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RESPONSE OF AMERICAN COOTS AND SORAS TO HERBICIDE-INDUCED VEGETATION CHANGES IN WETLANDS

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Abstract.—The effects of herbicide-induced changes in wetland vegetation (largely cattails, *Typha* spp.) on densities of American Coots (*Fulica americana*) and Soras (*Porzana carolina*) were assessed in northeastern North Dakota. In 1990 and 1991, 17 cattail-dominated wetlands were randomly assigned to 0% (reference wetlands), 50%, 70%, or 90% spray coverages with glyphosate-based herbicide. American Coot densities were lower in the reference wetlands than in the glyphosate-treated wetlands during one ($P = 0.09$) and two years post-treatment ($P = 0.04$). Numbers of American Coots were positively correlated with coverages of water and dead vegetation, but were negatively correlated with coverage of live vegetation (Ps < 0.1). One year post-treatment, reference wetlands harbored more Soras than did the treated wetlands ($P = 0.08$) but Sora numbers were similar among treatments two years post-treatment. Sora numbers were positively correlated with coverage of live vegetation ($P < 0.1$). Our results suggest that managers should strive to create a mosiac of open water, live emergent vegetation, and floating mats of dead vegetation to maximize wetland use by American Coot and Sora populations.

RESPUESTA DE FULICA AMERICANA Y PORZANA CAROLINA A LOS CAMBIOS EN LA VEGETACIÓN DE ANEGADOS INDUCIDOS POR HERBICIDAS

Sinopsis.—Se evalaron los efectos de cambios en la vegetación de anegados (principalmente en TYPHA spp.) inducidos por herbicidas en las densidades de *Fulica Americana* y de *Porzana Carolina* en el noreste de Dakota del Norte. En 1990 y 1991 se asignaron al azar 17 anegados dominados por TYPHA spp. a tratamientos de O (anegados de referencia), 50%, 70% o 90% de rocío con un herbicida de base de glifosfatos. Las densidades de *Fulica*

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Americana fueron menores en los anegados de referencia que en los anegados tratados con el herbicida durante uno ($P = 0.09$) y dos años después del tratamiento ($P = 0.04$). Los números de *Fulica Americana* se correlacionaron positivamente con la cobertura de agua y la vegetación muerta, pero se correlacionaron negativamente con la cobertura de vegetación viva ($Ps < 0.1$). Un año después del tratamiento, los anegados de referencia tenían mas *Porzana Carolina* que los anegados tratados ($P = 0.08$), pero los números de aves fueron similares entre los tratamientos dos años después. Números de *Porzana Carolina* se correlacionaron positivamente con la cobertura de vegetación viva ($P < 0.1$). Nuestros resultados sugieren que los manejadores deben tratar de crear un mosaico de agua descubierta, vegetación emergente viva, y de masas flotantes de vegetación muerta para maximizar el uso de anegados por poblaciones de *Fulica Americana* y *Porzana Carolina.*

In North Dakota and South Dakota, cattail-dominated wetlands are altered by aerially applying glyphosate to achieve open water-emergent vegetation ratios ranging from 50:50 to 90:10 (Linz et al. 1996a, Solberg and Higgins 1993). Since 1991, natural resource agencies have treated about 5500 ha of wetlands with glyphosate-based herbicide to disperse blackbird roosts and improve waterfowl habitat (Bergman et al. 1996). Wetlands treated with glyphosate tend to attract more ducks (Anatinae) (Linz et al. 1996a, Solberg and Higgins 1993) and Black Terns (*Chlidonias niger*) (Linz et al. 1994) than do untreated wetlands. On the other hand, breeding Red-winged Blackbirds (*Agelaius phoeniceus*), Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), and Marsh Wrens (*Cistothorus palustris*) are limited by reducing cattail density (Linz et al. 1996b).

American Coots (*Fulica americana*) and Soras (*Porzana carolina*) are species that are seldom considered when wetland habitat management plans are implemented to benefit waterfowl (Alisauskas and Arnold 1994, Eddleman et al. 1988, Melvin and Gibbs 1994). Wetland habitat loss and degradation most likely limit water-dwelling birds, including rallid populations (Eddleman et al. 1988, Melvin and Gibbs 1994). Yet experimental data on the response of rallids to cattail-dominated wetlands altered with aquatic herbicides are lacking. In this paper, we examine the effects of altering emergent vegetation (i.e., cattails) with glyphosate-based herbicide on densities of American Coots and Soras. Our objectives were (1) to compare densities of these two species among wetlands treated with various herbicide spray coverages and (2) to describe the relationships between bird abundance and various wetland habitat variables.

STUDY AREA AND METHODS

The study area and methods were described by Linz et al. (1996a). The study area was near Lakota, North Dakota (48°03′N, 98°21′W), in Grand Forks, Nelson, and Walsh counties of northeastern North Dakota. This area is characterized by the presence of many wetlands that are subject to large annual variations in water coverage (Stewart 1975). The primary land use is small grain farming.

In May 1990, we randomly designated 12 cattail-dominated wetlands as either untreated (reference) ($n = 4$), 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 May 1991, we randomly designated another 12 wetlands as either reference (n = 4), or treated at 50% (n = 4) or 70% (n = 4) spray coverage with glyphosate. Five of the designated wetlands had ≥25% open water before treatment with glyphosate and two wetlands were dry (Linz et al. 1996a); these wetlands were not included in the data set (Solberg and Higgins 1993). Statistical analyses were conducted with the following data set: reference (n = 5) and 50% (n = 3), 70% (n = 6), and 90% (n = 3) spray coverages (Linz et al. 1996a). Average size of the 17 experimental wetlands was 11.4 ± 2.7 (SE) ha.

Wetlands were treated in mid- to late July at a rate of 5.8 l/ha of glyphosate (Linz et al. 1994). The herbicide was mixed in an aqueous solution containing surfactant, drift retardant, and water. A fixed-wing spray plane was used to apply 15-m wide parallel strips of herbicide along the long axis of the wetlands. To achieve the 50%, 70%, and 90% treatment levels, the pilot skipped about 15 m, 6 m, or 2 m strips of vegetation, respectively.

Wetland sizes and coverages of open water and vegetation were determined from aerial photographs with Map and Image Processing System software (MicroImages, Inc., Lincoln, Nebraska). Although Ektachrome photographs were taken in June 1990, live and dead vegetation could not be distinguished on these slides. In August 1991–1993, color infrared slides were taken of the test wetlands. Species of plants were identified by color differences on the photographs and verified by ground truthing. Vegetation types could not be distinguished in the 1991-treated wetlands because the vegetation had begun to show the effects of the herbicide treatment.

Birds were counted on the experimental wetlands once before treatment (pretreatment) and for two years after treatment (post-treatment). During 2–18 June, wetlands were visited in random order within 5 h of local 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, observer(s) slowly walked around the perimeter of each wetland and recorded all American Coots and Soras heard or seen. In 1991, we established eight count stations at uniform intervals around the perimeter of each wetland (Linz et al. 1996a). The same stations were used from 1991–1993. Observers walked to each station and recorded all American Coots seen or heard during 6 min. Any American Coots detected while the enumerators moved between stations were also tallied. For Soras, the observers waited 1 min at each station and recorded all Soras vocalizing during the next 5 min. The total time spent at each wetland was 1.5–2.0 h.

STATISTICAL ANALYSES

A one-factor analysis of variance (ANOVA) was used to compare percent coverages of open water and vegetation among wetlands designated for various treatment levels (Cody and Smith 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 spray coverages one and two years post-treatment (Cody and Smith 1991).

The count data for American Coots and Soras were divided by the size of the wetland to obtain density estimates (birds/ha). Kruskal-Wallis tests were used to examine the null hypotheses that (1) densities of coots and Soras within each test year were similar among treatments and (2) densities of these birds using the test wetlands were comparable among experiment years (Cody and Smith 1991).

We used Spearman rank correlation analysis (Cody and Smith 1991) to investigate the relationship between the number of American Coots and Soras observed in each wetland during the two post-treatment years and hectares of live vegetation, dead vegetation, and open water. Similarly, correlation analysis was used to assess the relationship between bird numbers and percent coverages of water, live vegetation, and dead vegetation. We set the significance level at 0.1 (*a priori*) for all statistical tests because resources were not sufficient to increase sample sizes (Tacha et al. 1982), and the consequences of accepting false null hypotheses for populations of American Coots and Soras were much greater than rejection of true null hypotheses. All means are reported ± 1 SE.

RESULTS

Habitat characteristics.—Results of the habitat analysis were detailed by Linz et al. (1996a). Briefly, percent coverages of open water and emergent vegetation were not significantly different ($P = 0.72$) among treatments before the application of glyphosate. Percent coverage of open water was greater two years post-treatment than one year post-treatment ($P = 0.001$), and was greater in the sprayed wetlands than in the reference wetlands during the post-treatment years ($P = 0.01$). Coverages of live vegetation were greater two years post-treatment than one year post-treatment ($P = 0.04$). In these years, the coverage of live vegetation was greater in the reference wetlands than in the sprayed wetlands ($P < 0.001$). Dead vegetation was greater one year post-treatment than two years post-treatment ($P < 0.001$), and coverages of dead vegetation were greater in the sprayed wetlands than in the reference wetlands during the post-treatment years ($P = 0.01$).

American Coot.—American Coot densities differed among years ($P = 0.0001$); no birds were detected before treatment, 0.25 ± 0.07 bird/ha one year post-treatment, and 0.65 ± 0.11 bird/ha two years post-treatment. Within each post-treatment year, American Coot densities differed among the four treatment levels ($P < 0.1$); fewer birds were in the reference wetlands than in the treatments (Table 1). Coot numbers were positively correlated with percent coverage of open water during the post-treatment years ($r = 0.46$), whereas percent coverage of live vegetation was negatively related to bird numbers during those years ($r = -0.39$, Table 2). During this time, American Coot numbers were positively cor-

TABLE 1. Comparison of American Coot and Sora densities (birds/ha) using wetlands in northeastern North Dakota during June, 1990–1993. Wetlands were aerially sprayed with glyphosate-based herbicide during July, 1990 and 1991.

		Spray coverages								
		Reference (n = 5)		50% (n = 3)		70% (n = 6)		90% (n = 3)		
Species	Year	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	P
American Coot	Pretreatment	0.00		0.00		0.00		0.00		—
	1 yr post-treatment	0.17	(0.08)	0.67	(0.26)	0.22	(0.09)	0.00		0.09
	2 yr post-treatment	0.18	(0.04)	1.00	(0.29)	0.80	(0.21)	0.78	(0.13)	0.04
Sora	Pretreatment	0.14	(0.09)	0.14	(0.08)	0.01	(0.01)	0.00		0.26
	1 yr post-treatment	0.33	(0.15)	0.27	(0.11)	0.17	(0.07)	0.00		0.08
	2 yr post-treatment	0.54	(0.20)	0.24	(0.05)	0.30	(0.16)	0.11	(0.11)	0.37

TABLE 2. Spearman correlations (r) describing the relationships between numbers of American Coots and Soras found in 17 wetlands in northeastern North Dakota and coverages of three wetland habitat variables. Wetlands were aerially sprayed with glyphosate-based herbicide in July, 1990 and 1991.

	Habitat variable					
	Open water		Live emergent vegetation		Dead emergent vegetation	
Taxon	Percentage	Hectare	Percentage	Hectare	Percentage	Hectare
American Coot	0.459**	0.521***	−0.385**	0.191	0.043	0.310*
Sora	−0.057	0.168	0.125	0.450**	−0.141	0.050

* Marginally significant ($P < 0.10$).
** Moderately significant ($P < 0.05$).
*** Highly significant ($P < 0.01$).

related with hectares of open water ($r = 0.52$) and dead vegetation ($r = 0.31$).

Sora.—Sora densities differed among years ($P = 0.02$); 0.07 ± 0.03 bird/ha were detected before treatment, 0.20 ± 0.06 bird/ha one year post-treatment, and 0.33 ± 0.09 bird/ha two years post-treatment. Before treatment, Sora densities did not differ among the four treatment levels ($P = 0.26$, Table 1), averaging 0.07 ± 0.03 birds/ha. During year one post-treatment, Sora densities differed among the four treatments ($P = 0.08$), with reference wetlands harboring more Soras than did the treated wetlands. During year two post-treatment, Sora densities did not differ among the four treatments ($P = 0.37$), averaging 0.33 ± 0.09 birds/ha. Sora numbers were positively correlated with hectares of live emergent vegetation ($r = 0.45$), but not with hectares of water and dead vegetation and percent coverages of water, live vegetation, and dead vegetation (Table 2).

DISCUSSION

American Coot.—Numbers of American Coots increased following the reduction in cattail density. The negative correlations between coot abundance and percent live vegetation suggests that these birds avoid wetlands choked with emergent vegetation. On the other hand, creating wetlands with large areas devoid of live emergent vegetation will likely reduce the densities of nesting coots (Kantrud 1985). The number of coots using a wetland was positively related to the amount of open water and decaying vegetation available. Dead emergent vegetation provides nest sites for coots and other birds that nest over water (Arnold et al. 1993) and ideal habitat for aquatic invertebrates that may be available to foraging birds (Voigts 1976). Additionally, a mosiac of live and dead emergent vegetation provides visual isolation for breeding pairs and concealment for broods (Murkin et al. 1982). In general, it appears habitat requirements of American Coots are similar to those of several waterfowl species (Eddleman et al. 1988, Linz et al. 1996a). We submit that breeding American Coot populations can be positively affected on a local scale by fragmenting dense cattail coverage into a mosaic of live vegetation, open water, and dead vegetation (Weller and Spatcher 1965).

Sora.—Although no significant correlation existed between water coverage and Sora numbers, drought conditions during the first year of our study undoubtedly affected population levels. Indeed, by the third year of the study Sora numbers in the test wetlands increased 500% as water coverage increased in the experimental wetlands. A positive correlation between numbers of Soras and hectares of live vegetation suggests that Soras prefer wetlands with large areas of live vegetation (Johnson and Dinsmore 1986). Percentages and areas of open water and dead vegetation were not correlated with Sora numbers, indicating that other wetland features such as water depth and vegetational structure may be more important to these birds than coverages of water and dead vegetation. However, some dead vegetation probably provides substrate for easily accessing aquatic invertebrates (Melvin and Gibbs 1994, Kaufmann 1989).

Our data suggest that Sora populations using semipermanent wetlands may be negatively influenced by fragmenting stands of dense cattails. However, wetlands with a build-up of residual cattails may actually impede rail movement and discourage use by these birds (Conway and Eddleman 1994). Thus, wetland habitat management per se is not deleterious to rails and may benefit rails in cattail-dominated wetlands. The negative effects on local Sora populations may be ameloriated by the presence of seasonal wetlands (Kantrud and Stewart 1984), and by retaining some emergent vegetation in shallow water areas of the sprayed wetland (Eddleman et al. 1988, Johnson and Dinsmore 1986).

We conclude that managers should strive for roughly equal amounts of open water, live emergent vegetation, and floating mats of dead vegetation in individual wetlands to maximize avian diversity on a local scale (Linz et al. 1994, Linz et al. 1996b). We agree with Eddleman et al. (1988) that the habitat needs of many rails can be accommodated by staggering vegetation management treatments within and among wetlands so that successional stages of emergent vegetation are diversified. Experimental research on the effects of various wetland vegetation management programs on rallid populations should take into account local, regional, and continental scales.

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