Western North American Naturalist 69(4), © 2009, pp. 491–500

AVIAN USE OF HARVESTED CROP FIELDS IN NORTH DAKOTA DURING SPRING MIGRATION

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ABSTRACT.—Broad-spectrum herbicide applications and improved harvesting efficiency of crops have reduced the availability of weed seeds and waste grains for game and nongame wildlife. Over the last decade, corn and soybean plantings have steadily increased in the Prairie Pothole Region (PPR) of North Dakota, while sunflower plantings have declined. The PPR is an important corridor for migratory birds, and changes in food availabilities at stopover habitats may affect how food resources are used. In early spring 2003 and 2004, we compared bird use of harvested fields of sunflower, soybeans, small grains, and corn in the PPR of North Dakota. Across both years and all crop types, we observed 20,400 birds comprising 29 species. Flocks of Lapland Longspurs (*Calcarius lapponicus*) and Horned Larks (*Eremophila alpestris*) and flocks of Red-winged Blackbirds (*Agelaius phoeniceus*) made up 60% and 15%, respectively, of the bird counts. We found that species richness and bird densities were higher in harvested sunflower fields and cornfields than in harvested small-grain and soybean fields, with soybean fields harboring the fewest species and lowest bird density. Blackbird densities tended to be lower in fields tilled after fall harvest than in fields not tilled. These results suggest that some granivorous bird populations in the Northern Great Plains could be positively affected by planting of row crops with postharvest vertical structure (e.g., sunflower, corn) and use of no-till land management practices.

Key words: birds, untilled land, sunflower, corn, soybeans, small grains, weeds, North Dakota, Prairie Pothole Region.

Most avian ecology studies are conducted during the breeding season, resulting in a lack of understanding of bird-habitat relationships at other times of the year, especially during migration and winter (Moore et al. 1995, Hutto 1998, Igl and Ballard 1999, Hutto 2000, Peterjohn 2003, Tankersley and Orvis 2003, Holmes 2007). Knowledge of the types of habitats and food resources used by migratory bird species at stopover sites is still rudimentary (Russell et al. 1994, Hutto 2000, Petit 2000, Schaub and Jenni 2001, Sawin et al. 2006). Stopover times can last anywhere from a few hours to several days, depending on the energetic condition of the migrant and the quality of the stopover habitat (Moore et al. 1995). Lack of suitable stopover habitats could exacerbate mortality risks by slowing the pace of migration, and a slower migration might be a factor for increased mortality (Cody 1985, Schaub and Jenni 2001, Kelly et al. 2002, Rodewald and Brittingham 2002). Moreover, competition for foods at reduced numbers of stopover sites along a migration route could affect the ability of migrants to refuel (Cody 1985, Kelly et al. 2002).

Competition for limited food resources at other times of the year, besides during the migration period, can also have a negative impact on food availability at a stopover site. For example, during winter months, nonmigratory birds require high-energy foods to survive in northern temperate zones, which are characterized by snowcover, cold temperatures, and long nights (Best et al. 1998, Pravosudov et al. 1999). A change in available food resources caused by changes in agricultural practices may in turn affect the distribution and numbers of winter seed-eating bird species, both among and within fields (Robinson and Sutherland 1999, Perkins et al. 2000, Moorcroft et al. 2002). The increased foraging pressure on high-quality sites during winter could result in lower-quality stopover sites for the spring migrants.

Broad-spectrum herbicide applications and improved harvesting efficiency have reduced the availability of weed seeds and waste grains for game and nongame wildlife that use harvested fields as food resources. Over the last decade in the Prairie Pothole Region (PPR) of North Dakota, corn and soybean plantings have

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steadily increased. During the same time, sunflower plantings have declined. This region is an important bird migration corridor (Stewart 1975). Changes in the agricultural landscape of the PPR and reduced plant diversity in crop fields could severely diminish foraging opportunities for migratory and nonmigratory birds (Watkinson et al. 2000, Krapu et al. 2004). In this paper, we contribute data on bird use of 2 crops with substantial postharvest vertical structure (sunflower and corn) and 2 crops without postharvest vertical structure (wheat and soybean) during spring migration in a critical migratory corridor, the PPR of North Dakota.

In spring 2003 and 2004, we identified and quantified birds in each of these agricultural habitats. Our aim was to provide information that might lead to modified management guidelines and recommendations for private and government land managers charged with providing or enhancing site quality of stopover habitats. Efforts to preserve breeding grounds will fall short of conservation goals if quality stopover habitats en route are not provided (Moore et al. 1995, Holmes 2007).

METHODS

Study Area

Our study was conducted in the Southern Drift Plains (SDP) of North Dakota—one of the physiographic subregions of the PPR (Stewart 1975). This region is characterized by level to gently sloping landscapes and numerous natural-basin wetlands that were created by advancing and retreating glaciers during the late Pleistocene epoch. Growers in our 14 study counties planted an average of 765,351 ha of small grains (mainly barley, oats, and wheat), 330,522 ha of corn, 967,974 ha of beans (largely soybeans), and 184,979 ha of sunflower across study years (NDASS 2005).

Site Selection and Seasonal Timing

Compared to other crops, little data have been published on bird use of sunflower, particularly during spring migration. Thus, we chose to devote 50% of our resources to surveying sunflower fields and the other 50% to surveying small-grain, corn, and bean fields. In early spring 2003, we scouted 240 randomly selected legal quarter sections (each 65 ha) in the SDP and found that 37 quarter sections contained harvested sunflower; we randomly chose 30 of these units for our sample. For comparison, we also randomly selected another 30 quarter sections from the same 240 and found that 13 contained small-grain fields (largely wheat and barley), 5 contained cornfields, and 12 contained bean fields (soybeans and edible beans). Similarly, in spring 2004, we scouted the same 240 quarter sections and found that 22 contained harvested sunflower. We used all 22 and randomly chose another 32 quarter sections from the pool of 240 and found them to contain 16 small-grain fields, 6 cornfields, and 10 soybean fields. To maintain sample independence, adjacent quarter sections were not chosen.

We intended to count birds in each field 2 times per year between 22 March and 30 April 2003 and between 21 March and 2 May 2004. Prior to the second counts in 2003 and 2004, farmers tilled 38% and 56% of the sample fields, respectively, and thus no second counts were done for these fields. The counts were initiated when areal snow coverage was ≤50%. To reduce travel time, we grouped all fields into 4-field count units and randomly selected, without replacement, one unit per morning for counts.

Bird Density

We adhered to the bird-counting techniques established by Stewart and Kantrud (1972) and later followed by Igl and Johnson (1997). Stewart and Kantrud's (1972) methodology was designed to obtain a complete count of all birds on the study site. Upon arriving at the selected site, we scanned the field for large groups of birds (e.g., blackbirds, larks, and longspurs), wary birds (e.g., pheasants), and birds of prey (Best et al. 1998). Two trained biologists started at opposite sides of the field; each walked line transects that were 100 m apart and that ran perpendicular to the shortest axis of the field. Line transects started 50 m from the field edge (Stewart and Kantrud 1972, Igl and Johnson 1997). We identified and counted birds within 50 m of either side of transect lines. Birds that flew over the fields without landing were not counted. Deviation from the transect line was allowed for bird identification. Observers took care to minimize double counting of birds by noting the locations of birds that were flushed to other parts of the field (Best et al. 1998). Walking speed on transects was approximately 1.0–2.0 km $\cdot$ h^{-1}

(Hanowski et al. 1990). Counts were initiated at sunrise, and all 4 fields were completed approximately 5 hours later. Counts were not conducted during steady precipitation or winds >24 km · h^{-1}.

Seed Density

We collected seed samples along 4 randomly selected transects. Sampling occurred at 400-m intervals along each transect, starting from a random point between 1 and 400 m from the edge of the field. At each sampling point, we placed a 20 × 20-cm sampling frame on the ground and the top 1-cm layer of soil was collected with a garden trowel. We also collected seeds from standing vegetation within the frame. Soil samples were placed in small paper bags (labeled by site with sample number) and frozen (to prevent seed germination and molding) until seeds were sorted (Klute and Robel 1997). Each sample was emptied onto paper and allowed to dry for one week in a cool, dry, dark room. Dried samples were sifted through mesh sieves of successively smaller sizes (6.7–0.84-mm openings), and debris and large clumps of soil were discarded so that only seeds and fine vegetative parts were left. We separated the organic material from the fines using an aqueous solution of sodium hexametaphosphate, sodium bicarbonate, and magnesium sulphate (Malone 1967). The floating organic material was decanted from the solution, run through a 0.5-mm sieve, and rinsed to remove foam and minute soil particles. We air-dried the sample, sorted the seeds of sunflower, corn, small grain, beans, and weeds, and weighed the seeds to the nearest 0.01 g.

Surrounding Habitat

We obtained photographs of our study area from the USDA Natural Resources Conservation Service (NRCS) Data Gateway (NRCS 2004) as mosaics of digital orthophoto quarter quads. These were imported into ArcInfo v8.3 GIS. An 804-m buffer was placed around the borders of the quarter sections containing each study field. A nonmapping technique was used to estimate the area of the habitats available within the entire buffer area (Marcum and Loftsgaarden 1980). Habitat classes included wetland (temporary to intermittently exposed), grass (hay, alfalfa, pasture, and Conservation Reserve Program lands), tree (shelterbelts, woodlots, and riparian forests), small grain (oats, barley, rye, and various types of wheat), sunflower (oil and non-oil varieties), bean (soybeans and edible beans), corn (silage and grain), and other (roads, buildings, developed areas, lakes, ponds, and large rivers). We divided the frequency of each class by the total number of specified points (n) within the buffer area to get proportionate coverage of each habitat class, which was then converted to hectares. Means and standard errors were calculated for each year for different habitat types within the perimeter of the polygon surrounding each study field.

Analysis

We estimated seed densities by calculating the mass per volume of soil collected (g/[400 cm^2 · 1 cm]). Logarithmic transformations (ln) were performed on seed-density data to adjust for departure from normality. Differences in seed densities between crops were examined using a one-way ANOVA. We used simple linear regression to determine if there was any relationship between seed densities and bird density across fields. Bird density was used as the response variable, while seed density was used as the explanatory variable.

Categories of "passerine," "Lapland Longspur/Horned Lark," and "blackbird" densities (birds · ha^{-1}) were used as indicators of habitat quality because they had high frequencies of occurrence in our counts and were abundant (see Table 1 for scientific names). Horned Larks and Lapland Longspurs (*Calcarius lapponicus*) were often seen in large mixed-species flocks, making it hard to distinguish between individual species (Beason 1995, Hussell and Montgomerie 2002). For each study field, total species richness per hectare was estimated for each count and mean richness per hectare compared across crop types. We used logarithmic transformations (ln) on bird-density data to adjust for departure from normality and then back-transformed by raising 10 to the power of the mean species richness per hectare, which can result in asymmetrical error bars. We used t tests and analysis of variance (ANOVA) to assess the data. All statistical tests were conducted using an alpha of 0.05.

RESULTS

Areal coverage of sample fields was nearly identical between years, averaging 38 ha ($s_{\bar{x}}$ =

TABLE 1. Percentage of fields, across 2 counts, with avian species observed in harvested crop fields in the Southern Drift Plains, North Dakota, during 21 March–2 May in 2003 and 2004.

Common name	Scientific name	Sunflower (n = 69)	Corn (n = 20)	Small grain (n = 52)	Soybean (n = 34)
American Crow[a]	*Corvus brachyrhynchos*	3	0	0	0
American Robin	*Turdus migratorius*	16	15	4	18
American Tree Sparrow	*Spizella arborea*	23	30	6	9
Brown-headed Cowbird	*Molothrus ater*	4	5	4	3
Brewer's Blackbird	*Euphagus cyanocephalus*	6	0	0	0
Canada Goose	*Branta canadensis*	7	30	15	60
Common Grackle	*Quiscalus quiscula*	7	15	6	3
Wilson's Snipe	*Gallinago gallinago*	1	5	0	3
Dark-eyed Junco	*Junco hyemalis*	13	10	0	6
Field Sparrow[a]	*Spizella pusilla*	3	0	0	0
Horned Lark	*Eremophila alpestris*	94	38	88	94
Lapland Longspur	*Calcarius lapponicus*	42	14	25	21
Horned Lark/Lapland Longspur[b]		22	10	0	0
Killdeer	*Charadrius vociferus*	49	24	36	54
House Sparrow	*Passer domesticus*	0	5	2	0
Mallard	*Anas platyrhynchos*	10	30	12	24
Mourning Dove	*Zenaida macroura*	9	14	6	0
Northern Flicker	*Colaptes auratus*	1	5	0	0
Northern Pintail[a]	*Anas acuta*	1	0	0	0
Ring-necked Pheasant	*Phasianus colchicus*	1	10	4	3
Rock Pigeon[a]	*Columba livia*	1	0	0	0
Red-winged Blackbird	*Agelaius phoeniceus*	62	55	25	15
Sandhill Crane	*Grus canadensis*	0	0	2	0
Savannah Sparrow	*Passerculus sandwichensis*	13	20	10	12
Snow Goose	*Chen caerulescens*	0	5	2	0
Song Sparrow	*Melospiza melodia*	20	25	14	6
Sharp-tailed Grouse	*Tympanuchus phasianellus*	23	10	12	0
Vesper Sparrow	*Pooecetes gramineus*	16	30	14	9
Western Meadowlark	*Sturnella neglecta*	44	30	17	3
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	9	10	8	0

[a]Not seen in 2004
[b]Mixed-species flock

1.6). Likewise, land use within 0.8 km of the study quarter sections was similar (F range 0.24–3.38, P range 0.069–0.627) between years for 7 of 8 categories, averaging 55 ha ($s_{\bar{x}}$ = 3.6) wetland, 127 ha ($s_{\bar{x}}$ = 8.8) grass, 9 ha ($s_{\bar{x}}$ = 0.9) trees, 133 ha ($s_{\bar{x}}$ = 7.4) small grain, 120 ha ($s_{\bar{x}}$ = 7.9) beans, 34 ha ($s_{\bar{x}}$ = 4.5) corn, and 10 ha ($s_{\bar{x}}$ = 1.4) other. Areal coverage of ripening sunflower was significantly less (F = 9.94, P = 0.002) in 2004 ($\bar{x}$ = 23 ha, $s_{\bar{x}}$ = 3.3) than in 2003 ($\bar{x}$ = 51 ha, $s_{\bar{x}}$ = 5.0).

In 2004, waste-seed densities did not differ across crops (F = 0.21, P = 0.889), averaging 0.11 g/400 cm^3 ($s_{\bar{x}}$ = 0.02). During the first count, blackbird, Lapland Longspur/Horned Lark, and total passerine densities were not related to seed density (F range 0.06–0.62, P range 0.437–0.811). During the second count, blackbird density tended to be greater in fields with higher seed densities (F = 4.59, P = 0.052); whereas Lapland Longspur/Horned Lark density (F = 0.23, P = 0.637) and total passerine density (F = 0.58, P = 0.456) were similar across seed densities.

In 2003 and 2004, we identified 29 and 25 granivorous species, respectively (Table 1). We observed more species per hectare during the second count than we did during the first count (F = 17.15, P < 0.001; Table 2). Overall, the number of species per hectare differed across crops (F = 4.03, P = 0.008), with soybean hosting fewer species than sunflower, small grain, and corn. During the first count, the number of species differed among crops (F = 3.05, P = 0.032), with sunflower hosting more species than did soybean. During the second count, the number of species across crops was not significantly different (F = 2.40, P = 0.08).

Densities of blackbirds, Lapland Longspur /Horned Larks, and passerines were not different between years during the first counts (t range 0.78–1.00, P range 0.320–0.438) or second counts (t range 0.22–1.71, P range 0.094–0.827); therefore, bird densities were

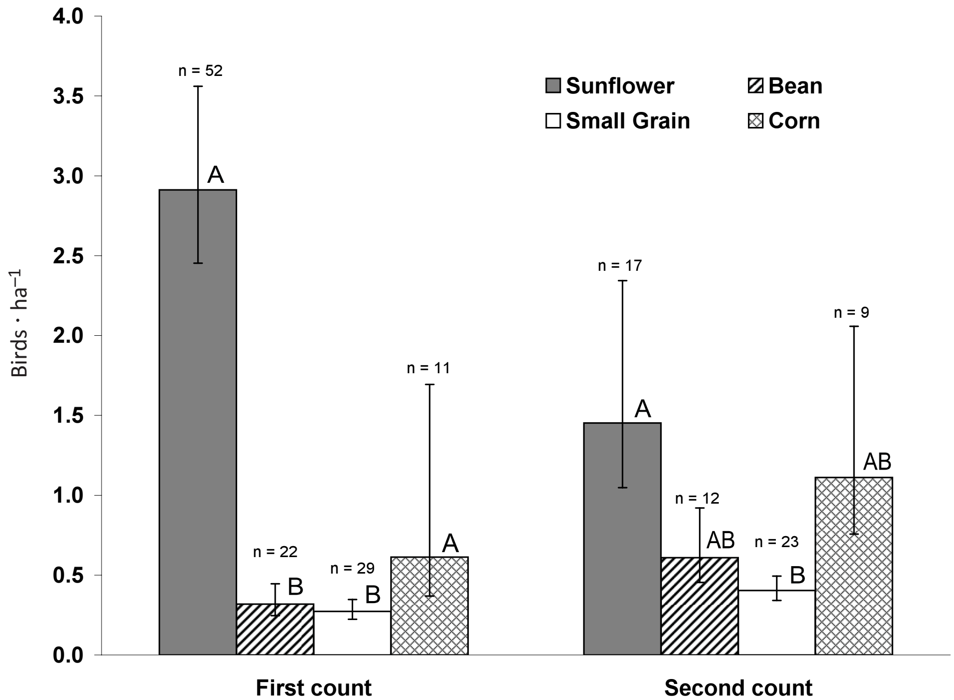

Fig. 1. Mean densities and associated standard errors of passerines (birds · ha^{-1}) in harvested sunflower, bean, small grain, and corn fields in the Southern Drift Plains, North Dakota, 2003 and 2004. Crops with different letters are significantly different at $\alpha = 0.05$. Data were back-transformed from natural-log transformations by raising 10 to the power of the mean species per hectare.

TABLE 2. Mean number of avian species per hectare (standard error) in 4 harvested crops in the Southern Drift Plains, North Dakota, during spring 2003 and 2004. Crop types with different letters are significantly different at $\alpha = 0.05$.

Count period	Sunflower	Bean	Small grain	Corn
21 March–17 April	0.13 (0.01) A	0.07 (0.02) B	0.09 (0.02) AB	0.12 (0.03) AB
18 April–2 May	0.22 (0.04) A	0.07 (<0.01) A	0.20 (0.06) A	0.28 (0.08) A

pooled across years within the early and late counts for subsequent analyses.

Passerine densities differed ($F = 14.99$, $P < 0.001$) between the first count ($\bar{x} = 1.27$, $s_{\bar{x}} = 0.18$) and the second count ($\bar{x} = 0.41$, $s_{\bar{x}} = 0.10$). Within the first count, passerine densities were not statistically different between fields tilled after fall harvest and fields not tilled (untilled) ($F = 0.52$, $P < 0.604$) but did differ between crops ($F = 25.55$, $P < 0.001$), with more birds using sunflower and corn than birds using soybean and small grain (Fig. 1). During the second count, passerine densities differed among crops ($F = 4.40$, $P = 0.008$), with sunflower hosting more birds than did small grain. Passerine densities were significantly higher ($F = 3.04$, $P < 0.004$) in untilled fields ($\bar{x} = 1.4$, $s_{\bar{x}} = 0.55$) than in tilled fields ($\bar{x} = 0.61$, $s_{\bar{x}} = 0.12$).

Blackbirds constituted 16% of the total number of birds counted. Blackbird densities did not differ ($P = 0.094$) between the first and second counts, averaging 0.60 birds · ha^{-1} ($s_{\bar{x}} = 0.20$). Blackbird densities were not significantly different ($F = 0.61$, $P = 0.614$) among crops within the first count (Fig. 2). During the second count, blackbird densities differed among the 4 crops ($F = 7.41$, $P < 0.001$), with sunflower and cornfields hosting more birds than did soybean fields. During the first count, blackbird densities were significantly greater ($t = 3.56$, P = <0.001) in untilled fields ($\bar{x} = 0.55$, $s_{\bar{x}} = 0.13$) than in tilled fields ($\bar{x} = 0.21$, $s_{\bar{x}} = 0.12$).

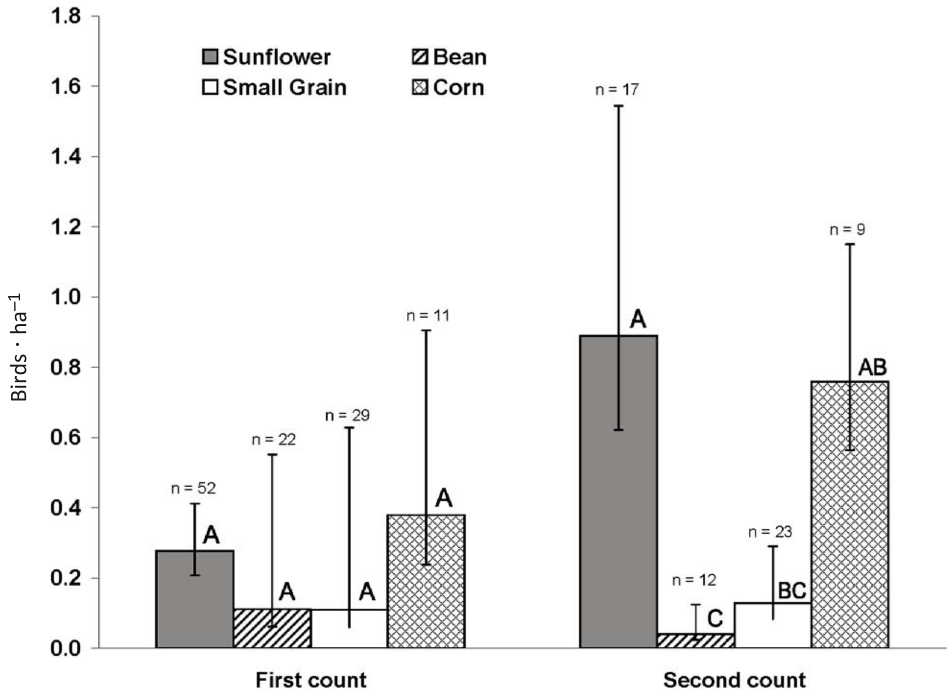

Fig. 2. Mean densities and associated standard errors of blackbirds (birds · ha^{-1}) in harvested sunflower, bean, small grain, and corn fields in the Southern Drift Plains, North Dakota, 2003 and 2004. Crops with different letters are significantly different at $\alpha = 0.05$. Data were back-transformed from natural-log transformations by raising 10 to the power of the mean species per hectare.

Lapland Longspurs/Horned Larks made up 60% of the birds counted during our study. Lapland Longspur/Horned Lark densities differed ($F = 5.08$, $P = 0.026$) between the first count ($\bar{x} = 2.74$, $s_{\bar{x}} = 0.43$) and second count ($\bar{x} = 0.80$, $s_{\bar{x}} = 0.43$). During the first count, Lapland Longspur/Horned Lark densities differed among the 4 crops ($F = 11.68$, $P < 0.001$), with sunflower hosting a greater density of birds than did corn, soybean, and small grain (Fig. 3). During the second count, their densities did not differ among crop types ($F = 1.61$, $P = 0.199$), with most migrating out of the study area prior to the second count. Lapland Longspur/Horned Lark densities did not differ between untilled and tilled fields during the first ($t = 1.72$, $P = 0.089$) or second counts ($t = 0.40$, $P = 0.691$).

Other bird species were relatively rare and thus were not subjected to inferential statistical analyses. When waterfowl were encountered, they were seen either in pairs or in large flocks and usually near wet areas. Most sparrows and gallinaceous birds were seen near vegetation along edges of fields and wetlands.

DISCUSSION

We found that species richness and bird densities were greater in harvested corn and sunflower fields than in harvested small grain and soybean fields, with soybean fields harboring the fewest species and lowest bird density. These differences might be partially related to the energy value of each seed crop, which is highest in sunflower (27 kJ · g^{-1}), followed by soybean (22 kJ · g^{-1}), corn (18.5 kJ · g^{-1}), and small grain (16 kJ · g^{-1}) (Kendeigh and West 1965, Warner et al. 1989, Diaz 1990). However, while soybeans do have a higher energy value than corn, they also have digestion inhibitors that can decrease a bird's appetite and result in weight loss (Dabbert and Martin 1994). Lastly, soybeans are harvested close to the ground, which leaves very few alternate food sources or little standing crop residue for protective cover. In contrast, corn stubble provides considerable vertical dimension, and the waste kernels are highly palatable grains, even for relatively small-sized passerines, because the kernels absorb soil

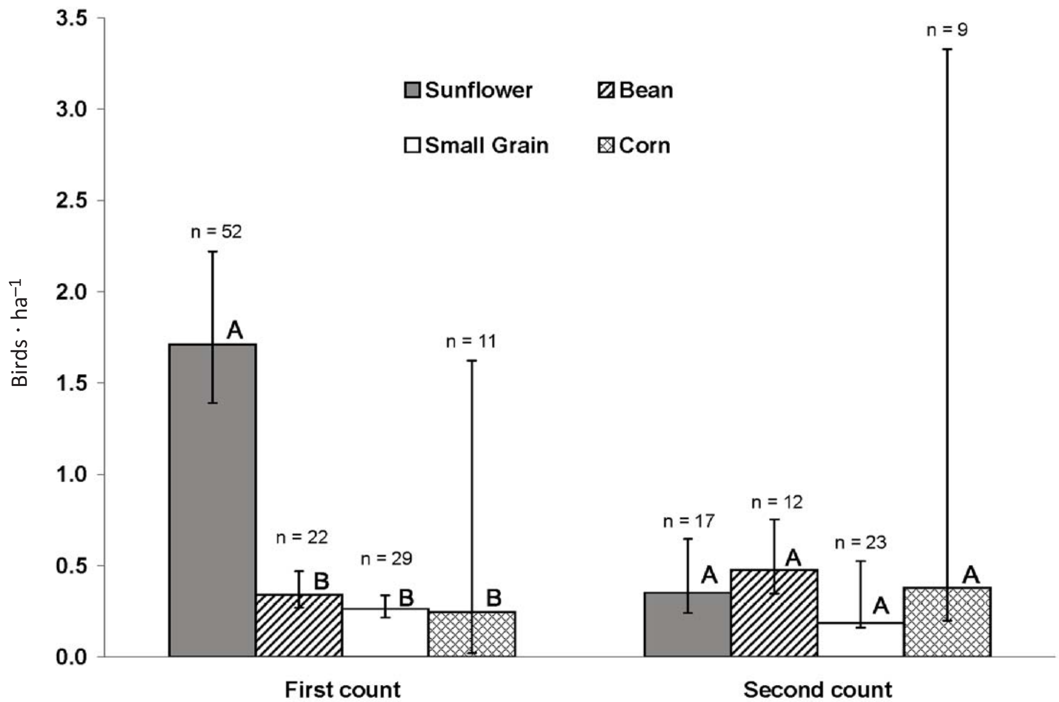

Fig. 3. Mean densities and associated standard errors of Horned Larks/Lapland longspurs (birds · ha^{-1}) in sunflower, bean, small grain, and corn fields throughout the Southern Drift Plains, North Dakota, 2003 and 2004. Crops with different letters are significantly different at $\alpha = 0.05$. Data were back-transformed from natural-log transformations by raising 10 to the power of the mean species per hectare.

moisture and soften considerably. These factors may account for the large numbers of birds that were found in cornfields. Currently, sunflower fields are not as prevalent as cornfields in the PPR, but sunflower's high energy value, and perhaps passerines' prior experience with foraging on ripening sunflower in the fall, attracted passerines to this crop (Linz et al. 1984, Schaaf et al. 2008). Although some stubble is maintained in small-grain fields after harvest, providing the necessary cover for birds, small-grain seeds have a comparatively lower energy value than the other crop types. This may account for the low use of harvested small-grain fields.

The development of broad-spectrum herbicides for soybeans and corn has made weed control cost-effective for both crops (Krapu et al. 2004). In contrast, herbicides developed for sunflower are less robust, sometimes leading to poor weed control and to formation of dense patches of weeds within fields. These patches can provide cover for birds while also allowing them to forage on weed seeds and waste sunflower (Linz et al. 1984). Mature weeds leave behind a store of seeds that can be of value to foraging birds (Wilson et al. 1996). For example, seed production of foxtail species common to the Northern Great Plains (e.g., *Setaria viridis* and *S. glauca*) is prolific. For *S. viridis* found growing in corn and soybean fields and not treated with postemergent herbicide, seed production was about 4000 seeds · m^{-2} (Forcella et al. 2001). Seed density declined to about 400 seeds · m^{-2} when postemergent herbicide was applied early in the growing season. While the stubble of small grains can contain weed seeds and waste grains, it lacks substantial cover compared to that of either sunflower or corn with their vertical structure.

Our data showed that untilled fields tended to support a greater density of foraging birds than fields tilled the previous fall. In tilled fields, the overturned soil hides waste grains, weed seeds, and arthropods that otherwise would be available to foraging birds (Castrale 1985, Warner et al. 1985, Koford and Best

1996, Hesler and Berg 2003). The amount of waste grains and seeds hidden through tilling is significant. Wastage from harvesting sunflower can range from 3% to 20% of total yield (Hofman and Hellevang 1997). In cornfields, Warner et al. (1989) found that between 247 and 446 kg · ha^{-1} of corn kernels were left after harvest, and between 142 and 214 kg · ha^{-1} of soybeans were left. Losses before and during harvest include (1) natural losses caused by weather conditions and animal contact, (2) harvesting losses as the crop enters the machine, and (3) combine threshing and separating losses.

Although the amount of waste is substantial, spring migrants may not always benefit from it. Waste availability decreases from fall through early spring (Robel and Slade 1965, Warner et al. 1989, Wilson and Aebischer 1995). Late-season migrants or resident birds feed steadily in harvested fields throughout fall and winter, causing a decline in seed density, especially near cover (Robinson and Sutherland 1999). In extreme cases, near large roosts of blackbirds for example, nearly all of the wastage may be taken from fields. Waste corn was measured at 69 kernels · m^{-2} in corn stubble near a blackbird roost during November; by February, density had dropped to <3 kernels · m^{-2} (Dolbeer et al. 1978). It is unlikely that harvested cornfields in the PPR would receive that kind of pressure, but certainly blackbirds numbering in the hundreds-of-thousands at fall roosts could remove large amounts of waste foods from harvested fields in the PPR. Foods might be available in other, less-preferred habitats (such as small grain) but lack of adequate cover may prevent foraging in these areas (Castrale 1985).

MANAGEMENT IMPLICATIONS

Ultimately, nutritional acquisition during spring migration could determine reproductive success on breeding grounds (Rappole and Warner 1976, Weatherhead and Bider 1979, Smith and Moore 2005). We agree with others (e.g., Moore et al. 1995, Holmes 2007) that efforts to preserve breeding grounds will fall short of conservation goals if quality stopover habitats en route are not provided. The possibility that interseasonal habitat quality affects productivity of breeding birds seems reasonable and warrants further investigation (Holmes 2007). Our data support the notion that harvested agricultural fields in the PPR are important stopover habitats for granivorous spring-migrating birds. Furthermore, it appears that leaving stubble in untilled grain fields provides preferred foraging patches needed by a variety of migratory birds (Wilson et al. 1996). Linking the effects of reduced availabilities of food and cover in harvested fields during spring migration to subsequent reproductive effort is difficult to quantify because of the technological difficulty of tracking individual birds over seasons. We speculate that some bird populations in the Northern Great Plains could be positively affected by continued planting of row crops with postharvest vertical structure (e.g., sunflower and corn) and use of no-till practices. By leaving crop residue in the fields through conservation practices or reduced tillage, the availability of food and cover for wildlife may be extended through spring migration (Gremaud 1983, Warner et al. 1989, Lokemoen and Beiser 1997).

ACKNOWLEDGMENTS

D. Schaaf, F. Chan, and H. Langord assisted with data gathering. J. Church and G. Forcey provided help with GIS and statistical analysis. This project was supported by the Department of Biological Sciences at North Dakota State University, Fargo; the National Sunflower Association, Bismarck, North Dakota; and the U.S. Department of Agriculture's North Dakota/South Dakota Wildlife Services and National Wildlife Research Center.

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Received 2 April 2008
Accepted 9 June 2009