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Vegetation Response to Cattail Management at Cheyenne Bottoms, Kansas

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ABSTRACT

Dense, monospecific cattail (*Typha* spp.) stands are a problem in many prairie wetlands because they alter habitat structure and function, resulting in a decrease in use by wildlife species. Cheyenne Bottoms Wildlife Area, a Wetland of International Importance in central Kansas, has experienced a large increase in cattails and a subsequent decrease in migratory wetland bird use. As a consequence, intensive cattail management is practiced. We assessed the effectiveness of prescribed burning, discing following prescribed burning, and cattle grazing following prescribed burning at two stocking rates of 5 and 20 head per 11 ha in suppressing cattail, as well as the effects of these treatments on non-cattail vegetation. The disced and high-intensity (20 head per 11 ha) grazed treatments resulted in the lowest cattail densities and biomass. Implementation of these treatments, however, was at the expense of the non-cattail aquatic plant community. Species richness and diversity, and non-cattail shoot density and biomass, were generally lowest in these treatments. In managed wetlands where cattail reduction is the objective, we recommend discing or high-intensity grazing following prescribed burning to improve wildlife use, at least in the short-term, as they suppressed cattail more effectively than burning alone or low-intensity (5 head per 11 ha) grazing.

Key words: discing, grazing, prescribed burning, *Typha*, wetland management.

INTRODUCTION

Cattail (*Typha* spp., Typhaceae Juss.) is considered a management problem in many prairie wetlands because it forms

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dense, monospecific stands (Murkin and Ward 1980, Mallik and Wein 1986, Ball 1990). These dense stands negatively impact most wetland wildlife (Smith and Kadlec 1985a). For example, stands of cattail often inhibit wetland use by desirable wildlife species such as waterfowl (Weller and Spatcher 1965, Weller and Fredrickson 1974, Kaminski and Prince 1981). Coverage of cattail has recently increased in many wetlands in response to increased sedimentation and altered hydrologic regimes, which facilitate invasion (Newman et al. 1998, Galatowitsch et al. 1999).

Cheyenne Bottoms is a naturally-formed wetland basin of 16,700 ha located in central Kansas. Large numbers of wetland-dependent birds use Cheyenne Bottoms as a stopover site during migration (Morrison 1984, Senner and Howe 1984, Schwilling 1985, Castro et al. 1990). Because of its importance as a stopover site, Cheyenne Bottoms has been designated as a "Wetland of International Importance" by the Ramsar Convention on Wetlands (2003) and as a site of hemispheric importance by the Western Hemisphere Shorebird Reserve Network (2003). Cheyenne Bottoms Wildlife Area (CBWA) constitutes 8,072 ha of the basin and includes five main pools. Compartmentalization of the marsh has resulted in more constant water supplies, helping to ensure year-round and annual availability of water (Kansas Department of Wildlife and Parks 1995). Water flow into the marsh from adjacent farmlands has increased sediment deposition; causing the marsh to become more shallow. Availability of water and sediment deposition have stimulated the increase in cattail populations and subsequent loss of mudflats and open-water areas used by migratory birds (Kansas Department of Wildlife and Parks 1995). Cattail covered <1% of each pool at CBWA in the 1970s; however, cattail covered 17 to 90% of each pool at CBWA by the 1990s (Von Loh and Oliver 1999).

Restoration of Cheyenne Bottoms' natural hydrology would be difficult and politically unpopular; therefore, intensive cattail management is practiced (Kansas Department of Wildlife and Parks 1995). Burning, discing, flooding, grazing, herbicide application, mowing, and scraping are used to reduce cattail coverage in wetlands (Smith and Kadlec 1985b, Mallik and Wein 1986, Smith 1989, Ball 1990, Saenz and Smith 1995), and several of these techniques are often used in combination to increase mortality of cattail. However, there has been little investigation of vegetation response to such manipulations (de Szalay and Resh 1997). Therefore, our objective was to assess whether discing, grazing, and prescribed burning treatments employed to suppress cattail were effective and whether these treatments influenced vegetation species richness and species diversity, and overall biomass and shoot density.

METHODS

Cattail coverage was reduced in Pool 3 (870 ha) at CBWA by utilizing prescribed burning, prescribed burning followed by cattle grazing, and prescribed burning followed by discing. Pool 3 was selected for treatment as it had extensive cattail coverage of approximately 82% in 1998 (Von Loh and Oliver 1999). Pool 3 is subdivided by a dike into 2 areas designated A and B. In 1999, burning and grazing treatments were implemented in Pool 3A, and unburned control and discing treatments were implemented in Pool 3B. There were three 4-ha replicates for each treatment. Replicates were randomly placed within available treated habitat. Prescribed burns were conducted during late winter and spring 1999 to remove above-ground biomass (Kostecke 2002). Discing was accomplished by discing once to a depth of 15 cm in July 1999. Cattle grazed cattail for 64 days from mid-May through early August 1999. Grazing was evaluated at two stocking rates of 5 and 20 head per 11 ha. Cattle grazing replicates were established within pre-existing 11 ha fenced pastures used to separate cattle within each stocking rate treatment (C. D. Lee, Kansas State University, Manhattan, KS, pers. comm.).

Twenty 200-m long transects were systematically established in each treatment replicate to facilitate vegetation sampling. The first transect within each replicate was established 10 m from the edge of the replicate and spacing between transects was 10 m. Flooding of Pool 3 occurred in mid-August 1999. Mean water depth in Pool 3 was 0.62 m during fall 1999 and was similar between Pools 3A and 3B.

Vegetation samples were collected from replicates 1) prior to implementation of cattail-management treatments in May 1999, 2) after flooding in August 1999 (3 mon. post-cattail management), and 3) after drawdown in May 2000 (1 year post cattail management). During each sampling date, 10 quadrats with dimensions of 0.5 m by 1.0 m of vegetation were clipped from random locations along 10 randomly-selected transects within each replicate (Higgins et al. 1996). Bare (1979), Stubbendieck et al. (1995), and Haukos and Smith (1997) were used as the authorities for plant identification.

Vegetation was dried after collection to a constant mass at 40 C. After a constant mass had been achieved, vegetation was separated by species, weighed, and shoots counted. Species richness was calculated as the mean number of species per quadrat. Simpson's index was used as a measure of species diversity (Barbour et al. 1987, Ailstock et al. 2001). Data were averaged within each replicate for pre-cattail management, 3 mon. post-cattail management, and 1 year post-cattail management time periods. Data were transformed (log [x+1]) to meet parametric assumptions of normality (Zar 1996). Although analyses were conducted on transformed data, non-transformed means and standard errors are presented.

Two-way analysis of variance (ANOVA) was used to examine treatment, time period (i.e, pre-cattail management, 3 mon. post-cattail management, and 1 year post-cattail management), and treatment × time period interaction effects on species richness, Simpson's species diversity indices, cattail shoot density and biomass, and non-cattail shoot density and biomass (SAS Institute, Inc. 1990). If pre-cattail management species richness, species diversity, cattail and non-cattail shoot densities, or cattail and non-cattail biomass differed among treatments, then analysis of covariance (ANCOVA), using the pre-management levels of these variables as covariates, was used to analyze treatment differences between post-cattail management time periods (SAS Institute, Inc. 1990). For all tests, if a treatment × time period interaction was significant, then a 1-way ANOVA or ANCOVA was used to assess treatment effects within time periods and time effects within treatments. Multiple comparisons were conducted using the LSMEANS (least-squares means) statement in SAS®.

RESULTS AND DISCUSSION

The dominant species within study plots were saltmarsh aster (*Aster subulatus* Michx.), goosefoot (*Chenopodium* spp., Chenopodiaceae Vent.), kochia (*Kochia scoparia* (L.) Schrad.), common purslane (*Portulaca oleracea* L.), and cattail (Table 1). Western ragweed (*Ambrosia psilostachya* DC.), western ironweed (*Vernonia fasiculata* Michx.), velvetleaf (*Abutilon theophrasti* Medic.), curly dock (*Rumex crispus* L.), alkali bulrush (*Scirpus maritimus* L.), blackseed plantain (*Plantago rugelii* Dcne.), western wheatgrass (*Pascopyrum smithii* Rydb.), sprangletop (*Leptochloa fascicularis* [Lam.] A. Gray), pale smartweed (*Polygonum lapathifolium* L.), and common knotweed (*Polygonum arenastrum* Jord. *ex* Bor.) were less commonly observed (Table 1).

Pre-cattail management species richness, diversity, and cattail biomass did not vary among treatments ($F_{4, 10} \leq 3.08$, $P \geq 0.07$). Cattail shoot density, non-cattail shoot density, and non-cattail biomass varied among treatments during the pre-cattail management period ($F_{4, 10} \geq 4.55$, $P < 0.02$). There were treatment × time period interactions for species richness ($F_{8, 30} = 11.09$, $P < 0.01$), non-cattail shoot density ($F_{4, 19} = 27.22$, $P < 0.01$), and non-cattail biomass ($F_{4, 19} = 8.88$, $P < 0.01$), but not for species diversity ($F_{8, 30} = 2.05$, $P = 0.07$), cattail shoot density ($F_{4, 19} = 1.01$, $P = 0.43$) or cattail biomass ($F_{8, 30} = 1.51$, $P = 0.20$).

Species richness varied among treatments 3 mon. post-cattail management ($F_{4, 10} = 18.59$, $P < 0.01$) and 1 year post-cattail management ($F_{4, 10} = 58.00$, $P < 0.01$) (Table 2). Richness was related to disturbance intensity. Richness was generally lowest in the disced and high-intensity grazed treatments, which cause more intense disturbance to the marsh than the burned, control, or low-intensity grazed treatments. Following cattail management, species diversity also varied among treatments ($F_{4, 30} = 3.85$, $P = 0.01$) (Table 3). Overall, highest diversity was found in the burned (mean ± SE = 0.11 ± 0.03), disced (0.13 ± 0.05), and low-intensity grazed treatments (0.13 ± 0.02). Lowest diversity was found in the control (0.03 ± 0.01) and high-intensity grazed treatment (0.03 ± 0.02). Burning and low-intensity grazing can be considered moderate disturbances when compared to the undisturbed control and more intensely disturbed high-intensity grazed treatment. Diversity is often highest at moderate levels of disturbance (Bakker and Ruyter 1981, Rosenzweig 1995, Berg et al. 1997, Esselink et al. 2002). High diversity in the intensely disturbed disced treatment is more difficult to explain, but may be related to competitive release following removal of cattail.

Species richness varied over time in all treatments ($F_{2, 6} \geq 12.76$, $P < 0.01$), except the burned ($F_{2, 6} = 0.55$, $P = 0.60$) (Table 2). Typically, there was a decrease in richness following treatment. Species diversity also varied over time ($F_{2, 30} = 10.27$, $P < 0.01$) (Table 3). Overall, pre-cattail management diversity (0.16 ± 0.04) was higher than 3 mon. post-cattail management (0.04 ± 0.02) and 1 year post-cattail management (0.05 ± 0.02) diversity. The pattern of lower richness and diversity following treatment can be attributed to time needed for communities to assemble after disturbance (Rosenzweig 1995).

Cattail shoot density ($F_{4, 19} = 15.42$, $P < 0.01$) (Table 4) and cattail biomass ($F_{4, 30} = 12.45$, $P < 0.01$) (Table 5) differed among treatments. Overall, following cattail management, shoot density was lowest in the disced (0.35 ± 0.10 shoots/m^2) and high-intensity grazed treatments (0.49 ± 0.17 shoots/m^2). Moderate cattail shoot density was found in the low-intensity grazed treatment (0.88 ± 0.10 shoots/m^2), but shoot density in this treatment was not different from that in the control. Highest cattail shoot densities were found in the burned

TABLE 1. FREQUENCY OF OCCURRENCE OF PLANT SPECIES BY TREATMENT DURING PRE- AND POST-CATTAIL MANAGEMENT TIME PERIODS AT CHEYENNE BOTTOMS, KANSAS, DURING 1999 AND 2000.

	Percent of samples in which specific plants were found within pre- and post-cattail management time periods within treatments														
	Control (no burn)			Burn only			Burned and disced			Burned and grazed, 20 head			Burned and grazed, 5 head		
Species	Pre	3 mo. post	1 yr post	Pre	3 mo. post	1 yr post	Pre	3 mo. post	1 yr post	Pre	3 mo. post	1 yr post	Pre	3 mo. post	1 yr post
Western ragweed	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Saltmarsh aster	0	97	0	0	57	0	0	10	0	0	3	0	0	0	0
Western ironweed	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Goosefoot	87	0	0	17	0	77	56	15	53	12	10	3	67	0	57
Kochia	0	7	0	27	0	0	16	3	0	16	0	0	33	0	0
Velvetleaf	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Curly dock	7	0	0	0	0	0	2	37	0	0	8	0	0	0	0
Alkali bulrush	0	3	0	0	3	13	18	0	30	0	10	3	0	3	10
Blackseed plantain	0	0	0	17	0	0	16	3	0	2	10	0	10	0	0
West. wheatgrass	23	7	0	3	0	0	6	0	7	4	0	0	10	0	13
Sprangletop	0	0	0	0	0	0	0	15	0	0	30	0	0	0	0
Pale smartweed	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Common knotweed	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
Common purslane	0	0	0	0	0	0	0	22	0	0	27	0	0	0	0
Cattail	67	67	60	100	70	83	62	25	57	50	57	17	93	33	53

Note: Cattle stocking rates were per 11 ha.

TABLE 2. MEAN ± STANDARD ERROR PRE- AND POST-CATTAIL MANAGEMENT SPECIES RICHNESS BY TREATMENT AT CHEYENNE BOTTOMS, KANSAS, 1999-2000.

Treatment	Species richness by time period		
	Pre-cattail management (May 1999)	3 mo. post-cattail management (August 1999)	1 yr post-cattail management (May 2000)
Control (no burn)	1.83 ^{Aa} ± 0.20	1.83 ^{Aa} ± 0.18	0.60 ^{Cb} ± 0.10
Burn alone	1.63 ^{Aa} ± 0.39	1.37 ^{Aa} ± 0.23	1.73 ^{Aa} ± 0.12
Burn and disced	1.86 ^{Aa} ± 0.30	0.80 ^{Bb} ± 0.20	0.13 ^{Dc} ± 0.03
Burn and grazed, 20 head	1.18 ^{Aa} ± 0.26	0.72 ^{Bb} ± 0.23	0.23 ^{Db} ± 0.03
Burn and grazed, 5 head	2.13 ^{Aa} ± 0.43	0.27 ^{Bb} ± 0.07	1.33 ^{Ba} ± 0.17

Notes: Analysis of variance indicated that means within a column followed by the same capital letter and means within a row followed by the same lowercase letter were not different ($\alpha > 0.05$). For the grazed treatments, stocking rates were per 11 ha. Analyses were conducted on log-transformed data, but non-transformed means and standard errors are presented.

treatment (1.37 ± 0.14 shoots/m^2) and in the control (1.15 ± 0.09 shoots/m^2). Results were similar for biomass. Biomass was lowest in the disced treatment (1.44 ± 0.31 g/m^2) and highest in the burned treatment (72.21 ± 36.49 g/m^2). Moderate cattail biomass was found in the control (12.50 ± 3.58 g/m^2), high-intensity grazed treatment (4.42 ± 1.60 g/m^2), and low-intensity grazed treatment (8.04 ± 3.30 g/m^2). Discing and grazing have been successfully used to suppress persistent emergent vegetation in other settings (Reimold et al. 1975, Kantrud et al. 1989, Van Deursen and Drost 1990, Esselink et al. 2002). Highest shoot density and biomass were typically found in the burned treatment. Burning alone was not effective in suppressing cattail. As in our study, higher shoot densities of persistent emergent vegetation have been observed following burning (Thompson and Shay 1985, 1989). Increased shoot densities following burning are likely related to nutrient release and litter removal allowing for more light to reach the soil, which results in increased production (Smith and Kadlec 1985b, Thompson and Shay 1985). In addition, burning in our study occurred during spring. Spring burns in wetlands are often not hot enough for heat to penetrate the soil to impede rhizome function and shoot viability (Thompson and Shay 1985, Smith and Kadlec 1985b), thus doing little to reduce subsequent coverage of dominating emergent vegetation (Laubhan 1995).

Cattail shoot density and biomass did not differ among post-cattail management time periods ($F_{1, 19} = 0.45$, $P = 0.51$ and $F_{2, 30} = 1.71$, $P = 0.20$, respectively) (Tables 4 and 5), indicating that the effects of the treatments lasted for at least one year. Overall, pre-cattail management, 3 mon. post-cattail management, and 1 year post-cattail management biomass were 5.38 ± 1.42 g/m^2, 34.14 ± 22.04 g/m^2, and 19.65 ± 9.93 g/m^2, respectively. Lack of temporal variation in cattail biomass is likely related to a relationship between biomass and shoot density. At high shoot density, the biomass of individual shoots is low. In contrast, at low shoot density, the biomass of individual shoots is higher, perhaps due to competitive release (Begon et al. 1990). Essentially, as shoot density is reduced by management activities, additional resources become available to shoots that survive management activities and these individual shoots can then develop greater biomass.

Non-cattail shoot density and biomass differed among treatments 3 mon. post-cattail management ($F_{4, 9} = 16.76$, $P < 0.01$ and $F_{4, 9} = 9.63$, $P < 0.01$, respectively) and 1 year post-cattail management ($F_{4, 9} = 43.18$, $P < 0.01$ and $F_{4, 9} = 4.11$, $P = 0.04$, respectively) (Tables 4 and 5). The control and burned treatment had highest non-cattail shoot density and biomass. Non-cattail shoot density and biomass were lowest in the disced and grazed treatments. Such results are not surprising as the discing and grazing treatments received more intense disturbance than the control or burned treatments.

Post-cattail management, temporal differences in non-cattail shoot density existed in the control and low-intensity grazing treatment ($F_{1, 3} = 84.87$, $P < 0.01$), but none of the other treatments ($F_{1, 3} \leq 2.87$, $P \geq 0.19$) (Table 6). Non-cattail biomass differed over time in the control ($F_{1, 3} = 21{,}904.90$, $P \leq 0.01$),

TABLE 3. MEAN ± STANDARD ERROR PRE- AND POST-CATTAIL MANAGEMENT SIMPSON'S SPECIES DIVERSITY INDICES BY TREATMENT AT CHEYENNE BOTTOMS, KANSAS, 1999-2000.

Treatment	Simpson's species diversity indices by time period		
	Pre-cattail management (May 1999)	3 mo. post-cattail management (August 1999)	1 yr post-cattail management (May 2000)
Control (no burn)	0.05 ^{A} ± 0.02	0.02 ± 0.01	0.00 ± 0.00
Burn alone	0.14 ^{A} ± 0.07	0.08 ± 0.05	0.12 ± 0.01
Burn and disced	0.29 ^{A} ± 0.03	0.08 ± 0.08	0.00 ± 0.00
Burn and grazed, 20 head	0.08 ^{A} ± 0.05	0.00 ± 0.00	0.00 ± 0.00
Burn and grazed, 5 head	0.25 ^{A} ± 0.13	0.01 ± 0.01	0.13 ± 0.03

Notes: Analysis of variance indicated that means within a column followed by the same capital letter were not different ($\alpha > 0.05$). For the grazed treatments, stocking rates were per 11 ha. Analyses were conducted on log-transformed data, but non-transformed means and standard errors are presented.

TABLE 4. MEAN ± STANDARD ERROR PRE- AND POST-CATTAIL MANAGEMENT CATTAIL SHOOT DENSITY (NO./M^2) BY TREATMENT AT CHEYENNE BOTTOMS, KANSAS, 1999-2000.

	Cattail shoot density (no./m^2) by time period		
Treatment	Pre-cattail management (May 1999)	3 mo. post-cattail management (August 1999)	1 yr post-cattail management (May 2000)
Control (no burn)	16.93^{B} ± 3.94	12.13 ± 5.07	16.53 ± 1.20
Burn alone	49.47^{A} ± 10.76	24.80 ± 10.65	32.27 ± 16.48
Burn and disced	13.80^{C} ± 2.66	2.53 ± 1.04	0.60 ± 0.31
Burn and grazed, 20 head	23.47^{B} ± 3.61	5.20 ± 2.62	1.67 ± 1.09
Burn and grazed, 5 head	30.80^{AB} ± 5.45	7.20 ± 2.81	8.27 ± 4.17

Notes: Analysis of variance indicated that means within a column followed by the same capital letter were not different (α > 0.05). For the grazed treatments, stocking rates were per 11 ha. Analyses were conducted on log-transformed data, but non-transformed means and standard errors are presented.

but none of the other treatments ($F_{1,3} \leq 3.11$, $P \geq 0.18$) (Table 7). These temporal differences are likely associated more with time of sampling than the effects of treatment. For example, most of the differences can be attributed to lower shoot density or biomass during May 2000 (i.e., 1 year post-cattail management). May is early in the growing season; thus, non-cattail vegetation may not have had time to become established yet.

Discing and high-intensity grazing treatments generally had the lowest post-treatment cattail shoot densities and biomass, thus providing the best cattail management. Therefore, if the highest degree of cattail reduction is the management objective, discing or high-intensity grazing could be used. Reduction of cattail in these treatments lasted for at least one year. Cattail management by these methods also reduced non-cattail productivity (e.g., species diversity and shoot density) at least in the short term.

Prescribed burning alone failed to create large expanses of mudflat and open-water habitat suitable for use by migratory wetland birds (Kostecke 2002). Several researchers have stated that burning should not be used as the sole means of cattail control (Mallik and Wein 1986, Sojda and Solberg 1993) and we agree; however, burning will remain an effective treatment to prepare a site (e.g., remove litter) before additional management is implemented (Payne 1992).

TABLE 5. MEAN ± STANDARD ERROR PRE- AND POST-CATTAIL MANAGEMENT CATTAIL BIOMASS (G/M^2) BY TREATMENT AT CHEYENNE BOTTOMS, KANSAS, 1999-2000.

	Cattail biomass (g/m^2) by time period		
Treatment	Pre-cattail management (May 1999)	3 mo. post-cattail management (August 1999)	1 yr post-cattail management (May 2000)
Control (no burn)	2.95^{A} ± 0.62	17.76 ± 9.20	16.80 ± 0.66
Burn alone	12.37^{A} ± 5.48	133.37 ± 102.89	70.90 ± 41.24
Burn and disced	2.26^{A} ± 0.48	1.55 ± 0.41	0.51 ± 0.12
Burn and grazed, 20 head	5.45^{A} ± 2.39	5.17 ± 4.34	2.64 ± 1.90
Burn and grazed, 5 head	3.86^{A} ± 0.94	12.87 ± 9.06	7.37 ± 5.17

Notes: Analysis of variance indicated that means within a column followed by the same capital letter were not different (α > 0.05). For the grazed treatments, stocking rates were per 11 ha. Analyses were conducted on log-transformed data, but non-transformed means and standard errors are presented.

TABLE 6. MEAN ± STANDARD ERROR PRE- AND POST-CATTAIL MANAGEMENT NON-CATTAIL SHOOT DENSITY (NO./M^2) BY TREATMENT AT CHEYENNE BOTTOMS, KANSAS, 1999-2000.

	Non-cattail shoot density (no./m^2) by time period		
Treatment	Pre-cattail management (May 1999)	3 mo. post-cattail management (August 1999)	1 yr post-cattail management (May 2000)
Control (no burn)	1547.07^{A} ± 492.36	1194.40^{Aa} ± 66.36	0.00^{Db} ± 0.00
Burn alone	46.80^{B} ± 35.80	46.00^{ABa} ± 24.50	122.93^{Aa} ± 61.54
Burn and disced	196.87^{A} ± 134.68	194.18^{BCa} ± 140.85	0.00^{Da} ± 0.00
Burn and grazed, 20 head	16.44^{B} ± 12.18	20.03^{Ca} ± 10.47	1.73^{Ca} ± 1.73
Burn and grazed, 5 head	65.47^{B} ± 40.86	0.13^{Cb} ± 0.13	19.60^{Ba} ± 5.80

Notes: Analysis of variance indicated pre-management differences in shoot density among treatments ($P < 0.05$); therefore analysis of covariance was used to analyze post-management shoot density. Means within a column followed by the same capital letter and means within a row followed by the same lowercase letter were not different ($P > 0.05$). For the grazed treatments, stocking rates were per 11 ha. Analyses were conducted on log-transformed data, but non-transformed means and standard errors are presented.

TABLE 7. MEAN ± STANDARD ERROR PRE- AND POST-CATTAIL MANAGEMENT NON-CATTAIL BIOMASS (G/M^2) BY CATTAIL MANAGEMENT TREATMENT AT CHEYENNE BOTTOMS, KANSAS, 1999-2000.

Treatment	Non-cattail biomass (g/m^2) by time period		
	Pre-cattail management (May 1999)	3 mo. post-cattail management (August 1999)	1 yr post-cattail management (May 2000)
Control (no burn)	194.83^{A} ± 65.94	404.64^{Aa} ± 14.72	0.00^{Bb} ± 0.00
Burn alone	2.26^{B} ± 1.76	118.11^{ABa} ± 70.69	6.62^{Aa} ± 3.44
Burn and disced	17.59^{B} ± 10.58	3.15^{BCa} ± 1.07	0.00^{Ba} ± 0.00
Burn and grazed, 20 head	5.88^{B} ± 5.85	1.86^{Ca} ± 0.90	0.19^{Ba} ± 0.19
Burn and grazed, 5 head	9.26^{B} ± 4.87	0.24^{Ca} ± 0.24	0.72^{Ba} ± 0.29

Notes: Analysis of variance indicated pre-management differences in biomass among treatments ($P < 0.05$); therefore analysis of covariance was used to analyze post-management biomass. Means within a column followed by the same capital letter and means within a row followed by the same lowercase letter were not different ($P > 0.05$). For the grazed treatments, stocking rates were per 11 ha. Analyses were conducted on log-transformed data, but non-transformed means and standard errors are presented.

Despite initial positive results following discing and high-intensity grazing, cattail management will need to be closely monitored. We did not quantitatively follow treatments for more than a year and therefore it is difficult to determine the duration of cattail control following these treatments. In some instances, the effects of cattail management activities have been short-term and have often resulted in more vigorous cattail growth in the long-term (Brooks and Kuhn 1987). Indeed, by summer 2001, cattail densities within high-intensity grazing areas approached pre-treatment levels (K. Grover, Kansas Department of Wildlife and Parks, pers. comm.). Cattail densities within disced areas remained at acceptable levels. Therefore, we recommend discing for suppressing cattail and improving wildlife use of the marsh; however, given past results at CBWA, it is likely that management such as discing may have to be repeated every few years to maintain low cattail density.

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