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EFFECTS OF WINTER BURNING AND STRUCTURAL MARSH MANAGEMENT ON VEGETATION AND WINTER BIRD ABUNDANCE IN THE GULF COAST CHENIER PLAIN, USA

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Abstract: Marshes in the Gulf Coast Chenier Plain provide important winter habitats for many species of birds. Many of these marshes are managed intensively through a combination of fall/winter burning and construction of impoundments to improve wintering waterfowl habitat, reduce wetland loss, and create emergent wetlands. Little information is available on effects of this management on wintering birds, particularly passerines. We conducted experimental burns in impounded and unimpounded marshes on Rockefeller State Wildlife Refuge in southwest Louisiana and recorded species composition and abundance of birds during the 1996 and 1997 winters. We found that burning and impoundment influenced vegetation structure, which in turn influenced bird abundance and species composition. Blackbirds (Icteridae) preferred recently burned plots. Sparrows (Emberizidae) and wrens (Troglodytidae) avoided recently burned plots but recolonized these plots after one year of vegetation recovery. Sparrows and wrens present in burned plots during the first winter following burning generally were observed in scattered patches of unburned vegetation. Suitability of Chenier Plain marshes as winter habitat for several bird species was reduced during the winter in which burning was conducted, particularly if a high proportion of the plot was burned. We recommend that patchy burns be used, at both the landscape level and within specific burned areas, to achieve management objectives and still provide suitable winter habitat for non-target species. Although many groups of birds depend on Chenier Plain marshes for winter habitat, these groups differ in their specific habitat requirements. We recommend that a diverse wetland complex (e.g., impoundments managed for waterfowl foraging habitat interspersed with those managed for passerine winter cover) be maintained.

Key Words: bird community, burning, coastal marshes, Gulf Coast Chenier Plain, impoundment, marsh management, vegetation, winter habitat

INTRODUCTION

The Chenier Plain of the Gulf of Mexico encompasses 1295 km^2 of coastal marsh from Vermilion Bay, Louisiana to East Bay, Texas (Gosselink 1979). Many of these marshes are managed intensively to reduce marsh loss and to improve habitat quality of existing marshes for wildlife, especially waterfowl (Anatidae). Two commonly applied techniques are controlled burning (usually during fall or winter) and structural marsh management (hereafter SMM), i.e., the use of impoundments and water-control structures (Cowan et al. 1988, Chabreck et al. 1989). Winter burning has been a management tool since the early 1930s (Lynch 1941, O'Neil 1949); SMM became common beginning in the 1940s (Nyman et al. 1990). Recently, the scientific and management communities have begun to evaluate the effectiveness and assess impacts of winter burning and SMM on the marsh ecosystem (Boesch et al. 1983, Wicker et al. 1983, Monatague et al. 1987, Cowan et al. 1988, Nyman et al. 1990, Rogers et al. 1994, Nyman and Chabreck 1995, Bryant and Chabreck 1998, US Environmental Protection Agency 1998).

The importance of winter habitat for avian conservation has been the focus of many recent research efforts (e.g., Smith et al. 1989, Hagan and Johnston 1992, Sherry and Holmes 1992). Chenier Plain marshes provide winter habitat for more than two-thirds of the Mississippi Flyway waterfowl population (Bellrose 1980, Michot 1996) and numerous other bird species (Lowery 1974, Gosselink 1979, Bettinger 1984, Root 1988). Many of these species are restricted to coastal marshes during winter (e.g., Nelson's Sharp-tailed Sparrow [*Ammodramus nelsoni*], Greenlaw and Rising 1994) or throughout the year (e.g., Seaside Sparrow [*A. maritimus*], Post and Greenlaw 1994). Several species that winter along the Gulf Coast (e.g., Sedge Wren, [*Cistothorus platensis*]) are considered "species of management concern" in parts of their ranges (Gibbs and Melvin 1992). The distribution and abundance of birds that winter in Chenier Plain marshes could be affected by current management practices.

Burning influences characteristics of the plant community, including species composition, cover, and vertical structure (Whelan 1995). Impoundment construction alters the hydrology (water depth, frequency and duration of inundation, and salinity) of a marsh, which in turn influences the interspersion of open water and emergent vegetation, plant species composition, and diversity of plant communities (Chabreck and Junkin 1989). Vegetation structure is an integral component of avian habitat selection (Morse 1985, Delisle and Savidge 1997); thus, plant community changes caused by management practices are predicted to influence bird species composition and relative abundance.

Bird species composition often changes after a fire and may continue to change for some time (Vogl 1973, Bendell 1974, Breininger and Schmalzer 1990, Whelan 1995). The post-fire community may lack some species present before burning and may contain others previously absent. Relative abundances of species also may change as well (e.g., Recher et al. 1985, Brooker and Rowley 1991, Herkert 1994). In addition, bird communities may differ between impounded and unimpounded marshes. Ducks, wading birds, and shorebirds often are more abundant in impounded marshes than in nearby unimpounded areas (Chabreck et al. 1974, Epstein and Joyner 1986, Weber and Haig 1996, Gordon et al. 1998). However, these studies considered only birds that forage in open water or on mudflats and did not include passerines that use emergent vegetation. We examined effects of experimental burns and impoundments on vegetation characteristics and bird abundance during winter in the Gulf Coast Chenier Plain. Our analysis focuses on comparisons made immediately following burning and again after one growing season.

METHODS

Study Area

We chose Rockefeller State Wildlife Refuge (RWR) in southwestern Louisiana as a representative area of the Gulf Coast Chenier Plain (Figure 1). RWR, a 30,700-ha area managed by the Louisiana Department of Wildlife and Fisheries (LDWF) in Cameron and Vermilion parishes, is bordered by Louisiana Highway 82 on the north and the Gulf of Mexico on the south. RWR consists of 17 marsh units (impoundments) ranging in size from 200 to >4,000 ha (Wicker et al. 1983) and approximately 11,700 ha of tidally influenced unimpounded marshes. Most impoundments were constructed during the late 1950s and are separated by a network of canals. Management burns on RWR are conducted on a 3-year rotation, with approximately one-third of the refuge area burned during a single fall/winter (October to February). Lightning-ignited fires occur frequently on RWR, usually from June to August (0–3 fires/year during 1993–1995, T. J. Hess, unpubl. data).

Marsh types on RWR range from a band of saline marsh along the Gulf Coast, a band of brackish marsh further inland, and intermediate marsh still further inland (Chabreck 1970, Chabreck and Linscombe 1988). Saline marsh (salinity ≥10 ppt) is dominated by *Spartina alterniflora* Loiseleur, *S. patens* (Ait.) Muhl., and *Distichlis spicata* (L.) Greene. Brackish marsh (5–10 ppt) is characterized by *S. patens, D. spicata,* and *Scirpus* spp. Intermediate marsh (1–5 ppt) is dominated by *Spartina patens* (Chabreck 1970, Chabreck 1972, Chabreck and Linscombe 1988). The small area of fresh marsh (salinity <1 ppt) on RWR was not included in our study. Impounded marshes in our study were intermediate or brackish; unimpounded marshes were exposed to tidal action of the Gulf and were brackish or saline.

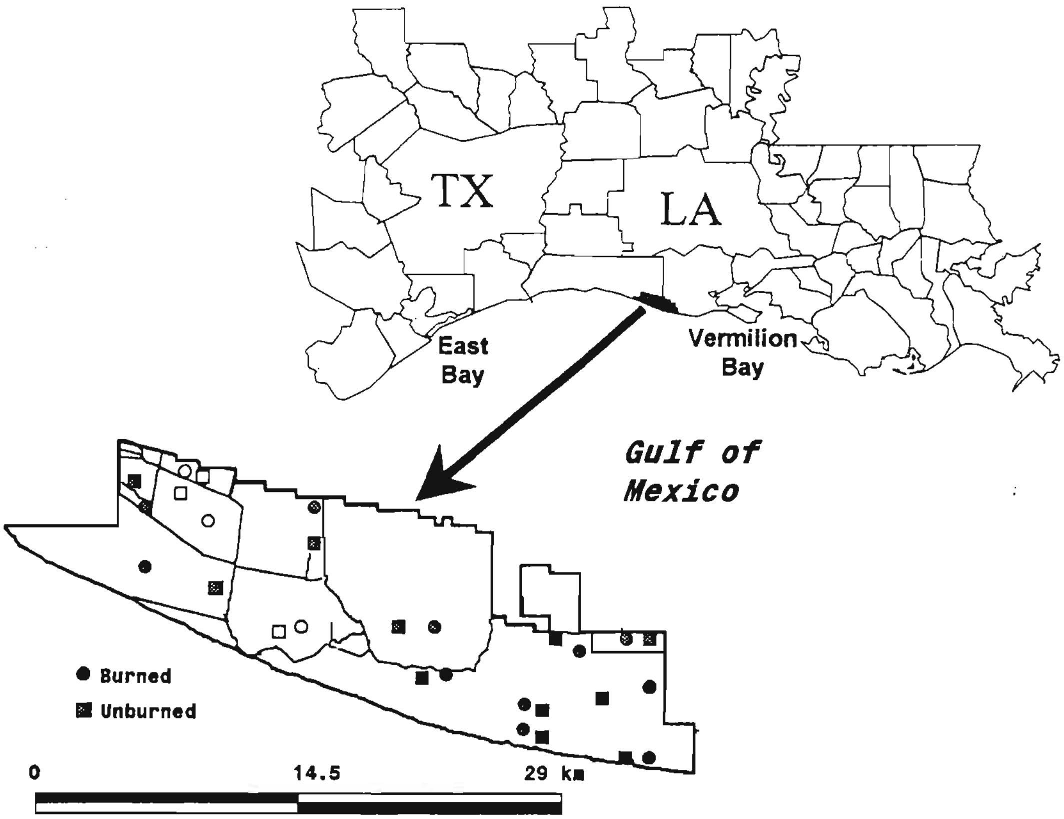

Figure 1. Map of Gulf Coast Chenier Plain showing location of Rockefeller State Wildlife Refuge and approximate locations of 14 pairs of burned and unburned sampling stations. Solid lines within the refuge boundary represent major levees. Solid and shaded symbols indicate stations in unimpounded and impounded marsh, respectively. Empty symbols indicate impounded stations from which data were collected in 1996 only.

General Study Design

Using vegetation-type and fire-history maps of RWR, we selected study marshes that met the following criteria: (1) minimum area of 100 ha of emergent vegetation with little open water, (2) presence of a firebreak (i.e., bayou, canal), (3) homogeneous marsh type and fire history within an area, (4) site accessibility, and (5) absence of other research or structures that potentially could be damaged by fire. We selected 15 suitable areas, one in each of nine impoundments and in six unimpounded areas (Table 1). Three impounded areas were in brackish marsh and six were in intermediate marsh. Three unimpounded areas were in brackish marsh and three in saline marsh.

We used a split-plot experimental design (Sokal and Rohlf 1981), in which each ≥100-ha area (the whole-plot) was divided into two tracts, each ≥50 ha (the split-plots), with a firebreak as the dividing line. We randomly assigned burn treatment to one side of each firebreak. A 100-m × 100-m sampling station was located randomly within each tract using a gridded USGS topographic map. Distance between paired stations ranged from 0.5 to 3.5 km and was less than 1 km for all but two pairs (Figure 1). Sampling stations consisted of (1) four 100-m transects arranged in a square, along which vegetation data were collected at 10-m intervals (40 vegetation points/station), and (2) a 0.4-ha (100 m × 40 m) section of the 100-m × 100-m square within which bird surveys were conducted. The 0.4-ha section was marked with conduit pipe at 20-m intervals along the longer centerline. Conduit pipes were placed in position before burning.

Assigned tracts were burned on 9–11 and 13 December 1995 and 9 January 1996. These were the only times we burned marshes during the study. One tract (Unit 14) did not burn (Table 1), and a suitable replacement area was not available in this impoundment. Consequently, those two sampling stations were excluded from the study. One control sampling station (Price Lake) was burned accidentally when fire advanced beyond the firebreak; this station was relocated to an unburned area about 100 m from the burn edge within the same impoundment. One unimpounded tract assigned to be burned (School Board) did not burn and was relocated to another location that burned from the fire for another tract (East Little Constance). These two

Table 1. Site characteristics of study marshes, Rockefeller State Wildlife Refuge, Louisiana.

Plot ID	Management type	Marsh type	Impoundment area (ha)	% of sampling station burned	Total area burned (ha)
Unit 1[1]	Impounded	Intermediate	506	90	25
Unit 2	Impounded	Intermediate	567	80	100
Unit 3[1]	Impounded	Intermediate	1498	50	75
Unit 4	Impounded	Intermediate	2299	50	50
Unit 14[2]	Impounded	Intermediate	971	0	0
Unit 15	Impounded	Intermediate	364	50	200
Unit 5[3]	Impounded	Brackish	1983	95	125
Unit 6	Impounded	Brackish	5463	99	75
Price Lake	Impounded	Brackish	4047	100	1000
Big Constance	Unimpounded	Saline		90	250
E. Little Constance	Unimpounded	Saline		95	400
Parra Bayou	Unimpounded	Brackish		35	100
Rollover Bayou	Unimpounded	Saline		60	400
School Board	Unimpounded	Brackish		95	400
Tower	Unimpounded	Brackish		95	225

[1] Plot was accidentally burned during March 1996 and was excluded from some analyses (see Methods).
[2] Plot did not burn and was excluded from all analyses.
[3] Plot was accidentally burned during September 1996 and was excluded from some analyses.

burned stations were >700 m apart. Two pairs of stations in intermediate impoundments were burned accidentally on 22 March 1996 and a third pair in a brackish impoundment on 13 September 1996 (Table 1). Consequently, we collected and analyzed data from 14 pairs of plots in 1996 and 11 in 1997.

Fires were either head or backfires and were conducted with approximately 5 cm of water over the marsh surface. Total area burned by each fire was determined by locating burned areas relative to landmarks (bayous, lakes, ditches, levees, etc.) from either airplane or airboat and then plotting locations on a USGS topographic map. On the first post-fire visit to each plot, we visually estimated the percent of the plot that was burned (± 5%).

Vegetation Characteristics

We collected vegetation data at each station during winter (January–February) of 1996 and 1997. At each of 40 points in a station, we measured visual obstruction (an index to plant height and density) following methods described by Robel et al. (1970). A 3-m pole marked at 0.1-m intervals was placed vertically at the vegetation point. The observer stood 4 m to the south and, with eye level at 1 m above the ground, recorded the lowest interval on the pole that was not completely obscured by vegetation. Percent of ground cover (all species combined and by individual species) at each point was determined by laying a 1-m pole marked at 0.1-m intervals on the ground and determining the percent of the pole covered (Chabreck et al. 1985). We categorized all rooted dead vegetation as a single species because of difficulties in identifying dead material. Cover classes were 7 (76–100%); 6 (51–75%); 5 (26–50%); 4 (6–25%); 3 (1–5%); 2 (few stems); and 1 (single stem) (Mueller-Dambois and Ellenberg 1974). Points located in a pond or unvegetated mud were given visual obstruction and cover scores of 0. To calculate mean values for categorical data, we converted cover classes to a continuous response using the midpoint of the class (i.e., Class 7 = 87.5%, Class 6 = 62.5, Class 5 = 37.5, Class 4 = 15, Class 3 = 2.5, and Classes 1 and 2 = 0.5 [Agresti 1996, Pahl et al. 1997]). We calculated the mean visual obstruction score and mean cover class midpoint at each station and described relative cover of plant species by calculating the mean cover class midpoint for each species at each station.

Birds Surveys

We surveyed birds three times at each 0.4-ha section between 6 January and 12 February 1996 and again between 16 January and 22 February 1997 (6 total surveys/station). Our experimental stations were accessible only by airboat. Through experience, we determined that most birds did not flush until the airboat had approached within 100 m. In fact, most passerines and rails did not flush until the airboat approached within 5 m (S. Gabrey, pers. obs.). To record birds that may have flushed from the study plots due to engine noise, we stopped the airboat 100 m from the 0.4-ha section and recorded any birds visible within the boundaries. We then recorded any additional birds that flushed as we drove to within 20–30 m of the plot boundary. At this point, we shut off the engine and walked to the plot, recording any additional birds that flushed from within the plot. Next, the observer slowly walked through the 0.4-ha section four times, beginning 15 m N of the center line, then 5 m N, 5 m S, and 15 m S of the center line, recording species and numbers of birds seen or heard within the boundaries. We used this method (instead of point counts) because secretive species (e.g., sparrows, wrens, and rails) were relatively inactive (little territorial behavior during winter) and not readily detected by stationary observers. Individuals often did not flush unless the observer approached within 5 m. We carefully noted location and direction that each flushed bird traveled to minimize repeated counting of the same individual. Birds perched on conduit pipes were recorded as present in the station. One observer conducted all surveys during 1996; a second observer conducted all surveys during 1997. Both observers were experienced field ornithologists; thus, we assumed that there was no observer bias in our statistical models. Surveys averaged 13 minutes in duration (range = 8–19, S.E. = 3, n = 150).

We completed most (61%, n = 150) bird surveys by 1100 hrs, but weather conditions and logistic constraints required that some surveys be conducted later. However, all were completed by 1500 hr. Surveys were not conducted when wind was >20 km/hr or in fog or steady rain. We conducted surveys at biweekly intervals, using a stratified random scheme. Strata consisted of 2–6 pairs of stations that were within 30 minutes travel time. During each survey period (2-week interval), group order, pair order, and station order within pairs were randomly assigned. Paired stations usually were surveyed within 20 minutes of each other (range = 6–96 minutes).

A common management goal of burning in the Chenier Plain is to attract Lesser Snow Geese (*Chen caerulescens caerulescens* L.); consequently, we recorded numbers and distribution of "white geese" (Lesser Snow and Ross's Geese [*Chen rossii* Cassin]) present on RWR during the 1995–1996 winter, immediately following the experimental burns. White goose use of burned and unburned marshes was recorded during five aerial surveys between 14 December 1995 and 12 February 1996 using a fixed-wing aircraft flying at 285 m altitude and 185 km/hr. When a flock of geese was sighted, we estimated size and noted whether it was in a burned or unburned area and in an impounded or unimpounded marsh. Given the altitude of the aircraft, we are confident that all white geese present on RWR were detected during each flight.

Statistical Analysis

We analyzed vegetation response variables (mean visual obstruction, mean percent cover) with a split-plot ANOVA (Proc. GLM, SAS Institute 1990). Management type was the whole-plot effect, burn treatment was the split-plot effect, and winter (January to February of 1996 and of 1997) was the repeated measure. We analyzed bird abundance responses (number of individuals/survey for all birds, and for icterids, wrens, and sparrows separately) similarly to vegetation data but with the addition of survey period (1, 2, or 3) as an additional repeated measure. Mean visual obstruction scores and bird abundance data were log-transformed before analysis ($\log_{10}[Y+1]$, Sokal and Rohlf 1981) to meet assumptions for parametric procedures; means and confidence intervals are reported here as back-transformed values. When a significant effect was detected, we conducted pairwise comparisons using the LSMEANS option (Proc. GLM, SAS Institute 1990). Only 11 paired stations with two winters of data were considered in ANOVAs of vegetation characteristics and numbers of birds (see General Study Design above).

We compared frequencies of occurrence for common bird species (i.e., species recorded on >5% of all surveys) with χ^2 tests (Sokal and Rohlf 1981) using Proc. FREQ (SAS Institute 1990). We included data from all 14 pairs of stations in analyses of frequency of occurrence of bird species.

RESULTS

Site Characteristics

The estimated area of each burn ranged from 25 to 1000 ha (Table 1). Vegetation at most stations did not burn completely, and there were numerous scattered clumps of unburned vegetation, often present as halos surrounding small potholes or puddles. Thirteen of the 14 plots were ≥50% burned; nine plots were ≥80% burned (Table 1).

Vegetation Characteristics

Spartina patens, dead vegetation, and *Distichlis spicata* were the dominant plant species (Table 2). Minor species included *Spartina alterniflora*, *Scirpus robustus* Pursh, *Scirpus californicus* (C. A. Mey) L., *Spartina cynosuroides* (Roth) L., *Aster* spp., *Typha* spp. and *Baccharus* spp. As expected, all species had low percent cover scores at burned stations in 1996, reflecting that much vegetation had been removed by fire. *Typha* spp. and *Scirpus californicus* were present only in intermediate impoundments (*Typha* in Units 15 and 4; *Scirpus* in Units 1, 2, 3, 4). *Spartina cyno-*

Table 2. Mean percent cover scores for three dominant plant species recorded in burned or unburned plots in impounded (Imp.) or unimpounded (Unimp.) marshes during January of 1996 and 1997 on Rockefeller State Wildlife Refuge in southwest Louisiana.

	1996				1997			
	Burned		Unburned		Burned		Unburned	
Species	Imp.	Unimp.	Imp.	Unimp.	Imp.	Unimp.	Imp.	Unimp.
Spartina patens	1.0	0.7	14.3	1.4	28.3	58.8	22.9	19.2
Dead vegetation	4.5	2.9	68.0	69.0	60.6	35.1	76.3	75.0
Distichlis spicata	0.0	0.03	0.5	0.7	2.0	11.2	1.3	5.0
Total species[1]	6	4	6	6	8	5	7	6

[1] Includes species with mean percent cover scores <1% (*Spartina alterniflora, Scirpus robustus, Scirpus californicus, Spartina cynosuroides, Aster* spp., *Typha* spp. and *Baccharus* spp.).

suroides was present only in unimpounded marshes. *Spartina alterniflora* was absent from intermediate impoundments.

Vegetation characteristics differed between burn treatments and between management types. The burn treatment × winter interactions were significant in analyses of visual obstruction and percent cover ($P \leq 0.05$, Table 3). Visual obstruction (Figure 2A) and percent cover (Figure 2B) were lowest at burned stations immediately following burning in 1996, but neither differed between burned and unburned stations the following winter. Management type × winter interactions were significant ($P \leq 0.05$, Table 3) in analyses of visual obstruction and percent cover. Visual obstruction was lower in unimpounded than in impounded stations in 1996 but did not differ between management types in 1997 (Figure 3A). Visual obstruction scores of both management types were higher in 1997 than in 1996 (Figure 3A). Percent cover was lower for unimpounded stations in 1996 than in 1997 but did not differ between winters in impounded stations (Figure 3B). Percent cover did not differ between management types within years (Figure 3B).

Bird Surveys

We identified 24 bird species, eight of which were common (i.e., recorded on >5% of all surveys, Table 4). Winter burning affected frequencies of occurrence of several bird species. In 1996, Boat-tailed Grackles (*Quiscalus major*) were recorded more often in burned (40% of surveys) than unburned stations (12%; $\chi^2 = 8.87$, df = 1, $P < 0.01$); however, they were rarely observed in 1997 (Table 4). In 1996, Red-winged Blackbirds (*Agelaius phoenicieus*) were recorded twice as often in burned stations (24% of surveys) than in unburned stations (10%), although this difference was not significant ($\chi^2 = 3.09$, df = 1, $P = 0.08$). Seaside Sparrows and Sedge Wrens were not recorded in burned stations during 1996. In 1996, Marsh Wrens (*Cistothorus palustris*) were recorded more frequently

Table 3. Summary of split-plot ANOVAs examining responses of vegetation characters to management type (impounded or unimpounded) and burn treatment (burned or unburned) during two winters on Rockefeller State Wildlife Refuge in southwest Louisiana.

			Visual Obstruction			% Total Cover		
Source[1]		df	MS[2]	*F*	*P*	MS	*F*	*P*
M		1	0.081	7.48	0.02	28.85	0.12	0.73
A(M)	(error A)	9	0.011			233.10		
W		1	0.35	56.55	<0.01	2405.67	34.74	<0.01
W × M		1	0.031	5.00	0.05	667.10	9.63	0.01
W × A(M)	(error B)	9	0.0061			69.25		
B		1	0.31	44.70	<0.01	2670.49	9.37	<0.01
B × M		1	0.0035	0.51	0.48	46.64	0.16	0.69
B × W		1	0.46	65.94	<0.01	1490.13	5.23	0.03
B × W × M		1	0.00016	0.02	0.88	166.02	0.58	0.46
Residual error[3]	(error C)	18	0.0069			285.05		

[1] M = management type, A = area (100 ha), W = winter, B = burn treatment.
[2] Mean squares.
[3] All factors that include burn treatment were tested with residual error.

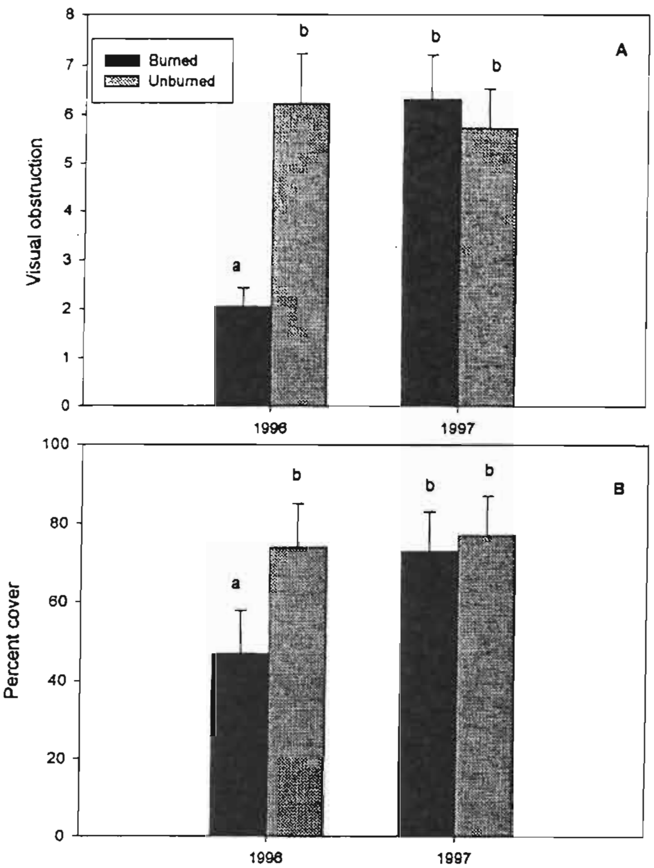

Figure 2. Visual obstruction (A) and percent cover (B) of vegetation in burned and unburned marshes during two winters at Rockefeller State Wildlife Refuge, southwestern Louisiana. Experimental burns were conducted during December 1995–January 1996, whereas vegetation data were collected following burns during January and February of 1996 and 1997. Error bars represent upper limits of 95% confidence intervals. Bars with the same letter are not significantly different ($P > 0.05$).

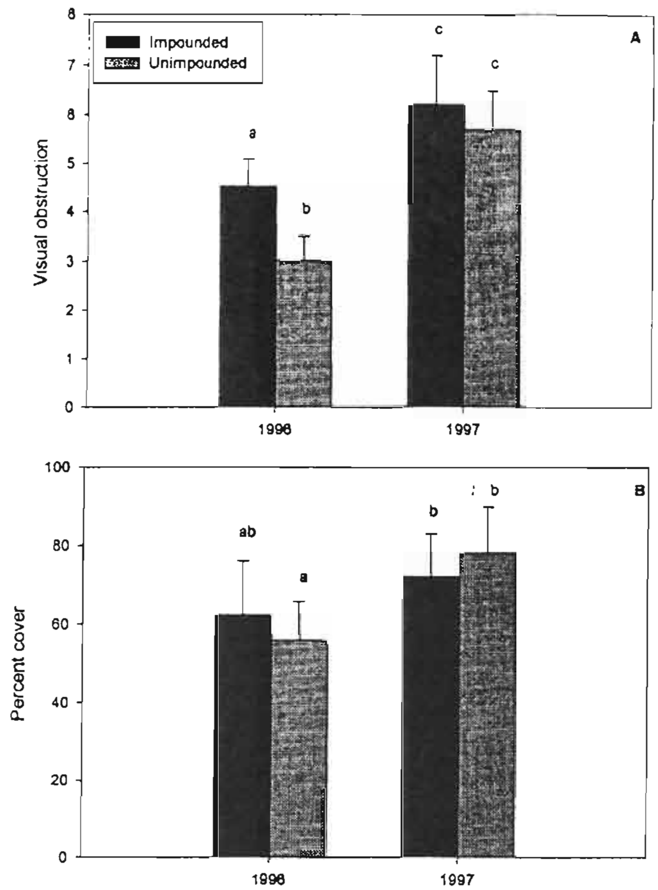

Figure 3. Visual obstruction (A) and percent cover (B) of vegetation in impounded and unimpounded marshes during two winters at Rockefeller State Wildlife Refuge, southwestern Louisiana. Error bars represent upper limits of 95% confidence intervals. Bars with the same letter are not significantly different ($P > 0.05$).

in unburned (43% of surveys) than in burned stations (10%; $\chi^2 = 12.07$, df = 1, $P < 0.01$).

Three less common bird species also were affected by burning. In 1996, Common Yellowthroats (*Geothlypis trichas*) were absent from recently burned stations, and all eight Nelson's Sharp-tailed Sparrows that we recorded in burned stations were found in a single station that had been burned only 60%. All of these individuals were observed in unburned vegetation ≥20 m from a burned edge. Six Swamp Sparrows (*Melospiza georgiana*) were recorded in burned stations in 1996 but only in stations in which 20–50% of the vegetation remained unburned.

Management type also affected frequencies of occurrence for several bird species, particularly for sparrows. For both winters combined, Seaside Sparrows were recorded more often (31% of surveys) in unimpounded than impounded marshes (12%; $\chi^2 = 8.26$, df = 1, $P < 0.01$). We observed only one Seaside Sparrow in intermediate marsh. Nelson's Sharp-tailed Sparrows were recorded only in unimpounded marshes, although they were observed at other times in brackish impoundments (S. Gabrey, pers. obs.). Red-winged Blackbirds were recorded more often in impounded (23% of surveys) than unimpounded marshes (10%; $\chi^2 = 4.81$, df = 1, $P = 0.03$) when winters were combined.

For all species combined, numbers of birds/survey did not differ among management types, burn treatments, winters, survey periods, or any of their interactions (Table 5). Overall, we recorded 3.04 birds/survey (95% C.I. = 2.50–3.67, $n = 132$). However, abundance of species groups differed between burn treatments and management types. Burn treatment × winter interactions were significant in analyses of icterids (Red-winged Blackbirds, Boat-tailed Grackles) ($P < 0.01$) and wrens (Marsh, Sedge, and unidentified wrens) ($P < 0.01$, Table 5). Numbers of icterids/sur-

Table 4. Percent of surveys during which at least one individual of a species was encountered in burned or unburned plots in impounded (Imp.) or unimpounded (Unimp.) marshes during two winters on Rockefeller State Wildlife Refuge in southwest Louisiana.

		1996				1997			
		Burned		Unburned		Burned		Unburned	
Species[1]	Total	Imp.	Unimp.	Imp.	Unimp.	Imp.	Unimp.	Imp.	Unimp.
Marsh Wren *Cistothorus palustris* Wilson	22	17	0	46	39	20	17	33	0
Seaside Sparrow *Ammodramus maritimus* Wilson	21	0	0	21	*[2]	20	72	*	44
Sedge Wren *Cistothorus platensis* Latham	21	0	0	54	28	*	22	27	28
Red-winged Blackbird *Agelaius phoeniceus* L.	17	25	22	13	*	33	11	33	0
Boat-tailed Grackle *Quiscalus major* Vieillot	16	29	56	8	17	0	*	*	0
Swamp Sparrow *Melospiza georgiana* Latham	9	20	0	13	0	27	0	13	0
Nelson's Sharp-tailed Sparrow *Ammodramus nelsoni* Allen	8	0	22	0	*	0	28	0	11
Common Yellowthroat *Geothlypis trichas* L.	7	0	0	17	0	33	0	13	0
Total birds[3,4]	811	148	105	85	169	69	101	90	44
Total species[3]	24	9	5	8	10	8	8	12	4
Number of Surveys	150	24	18	24	18	15	18	15	18

[a] Occurrences of positively identified individuals are reported (unidentified individuals were primarily wrens and sparrows).
[2] * indicates a species was detected on only one survey.
[3] Includes species recorded on <5% of all surveys: Savannah Sparrow (*Passerculus sandwichensis* Gmelin), American Coot (*Fulica americana* Gmelin), Belted Kingfisher (*Ceryle alcyon* L.), Common Moorhen (*Gallinula chloropus* L.), Gadwall (*Anas strepera* L.), Snowy Egret (*Egretta thula* Molina), Killdeer (*Charadrius vociferus* L.), Clapper Rail (*Rallus longirostris* Boddaert), American Bittern (*Botaurus lentiginosus* Rackett), Great Egret (*Ardea alba* L.), Little Blue Heron (*Egretta caerulea* L.), Sora (*Porzana carolina* L.), Virginia Rail (*Rallus limicola* Vieillot), American Pipit (*Anthus rubescens* Tunstall), Common Snipe (*Gallinago gallinago* L.), and Yellow Rail (*Coturnicops noveboracensis* Gmelin).
[4] Total number of birds includes individuals (n = 117) not identified to species.

vey in burned stations in 1996 were approximately four times higher than in the same stations in 1997 or unburned stations in both winters (Figure 4A). Numbers of wrens/survey were 13–16 times lower in burned stations in 1996 than in the same plots in 1997 or in unburned stations in either winter (Figure 4B). The winter × management interaction was significant in the analysis of sparrows (Seaside, Nelson's Sharp-tailed, Swamp, Savannah [*Passerculus sandwichensis*], and unidentified sparrows) (P = 0.02, Table 5). Sparrows were much more abundant in unimpounded stations in 1997 than in 1996 or in impounded stations in either winter (Figure 5).

Goose Censuses

We recorded 10 flocks of white geese, ranging in size from 300 to 17,500 during five aerial surveys (Table 6). All white geese observed were associated with burned areas. Two flocks were in Unit 3 on or near a previously established grit site (Harris 1990), which was on a burned-unburned edge. The remaining eight flocks were observed in burned areas, either in impounded brackish or unimpounded saline marsh.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Winter Burning

As predicted, we found that burning affected vegetation characteristics (visual obstruction and percent ground cover) during the first winter and concomitantly, bird abundance and species composition. We observed that Red-winged Blackbirds and Boat-tailed Grackles prefer marsh that was recently burned. Icterids are highly gregarious; reduced visual obstruction in burned marshes may increase visual contact with conspecifics or allow for better detection of predators (Powell 1974). Also, Boat-tailed Grackles feed on aquatic animals throughout the year (Peterson et al. 1995); we frequently observed grackles foraging along

Table 5. Summary of split-plot ANOVAs examining the number of birds/survey for all species combined and for common species groups in relation to management type (impounded or unimpounded) and burn treatment (burned or unburned) during two winters on Rockefeller State Wildlife Refuge in southwest Louisiana.

Source[1]		df	All Species			Icterids			Wrens			Sparrows		
			MS[2]	*F*	*P*	MS	*F*	*P*	MS	*F*	*P*	MS	*F*	*P*
M		1	0.015	0.06	0.81	0.0013	0.01	0.93	0.016	0.16	0.70	0.78	10.74	<0.01
A(M)	(error A)	9	0.23			0.18			0.10			0.072		
W		1	0.053	0.38	0.55	1.03	5.65	0.04	0.35	21.05	<0.01	0.27	2.68	0.14
W × M		1	0.079	0.54	0.48	0.53	2.88	0.12	0.042	2.49	0.15	0.77	7.60	0.02
W × A(M)	(error B)	9	0.14			0.18			0.017			0.10		
B		1	0.37	1.64	0.22	0.57	7.21	0.02	0.65	8.56	<0.01	0.27	2.25	0.15
B × M		1	0.14	0.61	0.44	0.17	2.10	0.16	0.16	2.06	0.17	0.12	0.94	0.39
B × W		1	0.19	0.82	0.38	0.78	9.83	<0.01	0.74	9.74	<0.01	0.30	2.45	0.14
B × W × M		1	0.13	0.56	0.46	0.072	0.91	0.35	0.039	0.52	0.48	0.030	0.24	0.63
B × W × A(M)	(error C)	18	0.23			0.079			0.076			0.12		
P		2	0.051	0.47	0.63	0.0048	0.04	0.96	0.021	0.56	0.57	0.033	1.04	0.36
P × M		2	0.0046	0.04	0.96	0.055	0.44	0.65	0.023	0.62	0.54	0.030	0.96	0.39
P × W		2	0.026	0.24	0.79	0.038	0.30	0.74	0.011	0.30	0.74	0.010	0.32	0.73
P × B		2	0.19	1.71	0.19	0.18	1.46	0.24	0.039	1.03	0.36	0.074	2.33	0.10
P × W × M		2	0.044	0.41	0.67	0.015	0.12	0.89	0.018	0.48	0.62	0.0042	0.13	0.88
P × W × B		2	0.062	0.57	0.57	0.11	0.84	0.43	0.041	1.09	0.34	0.072	2.29	0.11
P × B × M		2	0.015	0.14	0.87	0.067	0.54	0.59	0.036	0.95	0.39	0.012	0.39	0.68
P × W × B × M		2	0.20	1.86	0.16	0.29	2.30	0.11	0.039	1.02	0.36	0.040	1.27	0.29
Residual error[3]	(error D)	72	0.11			0.13			0.038			0.032		

[1] M = management type, A = area (100 ha), W = winter, B = burn treatment, P = survey period.
[2] Mean squares.
[3] All factors that include survey period were tested with residual error.

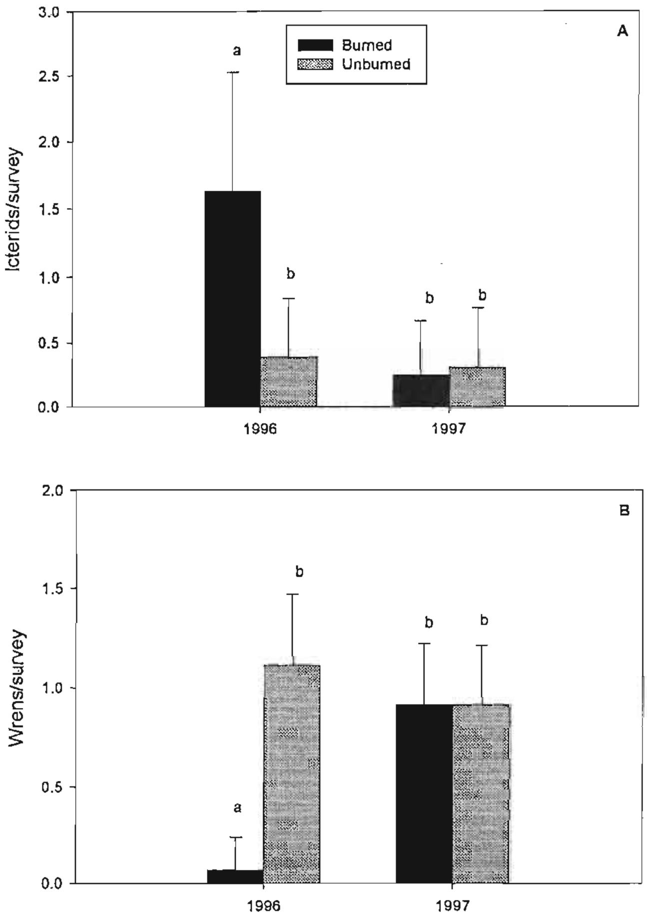

Figure 4. Number of birds/survey for icterids (A) and wrens (B) in burned and unburned marshes during two winters at Rockefeller State Wildlife Refuge, southwestern Louisiana. Experimental burns were conducted during December 1995–January 1996 whereas bird data were collected following burns during January and February of 1996 and 1997. Error bars represent upper limits of 95% confidence intervals. Bars with the same letter are not significantly different ($P > 0.05$).

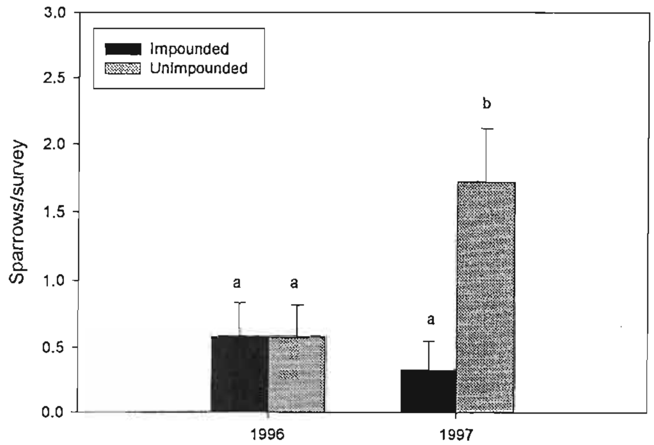

Figure 5. Number of sparrows/survey in impounded and unimpounded marshes during two winters at Rockefeller State Wildlife Refuge, southwestern Louisiana. Error bars represent upper limits of 95% confidence intervals. Bars with the same letter are not significantly different ($P > 0.05$).

pond edges or wading into shallow water over the marsh surface. Reduced ground cover in burned marshes may provide better visibility while searching for aquatic prey.

For certain other wintering bird species, however, we found that habitat suitability of coastal marshes was reduced temporarily following winter burning. Species such as Seaside Sparrow, Nelson's Sharp-tailed Sparrow, Marsh Wren, and Sedge Wren avoided areas in which little unburned vegetation remained standing. However, these species recolonized burned areas in the second winter following burning, after plant cover had returned to pre-burn levels. Effects of this short-term loss of winter habitat on breeding populations are unknown, but we believe that they could be important, particularly if the population is small or restricted to a specific habitat. For example, Baker (1973) documented a halving in the number of singing males of Dusky Seaside Sparrows (*Ammodramus mar-*

Table 6. Combined numbers of Lesser Snow and Ross's Geese recorded during five aerial censuses on Rockefeller State Wildlife Refuge during December 1995–February 1996 following experimental burns.

Date of survey	Flock size	Location	Burned	Marsh type
Dec. 14	750	Rollover Bayou	Yes	Unimpounded-saline
Dec. 27	400	E. Little Constance Bayou	Yes	Unimpounded-saline
	400	E. Little Constance Bayou	Yes	Unimpounded-saline
	3000	E. Little Constance Bayou	Yes	Unimpounded-saline
	6000	Unit 5	Yes	Unimpounded-saline
Jan. 9	700	Unit 3–grit site	No	Impounded-intermediate
	17,500	Price Lake	Yes	Impounded-brackish
	700	Unit 6	Yes	Impounded-brackish
Feb. 6	3000	Price Lake	Yes	Impounded-brackish
Feb. 12	300	Unit 3–grit site	No	Impounded-intermediate

itimus nigrescens Ridgway) in Florida, presumably due to a lack of suitable cover following two extensive wildfires in a single winter. The use of ignition methods that remove nearly all emergent vegetation, along with repeated "clean-up" burns of patches of unburned vegetation are common practices in some Texas Gulf Coast marshes (P. Walther, pers. comm.). Our results indicate that scattered unburned patches provide cover for small birds and should not be removed. Accordingly, we believe that a multi-year rotational burning program that creates a mosaic of burned and unburned marshes can be used to achieve certain management objectives (i.e., waterfowl and furbearer habitat) and still provide suitable winter habitat for selected passerines.

One management goal of winter marsh burning is to attract wintering waterfowl, especially Lesser Snow Geese, and to promote growth of and improve access to preferred plant foods, especially *Scirpus robustus* and *Scirpus americanus* Pers. (= *S. olneyi* Gray) (Lynch 1941, O'Neil 1949). We observed that white geese (eight of 10 flocks) were attracted directly to burned marshes immediately following burning from December 1995 through February 1996. The remaining two flocks apparently were drawn to a burned-unburned edge by a grit site. However, our vegetation data contradict earlier observations regarding the use of fire to regenerate *Scirpus* spp. (Lynch 1941, O'Neil 1949, Chabreck 1981). In our study, both preferred *Scirpus* species were absent from all 28 sampling stations in January 1996. *Scirpus robustus* was present in three of 22 stations (only one of which had been burned in 1996) during January 1997 (Table 2). Our findings, that burning did not stimulate growth of either species, suggests that regeneration may be more strongly influenced by other environmental factors (temperature, soil moisture, season of burn, etc.) than by burning. We observed Lesser Snow Geese in burned marshes that apparently lacked either *Scirpus* species, indicating that presence of these two plants is not essential to attract geese. Wintering Lesser Snow Geese also feed on below-ground parts of *Distichlis spicata* and *Spartina* spp. (Lynch et al. 1947, Alisauskas et al. 1988), and we speculate that geese are attracted to burned marshes because the absence of above-ground vegetation facilitates access to subterranean plant parts, regardless of plant species.

The resiliency and rapid recovery of some plant communities following fire presumably are the result of an evolutionary history of exposure to fire (Abrahamson 1984). Our finding that winter burning had only short-term effects on the Chenier Plain marsh plant and bird communities during winter is not surprising, given the frequent occurrence of natural lightning fires in this ecosystem (Nyman and Chabreck 1995). However, an important difference between our experimental burns and natural lightning fires is season of occurrence. We conducted our experimental burns during winter to mimic current management practices, whereas lightning fires occur mostly from June to August. Season of burning may influence plant species responses (Chabreck 1981, Mendelssohn et al. 1995) and consequently bird community responses. Also, our study plots were burned only in the first of the two winters; the frequency at which a specific area of marsh is struck by lightning obviously is unpredictable. Future comparative studies of managed burns of different frequencies or seasonality with natural lightning fires would further our understanding the role of fire in Chenier Plain ecosystem function and evolution.

Structural Marsh Management

Birds associated with open water or mudflats (ducks, herons, and shorebirds) generally are more abundant in impounded marshes than in nearby unimpounded marshes because of differences in vegetation, water depth variability, invertebrate abundance, foraging substrate, and other factors (Chabreck et al. 1974, Weber and Haig 1996, Gordon et al. 1998). In contrast, we found that some passerine species, particularly sparrows, were more abundant in unimpounded than in impounded marshes. We observed most (>83%) Seaside Sparrows and all Nelson's Sharp-tailed Sparrows in unimpounded marshes. Visual obstruction scores generally were lower in unimpounded stations, suggesting these species prefer shorter vegetation. Also, both species forage primarily on the ground (Greenlaw and Rising 1994, Post and Greenlaw 1994). Relatively high water levels maintained within impoundments during winter may inhibit sparrow foraging, and these species may require marshes in which the marsh surface periodically is exposed by tides. However, we frequently observed Seaside Sparrows in brackish impoundments during winter (particularly 1996), and breeding season densities exceed 10 birds/ha in other brackish impoundments on RWR (S. Gabrey, unpubl. data). Thus, attributes of the different marsh types (e.g., vegetation characters not measured in our study, salinity, invertebrate abundance, competitors) may influence abundance of these species as much as does management type. However, we were unable to separate the influence of marsh type and management type in our analysis because unimpounded intermediate and impounded saline marsh were not available on RWR. Our findings that sparrows were much more abundant in unimpounded brackish or saline marshes than in impoundments suggest that measures other than impoundment construction (e.g., reestablishing natural sediment deposition processes

[Gagliano 1994]) will be necessary to preserve or create appropriate winter habitat, given current marsh-loss trends in Louisiana.

Our results and those of others (Chabreck et al. 1974, Weber and Haig 1996, Gordon et al. 1998) indicate that although many groups of bird species depend on Chenier Plain marshes for winter habitat, these groups differ in their specific habitat requirements. Consequently, we recommend that marsh managers maintain a diverse wetland complex (e.g., impoundments managed for waterfowl foraging habitat interspersed with those managed for passerine winter cover).

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