October 2001

DECLINE OF THE RED-WINGED BLACKBIRD POPULATION IN OHIO CORRELATED TO CHANGES IN AGRICULTURE (1965-1996)

Bradley F. Blackwell
USDA/APHIS/WS National Wildlife Research Center, bradley.f.blackwell@aphis.usda.gov

Richard A. Dolbeer
U.S. Department of Agriculture, Animal and Plant Health lnspection Service, Wildlife Services, National Wildlife Research Center

DECLINE OF THE RED-WINGED BLACKBIRD POPULATION IN OHIO CORRELATED TO CHANGES IN AGRICULTURE (1965–1996)

BRADLEY F. BLACKWELL, U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Ohio Field Station, 6100 Columbus Avenue, Sandusky, OH 44870, USA
RICHARD A. DOLBEER, U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Ohio Field Station, 6100 Columbus Avenue, Sandusky, OH 44870, USA

Abstract: Based on North American Breeding Bird Survey (BBS) data since 1966, Ohio has traditionally hosted 1 of the highest breeding season densities of red-winged blackbirds (*Agelaius phoeniceus*) of any U.S. state or Canadian province. However, from 1966 through 1996, breeding populations of red-winged blackbirds in Ohio showed a marked decline ($\bar{x}$% change/yr in birds per route = –3.9), with breeding population indices decreasing by over 53%. Because the red-winged blackbird successfully adapted to habitats created by agricultural expansion over the last century and became a recognized pest of crops such as corn (*Zea mays*), understanding the decline of this species in Ohio is important from both ecological and damage control perspectives. We examined 35 crop and climatic factors relative to their relationship with the observed breeding population trend for the red-winged blackbird in Ohio 1966 to 1996. Each year, we found that the area of non-alfalfa (*Medicago sativa*) hay harvested, the combined area of corn and soybeans (*Glycine max*) harvested, the area of non-alfalfa hay cut by 30 May of the index year (1966–1996), and the area of hay (all types) cut by 30 May of the year prior to the index best explained the variance in the breeding population trend of the red-winged blackbird in Ohio. Given our findings, we suggest that a long-term population trend for this abundant bird in Ohio is negatively associated with the efficiency and expansion of modern agriculture.

JOURNAL OF WILDLIFE MANAGEMENT 65(4):661–667

Key words: *Agelaius phoeniceus*, habitat, hay, Ohio, population decline, red-winged blackbird.

Human manipulation of the landscape is arguably a driving force behind changes in avian species composition. For example, the clearing of U.S. forests east of the Mississippi River for agriculture precipitated the demise of the passenger pigeon (*Ectopistes migratorius*; Schorger 1955) and contributed to the growth and expansion of members of the Icteridae, particularly the red-winged blackbird (Dolbeer and Stehn 1983). Today, the red-winged blackbird (hereafter red-wing) is 1 of the most abundant avian species in North America (Dolbeer and Stehn 1979, 1983; Dolbeer 1980; Beletsky 1996; Peterjohn et al. 1996). Although its preferred breeding habitat is emergent marsh (Dyer 1970, Dyer et al. 1972, Beletsky 1996), this species has successfully adapted to breeding in upland habitats, particularly managed grasslands, pasture, and fallow fields (Dyer 1970, Dyer et al. 1972, Robbins and Erskine 1975). Moreover, Dyer et al. (1972) suggested that although marshes hold the highest densities of red-wings, expansive upland habitats provide a greater potential for red-wing production and, thus, population growth.

Despite successful adaptation to changing land-use practices, North American Breeding Bird Survey (BBS) data indicate that red-wing populations declined survey-wide ($\bar{x}$% change/yr in birds per route = –1.0, $P < 0.01$; Fig. 1) from 1966 to 1996 (Sauer et al. 1997). In Ohio, where breeding season densities of red-wings were once the highest of any U.S. state or Canadian province (Dolbeer and Stehn 1979, 1983; Dolbeer 1980), breeding populations also have declined ($\bar{x}$% change/yr in

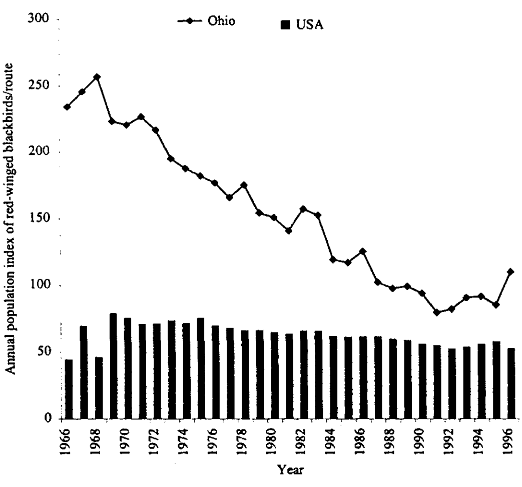

Fig. 1. North American Breeding Bird Survey annual indices of abundance (i.e., residuals from predicted trend [mean % change/yr in birds per route = –1.0, $P < 0.01$] obtained by route-regression analysis; Geissler and Sauer 1990) for red-winged blackbird populations in Ohio and the continental United States from 1966 to 1996 (Sauer et al. 1997).

birds per route = −3.9, $P < 0.01$, 1966–1996; Fig. 1; Sauer et al. 1997). Dolbeer and Stehn (1983) reported that from 1966 to 1981, a mean of 229 red-wings was seen per Ohio BBS route ($n = 46$). In contrast, from 1981 to 1996, a mean of 104 red-wings was seen per Ohio BBS route ($n = 74$). Given the serious economic consequences realized by farmers as a result of the rapid expansion of the red-wing into the agricultural niche and the species' damage to crops such as corn in Ohio, and rice (*Oryza sativa*) and sunflowers in other states ([*Helianthus annuus*] Dyer 1967, Weatherhead et al. 1980, Clark et al. 1982, Dolbeer 1990, Beletsky 1996, Linz and Hanzel 1997), identifying factors contributing to the decline of the species in Ohio is important from both ecological and management perspectives.

Table 1. Crop (× 1,000 ha harvested annually) and climatic variables evaluated relative to effects on North American Breeding Bird Survey (BBS) population indices for the red-winged blackbird in Ohio, USA (1966–1996). Periods represented include the year prior to the BBS index (1965–1995) and the index year (1966–1996). Blanks indicate that variables were not included for the specific period.

Variable	Year prior to index $\bar{x}$	Year prior to index SD	Index year $\bar{x}$	Index year SD
Corn	1,432	163	1,436	165
Soybeans	1,367	267	1,384	252
Corn and soybeans combined	2,799	329	2,820	313
Winter wheat	484	93	483	95
Oats	138	69	135	68
Winter wheat and oats combined	622	119	618	119
Corn, soybeans, winter wheat, and oats combined	3,422	303	3,438	293
Alfalfa hay	247	49	743	42
Area of alfalfa hay harvested by 30 May	56	46	55	46
Non-alfalfa hay	322	64	341	65
Area of non-alfalfa hay harvested by 30 May	35	31	34	32
Total hay	589	62	584	56
Total area of hay harvested by 30 May	91	73	89	74
Mean monthly precipitation (cm)				
Apr	8.7	2.8		
May	10.3	3.9		
Jun	9.6	3.2		
Mean precipitation–May and Jun	9.9	2.8		
Mean monthly temperature (°C)				
Apr	9.9	1.4		
May	15.4	1.9		
Jun	20.4	1.2		
Mean temperature–May and Jun	17.9	1.0		
Mean temperature (°C) in Alabama, Jan			6.4	2.6

Besser et al. (1984) attributed declining numbers of breeding red-wings in the Dakotas (1965–1981) to biennial precipitation that affected growth of emergent vegetation used for nesting, such as cattail (*Typha* sp.) and the amount of land under tillage (i.e., replacement of wetlands). Herkert (1994) examined the effects of habitat structure and area on bird species in grassland fragments in Illinois and found that red-wings were associated more with edge (not necessarily vegetation structure) and negatively affected by grassland area. O'Connor et al. (1999) used a geographical information system and regression tree analysis to model the effects of habitat characteristics (at the macroecological scale) on the distribution of 17 grassland bird species (not including red-wings) in the conterminous United States; strong associations were noted between species distribution and long-term annual precipitation, January and July temperatures, and agricultural land use. Most recently, Horn and Koford (2000) related negative trends in red-wing abundance in Conservation Reserve Program (CRP) fields in North Dakota to emergency haying during the previous breeding season. To date, however, potential causes behind the substantial decline in the red-wing breeding population in Ohio have not been evaluated. We questioned, therefore, whether agricultural and climatic factors were not also closely tied to the negative trend for the Ohio red-wing population. Here, we examine the statistical relationship between BBS annual population indices for the red-winged blackbird in Ohio (1966–1996) and 35 crop and climatic variables.

METHODS

We obtained our preliminary set of independent variables (Table 1), which represent the predominant crop coverage (ha) harvested annually in Ohio (1965–1996), from the National Agricultural Statistics Service (NASS). The NASS statistics were available only as annual reported harvest and yield totals. Because habitat changes can affect population levels in a subsequent year, crop coverage variables were evaluated for each year prior to a BBS index for red-wings (i.e., 1965–1995) as well as each index year (1966–1996). We then selected 9 climatic variables (Table 1), also obtained from the NASS, for potential effects on nest success (see Francis 1971, Besser et al. 1984, O'Connor et al. 1999). Also, we used the mean annual January temperature (also used by O'Connor et al. 1999) in Alabama (1966–1996; Southeast Regional Climate Center) as an index of potential climatic effects on red-wing survival in wintering areas in the southeastern United States (see Dolbeer 1978, 1982). Data relative to historic trends in wetland area in Ohio, representing potential breeding habitat for red-wings, were not available.

A priori functions (i.e., testable candidate models) relating aspects of red-winged blackbird population indices to land-use data for Ohio also were not available. Therefore, we pursued our analysis in a conventional exploratory format, but guided our selection of candidate variables (above) and any combined functional relationships to BBS indices on the basis of biological relevance (see, however, Burnham and Anderson 1998). We first regressed (SAS Institute 1990) annual BBS breeding population indices (residuals from the predicted trend obtained by route-regression analysis; Geissler and Sauer 1990) for red-wings in Ohio from 1966 to 1996 (Sauer et al. 1997) on each of 26 crop and 9 climatic factors (Table 1). The BBS encompasses approximately 3,700 randomly located survey routes (39.4 km each) throughout the continental United States, southern Canada, and Alaska that are surveyed annually in June (Peterjohn and Sauer 1993). Each route has 50 stops (at 0.8-km intervals), at which all birds seen within 0.4 km or heard at any distance are tallied during a 3-min point count (Robbins et al. 1986). Variables were retained as potential independent variables if $R^2 \geq 0.1$ at $\alpha \leq 0.05$. We then regressed the breeding population indices on the retained variables using stepwise linear regression (SAS Institute 1990). Variables were considered 1 by 1 and entered the model if the F statistic was significant at the 0.5 level (SAS default level selected arbitrarily). As each variable was added to the model, the STEPWISE option evaluated all model variables and retained only those producing an F statistic significant at the 0.05 level. We used partial regression residual plots to further corroborate the functional relationship between each variable examined in the stepwise procedure and the red-wing breeding population trend. We investigated potential interactions between variables retained in the final model by using residual plots. Also, we calculated Pearson's product-moment correlation coefficient for each pair of independent variables retained in the final model. Ultimate retention of variables in the model, however, was dependent first on their biological relevance and second on the variance explained (see below).

RESULTS

In the initial regression of red-wing BBS indices (1966–1996) on each of 35 habitat and climatic variables, 17 habitat variables were retained (Table 2). Variables that pertained to the respective areas of soybeans and oats (*Avena sativa, A. byzantina*) harvested annually (1965–1996; n = 4 variables) had R^2 values ranging from 0.72 to 0.85 and exhibited strong, but biologically questionable (see below), effects in the stepwise analysis. Therefore, we did not include the 4 variables that pertained to soybeans and oats individually in the model, but rather as components of other variables (Table 2).

Table 2. Variables retained under the condition of $R^2 \geq 0.1$ at the 0.05 level of significance after regression of North American Breeding Bird Survey population indices for the red-winged blackbird in Ohio, USA (1966–1996) on each of 35 crop and climatic variables (see Table 1).

Variable	R^2	F	P
Corn and soybeans combined: 1965–1995	0.50	29.0	0.0001
Corn and soybeans combined: 1966–1996	0.48	26.4	0.0001
Winter wheat and oats combined: 1965–1995	0.42	20.6	0.0001
Winter wheat and oats combined: 1966–1996	0.37	16.9	0.0003
Corn, soybeans, winter wheat, and oats combined: 1965–1995	0.26	10.4	0.0031
Corn, soybeans, winter wheat, and oats combined: 1966–1996	0.24	9.2	0.0050
Alfalfa hay: 1966–1996	0.27	10.6	0.0029
Area of alfalfa hay harvested by 30 May 1965–1995	0.26	10.2	0.0034
Area of alfalfa hay harvested by 30 May 1966–1996	0.35	15.7	0.0004
Non-alfalfa hay: 1965–1995	0.65	54.8	0.0001
Non-alfalfa hay: 1966–1996	0.70	69.3	0.0001
Area of non-alfalfa hay harvested by 30 May 1965–1995	0.14	4.6	0.0408
Area of non-alfalfa hay harvested by 30 May 1966–1996	0.17	5.8	0.0228
Total hay: 1965–1995	0.39	18.8	0.0002
Total hay: 1966–1996	0.35	15.4	0.0005
Total hay harvested by 30 May 1965–1995	0.23	8.5	0.0068
Total hay harvested by 30 May 1966–1996	0.30	12.1	0.0016

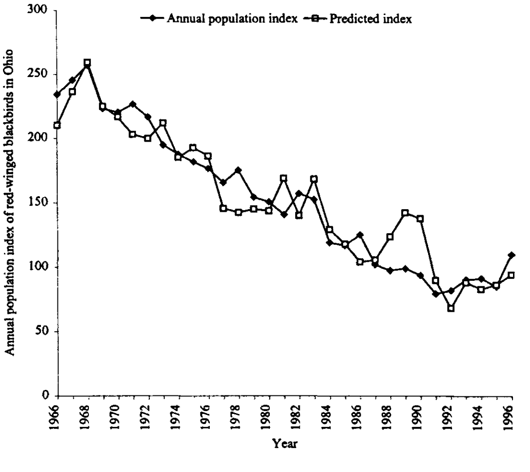

Fig. 2. Final regression model (R^2 = 0.88, F = 48.4, P = 0.0001) resulting from stepwise linear regression of North American Breeding Bird Survey annual indices of abundance (i.e., residuals from predicted trend obtained by route-regression analysis; Geissler and Sauer 1990) for red-winged blackbird populations in Ohio, USA (1966–1996; Sauer et al. 1997) on 17 crop variables representing area (ha) harvested annually. See Table 3 for partial R^2 values, parameter estimates, and standard errors.

Specifically, although the planting of soybeans in Ohio reduced potential breeding habitat for red-wings, the effects of this loss of area on the red-wing breeding population must be considered relative to planting practices. For example, the area of soybeans harvested annually exhibited a negative correlation coefficient with red-wing population indices of –0.9 (1966–1996), increased at an exponential rate of 2.5% per year, and represented on average 34.3% (SD = 5.4) of total crop area in Ohio. However, soybeans are interchanged regularly with corn—which composed the greatest amount of the total crop area harvested annually in Ohio (1966–1996)—but was not retained as a variable in the initial regression.

Although the Ohio corn crop exhibited a 0.6% decrease in area harvested annually (1966–1996), it represented 35.7% (SD = 2.7) of total crop area for the same period. Further, no difference (t-test assuming unequal variances: t = 0.94, df = 57, P = 0.35) occurred between mean area of corn harvested annually (1,435,532 ha; SD = 164,832) and that of soybeans (1,384,460 ha; SD = 252,003).

As for our omission of the 2 variables pertaining to oats from the stepwise analysis, the effect of these variables on the regression was more statistical than biological. Although the area of oats (a food source for red-wings) harvested annually (1966–1996) exhibited a positive correlation coefficient with the red-wing breeding population trend indices of 0.9, oats represented on average only 3.4% (SD = 1.9) of the total area of crops harvested annually in Ohio.

Stepwise linear regression of the population indices on the remaining 17 variables resulted in a model (R^2 = 0.88, mean square error = 2.1% of total error, F = 48.4, P = 0.0001) that contained 4 variables (Fig. 2; Table 3); we noted no interactions between variables. Each year, the area of non-alfalfa hay harvested, the combined area of corn and soybeans harvested, the area of non-alfalfa hay cut by 30 May of the index year (1966–1996), and the area of hay (all types) cut by 30 May of the year prior to the index (i.e., 1965–1995) best explained the variance in the breeding population trend of red-wings in Ohio. However, the area of non-alfalfa hay harvested and the combined area of corn and soybeans harvested were correlated (r = –0.50, df = 29, critical value = 0.355), thus bringing into question the relative importance of the 2 variables to the model.

Still, the correlation between the area of non-alfalfa hay harvested and the combined area of corn and soybeans harvested was expressed (upon the addition of the corn and soybean variable to the stepwise procedure) only as an inflation of the regression coefficient of the non-alfalfa hay variable (21.5%) and its standard error (4.6%). Otherwise, all variables evaluated in the procedure, as well as the 4 variables retained, maintained correct algebraic signs relative to their anticipated effects on the dependent variable. Further, all variables evaluated or retained in the model exhibited significant results when tested individually (see above).

Table 3. Final model (R^2 = 0.88, F = 48.4, P = 0.0001) resulting from stepwise linear regression of North American Breeding Bird Survey population indices for the red-winged blackbird in Ohio, USA (1966–1996) on 17 crop variables (see Table 2).

Variable	Partial R^2	Parameter estimate	SE
Intercept		203.782	55.546
Non-alfalfa hay: 1966–1996	0.70	0.459	0.070
Corn and soybeans combined: 1966–1996	0.10	–0.065	0.014
Non-alfalfa hay harvested by 30 May 1966–1996	0.05	–0.338	0.122
Total hay harvested by 30 May 1965–1995	0.03	–0.140	0.054

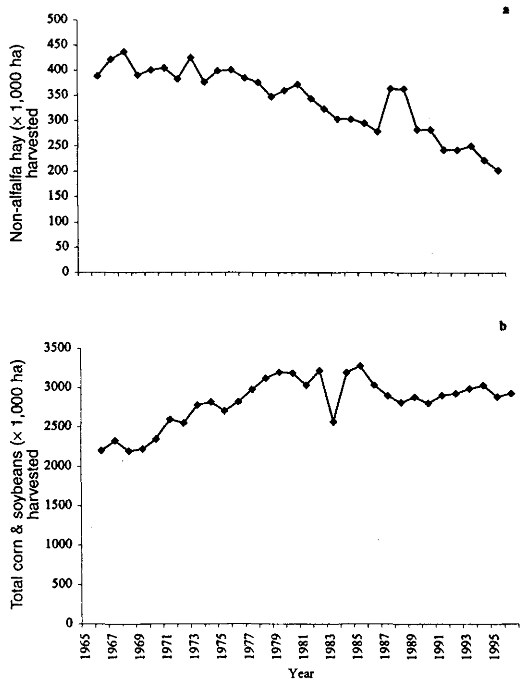

Fig. 3. National Agricultural Statistics Service records of (a) annual harvest (ha) of non-alfalfa hay and (b) combined annual harvest (ha) of corn and soybeans in Ohio, 1966 through 1996.

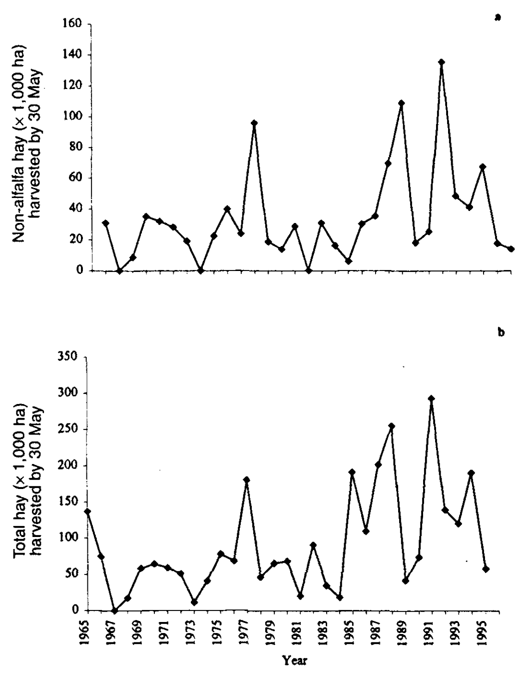

Fig. 4. National Agricultural Statistics Service records of (a) annual harvest (ha) of non-alfalfa hay by 30 May (1966–1996) and (b) total hay (1965–1995).

The first variable in the model—the area of non-alfalfa hay harvested in Ohio (1966–1996)—represented on average 8.5% (SD = 1.9) of total crop area harvested and decreased by 2.1% per year (Fig. 3a). The combined area of corn and soybeans (1966–1996) represented on average 70.0% (SD = 4.4) of total crop area harvested and increased by 1.0% per year (Fig. 3b). Next, the area of non-alfalfa hay cut by 30 May of the index year fluctuated widely ($\bar{x}$ = 34,400 ha; SD = 31,600; Fig. 4a) but represented on average only 0.9% (SD = 0.8) of total crop area harvested. Further, the total area of hay cut by 30 May of the year prior to the red-wing index also fluctuated widely ($\bar{x}$ = 92,300 ha; SD = 73,700; Fig. 4b) and represented on average 2.3% (SD = 1.8) of total crop area.

DISCUSSION

Our analysis revealed a relationship between the breeding population indices of the red-winged blackbird (1966–1996), a facultative grassland species (Vickery et al. 1999), and Ohio agricultural practices. Further, in addition to explaining some aspects of the variance associated with the red-wing breeding population trend, our regression model is biologically realistic. Specifically, the decrease in the area of non-alfalfa hay harvested annually (1966–1996) likely has reduced the availability of quality nesting habitat. Also, whereas corn attracts potential insect prey for red-wings—as well as representing a source of energy during the "milk" stage (Dolbeer 1980)—both corn and soybeans (soybeans are not a food source for red-wings) are ill-suited for nesting. The combined area of corn and soybeans harvested annually in Ohio represented on average 70% of the crop coverage from 1966 to 1996 (i.e., >2.8 million ha). Similarly, wide fluctuations in the annual area of non-alfalfa hay and total hay cut by 30 May, both in the year prior to and a current reproductive year, likely disrupted nesting and subsequent reproductive success (for data relative to effects of hay mowing on nesting of grassland birds, see Warner and Etter 1989, Warner 1994).

Importantly, our results support hypotheses regarding the effects of changing land-use practices on grassland avifauna populations. For example, Dyer et al. (1972) suspected that since the expansion of red-wing populations into upland habitats, a regulatory link has been established with land-use practices in the agricultural community. However, nearly 3 decades earlier, Moseley (1947) noted that advances in mechanized farming (e.g., the "alfalfa mill") allowed farmers to process hay early and in quantity, thereby disrupting habitat and nesting of grassland bird species in the north-central United States. Several authors have suggested that the following changes have contributed to the declines in grassland avifauna: (1) transition over the last century from farms with structurally diversified habitats containing cool-season grasses and legumes to monocultures of alfalfa and other row-crops, (2) fragmentation of remaining grasslands, and (3) earlier mowing of hay (Warner and Etter 1989; Warner 1992, 1994; Johnson and Schwartz 1993; Herkert et al. 1996; Dale et al. 1997). Similarly, changing patterns of agriculture in the forms of increased mechanization, narrowing crop complexity and timing of rotations, and increased cereal (Gramineae) acreage have also been associated with declining numbers of avian species once common in the fields and edge associated with farms in Great Britain (O'Connor and Shrubb 1986, Gregory and Baillie 1998).

In Ohio, dramatic changes in the landscape occurred from 1910 to 1977, with the human population increasing from 4.7 to over 10.7 million and metropolitan complexes, towns, and villages growing as well (Trautman 1977). Since 1915, Ohio farmers have become more mechanized, increased field size by a factor of 3 or more, and began using chemical fertilizers, herbicides, and insecticides. By 1975, the Ohio farmer began specializing, limiting crops grown to only 1 or 2 varieties and, in some cases, planting the same crop in the same field over several years (Trautman 1977). Peterjohn (1989) noted that intense urbanization and population expansion in Ohio over the last century, combined with mechanized agricultural practices and use of chemicals in farming (e.g., herbicides), produced an overall loss of traditional and nontraditional nesting habitat, resulting in a decrease in avian species diversity and richness. We suggest, therefore, that our findings demonstrate a plausible hypothesis for the decline of this abundant bird in Ohio. Specifically, the red-winged blackbird has been negatively affected by the decline in hay production, earlier mowing of hay, and the increase in row crops—a scenario synonymous with the plight of less numerous grassland bird species.

MANAGEMENT IMPLICATIONS

Our results suggest that the red-winged blackbird, a species that has shown remarkable adaptability to human-induced habitat changes (Dolbeer 1990), has been negatively affected by the increasing efficiency and narrowing diversity of modern agricultural practices in Ohio. Further, the decline in the red-wing population may be perceived as a positive event by Ohio corn producers (Dolbeer 1990), as well as those in the sunflower industry (Linz and Hanzel 1997). However, the agricultural practices that have precipitated the red-wing's decline in Ohio likely have had more severe effects on other, less common grassland species, such as the upland sandpiper (*Bartramia longicauda*) and grasshopper sparrow (*Ammodramus savannarum*; see trends in Sauer et al. 1997). Thus, our findings lend support to efforts like the Conservation Reserve Program (see Johnson and Schwartz 1993). Moreover, particularly in the United States, farming traditionally has represented not only a means of feeding our nation and others, but a system of stewardship for wildlife and other natural resources associated with agricultural lands. We therefore concur with recent research recommendations (Herkert et al. 1996, Dale et al. 1997, Horn and Koford 2000) that within the CRP and on other lands, management regimes (including mowing, burning, and grazing) should be modified by area, season, and annual rotation to increase opportunity for successful reproduction of grassland avifauna.

ACKNOWLEDGMENTS

Financial support for this study was provided by the U.S. Department of Agriculture, National Wildlife Research Center. T. Armstrong, S. C. Barras, G. M. Linz, and T. W. Seamans reviewed earlier drafts of the manuscript.

LITERATURE CITED

BELETSKY, L. 1996. The red-winged blackbird. The biology of a strongly polygynous songbird. Academic Press, London, United Kingdom.

BESSER, J. F., J. W. DEGRAZIO, J. L. GUARINO, D. F. MOTT, D. L. OTIS, B. R. BESSER, AND C. E. KNITTLE. 1984. Decline in breeding red-winged blackbirds in the Dakotas, 1965–1981. Journal of Field Ornithology 55:435–443.

BURNHAM, K. P., AND D. R. ANDERSON. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York, USA.

CLARK, R. G., R. D. TITMAN, J. R. BIDER, AND M. PRÉVOST. 1982. Aspects of the socio-economic impact of blackbirds and other vertebrates on farm production in Québec. Phytoprotection 63:56–67.

DALE, B. C., P. A. MARTIN, AND P. S. TAYLOR. 1997. Effects of hay management on grassland songbirds in Saskatchewan. Wildlife Society Bulletin 25:616–626.

DOLBEER, R. A. 1978. Movement and migration pattern of red-winged blackbirds: a continental review. Bird-Banding 49:17–34.

———. 1980. Blackbirds and corn in Ohio. U.S. Fish and Wildlife Service, Resource Publication 136, Washington, D.C., USA.
———. 1982. Migration patterns for age and sex classes of blackbirds and starlings. Journal of Field Ornithology 53:28–46.
———. 1990. Ornithology and integrated pest management: red-winged blackbirds *Agelaius phoeniceus* and corn. Ibis 132:310–322.
———, AND R. A. STEHN. 1979. Population trends of blackbirds and starlings in North America, 1966–76. U.S. Fish and Wildlife Service, Special Scientific Report–Wildlife Number 214, Washington, D.C., USA.
———, AND ———. 1983. Population status of blackbirds and starlings in North America, 1966–81. Proceedings of the Eastern Wildlife Damage Control Conference 1:51–61.
DYER, M. I. 1967. An analysis of blackbird flock feeding behavior. Canadian Journal of Zoology 45:765–772.
———. 1970. Territorial male red-winged blackbird distribution in Wood County, Ohio. Proceedings—Bird Control Seminar 5:185–194.
———, D. B. SINIFF, S. G. CURTIS, AND J. S. WEBB. 1972. Distribution of red-winged blackbird (*Agelaius phoeniceus* L.) populations in the Lake Erie region of the United States and Canada. Pages 213–234 *in* S. C. Kendeigh and J. Pinowski Warzawa, editors. Productivity, population dynamics and systematics of granivorous birds. Proceedings of the General Meeting of the Working Group on Granivorous Birds, IBP, PT section, The Hague, The Netherlands.
FRANCIS, W. J. 1971. An evaluation of reported reproductive success in red-winged blackbirds. Wilson Bulletin 83:178–185.
GEISSLER, P. H., AND J. R. SAUER. 1990. Topics in route-regression analysis. Pages 53–57 *in* J. R. Sauer and S. Droege, editors. Survey designs and statistical methods for the estimation of avian population trends. U.S. Fish and Wildlife Service, Biological Report 90, Laurel, Maryland, USA.
GREGORY, R. D., AND S. R. BAILLIE. 1998. Large-scale habitat use of some declining British birds. Journal of Applied Ecology 35:785–799.
HERKERT, J. R. 1994. The effects of habitat fragmentation on Midwestern grassland bird communities. Ecological Applications 4:461–471.
———, D. W. SAMPLE, AND R. E. WARNER. 1996. Management of midwestern grassland landscapes for the conservation of migratory birds. Pages 89–116 *in* F. R. Thompson, III, editor. Management of midwestern landscapes for the conservation of neotropical migratory birds. U.S. Forest Service General Technical Report NC 187.
HORN, J. D., AND R. R. KOFORD. 2000. Relation of grassland bird abundance to mowing of conservation reserve program fields in North Dakota. Wildlife Society Bulletin 28:653–659.
JOHNSON, D. H., AND M. D. SCHWARTZ. 1993. The conservation reserve program and grassland birds. Conservation Biology 7:934–937.
LINZ, G. M., AND J. J. HANZEL. 1997. Birds and sunflower. Pages 381–394 *in* A. Schneider, editor. Sunflower science and technology. American Society of Agronomy, Madison, Wisconsin, USA.
MOSELEY, E. L. 1947. Variations in the bird population of the north-central states due to climatic and other changes. Auk 64:15–35.
O'CONNOR, R. J., AND M. SHRUBB. 1986. Farming and birds. Cambridge University Press, London, United Kingdom.
———, M. T. JONES, R. B. BOONE, AND T. B. LAUBER. 1999. Linking continental climate, land use, and land patterns with grassland bird distribution across the conterminous United States. Studies in Avian Biology 19:45–59.
PETERJOHN, B. G. 1989. The birds of Ohio. Indiana University Press, Bloomington, USA.
———, AND J. R. SAUER. 1993. North American breeding bird survey annual summary 1990–1991. Bird Populations 1:52–67.
———, ———, AND W. A. LINK. 1996. The 1994 and 1995 summary of the North American breeding bird survey. Bird Populations 3:48–66.
ROBBINS, C. S., AND A. J. ERSKINE. 1975. Population trends in nongame birds in North America. Transactions of the North American Wildlife and Natural Resources Conference 40:288–293.
———, D. BYSTRAK, AND P. H. GEISSLER. 1986. The breeding bird survey: its first fifteen years, 1965–1979. U.S. Fish and Wildlife Service Research Publication 157, Washington, D.C., USA.
SAS INSTITUTE. 1990. SAS/STAT® user's guide. Volume 2. SAS Institute, Cary, North Carolina, USA.
SAUER, J. R., J. E. HINES, G. GOUGH, I. THOMAS, AND B. G. PETERJOHN. 1997. The North American breeding bird survey results and analysis. Version 96.4. Patuxent Wildlife Research Center, Laurel, Maryland, USA.
SCHORGER, A. W. 1955. The passenger pigeon; its natural history and extinction. University of Oklahoma Press, Norman, USA.
TRAUTMAN, M. B. 1977. The Ohio country from 1750 to 1977, a naturalist's view. Ohio Biological Survey, Biological Notes Number 10, The Ohio State University, Columbus, USA.
VICKERY, P. D., P. L. TUBARO, J. M. CARDOSO DA SILVA, B. G. PETERJOHN, J. R. HERKERT, AND R. B. CAVALCANTI. 1999. Conservation of grassland birds in the western hemisphere. Studies in Avian Biology 19:2–26.
WARNER, R. E. 1992. Nest ecology of grassland passerines on road rights-of-way in central Illinois. Biological Conservation 59:1–7.
———. 1994. Agricultural land use and grassland habitat in Illinois: future shock for midwestern birds? Conservation Biology 8:147–156.
———, AND S. L. ETTER. 1989. Hay cutting and the survival of pheasants: a long-term perspective. Journal of Wildlife Management 53:455–461.
WEATHERHEAD, P. L., R. G. CLARK, J. R. BIDER, AND R. D. TITMAN. 1980. Movements of blackbirds and starlings in southwestern Quebec and eastern Ontario in relation to crop damage and control. Canadian Field-Naturalist 94:75–79.

Received 20 November 2000.
Accepted 25 May 2001.
Associate Editor: Block.