewan only 23% of the original 16.3 million ha of native grassland remains (Samson and Knopf 1994). Recent changes to Canadian agricultural policies have eliminated the major subsidies that previously encouraged the conversion of native prairie to cropland (Reimer 1994). As a result of these changes, agricultural economists predict that up to 4 million ha of cropland in prairie Canada may be converted to permanent forages (i.e., seeded grassland or hayland). A large proportion of the land is expected to be seeded to crested wheatgrass (*Agropyron cristatum*) because it is inexpensive, easy to establish, and hardy (Holt 1994). More than 1 million ha of crested wheatgrass presently exist in prairie Canada (Dormaar et al. 1995).

Although bird response to crested wheatgrass in sagebrush (*Artemisia tridentata*) communities has been examined (Reynolds and Trost 1980, McAdoo et al. 1989), information on grassland songbird use of crested wheatgrass pastures in mixed-grass prairie is almost nonexistent. The purpose of this study was to compare grassland songbird occurrence on native and crested wheatgrass pastures in southern Saskatchewan. We also compared three types of seeded pastures (pure crested wheatgrass, crested wheatgrass/grass mix, and crested wheatgrass/legume mix) to determine if grassland songbirds are more attracted to a particular type of crested wheatgrass pasture. Lastly, we examined physiognomic and plant-species variables to gain additional insight into habitat selection by grassland songbirds.

STUDY AREA

The study was conducted in the Missouri Coteau region of southern Saskatchewan, Canada, from 24 May to 17 June 1995. This area was selected because a large portion of it consists of native and crested wheatgrass pasture. Classification of the type of crested wheatgrass pasture was initially made by subjective observation and subsequently checked following quantification of plant-species cover (see below).

Native pastures comprised primarily *Stipa* species, June grass (*Koeleria gracilis*), northern wheatgrass (*Agropyron dasystachyum*), blue grama grass (*Bouteloua gracilis*), upland sedges (*Carex* spp.), club moss (*Selaginella densa*), and pasture sage (*Artemisia frigida*). Pastures classified as pure crested wheatgrass had no other plant species with more than 5% cover. Crested wheatgrass/grass-mix pastures were characterized by crested wheatgrass, smooth brome (*Bromus inermis*), and bluegrass (*Poa* spp.), whereas crested wheatgrass/legume-mix pastures consisted of crested wheatgrass and alfalfa (*Medicago sativa*). All other plant species quantified in each of these pastures were present in trace amounts (< 5% cover).

METHODS

Field Methods

Two surveyors quantified the occurrence of singing male grassland songbirds within 100-m-radius 5-min point-count circles (Ralph et al. 1993). Surveys were conducted between 0425 and 0825 central standard time on days with no precipitation and winds less than 20 km/hr. Because roadside counts in grassland have inherent biases (G. Sutter, unpubl. data), the periphery of each point-count circle was situated 50–100 m from roads and fence lines. The periphery of each point count was also located more than 300 m from adjacent point counts. A total of 395 point counts were randomly selected along 30 survey routes, each of which was designed to sample both native and crested wheatgrass pastures. To reduce the influence of grazing intensity on songbird occurrence, we sampled only lightly and moderately grazed pastures.

Habitat variables were quantified for each point count using a 100- × 50-cm quadrat placed randomly in each quadrant of the 100-m circle. Percent cover for each plant species, standing dead vegetation, and bare ground was estimated visually in the quadrat. Litter depth and vegetation height were measured at the northeast corner of each quadrat using a 10-cm and 1-m rule, respectively. Means were calculated for each habitat variable in each circle for use in subsequent analyses.

Data Analysis

Analyses were conducted on the frequency of occurrence (i.e., presence/absence) of the nine most frequently recorded songbird species (> 10% occurrence) using the SAS/STAT package (SAS Institute 1990). Frequency of occurrence was analyzed because observers seldom recorded more than one individual per species in a point count, thus making normalization of the data problematic. We compared the occurrence of each songbird species inside point-count circles in native and crested wheatgrass pastures using chi-square contingency analyses, or Fisher's exact test if 25% of the cells had expected counts less than 5 (PROC FREQ).

Stepwise logistic regression (PROC LOGISTIC, $\alpha = 0.05$) was used to identify important habitat variables associated with the occurrence of individual grassland songbird species. If a species showed no preference for any pasture type, data from all pasture types were used in the analyses. Analyses were restricted to within-pasture types for those species that exhibited a habitat preference, to avoid confounding results with habitat variables important in predicting bird occurrence and those variables associated with a particular pasture type. Structural variables included in the analyses were vegetation height, standing dead vegetation, litter depth, and bare ground. Of the 82 plant species quantified in the study, only the 13 species with a mean cover value greater than 1% were used in the analyses (see Appendix). None of these independent variables were strongly correlated (Spearman rank, $r < 0.69$; PROC CORR).

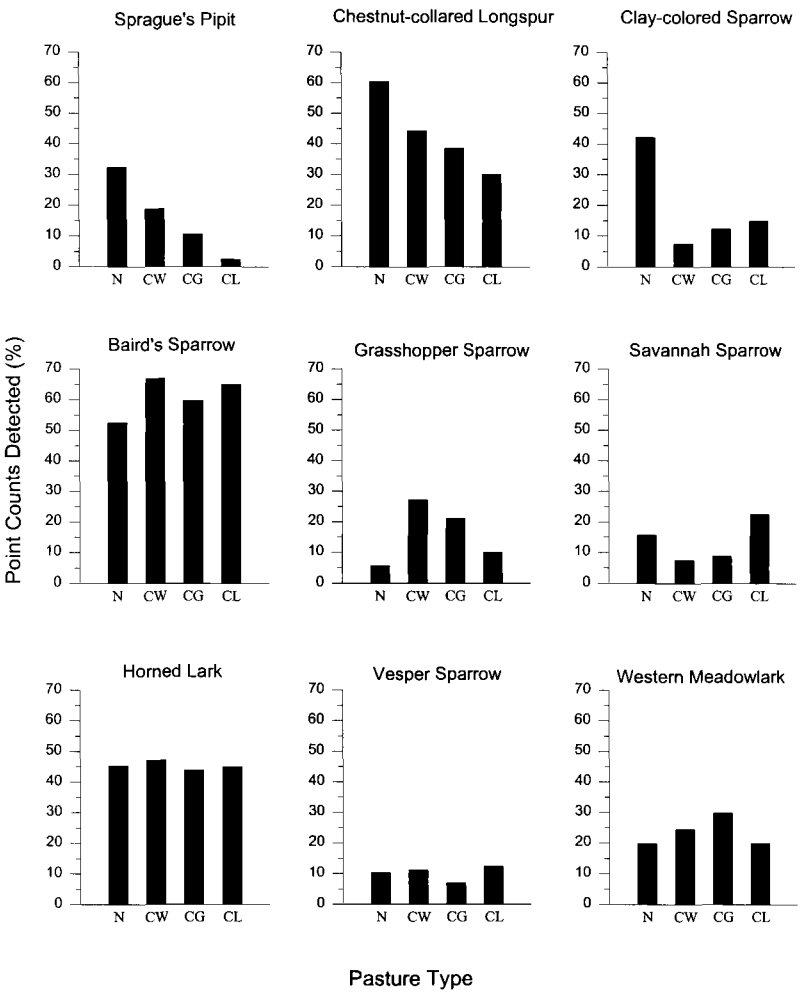

FIGURE 1. Frequency of singing males detected in point counts in native (N; N = 193), pure crested wheatgrass (CW; N = 103), crested wheatgrass/grass mix (CG; N = 60), and crested wheatgrass/legume mix (CL; N = 40) pastures in southern Saskatchewan.

RESULTS

Frequency of Occurrence

The frequency of occurrence of Horned Lark, Vesper Sparrow, Savannah Sparrow, Baird's Sparrow, and Western Meadowlark was not significantly different among pasture types (χ^2 = 0.054–6.652, df = 3, $P > 0.084$; Fig. 1). Significant differences in the frequency of occurrence among habitat types were found for Clay-colored and Grasshopper sparrows, Chestnut-collared Longspur, and Sprague's Pipit (χ^2 = 18.194–53.545, df = 3, $P < 0.001$). Pair-wise comparisons of each pasture type revealed that Sprague's Pipits, Clay-colored Sparrows, and Chestnut-collared Longspurs were recorded more often in native pasture than in any of the crested wheatgrass pastures (χ^2 = 7.307–18.527, df = 1, $P < 0.007$; Fig. 1). In addition, Sprague's Pipits were detected more often in pure crested wheatgrass than in crested wheatgrass/legume-mix pastures (χ^2 = 5.608, df = 1, P = 0.018; Fig. 1). Clay-colored Sparrows exhibited a trend toward higher occurrence in crested wheatgrass/legume-mix pastures than in pure crested wheatgrass pastures (Fisher's exact test, P = 0.057; Fig. 1). Grasshopper Sparrows were recorded significantly more often in pure crested wheatgrass and crested wheatgrass/grass-mix pastures than in native pastures (χ^2 = 27.099, df = 1, $P < 0.001$; χ^2 = 13.591, df = 1, $P < 0.001$, respectively), and they occurred more often in pure crested wheatgrass than in crested wheat-

TABLE 1. SUMMARY OF STEPWISE LOGISTIC REGRESSION ANALYSES OF GRASSLAND SONGBIRD-HABITAT RELATIONSHIPS IN NATIVE AND CRESTED WHEATGRASS PASTURES

Species	Variable	Estimate (β)	P	Model concordance
Horned Lark	Vegetation height	−0.110	< 0.001	76.8%
	Bare ground	0.031	0.001	
	Litter depth	−0.118	0.016	
	Pasture sage	0.077	0.002	
	Western snowberry	−0.125	0.018	
	Northern wheatgrass	−0.048	0.049	
Sprague's Pipit	Standing dead	0.025	0.011	60.6%
Clay-colored Sparrow	Western snowberry	0.131	0.004	71.3%
	Standing dead	0.029	0.003	
	Pasture sage	0.067	0.016	
Vesper Sparrow	Vegetation height	−0.143	< 0.001	73.0%
	Club moss	−0.107	0.007	
Savannah Sparrow	Alfalfa	0.046	0.002	71.0%
	Standing dead	0.047	< 0.001	
	Vegetation height	0.095	< 0.001	
	Upland sedges	0.056	0.025	
Baird's Sparrow	Vegetation height	0.138	< 0.001	73.2%
	Bare ground	−0.024	0.004	
	Upland sedges	−0.040	0.047	
Grasshopper Sparrow	Vegetation height	0.086	0.005	75.3%
	Crested wheatgrass	0.040	0.004	
	Bluegrass	0.066	0.015	
Chestnut-collared Longspur	Western snowberry	−0.121	0.009	68.2%
	June grass	0.069	0.004	
	Pasture sage	−0.061	0.033	
Western Meadowlark	June grass	−0.079	0.003	46.7%
	Stipa spp.	0.041	0.018	

Note: Variables are listed in order of their entry into the model.

grass/legume-mix pastures ($\chi^2 = 4.898$, df = 1, P = 0.027).

HABITAT VARIABLE ASSOCIATIONS

All pasture types were used in the logistic regression analyses of habitat variables for the five species that showed no habitat preference. Logistic regression analyses for Sprague's Pipit, Clay-colored Sparrow, and Chestnut-collared Longspur were conducted in native pastures, whereas the analyses for Grasshopper Sparrow were restricted to pure crested wheatgrass and crested wheatgrass/grass-mix pastures. The models for Horned Lark and Clay-colored, Vesper, Savannah, Baird's, and Grasshopper sparrows had fair explanatory power (71–76.8% concordance), whereas the Sprague's Pipit and Chestnut-collared Longspur models had somewhat poorer predictive power (Table 1). Variables entered into the Western Meadowlark model failed to explain more than 50% of the variation. Of the habitat variables we examined, structural variables were entered into the models for seven of nine songbird species and were the first variables entered in five of those species (Table 1). Vegetation height was an important predictor for five species; Baird's, Grasshopper, and Savannah sparrows were positively associated with vegetation height, whereas Horned Lark and Vesper Sparrow were negatively associated with this variable. Percent cover of standing dead vegetation was also an important predictor of songbird occurrence, with Sprague's Pipit and Clay-colored and Savannah sparrows positively associated with this variable. Baird's Sparrows were negatively associated with cover of bare ground, whereas Horned Larks were positively associated with bare ground and negatively associated with litter depth.

Plant species were selected for inclusion in the logistic regression model for eight of nine bird species. Clay-colored Sparrows were positively associated with cover of western snowberry (*Symphoricarpos occidentalis*), whereas Horned Larks and Chestnut-collared Longspurs were negatively associated with this shrub.

Grasshopper Sparrows were positively associated with cover of introduced grasses (crested wheatgrass and bluegrass species), whereas Chestnut-collared Longspurs were positively associated with June grass. Forb species were entered into four of the models. Horned Lark and Clay-colored Sparrows were positively associated with cover of pasture sage, whereas Chestnut-collared Longspurs were negatively associated with this forb. Savannah Sparrow was the only species positively associated with alfalfa.

DISCUSSION

Horned Lark, Vesper Sparrow, Savannah Sparrow, Baird's Sparrow, and Western Meadowlark were recorded as frequently in native pasture as in each type of crested wheatgrass pasture. This lack of discrimination between native pasture and the relative monoculture of crested wheatgrass pastures suggests that these species responded to vegetative structure rather than plant-species composition. Horned Larks and Vesper Sparrows were associated with pastures with low vegetative height. Horned Larks, however, preferred more sparsely vegetated pastures (see also Dubois 1935, Stewart and Kantrud 1972, Owens and Myres 1973, Wiens 1973, Kantrud 1981, Dale 1983). In comparison, Savannah Sparrows occupied pastures with taller, denser vegetation as indicated by the positive association with alfalfa, standing dead vegetation, and vegetation height (Table 1). Lein (1968) and Dale (1983) also found Savannah Sparrows to be associated with tall, dense vegetation in Saskatchewan, and Renken and Dinsmore (1987) found the species most abundant on alfalfa-wheatgrass habitats (but see Johnson and Schwartz 1993a). Baird's Sparrows occurred more often on pastures with greater amounts of vegetative cover as evidenced by their positive association with vegetation height and negative association with cover of bare ground. Dale (1983) and Sutter (1996) also found this species to be associated with taller and denser vegetation in Saskatchewan. The response of Baird's Sparrow to vegetation structure rather than to plant-species composition (see also Mahon 1995, Madden 1996) may allow this species to be more flexible in its habitat requirements than previously thought (Cartwright et al. 1937). The habitat variables measured in this study provided little predictability as to the occurrence of Western Meadowlarks (see also Johnson and Schwartz 1993a, Sutter 1996). These results are supported by previous studies which indicated that all five of these species are not native prairie specialists and are found in a variety of habitats (Owens and Myres 1973, Wiens and Dyer 1975, Rotenberry and Wiens 1980, Basore et al. 1986, Camp and Best 1993, Johnson and Schwartz 1993a, Davis et al. 1996).

Clay-colored Sparrows, Chestnut-collared Longspurs, and Sprague's Pipits were recorded more frequently in native pasture than in any of the crested wheatgrass pasture types. Because Clay-colored Sparrows were positively associated with native pastures with greater coverage of western snowberry, standing dead vegetation, and pasture sage, their preference for native pastures over crested wheatgrass pastures may be explained by the higher values for these three variables in native pasture (Appendix). The well-known attraction of Clay-colored Sparrows to shrub coverage (see also Knapton 1978, Kantrud 1981, Dale 1983, Arnold and Higgins 1986) may help explain their higher occurrence in crested wheatgrass/legume-mix pastures than in the other crested wheatgrass pastures. Clay-colored Sparrows may have been more attracted to crested wheatgrass pastures with alfalfa because alfalfa likely provides a structural substitute for shrubs (Johnson and Schwartz 1993a).

Our results for Sprague's Pipit are consistent with previous studies which have documented this species' preference for native over introduced vegetation (Wilson and Belcher 1989, Hartley 1994, Sutter et al. 1995, Madden 1996, Sutter 1996). In native pasture, Sprague's Pipit showed a positive association with cover of standing dead vegetation. Thus, the pipit's preference for native pastures may have resulted from the greater coverage of residual vegetation in these pastures than in crested wheatgrass pastures (Appendix). Dale (1983) found Sprague's Pipit to be positively associated with dead vegetation and density of vegetation 10 cm or less in height. Thus, the taller vegetative height and increased amount of bare ground in crested wheatgrass pastures (Appendix) may also have contributed to the pipit's greater occurrence in native pastures. Although previous studies have found Sprague's Pipit to be negatively associated with shrub cover (Dale 1983, Madden 1996), we detected no such association, possibly because native pastures examined in this study had few shrubs (Appendix).

Previous studies have found that Chestnut-collared Longspurs are associated with open and sparsely vegetated native prairie (Harris 1944, Stewart and Kantrud 1972, Owens and Myres 1973, Kantrud and Kologiski 1982, Dale 1983). In our study, this species was negatively associated with western snowberry and pasture sage but positively associated with June grass cover (Appendix). Interpretation of the significance of these three plant species in habitat selection by Chestnut-collared Longspurs is uncertain, with the strongest suggestion being an avoidance of

shrubs. Insight into why Chestnut-collared Longspurs preferred native over crested wheatgrass pastures is also difficult to determine from these results.

Grassland birds in Saskatchewan may benefit significantly if the amount of cropland that is predicted to be converted into crested wheatgrass pasture is realized. Six of the nine songbird species were detected in crested wheatgrass pasture in an equal or greater frequency than in native pastures, and the three species that preferred native pasture occurred in varying frequency in crested wheatgrass pastures. Thus, the conversion of cropland to crested wheatgrass pasture should benefit grassland songbirds, as cropland is unattractive to most bird species (Stewart and Kantrud 1972, Owens and Myres 1973, Hartley 1994). In addition, agricultural programs that have converted cultivated land to perennial cover have been shown to provide important habitat for grassland songbirds. The Conservation Reserve Program, for example, has been found to provide habitat that is attractive to many grassland bird species (Johnson and Schwartz 1993a, King and Savidge 1995) and has been suggested as one of the factors contributing to the recovery of some species (Johnson and Schwartz 1993b, Reynolds et al. 1994).

Landowners who seed their land to crested wheatgrass typically seed pure crested wheatgrass or crested wheatgrass/alfalfa to supplement native range and enhance forage quality (Campbell 1963, Hart et al. 1983). The crested wheatgrass/grass-mix pastures in this study were likely pure crested wheatgrass pastures that were subsequently invaded by exotic and native grasses. Of the two types of crested wheatgrass pasture intentionally seeded, pure crested wheatgrass pastures will likely have the greatest benefit for grassland songbirds in Saskatchewan; Sprague's Pipit and Grasshopper Sparrow were least attracted to crested wheatgrass/legume-mix pastures, whereas all other songbird species occurred in similar frequency in pure crested wheatgrass pastures and in those with alfalfa.

We caution that the relative abundance of singing males as we examined here is only one indicator of habitat quality. The reproductive consequences of selecting alternative nesting habitat must also be considered when assessing habitat quality (Van Horne 1983, Johnson and Temple 1986, Vickery et al. 1992). Few studies have examined nesting success of grassland songbirds (e.g., Hill 1976, Elliott 1978, Basore et al. 1986, Johnson and Temple 1986, Davis and Sealy in press), and to our knowledge, no research has been conducted in crested wheatgrass pastures. Research on the reproductive success of grassland songbirds in crested wheatgrass and native pastures is required to determine definitively the relative value of these pastures.

Although crested wheatgrass pastures were unexpectedly attractive to many grassland songbirds, they were less attractive than native pasture to three songbird species. Hence, preservation of existing native grasslands and restoration of grasslands that more closely mimic the native prairie community should continue to be priorities.

ACKNOWLEDGMENTS

Funding for this study was provided by the National Fish and Wildlife Foundation, Endangered Species Recovery Fund (World Wildlife Fund Canada and Canadian Wildlife Service of Environment Canada), and Saskatchewan Wetland Conservation Corporation (SWCC). We are grateful to J. Pollock and R. Shaw for their competent and dedicated field work and to T. Harrison for assistance in plant identification. D. H. Johnson (Northern Prairie Research Centre) and D. Anstey (SWCC) provided statistical advice. Thanks to D. Prescott, B. Dale, G. McMaster, K. Mazur, and J. Herkert for helpful comments on the manuscript. We especially thank the many landowners who allowed us access to their property.

LITERATURE CITED

ARNOLD, T. W., AND K. F. HIGGINS. 1986. Effects of shrub coverages on birds of North Dakota mixed-grass prairies. Canadian Field-Naturalist 100:10–14.

BASORE, N. S., L. B. BEST, AND J. B. WOOLEY. 1986. Bird nesting in Iowa no-tillage and tilled cropland. Journal of Wildlife Management 50:19–28.

BUDD, A. C. 1987. Budd's flora of the Canadian prairie provinces. Publication no. 1662, Canadian Department of Agriculture, Ottawa, ON.

CAMP, M., AND L. B. BEST. 1993. Bird abundance and species richness in roadsides adjacent to Iowa row-crop fields. Wildlife Society Bulletin 21:315–325.

CAMPBELL, J. B. 1963. Grass-alfalfa versus grass alone pastures grazed in a repeated-seasonal pattern. Journal of Range Management 16:78–81.

CARTWRIGHT, B. W., T. M. SHORTT, AND R. D. HARRIS. 1937. Baird's Sparrow. Transactions of the Royal Canadian Institute 46:153–198.

DALE, B. C. 1983. Habitat relationships of seven species of passerine birds at Last Mountain Lake, Saskatchewan. M.S. thesis. University of Regina, Regina, SK.

DAVIS, S. K., D. C. DUNCAN, AND M. SKEEL. 1996. The Baird's Sparrow: status resolved. Blue Jay 54:185–191.

DAVIS, S. K., AND S. G. SEALY. In press. Cowbird parasitism and nest predation in fragmented grasslands of southwestern Manitoba. *In* J. N. Smith, T. L. Cook, S. I. Rothstein, S. G. Sealy, and S. K. Robinson (editors). Ecology and management of cowbirds. University of Texas Press, Austin, TX.

DORMAAR, J. F., M. A. NAETH, W. D. WILLMS, AND D. S. CHANASYK. 1995. Effect of native prairie, crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) and Russian wildrye (*Elymus junceus* Fisch.) on soil

chemical properties. Journal of Range Management 48:258–263.

DUBOIS, A. D. 1935. Nests of Horned Larks and longspurs on a Montana prairie. Condor 37:56–72.

ELLIOTT, P. F. 1978. Cowbird parasitism in the Kansas tallgrass prairie. Auk 95:161–167.

HARRIS, R. D. 1944. The Chestnut-collared Longspur in Manitoba. Wilson Bulletin 56:105–115.

HART, R. H., J. W. WAGGONER, JR., D. H. CLARK, C. C. KALTENBACH, J. A. HAGER, AND M. B. MARSHALL. 1983. Beef cattle performance on crested wheatgrass plus native range vs. native range alone. Journal of Range Management 36:38–40.

HARTLEY, M. J. 1994. Passerine abundance and productivity indices in grasslands managed for waterfowl nesting cover. Transactions of the North American Wildlife and Natural Resources Conference 59: 322–327.

HERKERT, J. R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications 4:461–471.

HILL, R. A. 1976. Host-parasite relationships of the Brown-headed Cowbird in prairie habitat of west-central Kansas. Wilson Bulletin 88:555–565.

HOLT, N. W. 1994. Management of seeded forage for pasture in southwest Saskatchewan. Pp. 216–223 *in* F. K. Tahan, Z. Abouguendia, and P. R. Horton (editors). Managing Canadian rangelands for sustainability and profitability. Grazing and Pasture Technology Program, Regina, SK.

JOHNSON, D. H., AND M. D. SCHWARTZ. 1993a. The Conservation Reserve Program: habitat for grassland birds. Great Plains Research 3:273–295.

JOHNSON, D. H., AND M. D. SCHWARTZ. 1993b. The Conservation Reserve Program and grassland birds. Conservation Biology 7:934–937.

JOHNSON, R. G., AND S. A. TEMPLE. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairie. Pp. 245–249 *in* J. Verner, M. L. Morrison, and C. J. Ralph (editors). Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, WI.

KANTRUD, H. A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. Canadian Field-Naturalist 95:404–417.

KANTRUD, H. A., AND R. L. KOLOGISKI. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern great plains. U.S. Fish and Wildlife Service Wildlife Report no. 15, Washington, D.C.

KING, J. W., AND J. A. SAVIDGE. 1995. Effects of the Conservation Reserve Program on wildlife in southeast Nebraska. Wildlife Society Bulletin 23:377–385.

KNAPTON, R. W. 1978. Breeding ecology of the Clay-colored Sparrow. Living Bird 17:137–157.

KNOPF, F. L. 1994. Avian assemblages on altered grasslands. Studies in Avian Biology 15:247–257.

LEIN, M. R. 1968. The breeding biology of the Savannah Sparrow, *Passerculus sandwichensis* (Gmelin) at Saskatoon, Sask. M.S. thesis. University of Saskatchewan, Saskatoon, SK.

MADDEN, E. M. 1996. Passerine communities and bird-habitat relationships on prescribed-burned, mixed-grass prairie in North Dakota. M.S. thesis. Montana State University-Bozeman, Bozeman, MT.

MAHON, C. L. 1995. Habitat selection and detectability of Baird's Sparrows in southwestern Alberta. M.S. thesis. University of Alberta, Edmonton, AB.

MCADOO, J. K., W. S. LONGLAND, AND R. A. EVANS. 1989. Nongame bird community responses to sagebrush invasion of crested wheatgrass seedings. Journal of Wildlife Management 53:494–502.

OWENS, R. A., AND M. T. MYRES. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Canadian Journal of Zoology 51:697–713.

PETERJOHN, B. G., AND J. R. SAUER. 1993. North American Breeding Bird Survey annual summary 1990–1991. Bird Populations 1:1–15.

RALPH, C. J., G. R. GEUPEL, P. PYLE, T. E. MARTIN, AND D. F. DESANTE. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service Gen. Tech. Rep. PSW-GTR-144. USDA Forest Service Pacific Southwest Research Station, Albany, CA.

REIMER, G. E. 1994. Agricultural policy impacts on rangeland and options for reform: an overview and evaluation. Pp. 321–327 *in* F. K. Tahan, Z. Abouguendia, and P. R. Horton (editors). Managing Canadian rangelands for sustainability and profitability. Grazing and Pasture Technology Program, Regina, SK.

RENKEN, R. B., AND J. J. DINSMORE. 1987. Nongame bird communities on managed grasslands in North Dakota. Canadian Field-Naturalist 101:551–557.

REYNOLDS, R. E., T. L. SHAFFER, J. R. SAUER, AND B. G. PETERJOHN. 1994. Conservation Reserve Program: benefit for grassland birds in the northern plains. Transactions of the North American Wildlife and Natural Resources Conference 59:328–336.

REYNOLDS, T. D., AND C. H. TROST. 1980. The response of native vertebrate populations to crested wheatgrass planting and grazing by sheep. Journal of Range Management 33:122–125.

ROTENBERRY, J. T., AND J. A. WIENS. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. Ecology 61:1228–1250.

SAMSON, F. B., AND F. L. KNOPF. 1994. Prairie conservation in North America. BioScience 44:418–421.

SAS INSTITUTE INC. 1990. SAS/STAT user's guide. Ver. 6, 4th ed. Vols. 1 and 2. SAS Institute Inc., Cary, NC.

STEWART, R. E., AND H. A. KANTRUD. 1972. Population estimates of breeding birds in North Dakota. Auk 89:766–788.

SUTTER, G. C. 1996. Habitat selection and prairie drought in relation to grassland bird community structure and the nesting ecology of Sprague's Pipit, *Anthus spragueii.* Ph.D. dissertation. University of Regina, Regina, SK.

SUTTER, G. C., T. TROUPE, AND M. FORBES. 1995. Abundance of Baird's Sparrows, *Ammodramus bairdii,* in native prairie and introduced vegetation. Ecoscience 2:344–348.

VAN HORNE, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893–901.

VICKERY, P. D., M. L. HUNTER, JR., AND J. V. WELLS. 1992. Use of a new reproductive index to evaluate relationship between habitat quality and breeding success. Auk 109:697–705.

WIENS, J. A. 1973. Patterns and process in grassland bird communities. Ecological Monographs 43:237–270.

WIENS, J. A., AND M. I. DYER. 1975. Rangeland avifaunas: their composition, energetics, and role in the ecosystem. Pp. 146–182 *in* D. R. Smith (editor). Symposium on management of forest and range habitats for nongame birds. USDA Forest Service Gen. Tech. Rep. WO-1. USDA Forest Service, Washington, D.C.

WILSON, S. D., AND J. W. BELCHER. 1989. Plant and bird communities of native prairie and introduced Eurasian vegetation in Manitoba, Canada. Conservation Biology 3:39–44.

APPENDIX. VEGETATIVE-STRUCTURE AND PLANT-SPECIES VARIABLES IDENTIFIED BY LOGISTIC REGRESSION ANALYSIS AS IMPORTANT PREDICTORS OF THE OCCURRENCE OF GRASSLAND SONGBIRDS[a]

	Pasture type			
Variable	Native	Crested wheatgrass	Crested wheatgrass/ grass mix	Crested wheatgrass/ legume mix
Standing dead	27.2 ± 1.1	14.1 ± 1.1	14.8 ± 1.5	11.2 ± 1.4
Bare ground	11.2 ± 0.8	27.9 ± 1.6	22.6 ± 1.5	26.2 ± 2.5
Litter depth (m)	3.1 ± 0.3	3.4 ± 0.4	3.8 ± 0.7	1.4 ± 0.3
Vegetation height (cm)	8.6 ± 0.4	13.9 ± 0.7	15.1 ± 0.8	15.7 ± 0.8
Northern wheatgrass	4.5 ± 0.4	0.1 ± 0.0	0.5 ± 0.2	0.00
June grass	8.4 ± 0.5	0.1 ± 0.0	0.7 ± 0.5	0.00
Stipa spp.	8.7 ± 0.6	0.3 ± 0.1	0.9 ± 0.4	0.00
Upland sedges	5.6 ± 0.5	0.3 ± 0.1	1.5 ± 0.4	0.00
Club moss	6.8 ± 0.5	1.3 ± 0.3	0.8 ± 0.3	0.00
Crested wheatgrass	0.2 ± 0.1	47.1 ± 1.5	29.8 ± 1.7	34.0 ± 2.5
Pasture sage	5.3 ± 0.4	3.8 ± 0.6	2.7 ± 0.6	1.1 ± 0.5
Western snowberry	2.2 ± 0.3	0.7 ± 0.2	1.3 ± 0.4	0.2 ± 0.1
Bluegrass	2.4 ± 0.4	0.4 ± 0.2	6.1 ± 1.4	0.4 ± 0.4
Alfalfa	0.00	0.1 ± 0.0	1.2 ± 0.4	21.9 ± 2.3

Note: Mean (± SE) values are percent cover except where indicated. Plant-species nomenclature follows Budd 1987.

[a] Three plant species used in the logistic regression analyses not entered into any bird species' models were *Agropyron smithii*, blue grama grass, and smooth brome.