J. Field Ornithol., 67(1):167–176

RESPONSES OF RED-WINGED BLACKBIRDS, YELLOW-HEADED BLACKBIRDS AND MARSH WRENS TO GLYPHOSATE-INDUCED ALTERATIONS IN CATTAIL DENSITY

GEORGE M. LINZ
U.S. Department of Agriculture
Denver Wildlife Research Center
North Dakota Field Station
North Dakota State University
Fargo, North Dakota 58105-5517 USA

DAGE C. BLIXT[1]
Department of Zoology
Stevens Hall
North Dakota State University
Fargo, North Dakota 58105-5517 USA

DAVID L. BERGMAN
U.S. Department of Agriculture
Denver Wildlife Research Center
North Dakota Field Station
North Dakota State University
Fargo, North Dakota 58105-5517 USA

WILLIAM J. BLEIER
Department of Zoology
Stevens Hall
North Dakota State University
Fargo, North Dakota 58105-5517 USA

Abstract.—The effects of herbicide-induced changes in wetland emergent vegetation on densities of territorial male Red-winged Blackbirds (*Agelaius phoeniceus*), Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), and Marsh Wrens (*Cistothorus palustris*) were assessed in northeastern North Dakota. In 1990 and 1991, 23 cattail-dominated wetlands were randomly assigned to 0% (reference wetlands), 50%, 70%, or 90% areal spray coverages with glyphosate herbicide. Two years post-treatment, densities of redwings were higher in the reference wetlands ($\bar{x}$ = 1.59 ± 0.24 [SE]/ha) than in the 90% treated wetlands ($\bar{x}$ = 0.55 ± 0.14/ha, P = 0.063). Yellowheads were more abundant in reference wetlands ($\bar{x}$ = 3.80 ± 0.83/ha) than in treated wetlands ($\bar{x}$ = 2.05 ± 0.40/ha, P = 0.061). Likewise, wrens were more abundant in reference wetlands ($\bar{x}$ = 2.21 ± 0.27/ha) than in treated wetlands ($\bar{x}$ = 0.66 ± 0.13/ha, P = 0.001). Percent coverage of live emergent vegetation (largely cattails, *Typha* spp.) was positively correlated with blackbird and wren numbers ($P \leq 0.1$). Results of this study suggest that numbers of these three wetland-dwelling species were limited by altering cattail density. Staggering vegetation management treatments on large wetland complexes may help diversify the stages of cattail regeneration and provide heterogenous nesting and foraging habitat for these birds.

[1] *Current address: P.O. Drawer FW, Room 200, Forest Resources Building, Mississippi State University, Mississippi 39762 USA.*

RESPUESTA DE *AGELAIUS PHOENICEUS, XANTHOCEPHALUS XANTHOCEPHALUS* Y *CISTOTHORUS PALUSTRIS* A ALTERACIÓN EN LA DENSIDAD DE ENEAS TRATADAS CON YERBICIDAS

Sinopsis.—Se evaluó en un anegado de Dakota del Norte, la respuesta de *Agelaius phoeniceus, Xanthocephalus xanthocephalus* y *Cistothorus palustris* a la alteración de la densidad de eneas (*Typha* spp.) como resultado del tratamiento de esta con yerbicidas. Durante 1991 y 1992 un total de 23 anegados a los cuales se le asignó al azar un tratamiento de 0% (grupo control), 50%, 70% y 90% de tratamiento, fueron asperjados aéreamente con yerbicida glicofosfatado. Dos años después del tratamiento la densidad de individuos de *Agelaius phoeniceus* resultó mayor en las áreas controles ($\bar{x}$ = 1.59 ± 0.24 [SE]/ha) que en las localidades en donde se asperjó el 90% del área ($\bar{x}$ = 0.55 ± 0.14/ha, P = 0.063). Por su parte *Xanthocephalus xanthocephalus* resultó más abundante en las áreas controles ($\bar{x}$ + 3.80 ± 0.83/ha) que en las áreas tratadas ($\bar{x}$ = 2.05 ± 0.40/ha, P = 0.061). De igual manera *Cistothorus palustris* resultó más abundante en las áreas controles ($\bar{x}$ = 2.21 ± 0.27/ha) que en áreas tratadas ($\bar{x}$ = 0.66 ± 0.13/ha, P = 0.001). El porciento de cobertura de las eneas correlacionó positivamente con los números de *Agelaius phoeniceus* y de *Cistothorus palustris*. El resultado de este estudio sugiere que el número de individuos de las tres especies estudiadas se limitó al alterarse la densidad de las eneas. El tratamiento de grandes extensiones de anegados con yerbicidas muy bien pudiera diversificar las etapas de regeneración de las eneas proveyendo entonces un hábitat heterogéneo para el forrajeo y anidamiento de aves.

In the northern Great Plains, Common Cattail (*Typha latifolia*) and Narrow-leaved Cattail (*Typha angustifolia*) have hybridized to produce *T.* × *glauca,* the most common large hydrophyte in North Dakota wetlands (Kantrud 1986). When cattails dominate a wetland by forming dense homogenous stands, the abundance and diversity of wetland-dwelling birds is reduced (Kantrud 1986, Weller and Spatcher 1965). Moreover, dense cattail stands located near grain crops provide ideal roosting locations for crop-depredating blackbirds (lcterinae) (Linz et al. 1993). In comparison, cattail patches interspersed with open water may benefit wetland birds by increasing habitat heterogeneity (Kantrud 1986, Linz et al. 1994, Weller and Spatcher 1965) and may deprive blackbirds of essential roost habitat.

Recognizing that fragmenting dense cattail stands is beneficial for waterfowl (Kaminski and Prince 1981, Kantrud 1986, Murkin et al. 1982, Solberg and Higgins 1993) and may reduce large concentrations of blackbirds (Linz et al. 1993), wildlife agencies are attempting to manage cattails with aquatic herbicides (Baltezore et al. 1994). Quantitative data documenting the effects of cattail reduction on breeding populations of birds are limited, however (Blixt 1993, Kantrud 1986, Linz et al. 1994).

In this paper, we examine the effects of reducing emergent vegetation (i.e., cattails) with glyphosate herbicide on densities of territorial male Red-winged Blackbirds (*Agelaius phoeniceus*), Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), and Marsh Wrens (*Cistothorus palustris*). Our objectives were (1) to compare densities of these three species among wetlands treated with various herbicide spray coverages and (2) to describe the relationships among bird abundance and various wetland habitat variables.

STUDY AREA AND METHODS

The study area and methods were previously described by Linz et al. (1994). Our study area was located near Lakota, North Dakota (48°03′N, 98°21′W) in the Northeastern Drift Plains, which is characterized by the presence of many shallow basin wetlands (Stewart 1975).

In 1990, we randomly designated 11 cattail-dominated wetlands as reference ($n = 3$) or treated at 70% ($n = 4$) or 90% ($n = 4$) spray coverage with aerially applied glyphosate herbicide (Rodeo® formulation, Monsanto Company, St. Louis, Missouri). In 1991, we randomly designated another 12 wetlands as reference ($n = 4$) or treated at 50% ($n = 4$) or 70% ($n = 4$) spray coverage with glyphosate. Average size of the 23 experimental wetlands was 11.6 ± 1.7 SE ha.

Treatment wetlands were sprayed in mid- to late July at a rate of 5.8 l/ha of glyphosate. The herbicide was mixed in a 46.7 l/ha mixture containing surfactant, drift retardant, and water (Linz et al. 1994). The mixture was applied with a fixed-wing agricultural spray plane in strips that were 15-m wide and ran along the long axis of the wetlands (Linz et al. 1994).

During 2–18 June, territorial birds were counted on the 23 experimental wetlands one time prior to treatment and for 2 yr post-treatment. Wetlands were visited in random order between local sunrise and 5 h post-sunrise by one or two observers in 1990 and two of three observers in 1991–1993. Counts were made by the same pool of three experienced observers throughout the study.

In 1990, the observer(s) slowly walked around the perimeter of each wetland and recorded all birds seen or heard. In 1991–1993, we established eight fixed count points at uniform intervals around the perimeter of each wetland (Hutto et al. 1986, Linz et al. 1994). The observers walked to each count point, waited for 1 min, and recorded all wetland birds seen or heard during the next 5 min. Censuses were not conducted in persistent rain or winds exceeding 24 km/h.

Wetland size and coverages of open water, live vegetation (largely live cattails) and dead vegetation (largely dead cattails) were determined from aerial photographs using Map and Image Processing System software (MicroImages, Inc., Lincoln, Nebraska; Homan et al. 1992). Ektachrome photographs were used for the 1990 habitat analysis. Live and dead vegetation could not be distinguished on the Ektachrome slides, however. In August 1991–1993, color infrared photographs were taken of all 23 test wetlands. In 1991, live and dead vegetation could not be distinguished in the 1991-treated wetlands because the vegetation had begun to show the effects of the herbicide treatment.

Statistical analyses.—A one-factor analysis of variance (ANOVA) was used to compare arcsine-transformed percent coverages of open water and vegetation among study wetlands for each pretreatment year (Cody and Smith 1991, Montgomery 1991). A two-factor repeated measure ANOVA (RMANOVA) was used to test the null hypotheses of no differences in percent coverage of open water, live vegetation and dead vegetation among treatments one and two years posttreatment (Cody and Smith 1991, Montgomery 1991).

Redwings, yellowheads, and wrens were chosen as indicator species because of their reliance on emergent vegetation for nesting substrate (Stewart 1975) and because they were present in sufficient densities for meaningful statistical analyses of abundance. The count data for each species were divided by the size of the wetland to obtain the number per hectare and transformed using the square root (Montgomery 1991). A two-factor RMANOVA was used to examine the null hypotheses that average densities of birds counted were similar among treatments. Interaction among treatments and year was also tested to examine for differences in trends in bird densities between treated and reference wetlands over the 2 yr post-treatment period. When a RMANOVA indicated a significant difference among treatments, the Student-Newman-Keuls multiple range test was used to compare individual pairs of means (Cody and Smith 1991, Montgomery 1991).

We investigated the relationship between the number of birds per hectare of wetland (dependent variable) and percent coverages of water, live vegetation and dead vegetation (regardless of treatment) using Pearson correlation analysis (Cody and Smith 1991, Montgomery 1991). We set the significance level at 0.10 (*a priori*) because (1) resources were not sufficient to increase sample sizes and (2) the consequences of accepting false null hypotheses (Type II errors) on populations of birds using wetlands are much greater than if Type I errors (rejecting true null hypotheses) were made (Tacha et al. 1982).

RESULTS

Habitat characteristics.—Before the application of glyphosate, percent coverages of open water ($\bar{x}$ = 15.8 ± 3.4 [SE] %) and emergent vegetation ($\bar{x}$ = 84.2 ± 3.4%) were not significantly different among treatments (F = 1.59; df = 3, 19; P = 0.224, Fig. 1). Coverages of open water were greater (F = 12.02; df = 1, 19; P = 0.003) 2 yr post-treatment ($\bar{x}$ = 33.1 ± 3.9%) than 1 yr post-treatment ($\bar{x}$ = 19.9 ± 2.9%). Coverages of open water did not differ among treatments (F = 1.25; df = 3, 19; P = 0.317), however, averaging 26.5 ± 2.6% coverage.

Coverages of emergent vegetation were greater (F = 9.61; df = 1, 19; P = 0.006) 2 yr post-treatment ($\bar{x}$ = 44.3 ± 3.9%) than 1 yr post-treatment ($\bar{x}$ = 38.2 ± 5.4%, Fig. 1). In these years, cattail coverages were greater (F = 9.16; df = 3, 19; P = 0.001) in reference wetlands ($\bar{x}$ = 64.8 ± 3.9%) than in the treated wetlands ($\bar{x}$ = 31.0 ± 3.0%). Cattails showed a significant interaction between treatments and years, due to the regrowth of cattail in the treated wetlands and a decrease of cattail coverage in the reference wetlands 2 yr post-treatment (F = 5.10; df = 1, 19; P = 0.009).

Coverages of dead vegetation were greater (F = 18.44; df = 1, 19; P = 0.001) 1 yr post-treatment ($\bar{x}$ = 41.8 ± 4.6%) than 2 yr post-treatment ($\bar{x}$ = 22.6 ± 2.7%, Fig. 1). During the post-treatment years, dead vegetation coverages were greater (F = 11.27; df = 3, 19; P = 0.001) in the treated wetlands ($\bar{x}$ = 39.6 ± 3.4%) than in the reference wetlands ($\bar{x}$ = 15.3 ± 2.8%).

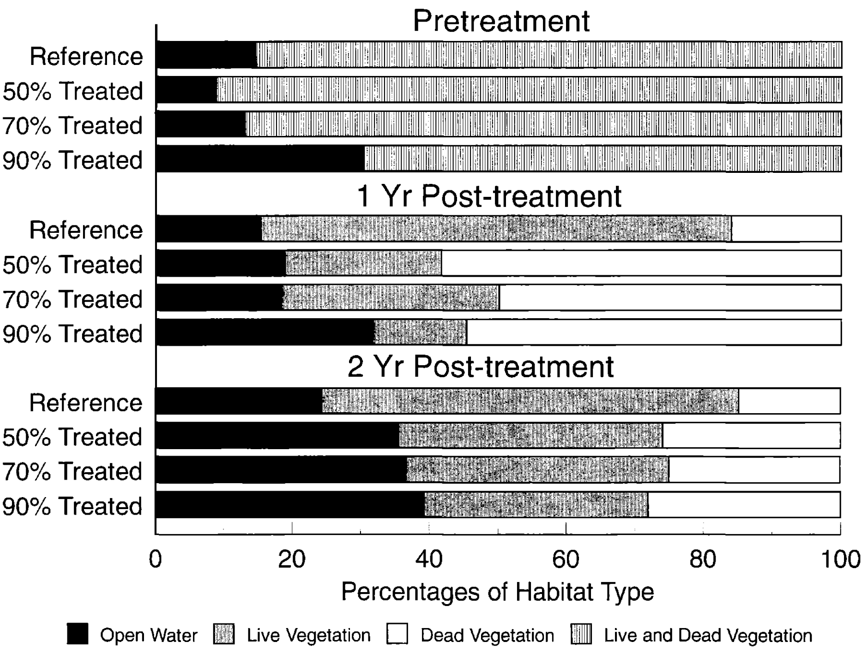

FIGURE 1. Habitat characteristics of 23 wetlands in northeastern North Dakota randomly designated as either treated at 50% (n = 4), 70% (n = 8), or 90% (n = 4) spray coverages with glyphosate herbicide during August 1990 and 1991 or untreated (reference) (n = 7). Live vegetation and dead vegetation were not distinguished during the pretreatment year.

Red-winged Blackbird.—Prior to treatment, redwing densities did not differ among the four treatments ($F = 0.43$; df = 3, 19; $P = 0.732$; Table 1), averaging 1.42 ± 0.22/ha. Redwing populations were similar across post-treatment years ($\bar{x}$ = 1.00 ± 0.11/ha; $F = 2.28$; df = 1, 19; P = 0.148). During this time, their densities differed among the four treatments ($F = 2.88$; df = 3, 19; $P = 0.063$), with more birds present in the

TABLE 1. Comparison of Red-winged Blackbird densities using wetlands in northeastern North Dakota during June, 1990–1993. Wetlands were treated with glyphosate herbicide during August 1990 and 1991.

	Glyphosate coverages							
	Reference (n = 7)		50% (n = 4)		70% (n = 8)		90% (n = 4)	
Year	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Pretreatment	1.57	(0.52)	0.87	(0.19)	1.42	(0.24)	1.75	(0.79)
1 yr post-treatment	1.62	(0.26)	0.85	(0.16)	0.96	(0.25)	0.59	(0.23)
2 yr post-treatment	1.57	(0.42)	0.53	(0.15)	0.77	(0.14)	0.51	(0.19)

TABLE 2. Pearson correlations describing the relationship between the density of male territorial birds found in 23 cattail-dominated wetlands in northeastern North Dakota and percent coverage of three wetland habitat variables. Wetlands were aerially sprayed with glyphosate herbicide in August 1990 and 1991.

Species	Years post-treatment	Habitat variable: Open water r	P	Live emergent vegetation r	P	Dead emergent vegetation r	P
Red-winged Blackbird	1	−0.430	0.040	0.667	0.001	−0.451	0.031
	2	−0.450	0.031	0.590	0.003	−0.134	0.544
Yellow-headed Blackbird	1	−0.123	0.576	0.204	0.351	−0.200	0.361
	2	−0.054	0.805	0.351	0.100	−0.357	0.094
Marsh Wren	1	−0.136	0.536	0.463	0.026	−0.480	0.020
	2	−0.171	0.435	0.420	0.046	−0.299	0.166

reference wetlands ($\bar{x}$ = 1.59 ± 0.24/ha) than in the 90% treated wetlands ($\bar{x}$ = 0.55 ± 0.14/ha).

Redwing densities were positively correlated with percent coverage of live vegetation during both post-treatment years (r = 0.590–0.667, P = 0.003–0.001), whereas percent coverage of open water negatively influenced bird densities during those years (r = −0.430–0.450, P = 0.040–0.031, Table 2). Percent coverage of dead vegetation negatively influenced bird abundance one year posttreatment (r = − 0.480, P = 0.020), when peak amounts of dead vegetation were present.

Yellow-headed Blackbird.—Prior to treatment, yellowhead densities did not differ among the four treatments (F = 0.58; df = 3, 19; P = 0.635; Table 3), averaging 1.00 ± 0.39/ha. Yellowhead populations were similar across post-treatment years ($\bar{x}$ = 2.58 ± 0.39/ha; F = 1.99; df = 1, 19; P = 0.174) and their numbers were not different among the four treatments (F = 1.87; df = 3, 19; P = 0.168). Yellowhead densities did differ between reference ($\bar{x}$ = 3.80 ± 0.83/ha) and treated wetlands ($\bar{x}$ = 2.05 ± 0.40/ha; F = 3.91; df = 1, 21; P = 0.061), however.

One year post-treatment, yellowhead densities were not correlated with

TABLE 3. Comparison of Yellow-headed Blackbird densities using wetlands in northeastern North Dakota during June, 1990–1993. Wetlands were aerially treated with glyphosate herbicide during August 1990 and 1991.

Year	Glyphosate coverages: Reference (n = 7) Mean	(SE)	50% (n = 4) Mean	(SE)	70% (n = 8) Mean	(SE)	90% (n = 4) Mean	(SE)
Pretreatment	2.09	(1.20)	0.52	(0.06)	0.50	(0.24)	0.57	(0.40)
1 yr post-treatment	2.79	(0.71)	3.00	(1.81)	1.92	(0.59)	0.80	(0.42)
2 yr post-treatment	4.80	(1.47)	1.91	(0.90)	2.91	(0.88)	1.05	(0.38)

TABLE 4. Comparison of Marsh Wren densities using wetlands in northeastern North Dakota during June, 1990–1993. Wetlands were aerially treated with glyphosate herbicide during August 1990 and 1991.

	Glyphosate coverages							
	Reference (n = 7)		50% (n = 4)		70% (n = 8)		90% (n = 4)	
Year	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Pretreatment	2.24	(0.89)	0.73	(0.24)	1.75	(0.82)	6.53	(4.46)
1 yr post-treatment	1.94	(0.29)	1.10	(0.36)	0.39	(0.14)	0.16	(0.16)
2 yr post-treatment	2.46	(0.47)	0.98	(0.45)	0.93	(0.31)	0.36	(0.32)

percent open water, live vegetation, or dead vegetation (r = −0.123–0.204, P = 0.576–0.351, Table 2). Two years post-treatment, percent coverage of live vegetation was positively correlated with yellowhead densities (r = 0.351, P = 0.100), whereas coverage of dead vegetation had a negative influence on their densities (r = −0.357, P = 0.094). Percent water coverage did not influence yellowhead densities.

Marsh Wren.—Wren densities did not differ among the four treatments before herbicide application (F = 1.37; df = 3, 19; P = 0.283; Table 4), averaging 2.55 ± 0.88/ha. Densities of wrens were similar across post-treatment years ($\bar{x}$ = 1.13 ± 0.16/ha; F = 2.22; df = 1, 19; P = 0.152). Their densities differed among treatments (F = 9.62; df = 3, 19; P = 0.001), however, with more birds in the reference wetlands ($\bar{x}$ = 2.21 ± 0.27/ha) than in the treated wetlands ($\bar{x}$ = 0.66 ± 0.13/ha) and more birds in the 50%-treated wetlands ($\bar{x}$ = 1.04 ± 0.27/ha) than the 90%-treated wetlands ($\bar{x}$ = 0.26 ± 0.17/ha).

Wren densities were positively correlated with percent coverage of live vegetation in both post-treatment years (r = 0.420–0.463, P = 0.046–0.020, Table 2). Percent coverage of dead vegetation negatively influenced bird abundance 1 yr post-treatment (r = −0.480, P = 0.020), when peak amounts of dead vegetation were present. Percent coverage of open water did not influence wren abundance during the two post-treatment years.

DISCUSSION

Results of this field experiment suggest that numbers of territorial male Red-winged Blackbirds, Yellow-headed Blackbirds and Marsh Wrens were limited by reducing the density of live emergent vegetation (i.e., cattails). By manipulating cattail coverages in 60 × 60 m plots, Murkin et al. (1989) demonstrated that redwings preferred plots where 50% of the cattails were removed over plots with 30% or 70% of the cover removed. We did not detect statistical differences in bird densities between wetlands receiving 50% and 70% spray coverages. The lack of differences in bird densities between these two treatments, however, may be due to their similar coverages of live vegetation 2 yr post-treatment.

We found significant positive correlations between blackbird and wren abundances, and percent coverage of live vegetation, whereas percent coverage of dead vegetation tended to be negatively correlated with numbers of these birds. This suggests that breeding blackbirds and wrens prefer to nest in live vegetation and avoid wetlands with large amounts of dead vegetation. Weber (1978) reported a negative relationship between density of redwings and percent water coverage in South Dakota. We found similar results for redwings in North Dakota. Redwings may be responding to (1) a lack of suitable nest substrate and (2) competition from yellowheads for the remaining nesting habitat (Picman 1988). The latter may result in redwings choosing alternate nesting sites on wetland margins, in shallow seasonal wetlands (Class III, Stewart and Kantrud 1971) and in uplands (Nelms et al. 1994). Percent coverage of water did not appear to significantly influence yellowhead or wren densities. We speculate that water depth and vegetational features of the wetland may be more important to breeding yellowheads and wrens than is water coverage (Willson 1966).

Generally, managers alter cattail density in semi-permanent wetlands (Class IV) that typically maintain water coverage throughout the year (Linz et al. 1993). In North Dakota, 35% of redwings use semi-permanent wetlands and 61% use seasonal wetlands, whereas >90% of yellowheads and wrens nest in semi-permanent wetlands and <10% use seasonal wetlands Kantrud and Stewart (1984). Within semi-permanent wetlands, redwings, yellowheads and wrens are spatially separated. Redwings nest in vegetation on wetland margins, whereas yellowheads prefer to nest in scattered dense stands of vegetation located in deep-water zones of wetlands (Weber 1978, Weller and Spatcher 1965, Willson 1966). Wrens tend to nest in dense vegetation, segregated from blackbirds to reduce the impact of blackbird aggression (Leonard and Picman 1986, Picman 1983, Verner 1975). Thus, breeding redwing populations probably would not be significantly affected on a regional scale by cattail management programs because of the redwing's nest-site selection plasticity. On the other hand, our data indicate that drastically reducing cattail coverage in semi-permanent wetlands may temporarily reduce local breeding populations of yellowheads and wrens. These species, however, tend to increase their use of treated wetlands at 2 yr post-treatment as the cattails begin to reestablish.

Staggering herbicide treatments on wetland complexes may help maintain bird populations by providing wetlands with diverse stages of cattail decomposition and subsquent regeneration. Experimental research on the optimal size, configuration and density of vegetation patches in relation to water-depth and coverage is needed before definitive recommendations can be made to help wetland managers maximize the number of birds using wetlands. Presently, we are recommending that managers strive for roughly equal amounts of open water, live vegetation and floating mats of dead vegetation to maximize avian diversity (Linz et al. 1994).

ACKNOWLEDGMENTS

K. Higgins, E. Hill, J. Homan and an anonymous referee reviewed earlier drafts of the manuscript. R. Carlson provided statistical guidance. The Monsanto Company and the North Dakota Game and Fish Department donated much of the herbicide, which was applied by R. Marquart. The U.S. Fish and Wildlife Service granted permission to conduct research on Waterfowl Production Areas. This study was funded by the Denver Wildlife Research Center, Denver, Colorado, and the Department of Zoology, North Dakota State University, Fargo. Reference to commercial products does not imply endorsement by the U.S. Department of Agriculture and North Dakota State University. This study was conducted under the auspices of Denver Wildlife Research Center study protocols QA-114, QA-180, and QA-242, as amended.

LITERATURE CITED

BALTEZORE, J. F., J. A. LEITCH, AND G. M. LINZ. 1994. The economics of cattail management: assessing the trade-offs. Agr. Econ. Rep. No. 320. North Dakota State Univ., Fargo. 137 pp.

BLIXT, D. C. 1993. Effects of glyphosate-induced habitat alterations on birds using wetlands. M.Sc. thesis. North Dakota State Univ., Fargo.

CODY, R. P., AND J. K. SMITH. 1991. Applied statistics and the SAS programming language. Third ed. Prentice Hall, Englewood Cliffs, N.J. 403 pp.

HOMAN, H. J., W. J. BLEIER, D. L. BERGMAN, AND G. M. LINZ. 1992. Using GIS to analyze wetland basins in northcentral North Dakota. Pp. 32–34 *in* G. M. Linz, ed. Proc. of the Cattail Management Symp. Fargo, N.D.

HUTTO, R. L., S. M. PLETSCHET, AND P. HENDRICKS. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593–602.

KANTRUD, H. A. 1986. Effects of vegetation manipulation on breeding waterfowl in prairie wetlands—a literature review. U.S. Fish Wildl. Serv. Tech. Rep. 3. 15 pp.

———, AND R. E. STEWART. 1984. Ecological distribution and crude density of breeding birds on prairie wetlands. J. Wildl. Manage. 48:426–437.

KAMINSKI, R. M., AND H. H. PRINCE. 1981. Dabbling duck and aquatic macroinvertebrate responses to manipulated wetland habitat. J. Wildl. Manage. 45:1–15.

LEONARD, M. L., AND J. PICMAN. 1986. Why are nesting Marsh Wrens and Yellow-headed Blackbirds spatially segregated? Auk 103:135–140.

LINZ, G. M., R. A. DOLBEER, J. J. HANZEL, AND L. E. HUFFMAN. 1993. Controlling blackbird damage to sunflower and grain crops in the northern Great Plains. U.S. Dept. Agr., Agr. Info. Bull. No. 679. 15 pp.

———, ———, D. C. BLIXT, AND W. J. BLEIER. 1994. Response of Black Terns (*Chlidonias niger*) to glyphosate-induced habitat alterations on wetlands. Col. Waterbirds 17:160–167.

MONTGOMERY, D. C. 1991. Design and analysis of experiments. Third ed. J. Wiley & Sons, Publ., New York. 649 pp.

MURKIN, H. R., R. M. KAMINSKI, AND R. D. TITMAN. 1982. Responses by dabbling ducks and aquatic invertebrates to an experimentally manipulated cattail marsh. Can J. Zool. 60: 2324–2332.

———, ———, AND ———. 1989. Responses by nesting red-winged blackbirds to manipulated cattail habitat. Pp. 673–680, *in* R. R. Sharitz and J. W. Gibbons, eds. DOE Symp. Series No. 61. USDOE Office Sci. Tech. Info., Oak Ridge, Tenn.

NELMS, C. O., W. J. BLEIER, D. L. OTIS, AND G. M. LINZ. 1994. Population estimates of breeding blackbirds in North Dakota, 1967, 1981–1982 and 1990. Am. Midl. Nat. 132: 256–263.

PICMAN, J. 1983. Aggression by red-winged blackbirds towards marsh wrens. Can. J. Zool. 61: 1896–1899.

SOLBERG, K. L., AND K. F. HIGGINS. 1993. Effects of glyphosate herbicide on cattails, invertebrates, and waterfowl in South Dakota wetlands. Wildl. Soc. Bull. 21:299–307.

STEWART, R. E. 1975. Breeding birds of North Dakota. Tr-College Center for Environmental Studies. Harrison Smith, Lund Press, Minneapolis, Minn. 295 pp.

———, AND H. A. KANTRUD. 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Fish Wildl. Serv., Resour. Publ. 92. 57 pp.

TACHA, T. C., W. D. WARDE, AND K. P. BURNHAM. 1982. Use and interpretation of statistics in wildlife journals. Wildl. Soc. Bull. 10:355–362.

VERNER, J. 1975. Interspecific aggression between Yellow-headed Blackbirds and Long-billed Marsh Wrens. Condor 77:328–331.

WEBER, M. J. 1978. Non-game birds in relation to habitat variation on South Dakota wetlands. M.Sc. thesis. South Dakota State Univ., Brookings.

WELLER, M. W., AND C. E. SPATCHER. 1965. Role of habitat in the distribution and abundance of marsh birds. Iowa Agr. and Home Econ. Exp. Stn., Ames. Spec. Rep. 43. 31 pp.

WILLSON, M. F. 1966. Breeding ecology of the yellow-headed blackbird. Ecol. Monogr. 36: 51–77.

Received 14 Mar. 1995; accepted 7 Jul. 1995.