HAS AN INTEGRATED PEST MANAGEMENT APPROACH REDUCED BLACKBIRD DAMAGE TO SUNFLOWER?

GEORGE M. LINZ, BRIAN D. PEER, H. JEFFREY HOMAN, RYAN L. WIMBERLY, DAVID L. BERGMAN AND WILLIAM J. BLEIER

Abstract: Since the mid-1970s many new and modified damage abatement methods have been implemented to reduce blackbird damage to ripening sunflower in the northern Great Plains. Concurrently, estimates were made of breeding blackbird densities and sunflower damage to track changes in population size and chart progress toward reducing damage. Breeding density estimates were made at both the regional and county levels, whereas sunflower damage estimates were made at the county level only. Periodic regional estimates of breeding densities, between 1967 and 1998, showed that numbers of red-winged blackbirds (*Agelaius phoeniceus*) and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) did not differ among years, while common grackle (*Quiscalus quiscula*) numbers tended to increase. To improve our ability to detect changes in breeding density, we started intensive county-level surveys in 1996. These surveys, conducted in 4 counties in North Dakota and South Dakota, showed that blackbird densities differed among years from 1996 to 1999. We surveyed sunflower damage in 2 of these 4 counties from 1994 to 1998 and found no difference in damage ($\bar{x}$ = 1.8%) among years. In 1997 and 1998, with an additional 2 counties added to the survey, we again found that damage was similar between years, averaging 2.2%. Overall, breeding blackbird densities have increased in recent years, but dollar loss per hectare trended lower in three of the study counties that had historical databases for comparison. We will continue to use annual estimates of breeding densities and sunflower damage to assess the effects of an evolving integrated pest management program.

Key words: blackbirds, common grackle, crop damage, northern Great Plains, red-winged blackbird, sunflower, yellow-headed blackbird.

Sunflower (*Helianthus annuus*) growers in North Dakota, South Dakota, and Minnesota annually face the vexing production problem of deterring red-winged blackbirds (*Agelaius phoeniceus*), common grackles (*Quiscalus quiscula*), and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) from eating their crop (Linz and Hanzel 1997). In the 1970s, the U.S. Fish and Wildlife Service responded to this problem by initiating a research program focused on definition of the problem, avian repellents, mechanical scare devices, and bird-resistant sunflowers. In 1986 this research issue was transferred to the U.S. Department of Agriculture, Animal and Plant Health Inspection Service. Current research has focused on cost reduction and environmental impacts of managing dense emergent vegetation favored by roosting blackbirds and use of DRC-1339 avicide for baiting migrating populations, particularly regional populations of red-winged blackbirds.

Historical data on breeding blackbird densities and sunflower damage in the northern Great Plains are extensive. In 1967, Stewart and Kantrud (1972) estimated the breeding populations of all species of birds in North Dakota. They separated North Dakota into 8 strata based on biotic characteristics. Each biotic region was relatively homogeneous over its extent and differed markedly from the other biotic regions. Their sampling units consisted of legal quarter sections (64.7 ha) randomly selected from the 8 biotic regions. The number of sampling units allocated to each biotic region was proportional to its area. Population estimates within the biotic regions were combined to form state-wide estimates based on a total of 130 sampled quarter sections. Nearly all of these quarter sections were surveyed again in 1981-1982 (Besser 1985), 1990 (Nelms et al. 1994), and 1992-1993 (Igl and Johnson 1997).

In 1972 and 1979-1980, statewide surveys of sunflower damage were conducted in North Dakota, South Dakota, and Minnesota (Henne et al. 1979, Hothem et al. 1988). In 1981, 4 counties in North Dakota were intensively surveyed for sunflower damage (Hothem et al. 1988). These surveys provided a historical database for charting progress toward reducing sunflower damage.

In this paper, we report results from several surveys of breeding blackbird densities and sunflower damage that were conducted during the 1990s in North Dakota and South Dakota. Our objective was to document changes in blackbird populations and sunflower damage.

METHODS

Study Area

We estimated densities of breeding blackbirds and conducted damage assessments in Pierce and Stutsman Counties in central North Dakota and Brown and Clark counties in eastern South Dakota. These counties lie within the Prairie Pothole Region (PPR) of the northern Great Plains, USA. The 4-county study area consisted of about 1 million hectares of cropland and grassland situated on low, rolling hills interspersed with lakes and wetlands (North Dakota Agricultural Statistics Service 1999, South Dakota Agricultural Statistics Service 1999). Farms in these counties averaged 447 ha (SD=64.4).

Major cultivated crops, in decreasing order, were small grains (oats, barley, wheat), soybeans, sunflower, and corn. The long-term average annual temperature and precipitation are 18.5° C and 43.0 cm, respectively.

We also estimated densities of red-winged blackbirds, yellow-headed blackbirds and common grackles throughout the PPR of North Dakota (Leitch 1989). This area consisted of about 93,000 km^2 and included the Northeastern Drift Plain, Southern Drift Plain, Northwestern Drift Plain, and Missouri Coteau physiographic regions (Stewart and Kantrud 1972). The PPR is well known for shallow wetlands, which produce over half of the waterfowl in North America (Batt et al. 1989). Emergent vegetation which serves as cover for waterfowl broods and harbors many invertebrates (Kantrud et al. 1989, Swanson and Duebbert 1989), also provides nesting substrate for red-winged blackbirds and yellow-headed blackbirds (Linz et al. 1996).

Breeding Bird Surveys

Prairie Pothole Surveys. -- From 20 May to 5 June 1996, 1997, and 1998, we surveyed 67 of the original 130 quarter sections surveyed by Stewart and Kantrud (1972). The 67 quarter sections were in the major sunflower growing region, which lies within the PPR. We used the same methods as our predecessors. Briefly, we used binoculars and spotting scopes to count adult male red-winged blackbirds (after-second-year), yellow-headed blackbirds (after-second-year), and common grackles on each quarter section. We either walked or drove to view areas of reduced visibility. The surveys occurred during 2 daily sampling periods from 0.5 hr after sunrise to 1100 hr and from 1600 hr to 0.5 hr before sunset. Population estimates for the polygynous red-winged blackbird and yellow-headed blackbird were considered minimums because (1) we assumed all territorial males were detected and (2) we credited each male with a single female. We did not conduct surveys in sustained winds with velocities >48 km/h or in steady rains.

County Surveys. – We used a 2-stage cluster sampling design with townships (36 sections; 9324 ha) as primary units and quarter sections as secondary units. A cluster design reduces the time needed to adequately sample a large area and thus optimizes the limited time available for surveying (Nelms et al. 1999). The procedures used to count birds in the county surveys were the same as those used for the PPR surveys.

We allocated 5 randomly selected townships to Clark and Pierce counties and 10 townships to Stutsman County. Within each township, we randomly selected 3 quarter sections that were surveyed each year from 1996 to 1999. In 1998 and 1999, we expanded our census to include 15 quarter sections in Brown County, South Dakota, and increased the number of surveyed quarter sections in Stutsman County from 30 to 74.

Sunflower Damage Assessments

We surveyed sunflower damage in Pierce (1996-1998) and Stutsman (1994-1998) counties, North Dakota, and Brown (1997-1998) and Clark (1994-1998) counties, South Dakota. We used 2-stage cluster sampling with townships as primary units and sections as secondary units. We allocated 5 randomly selected townships in Clark, Brown, and Pierce counties and incrementally increased the number of townships in Stutsman County as follows: 5 in 1994 and 1995, 10 in 1996, and 26 in 1998.

We divided each sampled field ≥4.0 ha into a predetermined number of strata, each containing an equal number of rows. From 1994 to 1996 each field was divided into 4 strata. In 1997 and 1998 each field was divided into 2 strata. One row was randomly selected from the first stratum; we then selected a corresponding row in the same relative position in the other stratum. The location of the first sample plot of 5 consecutive sunflower heads was a randomly selected distance in paces (about 1 m) between 0 m (i.e., the edge of the field) and 135 m. After establishing the first plot, we systematically sampled plots of 5 consecutive sunflower heads every 135 m until the end of the field. If an uncultivated area existed within the sampled row, it was paced through as if it were a cultivated area. On sunflower heads that were damaged by birds, we measured the diameter of the head and its undeveloped center (i.e., light-colored immature achenes). The diameters were determined by averaging 2 perpendicular measurements (nearest cm) made with a measuring tape. The area (cm^2) of seed missing from each damaged head was estimated with a gridded plastic template (Dolbeer 1975). For undamaged heads we simply recorded 0% damage; undamaged heads were left measured. The percentage of seed lost on each subsample of 5 heads was determined by dividing the total area of bird damage by the total area of mature seed potentially available in the 5 heads. The percent loss for each field was calculated by averaging the percent loss of all plots across strata. The average damage in each field was used to calculate average percent losses and associated variances for each township (Cochran 1977).

Statistical Analyses

Two-factor repeated measure ANOVAs (RMANOVA) were used to test the null hypotheses of (1) no difference in average square-root transformed numbers of birds counted among years and biotic strata and (2) no difference in arcsine-transformed percent damage among years and counties (Cody and Smith 1997). Transformations were used to help normalize the data. When a RMANOVA indicated a significant difference among treatments, Duncan's multiple range test was used to compared individual pairs of means (Cody and Smith 1997).

RESULTS

Breeding Bird Surveys

Prairie Pothole surveys. – Six breeding bird surveys conducted over a 32-year span showed that breeding populations of red-winged blackbirds (P=0.098) and yellow-headed blackbirds (P=0.084) remained stable in the PPR of North Dakota, while common grackles (P=0.014) tended to increase across years (Table 1). We detected more common grackles (P=0.027) in the Southern Drift Plain than in the other 3 surveyed biotic regions. In comparison, red-winged blackbird and yellow-headed blackbird densities were similar (P range=0.127-0.147) among biotic regions (Table 2). Analyses of the 6 surveys, with all species pooled, showed that blackbird density was marginally similar across survey years (P=0.066) and biotic strata (P=0.065).

Table 1. Mean number (SD) of breeding pairs of red-winged blackbirds, yellow-headed blackbirds, and common grackles in 67 randomly selected legal quarter sections (64.7 ha) in North Dakota.

Year	Red-winged blackbird	Yellow-headed blackbird	Common grackle	Total blackbirds
1967	10.0 (8.78)	1.4 (4.55)	1.9 (4.30)	13.3 (10.81)
1981-1982	8.0 (8.36)	6.5 (25.97)	2.9 (4.17)	17.4 (30.56)
1990	4.8 (7.60)	2.7 (12.20)	3.0 (7.05)	10.5 (16.91)
1996	10.2 (10.84)	5.0 (12.19)	3.6 (7.83)	18.8 (19.53)
1997	12.1 (13.06)	9.1 (18.23)	6.2 (21.32)	27.4 (38.00)
1998	11.0 (12.25)	8.5 (15.65)	5.3 (12.78)	24.8 (30.95)
P[1]	0.098	0.084	0.014	0.066

[1] Repeated measures Analysis of Variance

Table 2. Mean number (SD) of breeding pairs of red-winged blackbirds, yellow-headed blackbirds, and common grackles in 67 randomly selected legal quarter sections (64.7 ha) by biotic region in North Dakota during 1967, 1981, 1990, 1996-98.

Biotic Regions	Red-winged blackbird	Yellow-headed blackbird	Common grackle	Total blackbirds
Northeastern Drift Plain n=17	9.9 (10.67)	6.7 (14.97)	2.6 (5.29)	19.2 (23.90)
Southern Drift Plain n=18	11.2 (10.70)	7.1 (12.62)	6.4 (8.86)	24.7 (23.29)
Northwestern Drift Plain n=15	5.5 (6.17)	4.8 (16.88)	1.8 (3.32)	12.1 (17.65)
Missouri Coteau n=17	9.9 (12.41)	3.4 (19.96)	4.3 (19.16)	17.6 (36.11)
P[1]	0.147	0.127	0.027	0.065

[1] Repeated measures Analysis of Variance

County Surveys. – From 1996 to 1999, densities of red-winged blackbirds, yellow-headed blackbirds, and common grackles in Stutsman, Pierce, and Clark counties differed (P range=0.007-0.042) among years (Table 3). Blackbirds were 33% more prevalent in 1998 and 1999 than in 1996 and 1997.

Table 3. Mean number (SD) of breeding pairs of red-winged blackbirds, yellow-headed blackbirds, and common grackles in 60 quarter sections (64.7 ha) in Clark County (n=15), South Dakota, and Pierce (n=15) and Stutsman (n=30) counties, North Dakota.

Year	Red-winged blackbird	Yellow-headed blackbird	Common grackle	Total blackbirds
1996	9.1 (7.83)	5.6 (10.88)	3.5 (6.41)	18.2 (16.21)
1997	9.9 (9.09)	5.7 (11.73)	4.4 (7.16)	20.0 (18.64)
1998	13.8 (11.88)	10.5 (20.37)	5.8 (9.31)	30.1 (27.73)
1999	12.2 (8.47)	8.1 (14.36)	7.0 (10.14)	27.3 (20.98)
P[1]	0.007	0.042	0.040	0.002

[1] Repeated measures Analysis of Variance

Table 4. Mean number (SD) of breeding pairs of red-winged blackbirds, yellow-headed blackbirds, and common grackles in Brown and Clark counties, South Dakota, and Pierce and Stutsman counties, North Dakota in 1998 and 1999 combined.

Counties	Red-winged blackbird	Yellow-headed blackbird	Common grackle	Total blackbirds
Brown, SD[1]	17.4 (12.58)	7.8 (12.68)	15.5 (17.95)	40.7 (26.69)
Clark, SD[1]	17.5 (12.51)	5.1 (8.30)	10.7 (14.17)	33.3 (20.39)
Pierce, ND[1]	9.3 (6.04)	11.4 (15.04)	5.2 (7.28)	25.9 (19.74)
Stutsman, ND[2]	12.0 (9.71)	16.0 (29.25)	4.9 (7.90)	32.9 (34.89)
P[3]	0.071	0.106	0.008	0.543

[1]15 Quarter sections

[2]74 Quarter sections

[3]Repeated Measures Analysis of Variance

An additional county (Brown County, South Dakota) was added for the 1998-1999 surveys. Densities were similar between 1998-1999 for all 3 species of blackbirds pooled (P range = 0.140-0.846). The density of common grackles differed (P=0.01) among counties, with Brown and Clark counties in South Dakota averaging 2 to 3 times more common grackles than Pierce and Stutsman in North Dakota. Densities of red-winged blackbirds (P=0.071) and yellow-headed blackbirds (P=0.601) were similar among counties, with both species averaging 13.0 pairs per quarter section (Table 4).

Sunflower Damage Assessments

From 1994 to 1998, an average of 95,900 hectares of sunflower (worth about $38.0 million @$398.5/ha) was harvested in the 4 study counties (NDASS 1999,

Table 5. Average percent bird damage (SD) in Brown and Clark counties, South Dakota, and Pierce and Stutsman counties, North Dakota, 1994-98.

Year	Brown	Pierce	Clark	Stutsman
1994			0.2 (0.30)	1.8 (3.22)
1995			0.5 (0.68)	2.0 (3.72)
1996		6.2 (7.14)	0.5 (1.10)	3.3 (8.09)
1997	1.1 (1.60)	11.6 (18.27)	0.2 (0.16)	1.3 (2.14)
1998	0.6 (1.24)	1.6 (2.22)	0.5 (0.91)	2.4 (4.93)

SDASS 1999). The percent damage in Clark and Stutsman counties from 1994 to 1998 were similar across years (P=0.301) and between counties with years pooled (P=0.052), averaging 1.8% (SD = 4.36). In 1997 and 1998, with Brown and Pierce counties added to the survey, we found that damage differed (P=0.012) among counties (Table 5). Pierce had more damage ($\bar{x}$ = 6.8%, SD=13.96) than either Brown ($\bar{x}$ = 0.9%, SD=1.45), Clark ($\bar{x}$ = 0.3%, SD=0.62) or Stutsman ($\bar{x}$ =1.8%, SD=3.69) counties. Damage pooled across counties was similar between 1997 and 1998 (P=0.234), averaging 2.2%.

Blackbird damage per hectare was 10 times higher in the 2 North Dakota counties (24.3 kg/ha) than in the 2 South Dakota counties (2.4 kg/ha) (Table 6). The total damage in the 4 counties was valued at $764,000 or $8.68/ha. Stutsman County had the greatest estimated dollar loss of about $460,000. The maximum recorded damage in an individual field was 56.0%.

After pooling years and counties, fields with ≥5% (P<0.001) and ≥10% (P<0.001) damage occurred at higher than expected frequencies in Pierce County. However, the number of fields receiving (5% (P=0.156) and (10% (P=0.194) damage did not change across years. Of the 345 sample fields, 36 (10.4%) and 22 (6.4%) had damage ≥5% and ≥10%, respectively.

DISCUSSION

Blackbird Populations

From 1967 to 1998, densities of blackbirds in the PPR fluctuated from a low of 10.5 pairs/quarter in 1990 to a high of 24.8 pairs/quarter in 1997, a difference of 136%. The significant increases in breeding blackbirds documented in Brown, Clark, Stutsman, and Pierce counties provide additional supporting evidence of an increasing population. We believe that the greater densities recorded in the latter 1990s were the result of increases in both quantity and quality of emergent nesting cover created by above average precipitation in the mid- to late 1990s (NDASS 1999, SDASS 1999).

Common grackles were more abundant in the Southern Drift Plain than in the other 3 biotic regions surveyed in North Dakota. Likewise, common grackle densities were 2 to 3 times higher in Brown and Clark counties South Dakota than in Pierce and Stutsman counties North Dakota. The higher densities in southern North Dakota and eastern South Dakota might be related to greater availabilities of food associated with the numerous livestock operations in South Dakota (Homan et al. 1996, SDASS 1999). Additionally, shelterbelt plantings associated with farmsteads provided an abundance of preferred nesting habitat for common grackles. We noted similar densities of red-winged blackbirds and yellow-headed blackbirds among Brown, Clark, Pierce, and Stutsman counties, that indicated similar nesting habitats were available across these counties.

Sunflower Damage

Blackbird damage in our study counties was variable within and among years but overall was similar to historic state-wide levels of 1% to 2% recorded by Henne et al. (1979) and Hothem et al. (1988). Damage variability is probably due to changes in cropping patterns and suitability of wetlands for roosting blackbirds.

The only damage data available for direct comparison with our results were collected in Brown, Pierce, and Stutsman counties in 1979-1980 (Hothem et al. 1988). During those years, annual monetary losses were US$15.9/ha (Hothem et al. 1988) compared to US$11.4/ha in our study. This decrease is encouraging, given that in 1979-1980 these same 3 counties averaged 41% more hectares of sunflower. Greater coverage of sunflower in 1979-1980 should have dispersed the damage more than in 1997-1998. Moreover, sunflower was US$0.03/kg higher in 1997-1998, thereby driving up monetary losses per hectare.

Some of the reduction in damage was probably the result of growers not planting sunflower near traditionally large blackbird roosts (Arnett 1984). However, the introduction of new damage management techniques starting in the mid-1980s may have caused some reduction in damage (Linz and Hanzel 1997, Linz and Homan 1998). For example, from 1991 to 2000 the North Dakota/South Dakota Wildlife Services program aerially sprayed about 17,000 ha of cattail-dominated wetlands with glyphosate to disperse blackbird roosts (Homan et al. 2001). Apparently, limited efforts at baiting red-winged blackbirds with DRC-1339 in 1997-1998 did not lower local breeding populations. This suggests that managing dense cattail stands may have dispersed the roosts, which in turn reduced sunflower damage in local areas (Linz et al. 1995).

CONCLUSIONS

Growers value sunflower because it is a profitable crop that grows well in the semi-arid climate of the northern Great Plains (Bangsund and Leistritz 1995, Blamey et al. 1997). Blackbird damage can be so severe,

however, that growers are forced to eliminate sunflower from their crop rotation. This results in decreased income diversity and increased potential for disease and insect outbreaks in the remaining few crops that can be grown in the northern Great Plains.

Our data offer hope to growers because, despite increases in blackbird breeding populations, dollar loss per hectare in 3 of the surveyed counties was lower in the 1990s than in 1979-1980. To further reduce damage, the National Wildlife Research Center, North Dakota State University, and North Dakota/South Dakota Wildlife Service scientists and their cooperators are striving to reduce the application costs of glyphosate to control cattail and build a database on environmental impacts of cattail reduction (Leitch et al. 1997, Homan et al. 2001). Baiting blackbirds with avicides to reduce their populations may eventually prove to be cost-beneficial but faces opposition from environmental groups. We will continue to develop and assess new methods to reduce blackbird damage to sunflower in the northern Great Plains. Accordingly, we plan to continue our annual surveys of sunflower damage and breeding bird populations to help evaluate the efficacy of new damage management techniques.

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Table 6. Estimated sunflower acreage, production, and bird damage in Brown and Clark counties, South Dakota, and Stutsman and Pierce counties, North Dakota, and a summary for the surveyed counties, 1994-98.

	Counties									
	Brown[2]		Clark[3]		Pierce[4]		Stutsman[3]			
Category[1]	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Mean farm size (hectares)	430.4		369.6		467.5		522.9		447.6	64.40
Mean sunflower hectares (10^3)	18.4	3.12	7.4	4.66	14.9	7.50	53.8	9.30	25.8	21.80
Percent of land planted to sunflower	4.1		2.9		5.5		9.1		5.4	2.70
Total production (10^3t)	33.3	5.17	10.5	6.86	23.7	11.65	83.4	21.36	40.5	34.80
Value (@250t) of harvest (US$$10^6$)	8.3	1.29	2.6	1.72	5.9	2.91	20.8	5.34	10.1	8.70
Mean number of townships surveyed	3.0	0.00	3.4	0.40	3.0	0.00	14.6	4.16	6.0	5.74
Mean number of fields surveyed per township	2.2	0.31	3.3	0.19	3.6	0.18	3.4	0.11	3.1	0.63
Mean (%) damage per seed head	0.4	0.33	0.4	0.18	6.5	4.97	2.2	0.75	2.2	0.03
Total bird damage (10^3 t)	0.11	0.09	0.04	0.02	1.42	1.16	1.84	0.77	0.9	1.04
Mean bird damage (kg/ha)	2.6	2.42	2.3	1.14	41.5	30.20	14.0	6.02	14.1	19.27
Total bird damage (US$$10^4$)	2.7	2.27	0.9	0.63	35.5	29.06	46.0	19.20	23.1	26.09
Mean annual value bird damage (US$/ha)	1.6	1.50	1.4	0.70	25.6	18.64	8.6	3.72	8.7	11.90

[1]Production estimates from North Dakota Agricultural Statistics Service (1999) and South Dakota Agricultural Statistics Service (1999)

[2]Surveyed from 1997 to 1998

[3]Surveyed from 1994 to 1998

[4]Surveyed from 1996 to 1998

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