Studies in Avian Biology No. 19:87–94, 1999.

CHANGES IN BIRD POPULATIONS ON CANADIAN GRASSLANDS

C. STUART HOUSTON AND JOSEF K. SCHMUTZ

Abstract. Before the Canadian prairies were settled in the 1880s, the grassland birds of that region were catalogued in the 1820s, 1850s, and 1870s by John Richardson, Thomas Blakiston, and Elliott Coues, respectively. Ernest Thompson Seton recorded changes in southern Manitoba during the first 10 years of settlement. Tree plantings on the open plains made nest sites available for several species, but human encroachment was harmful to other, especially larger, species. Breeding Bird Surveys on the Canadian prairies between 1966 and 1994 documented steep declines of Sprague's Pipit (*Anthus spragueii*; 7.3 percent per year) and Loggerhead Shrike (*Lanius ludovicianus*; 5.6 percent per year) and less severe (but still more than 2.0 percent per year) declines of Northern Harrier (*Circus cyaneus*), Killdeer (*Charadrius vociferus*), Burrowing Owl (*Athene cunicularia*), Short-eared Owl (*Asio flammeus*), and Western Meadowlark (*Sturnella neglecta*). Swainson's Hawk (*Buteo swainsoni*) and Ferruginous Hawk (*B. regalis*) have shown significantly reduced productivity, coincident with sharp declines in their main prey, Richardson's ground squirrel (*Spermophilus richardsonii*). Both hawk species are now showing evidence of population declines as well. Introduced trees in deserted farmsteads are dying from neglect, drought, herbicides, and bulldozers, offering fewer nesting sites and less protective cover. Until recently, the Canadian government has encouraged plowing native prairie and substituting grain crops or crested wheatgrass (*Agropyron cristatum*) in its place. Marked increases in red fox (*Vulpes fulva*) numbers (which may have contributed to decreased numbers of Richardson's ground squirrels) and increased use of pesticides, fertilizers, and other chemicals have coincided with bird declines. Declines in numbers of small grassland birds and in numbers and productivity of three grassland raptors seem disproportionate to these factors and may be more severe than in the western United States.

CAMBIOS EN LAS POBLACIONES DE AVES EN LOS PRADOS DE CANADÁ

Sinopsis. Antes de la colonización de los prados canadienses en los años de la década de 1880, las aves de pastizal de esa región habían sido catalogadas en las décadas de 1820, 1850 y 1870 por John Richardson, Thomas Blakiston y Elliott Coues, respectivamente. Ernest Thompson Seton anotó cambios en el sur de Manitoba durante los primeros 10 años de colonización. La siembra de árboles en las llanuras descampadas proporcionó sitios de nidos para algunas especies, pero la invasión humana fue perjudicial para otras especies, especialmente las más grandes. Los Breeding Bird Surveys en las llanuras canadienses entre 1966 y 1994 documentaron disminuciones precipitadas de la Bisbita de Sprague (*Anthus spragueii*; 7,3 por ciento por año) y de Lanio Americano (*Lanius ludovicianus*; 5,6 por ciento por año) y disminuciones menos severas (pero de todos modos de más de un 2,0 por ciento por año) del Gavilán Rastrero (*Circus cyaneus*), del Chorlito Tildío (*Charadrius vociferus*), del Búho Llanero (*Athene cunicularia*), del Búho Orejicorto (*Asio flammeus*) y del Pradero Occidental (*Sturnella neglecta*). El Aguililla de Swainson (*Buteo swainsoni*) y el Aguililla Real (*B. regalis*) han experimentado una importante reducción en la productividad, coincidente con una drástica disminución de su presa principal, la ardilla terrestre de Richardson (*Spermophilus richardsonii*). Asimismo, ambas especies de halcón ahora muestran indicios de disminuciones poblacionales. Los árboles introducidos en cortijos abandonados están muriendo por el descuido, por la sequía, por los herbicidas y por los bulldozers, y ofrecen menos sitios de nidos y menos cobertura protectora. Hasta hace poco, el gobierno canadiense ha favorecido el arado de la pradera nativa y, en su lugar, ha dado preferencia a la sustitución de cosechas de granos o de *Agropyron cristatum.* Aumentos marcados de los números de los zorros rojos (*Vulpes fulva*) (que pueden haber contribuido a los números redicidos de ardillas terrestres de Richardson) y el aumento del uso de pesticidas, de abonos y de otras sustancias químicas han coincidido con las disminuciones de las aves. Las disminuciones de los números de aves pequeñas de pastizal y de los números y la productividad de tres aves rapaces de pastizal parecen desproporcionadas para estos factores y pueden ser más severas que en el oeste de los Estados Unidos.

Key Words: agriculture; Alberta; Canadian prairies; grassland birds; Manitoba; presettlement; Saskatchewan.

There is widespread concern about the decline in grassland birds throughout the Canadian prairies, a profoundly altered habitat. "Between plowing and overgrazing, it is perhaps the most extensively altered biome on the planet" (Gayton 1990:25). With historical information that extends back to the 1820s (Richardson and Swainson 1832, Blakiston 1861–1863, Coues 1878), no locality in North America can surpass the presettlement inventory available for Saskatchewan. In this paper we summarize for selected species 177 yr of observations in southern Saskatchewan, describe population trends for selected species since 1966, and suggest possible

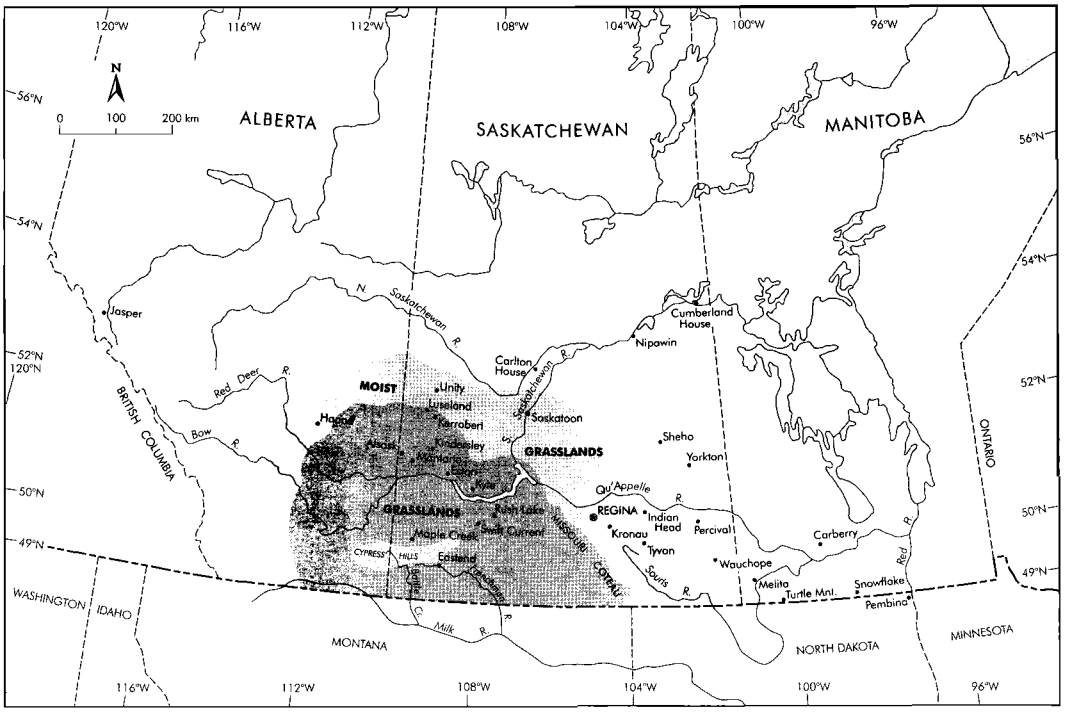

FIGURE 1. Map of Canadian prairie grasslands and of cities and villages mentioned in text. Dark shading represents open grassland, lighter shading represents moist grassland with some aspen copses. (Map by K. Bigelow, Department of Geography, University of Saskatchewan, Saskatoon, SK.)

links between species declines and widespread ecosystem change. We stress some of the major changes in bird populations resulting from the extirpation of bison (*Bison bison*), the conversion of native grassland to agricultural fields, the cessation of regular prairie fires, the regrowth of quaking aspen (*Populus tremuloides*) from dormant roots (Maini 1960), the planting of trees in shelterbelts, and the declines in trees associated with deserted farmsteads, herbicides, bulldozers, and drought.

Some bird species, among them Mourning Dove (*Zenaida macroura*), Western Kingbird (*Tyrannus verticalis*), Black-billed Magpie (*Pica pica*), American Crow (*Corvus brachyrhynchos*), Tree Swallow (*Tachycineta bicolor*), Barn Swallow (*Hirundo rustica*), and Mountain Bluebird (*Sialia currucoides*), adapted to human settlement and the tree planting that followed it and increased in numbers (Houston 1977a, b, 1979, 1986; Houston and Houston 1988, 1997). Populations of most other species in the mixed prairie ecosystem of the prairie ecozone (Padbury and Acton 1994) remained relatively stable until about 1970, although satisfactory monitoring of numbers by Breeding Bird Surveys (BBSs) has been available only since 1966. In the early 1970s, about the same time as agriculture became more technological with higher chemical inputs (Goldsborough 1993), declines in populations and productivity of several grassland species became evident (Downes and Collins 1996). For Burrowing Owls (*Athene cunicularia*; Houston et al. 1996) and Loggerhead Shrikes (*Lanius ludovicianus*; Peterjohn and Sauer 1995), evidence of decline has been universal and consistent across the Canadian prairies.

HISTORICAL PERSPECTIVE

The Nineteenth Century

In the 1820s, bison and recurrent fires maintained open grassland north to Carlton House, Saskatchewan (52°52′ N, 106°32′ W; Fig. 1) on the North Saskatchewan River (Houston 1977a). This was the site of intensive natural-history cataloguing by two Scotsmen, surgeon-naturalist Dr. John Richardson and naturalist Thomas Drummond (Richardson 1823, 1829, 1836; Sabine 1823; Richardson and Swainson 1832; Kirby 1837; Hooker 1840). On his first visit to Carlton House, in May 1820, Richardson noted that the interface between mixed forest and grassland had exceptional diversity (Houston and Street 1959).

Three decades later, from October 1857 until June 1858, the birdlife at Carlton House was assessed by English surveyor Thomas Wright Blakiston (Blakiston 1861–1863, Houston and Street 1959). Blakiston found the American Crow so uncommon he could not collect a specimen of it, whereas the Common Raven (*Corvus corax*) was numerous and nested commonly on open grasslands. In 1873 and 1874, further studies prior to the advent of farming were carried out along the Manitoba-United States boundary by American surgeon-naturalist Elliott Coues (1878), who reported that Tree Swallows were rare and that Barn Swallows nested sparingly on cliff faces, separate from the more common Cliff Swallows (*Hirundo pyrrhonota*). Red-winged Blackbird (*Agelaius phoeniceus*) was the least common blackbird, and the American Crow was still uncommon. Upland Sandpipers (*Bartramia longicauda*) were numerous, and both Whooping Cranes (*Grus americana*) and Sandhill Cranes (*G. canadensis*) were sparingly but quite evenly distributed. Coues commented that between Pembina Mountain (present-day Snowflake) and Turtle Mountain, Manitoba (Fig. 1), Baird's Sparrow (*Ammodramus bairdii*) was the "most abundant and characteristic species. . .in some places outnumbering all the other birds together" (Coues 1873:695–696). Coues also noted that in the same area Chestnut-collared Longspurs (*Calcarius ornatus*) occurred "in profusion" (Coues 1878:579). West of where the Missouri Coteau crosses the 49th parallel, near the present boundary between North Dakota and Montana, shortgrass prairie predominated and McCown's Longspurs (*C. mccownii*) became abundant as Chestnut-collared Longspurs declined. When Walter Raine, a lithographer by trade and an oologist by avocation, visited new ranching territory at Rush Lake, Saskatchewan (Fig. 1), in 1891, McCown's Longspur was the most common small bird on the elevated prairies (Raine 1892, Houston 1981). In 1873 and 1874, Chestnut-collared Longspurs and Sprague's Pipits (*Anthus spragueii*) were also abundant (Coues 1873); at the eastern crossing of the Souris River loop, Sprague's Pipits were "so numerous that the air seemed full of them" (Coues 1878:560).

By 1882, naturalist and well-known author Ernest E. Thompson (later known as Ernest Thompson Seton) had made careful observations in southwestern Manitoba and adjacent Saskatchewan (Thompson 1890); settlers were still thinly scattered but the Passenger Pigeon (*Ectopistes migratorius*) had all but vanished. Ten years later, Seton noted the influx of Mourning Doves, the westward advance of the Greater Prairie-Chicken (*Tympanuchus cupido*) and Eastern Bluebird (*Sialia sialis*) with settlement, and the virtual disappearance of Upland Sandpipers and Sprague's Pipit as native prairie was plowed for agriculture (Houston 1980). Seton also noted declines in Chestnut-collared Longspurs and Swainson's Hawks (*Buteo swainsoni*) and increases in Western Meadowlarks (*Sturnella neglecta*) and Horned Larks (*Eremophila alpestris*) during the first 10 yr of settlement (Houston 1980).

Because they provided food, large birds were often hunted by farmers. Canada Geese (*Branta canadensis*) soon became less common. Greater Sandhill Cranes (*Grus canadensis tabida*) and Whooping Cranes were also shot for food. Some large birds, however, did not disappear until the end of the nineteenth century. At Rush Lake in 1891, Turkey Vultures (*Cathartes aura*), present since the days of the bison, were still common on the open prairie, as were a few Common Ravens (Raine 1892).

The Twentieth Century

In Saskatchewan, Black-billed Magpies (*Pica pica*) retreated from the plains in the late 1800s and by the early twentieth century were restricted to the Cypress Hills in southwestern Saskatchewan (Houston 1977a; Fig. 1). From 1904 through 1910, magpies disappeared even from nearby Maple Creek and Eastend (Fig. 1), but in the 1920s they increased and spread out. They reappeared in small numbers to the north and east at Unity and Sheho in 1926, Percival in 1929, and Nipawin in 1930, and they were common at Wauchope in 1939 and Yorkton in 1951 (Fig. 1). They became city residents in Saskatoon (Fig. 1) beginning in the late 1960s and have increased throughout the province since then (Houston 1977a). Between 1885 and 1903, Mourning Doves spread out from the Qu'Appelle River valley onto the newly settled plains near Indian Head (Houston 1986; Fig. 1).

Spreading northeastward from river valleys onto the plains as domestic trees reached about 6 m in height, the Western Kingbird has served as a useful indicator species for tree growth. For example, at the Harley Ranson farm at Tyvan, Saskatchewan (Fig. 1), where trees were planted in 1903, Western Kingbirds first nested in 1924; at the Stewart Houston farm 8 km to the west, where trees were planted in 1917, the kingbirds took up residence in 1937 (Houston 1979). Red-tailed Hawks (*Buteo jamaicensis*), once quite uncommon even in migration, extended their range southward onto former prairie areas as aspen (*Populus* spp.) copses, locally known as "bluffs," grew up from dormant roots once prairie fires came under control about 1910 (Houston and Bechard 1983).

Grasslands and trees

Native grasslands were quickly plowed following settlement. By 1911 there were 95,013 farms in Saskatchewan comprising an area of 113,843 km^2, of which 48,076 km^2 (42%) were plowed (Archibold and Wilson 1980). The number of farms peaked at 142,391 in 1936 and dropped to 60,840 by 1991, yet total farm area increased to 268,738 km^2 in 1991, a year when 134,624 km^2 (50%) were in crops, 57,143 km^2 (21%) in summerfallow, 10,759 km^2 (4%) in tame pasture, and 66,198 km^2 (25%) were undesignated (Saskatchewan Agriculture and Food 1994). As a result of these changes, remaining grasslands have became smaller, more fragmented, and of poorer quality. Between 1976 and 1986, 8% of grassland was lost in Alberta, 8% in Manitoba, and 6% in Saskatchewan (Wellicome and Haug 1995). By 1978, nearly 18% (69,243 of 385,832 ha) of the Prairie Farm Rehabilitation Administration (PFRA) pastures in the mixed grassland ecoregion had been seeded (Agriculture and Agri-Food Canada 1996).

A 1972 study of 16 townships in Saskatchewan, together representing more than 1% of Saskatchewan grassland, showed 269 occupied farmsteads and 244 abandoned farmsteads, 80% of the latter still with tree cover (Smith 1973).

Insecticides, herbicides, and fertilizer

Chemicals were used sparingly by Canadian farmers prior to 1947. Use of 2,4-D, one of the phenoxy herbicides, began at this time, and by 1966 high volumes of it were in use (Goldsborough 1993). Other herbicides appeared in 1965 and were being used in high volumes by 1980.

Peregrine Falcons (*Falco peregrinus*) were rare and local breeders along the Frenchman River valley and Battle Creek in the grasslands of extreme southwestern Saskatchewan until at least 1917 (Bechard 1981, 1982) but persisted until the 1950s in Alberta valleys such as that of the Red Deer River (e.g., Taverner 1919; Fig. 1). In 1975, following widespread use of DDT, a survey of historical Peregrine Falcon breeding sites in southern Alberta showed that none were occupied (Fyfe et al. 1976).

With extensive use of dieldrin in the late 1950s and early 1960s, Merlins (*Falco columbarius*) declined moderately in Alberta and almost disappeared from the grassland near Kindersley, Saskatchewan, for 10 yr (Hodson 1976, Houston and Schmidt 1981); by 1995, Merlin numbers had returned to preinsecticide levels in Saskatchewan (Houston and Hodson 1997).

Mammalian predators

Red foxes (*Vulpes fulva*) were extremely rare in southern Saskatchewan until 1965 at Luseland and 1966 at Kyle (Fig. 1); they quickly became common in the 1970s (Jordheim 1995, Finley 1996). Coyotes (*Canis latrans*) have increased in the same area since the late 1980s (Finley 1996). It is likely that increasing populations of foxes on the Canadian prairies have had a detrimental effect on populations of grassland birds. In North Dakota, Sovada et al. (1995) found that duck nesting success averaged 32% where coyotes were the principal canid but fell to 17% where foxes were the principal canid.

Breeding Bird Surveys

BBSs began in Manitoba, Saskatchewan, and Alberta in 1966. Since that time, populations of many grassland species in the southern portions of the Canadian prairie provinces have shown significant negative trends. For example, BBS data for grassland portions of Alberta, Saskatchewan, and southwestern Manitoba indicate significant ($P < 0.05$) population declines between 1966 and 1994 for Sprague's Pipit (−7.3% per annum), Loggerhead Shrike (−5.2%), Killdeer (*Charadrius vociferus*; −3.3%), Short-eared Owl (*Asio flammeus*; −2.9%), Western Meadowlark (−2.1%), and Burrowing Owl (−2.0%) (Downes and Collins 1996). Grassland species that have shown nonsignificant ($P > 0.05$) population declines during the same period include Lark Bunting (*Calamospiza melanocorys*; −11.2% per annum), McCown's Longspur (−9.0%), Lark Sparrow (*Chondestes grammacus*; −3.2%), Chestnut-collared Longspur (−2.2%), and Horned Lark (−1.1%) (Downes and Collins 1996). All of these species, with the exception of the shrike, are ground-nesters that are likely to be extremely vulnerable to predation. Knopf (1994:25), referring to both the United States and Canada, noted that "grassland birds have shown steeper, more consistent and more geographically widespread declines than any other behavioral or ecological guild of North American species."

Burrowing Owls

Burrowing Owls, which in the 1830s extended north at least to Carlton House, Saskatchewan (Houston and Street 1959), have declined steadily in range and abundance in the three prairie provinces since the late 1970s (Houston et al. 1996). The harmful effects of the insecticide Carbofuran on this species were first demonstrated in 1986 (James and Fox 1987), but the decline has continued even after restrictions on using this chemical within 250 m of owl colonies were implemented. This decline is due in part to habitat loss and fragmentation and to increases in predator populations (Wellicome and Haug 1995). On the plains near Regina, Sas-

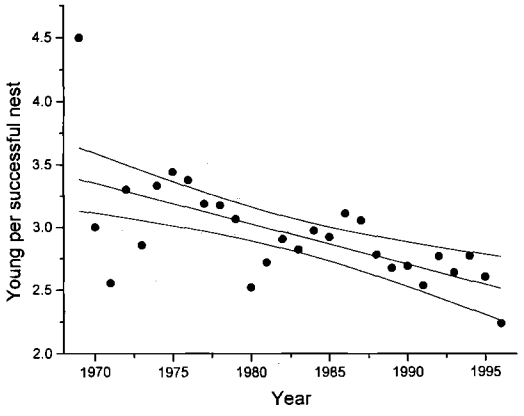

FIGURE 2. Productivity (young per successful nest produced to banding age) of Ferruginous Hawks in Saskatchewan, 1969–1996. Curved lines represent the 95% confidence interval about the linear regression ($r = -0.63$, $P < 0.001$)

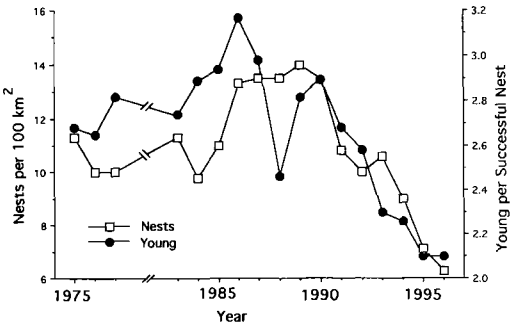

FIGURE 3. Population (nests per 100 km^2) and productivity (young per successful nest) of Ferruginous Hawks near Hanna, Alberta, 1975–1996.

katchewan, the Burrowing Owl population declined steadily from 76 pairs in 1987 to 29 pairs in 1992 and 9 pairs in 1994 (Warnock and James 1997). During this period, the percentage of successful pairs dropped from 72 to 45%, and the number of young produced per nest attempt dropped from 3.1 to 1.8 (James et al. 1997). In large PFRA pastures in the Kindersley, Saskatchewan, region (Fig. 1), Burrowing Owls were last seen breeding at Antelope Park in 1980, Heart's Hill in 1985, Mantario in 1986, Newcombe in 1990, Eagle Lake in 1993, Kindersley-Elna in 1993, and Progress in 1994. A single pair persisted at Mariposa in 1996. At Kindersley-Elna Pasture (63.5 km^2) there were 18 pairs of Burrowing Owls in 1991, 9 pairs in 1992, 2 pairs in 1993, and none thereafter (Houston et al. 1996). The Committee on the Status of Endangered Wildlife in Canada elevated the Burrowing Owl's status from threatened to endangered in 1995 (Wellicome and Haug 1995).

Swainson's and Ferruginous hawks

In Saskatchewan, Swainson's Hawk productivity averaged 2.09 young per successful nest from 1964 through 1987 (N = 985 successful nests; S. Houston, unpubl. data). Productivity then declined sharply, averaging 1.63 young per successful nest from 1988 through 1994 and dropping as low as 1.27 young per successful nest in 1993 (N = 602 successful nests; Houston and Schmutz 1995).

Near Hanna, Alberta (Fig. 1), Swainson's Hawk productivity fell from a long-time mean of 2.03 to 1.14 young per successful nest in 1993 (N = 1,170; Houston and Schmutz 1995), rose to 1.69 in 1994, and then dropped to 1.22 in 1995 and 1.40 in 1996 (J. Schmutz, unpubl. data). We know of no mechanism by which short-acting pesticide (monocrotophos) poisoning on this species' wintering grounds in Argentina (Goldstein et al. 1996) should have detrimental effects on brood size 6 mo later.

Ferruginous Hawks have disappeared from nearly half of their presettlement territory in Saskatchewan (Houston and Bechard 1984), and their productivity has declined. Between 1969 and 1987, the number of young fledged per successful nest averaged 3.01 (N = 369 successful nests; S. Houston, unpubl. data). Since 1988 this number has remained below 2.82 and has averaged 2.63 (N = 488 successful nests; S. Houston, unpubl. data). Overall productivity has declined in recent years ($r = 0.63$, $P < 0.001$; S. Houston, unpubl. data; Fig. 2). The species has declined even more severely in Alberta. The number of nests in the Hanna study area dropped from a peak of 14 per 100 km^2 in 1989 to 7 and 6 per 100 km^2 in 1995 and 1996, respectively, and productivity declined from 3.2 young per successful nest in 1986 to 2.1 in 1995 and 1996 (J. Schmutz, unpubl. data; Fig. 3).

The nesting period of the Ferruginous Hawk coincides with the peak abundance of young Richardson's ground squirrels (*Spermophilus richardsonii*), which are the main prey of Ferruginous Hawks in Saskatchewan and Alberta (Schmutz et al. 1980). The decline in productivity of both Ferruginous and Swainson's hawks is probably the result of the sharp decline in this rodent since 1987. This decrease began at Kindersley, Saskatchewan, and extended west to Mantario, Saskatchewan, and then Hanna, Alberta (Houston and Schmutz 1995; S. Houston and J. Schmutz, unpubl. data). One possible explanation for the steep decline in ground squirrels is the substantial increase in the red fox population.

Nest sites for both Ferruginous and Swainson's hawks have also been lost. South of the aspen parkland belt, the remaining planted trees, largely in shelterbelts of deserted farms, are dying from neglect, drought, and herbicide sprays and are razed by bulldozers as farmers try to increase the amount of land they have in production.

DISCUSSION

The declines of small grassland birds in Canada since the mid-1960s and the earlier decline of the Upland Sandpiper more than a century ago can be explained, at least in part, by an ever-diminishing and ever-more-fragmented amount of native grassland. This pertains particularly to Sprague's Pipit and Chestnut-collared Longspur, species that prefer native grassland over seeded pasture, hayland, and cropland (S. K. Davis, unpubl. data). The decline in Sprague's Pipit may have been hastened by overgrazing (Dale 1984, Sutter 1996), but Horned Larks and Chestnut-collared Longspurs, which usually respond favorably to grazing (Owens and Myres 1973), have also declined (Dale 1984). In Saskatchewan, numbers of Baird's Sparrows correlated positively with grass/sedge (*Carex*) cover and negatively with bare ground cover (Sutter et al. 1995). Clay-colored Sparrows (*Spizella pallida*) were also detected more often in native pasture than in any seeded pasture with crested wheatgrass (*Agropyron cristatum*; Davis and Duncan 1999). Fragmentation of prairie can also have adverse effects, including an increase in Brown-headed Cowbird (*Molothrus ater*) parasitism (Davis and Sealy in press).

The Canadian government has provided monetary incentives that have encouraged grain rather than cattle production and hence has encouraged the breaking of marginal lands (Fulton et al. 1989; Anderson et al. 1991; Riemer 1993, 1995). The "Crow's Nest Pass Rate," for example, which was in effect from 1897 until 1995, subsidized grain but not cattle shipments to ports, and the grain quota system, abandoned only in 1996, allowed sales based on cultivated acreage—the more land a farmer plowed, the more grain he was allowed to sell. The government has paid farmers when grain (but not cattle) prices fell below a 5-yr average and has subsidized crop insurance to underwrite the risk of growing grain. These are but a few examples of the government policies that have favored grain production over cattle production in the twentieth century. Additionally, the development of larger farm machinery and of mechanical rock-pickers has allowed hilly and rocky pastures to be broken, large sloughs to be drained, and shelterbelts and streamside vegetation to be removed (Anderson et al. 1991). Increasing farm debt, which averaged $89,000 per farm by 1985, has added financial pressures to this mix (Anderson et al. 1991). Although major government assistance programs were discontinued in 1995 and 1996, which should reduce pressure to convert pastures into cropland, such changes are so recent that beneficial effects will probably not be apparent or measurable for at least a few years.

Concern is not restricted to small grassland birds and three raptor species. Waterfowl nest success in the prairie pothole region has declined at a significant annual rate of about 0.5%, even on islands without mammalian predators and in study areas where large predators have been removed or excluded by fencing (Beauchamp et al. 1996). Increased predation by mammals, especially red foxes, striped skunks (*Mephitis mephitis*; Pasitschniak-Arts and Messier 1995), and Franklin's ground squirrels (Sargeant et al. 1987), has contributed to duck declines, with as yet undetermined effects on ground-nesting passerines.

The loss of prairie alone cannot explain the severity of the Burrowing Owl decline in the Canadian prairies and northwestern North Dakota (R. K. Murphy, pers. comm.), which contrasts with slowly declining numbers in southwestern North Dakota and increasing numbers in southwestern Idaho from the 1970s through the 1990s (K. Steenhof, pers. comm.). Carbofuran may have contributed to Burrowing Owl declines at one stage, but its use is now prohibited within 250 m of a Burrowing Owl nest. The declines in productivity among Swainson's and Ferruginous hawks, which have continued for 9 yr in Saskatchewan and Alberta, appear to differ from anything described in the United States. The causes of these declines, though probably associated with acute declines in prey species, are still not well understood.

Unprecedented industrialization of farming has occurred, partially overlapping with the declines in grassland birds described here. Such associations, while intriguing, may be partially coincidental, but further scrutiny is indicated. We do not know the cause of the recent but widespread declines in productivity, largely or entirely restricted to Canada, among three grassland raptor species. Careful study of these species must continue as we search for answers.

ACKNOWLEDGMENTS

M. Fulton, Saskatchewan Institute of Pedology, provided valuable insight and commentary; G. Riemer, B. Bristol, and G. Wrubleski provided unpublished data about the PFRA and other government projects; and K. Bigelow, University of Saskatchewan, and D. S. Houston assisted with graphics. J. Harris, D. Francis,

and D. Zazelenchuk found many Swainson's and Ferruginous hawk nests in Saskatchewan, and D. G. Miller and M. A. Gerard were among the many people who helped with the Saskatchewan banding operation. P. D. Vickery, B. Dale, and two anonymous reviewers provided helpful criticism.

LITERATURE CITED

AGRICULTURE AND AGRI-FOOD CANADA. 1996. Sensitivity analysis of economic impacts of proposed endangered species legislation and community pasture grazing. Internal report, Land Management and Diversification Service, Prairie Farm Rehabilitation Administration, Regina, SK.

ANDERSON, D. W., C. J. ROPPEL, AND R. M. GRAY. 1991. Sustainability in Canadian agriculture. Science Council of Canada, Ottawa, ON.

ARCHIBOLD, O. W., AND M. B. WILSON. 1980. The natural vegetation of Saskatchewan prior to agricultural settlement. Canadian Journal of Botany 58:2031–2042.

BEAUCHAMP, W. D., T. D. NUDDS, AND R. G. CLARK. 1996. Duck nest success declines with and without predator management. Journal of Wildlife Management 60:258–264.

BECHARD, M. J. 1981. Historic nest records of the Peregrine Falcon in southern Saskatchewan and southern Manitoba. Blue Jay 39:182–183.

BECHARD, M. J. 1982. Further evidence for a historic population of Peregrine Falcons in southern Saskatchewan. Blue Jay 40:125.

BLAKISTON, T. 1861–1863. On birds collected and observed in the interior of British North America. Ibis 3:314–320; 4:3–10; 5:39–87; 5:121–155.

COUES, E. 1873. Notes on two little-known birds of the United States. American Naturalist 7:695–697.

COUES, E. 1878. Field-notes on birds observed in Dakota and Montana along the forty-ninth parallel during the seasons of 1873 and 1874. Bulletin of the U.S. Geological and Geographical Survey of the Territories 4(3):545–661.

DALE, B. C. 1984. Birds of grazed and ungrazed grasslands in Saskatchewan. Blue Jay 42:102–104.

DAVIS, S. K., AND D. C. DUNCAN. 1999. Grassland songbird abundance in native and crested wheatgrass pastures of southern Saskatchewan. Studies in Avian Biology 19:211–218.

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.

DOWNES, C., AND B. T. COLLINS. 1996. The Canadian Breeding Bird Survey, 1966–1994. Canadian Wildlife Service Progress Notes no. 210.

FINLEY, K. 1996. The red fox invasion and other changes in wildlife populations in west-central Saskatchewan since the 1960s. Blue Jay 54:206–210.

FULTON, M., K. ROSAASEN, AND A. SCHMITZ. 1989. Canadian agricultural policy and prairie agriculture. Economic Council of Canada, Ottawa, ON.

FYFE, R. W., S. A. TEMPLE, AND T. J. CADE. 1976. The 1975 North American Peregrine Falcon survey. Canadian Field-Naturalist 90:228–273.

GAYTON, D. 1990. The wheatgrass mechanism: science and imagination in the western Canadian landscape. Fifth House, Saskatoon, SK.

GOLDSBOROUGH, L. G. 1993. Studies on the impact of agricultural and forestry herbicides on non-target aquatic plant communities. Pp. 49–57 *in* G. L. Holroyd, H. L. Dickson, M. Regnier, and H. C. Smith (editors). Prairie conservation and endangered species workshop, Brandon, 1992. Provincial Museum of Alberta Occasional Papers no. 19.

GOLDSTEIN, M. L., B. WOODBRIDGE, M. E. ZACCAGNINI, AND S. B. CANEVELLI. 1996. An assessment of mortality of Swainson's Hawks on wintering grounds in Argentina. Journal of Raptor Research 30:106–107.

HODSON, K. A. 1976. The ecology of Richardson's Merlins on the Canadian prairies. M. S. thesis. University of British Columbia, Vancouver, BC.

HOOKER, W. J. 1840. Flora boreali-americana. William G. Bohn, London, U.K.

HOUSTON, C. S. 1977a. Changing patterns of corvidae on the prairies. Blue Jay 35:149–155.

HOUSTON, C. S. 1977b. The prairie bluebird trail. Nature Canada 6(2):3–9.

HOUSTON, C. S. 1979. The spread of the Western Kingbird across the prairies. Blue Jay 37:149–157.

HOUSTON, C. S. 1980. Introduction. Pp. 5–15 *in* Ernest Thompson Seton in Manitoba [no editor]. Manitoba Naturalists' Society, Winnipeg, MB.

HOUSTON, C. S. 1981. An assessment of Walter Raine and his Saskatchewan records. Blue Jay 39:168–181.

HOUSTON, C. S. 1986. Mourning Dove numbers explode on the Canadian prairies. American Birds 40: 52–54.

HOUSTON, C. S., AND M. J. BECHARD. 1983. Trees and the Red-tailed Hawk in southern Saskatchewan. Blue Jay 41:99–109.

HOUSTON, C. S., AND M. J. BECHARD. 1984. Decline of the Ferruginous Hawk in Saskatchewan. American Birds 38:166–170.

HOUSTON, C. S., D. G. HJERTAAS, R. L. SCOTT, AND P. C. JAMES. 1996. Experience with Burrowing Owl nest-boxes in Saskatchewan, with comment on decreasing range. Blue Jay 54:136–140.

HOUSTON, C. S., AND K. A. HODSON. 1997. Resurgence of breeding Merlins, *Falco columbarius richardsonii,* in Saskatchewan grasslands. Canadian Field-Naturalist 111:243–248.

HOUSTON, C. S., AND M. I. HOUSTON. 1988. Tree Swallow banding near Saskatoon, Saskatchewan. North American Bird-Bander 12:103–108.

HOUSTON, C. S., AND M. I. HOUSTON. 1997. Saskatchewan bird species which increased with settlement. Blue Jay 55(2):90–96.

HOUSTON, C. S., AND A. SCHMIDT. 1981. History of Richardson's Merlin in Saskatchewan. Blue Jay 39: 30–37.

HOUSTON, C. S., AND J. K. SCHMUTZ. 1995. Declining reproduction among Swainson's Hawks in prairie Canada. Journal of Raptor Research 29:198–201.

HOUSTON, C. S., AND M. G. STREET. 1959. The birds of the Saskatchewan River. Saskatchewan Natural History Society, Regina, SK.

JAMES, P. C., T. J. ETHIER, AND M. K. TOUTLOFF. 1997. Parameters of a declining Burrowing Owl popula-

tion in Saskatchewan. Raptor Research Report 9:34–37.

JAMES, P. C., AND G. A. FOX. 1987. Effects of some insecticides on productivity of Burrowing Owls. Blue Jay 45:65–71.

JORDHEIM, S. 1995. Foxes in south-central Saskatchewan. Blue Jay 43:232–233.

KIRBY, W. 1837. Fauna boreali-americana. Vol. 4. The insects. Josiah Fletcher, Norwich, U.K.

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

MAINI, J. S. 1960. Invasion of grassland by *Populus tremuloides* in the northern Great Plains. Ph.D. dissertation. University of Saskatchewan, Saskatoon, SK.

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.

PADBURY, G. A., AND D. F. ACTON. 1994. Ecoregions of Saskatchewan. Central Survey and Mapping Agency, Regina, SK.

PASITSCHNIAK-ARTS, M., AND F. MESSIER. 1995. Predator identification at simulated waterfowl nests using inconspicuous hair catchers and wax-filled eggs. Canadian Journal of Zoology 73:984–990.

PETERJOHN, B. G., AND J. R. SAUER. 1995. Population trends of the Loggerhead Shrike from the North American Breeding Bird Survey. Proceedings of the Western Foundation of Vertebrate Zoology 6:117–121.

RAINE, W. 1892. Bird nesting in north-west Canada. Hunter Rose, Toronto, ON.

RICHARDSON, J. 1823. Botanical appendix. Pp. 729–768 *in* J. Franklin. Narrative of a journey to the shores of the Polar Sea in the years 1819, 20, 21, and 22. John Murray, London, U.K.

RICHARDSON, J. 1829. Fauna boreali-americana. Vol. 1. The mammals. John Murray, London, U.K.

RICHARDSON, J. 1836. Fauna boreali-americana. Vol. 3. The fish. Richard Bentley, London, U.K.

RICHARDSON, J., AND W. SWAINSON. 1832. Fauna boreali-americana. Vol. 2. The birds. John Murray, London, U.K.

RIEMER, G. 1993. Agricultural policy impacts on land use decision making and options for reform. Pp. 123–132 *in* P. Rakowski and R. Massey (editors). Proceedings of the first national Wildlife Habitat workshop. Wildlife Habitat Canada, Ottawa, ON.

RIEMER, G. 1995. The effects of GATT on Canadian environmental and farm policy. Pp. 129–135 *in* R. Gray, T. Becker, and A. Schmitz (editors). World agriculture in a post-GATT environment: new rules, new strategies. University Extension Press, University of Saskatchewan, Saskatoon, SK.

SABINE, J. 1823. Zoological appendix. Pp. 647–703 *in* J. Franklin. Narrative of a journey to the shores of the Polar Sea in the years 1819, 20, 21, and 22. John Murray, London, U.K.

SARGEANT, A. B., M. A. SOVADA, AND R. J. GREENWOOD. 1987. Responses of three prairie ground squirrel species, *Spermophilus franklinii, S. richardsonii,* and *S. tridecemlineatus,* to duck eggs. Canadian Field-Naturalist 101:95–97.

SASKATCHEWAN AGRICULTURE AND FOOD. 1994. Agricultural statistics 1993. Saskatchewan Agriculture and Food, Regina, SK.

SCHMUTZ, J. K., S. M. SCHMUTZ, AND D. A. BOAG. 1980. Coexistence of three species of hawks (*Buteo* spp.) in the prairie-parkland ecotone. Canadian Journal of Zoology 58:1075–1089.

SMITH, A. R. 1973. The value of abandoned farmsteads as a wildlife resource. Department of Natural Resources, Saskatoon, SK.

SOVADA, M. A., A. B. SARGEANT, AND J. W. GRIER. 1995. Differential effects of coyotes and red foxes on duck nest success. Journal of Wildlife Management 59:1–9.

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.

TAVERNER, P. A. 1919. The birds of the Red Deer River, Alberta. Auk 36:1–21, 248–265.

THOMPSON, E. E. 1890. The birds of Manitoba. Proceedings of the U.S. National Museum 13:457–643.

WARNOCK, R. G., AND P. C. JAMES. 1997. Habitat fragmentation and Burrowing Owls (*Speotyto cunicularia*) in Saskatchewan. Pp. 477–486 *in* J. R. Duncan, D. H. Johnson, and T. H. Nicholls (editors). Biology and conservation of owls of the northern hemisphere. USDA Forest Service Gen. Tech Rep. NC-190. USDA Forest Service North Central Experiment Station, St. Paul, MN.

WELLICOME, T. L., AND E. A. HAUG. 1995. Second update on status report on the Burrowing Owl, *Speotyta cunicularia.* Committee on the Status of Endangered Species in Canada, Ottawa, ON.