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SEASONAL DYNAMICS OF BIRD ASSEMBLAGES IN A TEXAS ESTUARINE WETLAND

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Abstract.—Bird species richness and seasonality were sampled in diverse habitats of an estuarine wetland complex of San Bernard National Wildlife Refuge on the mid-Texas coast. Observations made between 1985 and 1991 included all months, and form a composite annual view; 121 species were recorded, with 54 taxa identified in 1 mo. Only 23 species occurred regularly over a series of months, and their patterns of wetland use varied markedly by species and season. The wetland complex served different functions for different species, but most used the area for migration stops and wintering. Eleven species were considered breeders in the brackish marsh, but another 33 species probably nested in nearby freshwater wetlands, coastal islands or in shrubs or small trees, and fed or rested in the marsh. Such coastal areas are used by birds year-round and, in addition to protection, need management strategies to ensure habitat diversity and normal water regimes which will maintain natural bird diversity and serve all species for different life stages.

DINÁMICA ESTACIONAL DE AGREGACIONES DE AVES EN UN ESTUARIO EN TEXAS

Sinopsis.—Se muestrearon la riqueza en especies de aves en habitats diversos dentro del complejo estuarino del Refugio de Vida Silvestre de San Bernard en la costa media de Texas. Se hicieron observaciones que incluyeron todos los meses entre 1985 y 1991, lo que forma una visión anual. Se registraron 121 especies en un mes. Sólo 23 especies se observaron regularmente a través de varios meses, y sus patrones en el uso de la zona anegada variaron por especie y por temporada. Diferentes especies utilizaron el complejo de zonas anegadas con diferentes propósitos, pero la mayoría utilizó el área para descanso en la migración y para invernar. Once especies se consideraron reproductivos en la ciénaga salobre, pero otras 33 especies probablement anidaron en los pantanos de agua dulce cercanos, en islotes costeros o en árboles cercanos, y se alimentaron o descansaron en la ciénaga. Estas áreas costaneras son utilizadas por las aves a través del año y necesitan protección, además de estrategias de manejo para asegurar diversidad de hábitats y regímenes normales de agua que mantengan una diversidad de aves natural y que sirvan a todas las especies en todas sus etapas de vida.

Although there are several studies of bird assemblages of northern freshwater wetlands where breeding is the major avian use, only a few studies have quantitatively assessed breeding birds in saline vegetation (Burger et al. 1982). Moreover, there seem to be no studies of year-round use of Gulf Coast estuarine marshes where winter temperatures are less limiting and habitats are used by different species for different phases of their annual cycle. High diversity is expected in these warm temperate wetlands, as shown by intense interest in such areas by birders, but species observed at any one time represent species using the area for quite different purposes. Although breeding-bird diversity generally is assumed to be lower than in northern wetlands, documentation is sparse.

Unfortunately, these habitats are vulnerable to coastal developments such as housing, industry and fishing or shipping support, and have suf-

fered losses in excess of 35% and degradation of additional areas (Texas Parks and Wildlife 1988). As part of a long-term study designed to appraise habitat use by birds along the coast, it was essential to establish when and how areas were used by birds. Eventually, these data should allow us to assess impacts of permanent development that influence bird uses of the wetlands for breeding, migration rest stops, and non-breeding summering or wintering. Moreover, these data should be useful to predict the success of various wildlife management strategies on state and federal wildlife areas.

The objectives of this phase of the study were (1) to determine seasonality as measured by species richness and frequency of occurrence of bird assemblages in higher elevation, low-salinity sections of an estuarine marsh; and (2) to document seasonal population dynamics of dominant species in relation to their various uses of the wetland resources.

STUDY AREA

Field work was conducted at the San Bernard National Wildlife Refuge (SBNWR), a 9900-ha area in Brazoria and Matagorda Counties about 11 km south of Brazoria, Texas (28°45′N, 95°30′W). A typical range of original habitats exist, including tree or shrub-covered uplands, ephemeral freshwater and brackish basins, and large shallow bays. This project was limited to the drier and more accessible segment of the estuarine vegetation (Fig. 1) that is subject to damage through development, and is similar to the "high" marsh zone of the East Coast (Nixon 1982). Plant communities in this Gulf Coast freshwater/saline interface are perhaps even more complex than on the East Coast due to the shallow gradient of the Gulf Coastal Plain (Chabreck 1972), and are influenced by water depth, freshwater flooding and salinity. The Gulf of Mexico tidal regime is modest compared to the East Coast, usually ranging 31–41 cm (Nixon 1982), and wind influences often are more important than lunar tides (Ward et al. 1980). Rainfall in the area varies 110–130 cm (Texas Department of Water Resources 1984), but seasonal distribution is highly variable and evaporation is extreme during the warm summer months (creating soil water salinities exceeding 50 ppt). Freshwater influences on bird use of the study area included spaced borrow pits along the access road and a nearby impoundment (Moccasin Pond) (Fig. 1). These ponds held fish as well as aquatic invertebrates, and attracted waterbirds common to the general area but that otherwise might have been recorded less frequently in the brackish zone. Drier parts of the study area were grazed by cattle during winters between 1985 and 1990, but grazing ended in spring 1990.

The study site was selected because of an access road (Oil-Field Road) not open to the public that transected six distinct plant communities existent during the early years of study in 1985 and 1986 (Fig. 1). This zonation was due partly to the gradual slope that created a gradient in water depth and salinity. Six habitats were substratified by dominant plants, proceeding from higher areas periodically flooded by freshwater

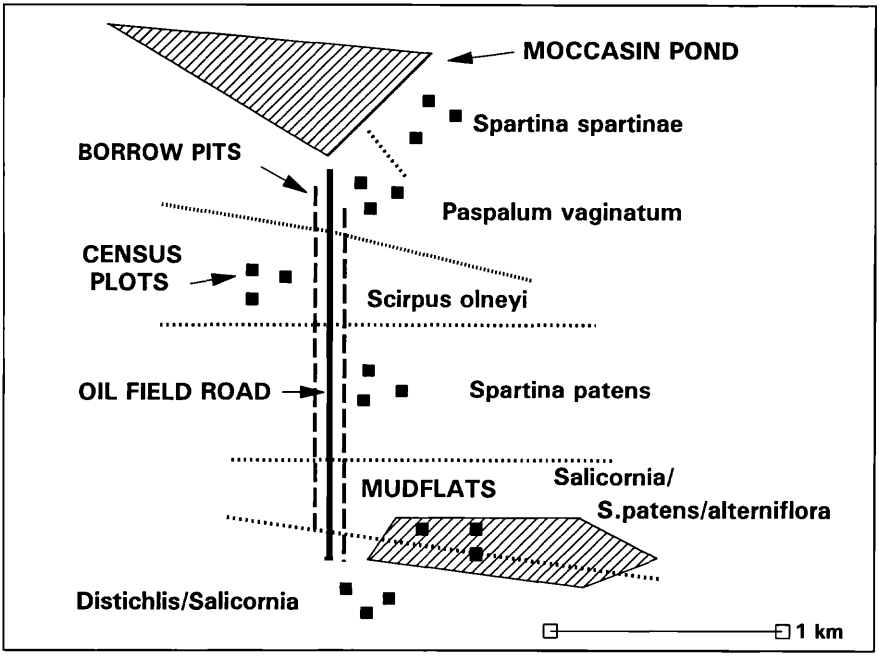

FIGURE 1. Schematic map of vegetation zonation and location of study plots on San Bernard National Wildlife Refuge, Brazoria, Texas.

to areas more regularly flooded by saline water: Gulf cordgrass (*Spartina spartinae*), seashore paspalum (*Paspalum vaginatum*), Olney's three-square bulrush (*Scirpus olneyi*), marshhay cordgrass (*Spartina patens*), saltgrass (*Distichlis spicata*), and tidal mud flats sparsely vegetated with smooth cordgrass (*Spartina alterniflora*), saltgrass, or glasswort (*Salicornia* spp.). Although smooth cordgrass is the most common plant in the higher tidal regimes of East Coast "low" marshes (Nixon 1982, Wiegert et al. 1981), it was present only as narrow strips along tidal creeks or in small basins, so no areas large enough for bird censusing were available for study.

METHODS

Bird survey and analysis procedures.—To avoid the confounding effects of cover-water or cover-cover edges known to influence avian use of marsh vegetation (Craig and Beal 1992, Weller 1978), single-species stands of the above 6 vegetation zones were selected where possible. Three 100 × 200-m sample plots were established in each vegetative zone. Plots were censused in early morning by walking slowly along the midline of the 200-m plot. As the entire plot was visible from the starting point, conspicuous birds on territory or groups of birds that might be disturbed by the observer were mapped first. All censuses were done in the mornings, but to

compensate for possible time differences, direction of entering plots was reversed for each count.

Several closely related birds created identification problems when in poor light or when flushed at a distance, and often were pooled for analysis to avoid bias toward one or the other species. These included: Double-crested and Neotropical Cormorants (see Table 1 for scientific names), Greater and Lesser Yellowlegs, Long-billed and Short-billed Dowitchers, King and Clapper Rails, Yellow-crowned and Black-crowned Night-Herons, the smaller Calidrid sandpipers ("peeps"), and certain egrets and herons.

Timing and number of surveys.—As a result of lack of continuous funding, field work was done in different years by seasons and involved different field assistants. A pilot study was initiated in summer 1985, but one important zone was not sampled; thus, data analyzed here are only for periods in which all six vegetation zones were sampled and study techniques were standardized: summer 1986, late winter and spring of 1990, and summer and fall of 1991. Water conditions varied considerably over this time frame, but the resulting variability should be more representative of avian diversity and community dynamics in the region than surveys from a single very dry or very wet season.

Number of surveys varied by season and year, depending not only on availability of field crews but limitations of weather. For this analysis, surveys were used from summers of 1986 (14 surveys 23 May–15 August) and 1991 (seven surveys 4 June–8 August). In 1990, seven surveys were conducted in winter (January–March), and eight were in spring (April–May). Data for fall were gathered from 12 surveys between late August and late December 1991. Not all zones were sampled on the same day because surveys were limited to early morning hours.

Water depth and vegetation composition.—Water depths were recorded during bird surveys in each of the three plots in each vegetation zone. Three randomly chosen sites were measured in each plot during each survey, for a total of nine readings per zone per survey. Vegetation surveys were conducted in all six zones in summers of 1986 and 1991 to establish species composition and to provide an index to structure. In 1986, one point-intercept transect was selected randomly in each plot each year from the 11 possible transect lines established at 10-m intervals; the sample was increased to three during 1991. Plants or substrate under each meter point of the tape were recorded. As a result of its potential influence on bird use, vegetation height was measured at 10-m intervals.

RESULTS

Water depth by zone.—On the basis of data taken in summer when both bird and plant surveys overlapped, water depths differed significantly between zones in 1986 (ANOVA, $F = 20.81$, df = 5, $P < 0.001$) and 1991 ($F = 14.16$, df = 5, $P < 0.001$) (Analytical Software 1992). Although mean water depths in 1991 ranged from 2.8 cm for inshore plant zones to 10.1 cm on the coastal side, the Olney three-square bulrush zone was behind

TABLE 1. Birds observed on estuarine census plots, San Bernard National Wildlife Refuge, 1985–1991.

**Pied-billed Grebe, *Podilymbus podiceps*
American White Pelican, *Pelecanus erythrorhynchos*
Double-crested Cormorant, *Phalacrocorax auritus*
Neotropical Cormorant, *P. olivaceus*
Anhinga, *Anhinga anhiga*
American Bittern, *Botaurus lentiginosus*
*Least Bittern, *Ixobrychus exilis*
**Great Blue Heron, *Ardea herodias*
**Great Egret, *Casmerodias albus*
**Snowy Egret, *Egretta thula*
**Little Blue Heron, *E. caerulea*
**Tricolored Heron, *E. tricolor*
**Reddish Egret, *E. rufescens*
**Cattle Egret, *Bubulcus ibis*
**Green-backed Heron, *Butorides striatus*
**Black-crowned Night-heron, *Nycticorax nycticorax*
**Yellow-crowned Night-heron, *N. violaceus*
**White Ibis, *Eudocimus albus*
**White-faced Ibis, *Plegadis chihi*
**Roseate Spoonbill, *Ajaia ajaja*
Wood Stork, *Mycteria americana*
Fulvous Whistling-duck, *Dendrocygna bicolor*
Black-bellied Whistling-Duck, *D. autumnalis*
Greater White-fronted Goose, *Anser albifrons*
Lesser Snow Goose, *Chen caerulescens*
Canada Goose, *Branta canadensis*
Green-winged Teal, *Anas crecca*
*Mottled Duck, *A. fulvigula*
Mallard, *A. platyrhynchos*
Northern Pintail, *A. acuta*
*Blue-winged Teal, *A. discors*
Northern Shoveler, *A. clypeata*
Gadwall, *A. strepera*
American Wigeon, *A. americana*
Bufflehead, *Bucephala albeola*
Common Merganser, *Mergus merganser*
Red-breasted Merganser, *M. serrator*
Black Vulture, *Coragyps atratus*
Turkey Vulture, *Cathartes aura*
Black-shouldered Kite, *Elanus caeruleus*
**Northern Harrier, *Circus cyaneus*
Red-tailed Hawk, *Buteo jamaicensis*
Osprey, *Pandion haliaetus*
American Kestrel, *Falco sparverius*
Merlin, *F. columbarius*
Peregrine Falcon, *F. peregrinus*
Yellow Rail, *Coturnicops noveboracensis*
*Clapper Rail, *Rallus longirostris*
*King Rail, *R. elegans*
Virginia Rail, *R. limicola*
Sora, *Porzana carolina*
**Purple Gallinule, *Porphyrula martinica*
**Common Moorhen, *Gallinula chloropus*
**American Coot, *Fulica americana*

TABLE 1. Continued.

Sandhill Crane, *Grus canadensis*
Black-bellied Plover, *Pluvialis squatarola*
Wilson's Plover, *Charadrius wilsonia*
Semipalmated Plover, *C. semipalmatus*
**Killdeer, *C. vociferus*
*Black-necked Stilt, *Himantopus mexicanus*
American Avocet, *Recurvirostra americana*
Greater Yellowlegs, *Tringa melanoleuca*
Lesser Yellowlegs, *T. flavipes*
Solitary Sandpiper, *T. solitaria*
*Willet, *Catoptrophorus semipalmatus*
Spotted Sandpiper, *Actitis macularia*
Wrimbrel, *Numenius phaeopus*
Long-billed Curlew, *N. americanus*
Hudsonian Godwit, *Limosa haemastica*
Marbled Godwit, *L. fedoa*
Semipalmated Sandpiper, *Calidris pusilla*
Western Sandpiper, *C. mauri*
Least Sandpiper, *C. minutilla*
White-rumped Sandpiper, *C. fuscicollis*
Pectoral Sandpiper, *C. melanotos*
Dunlin, *C. alpina*
Stilt Sandpiper, *C. himantopus*
Short-billed Dowitcher, *Limnodromus griseus*
Long-billed Dowitcher, *L. scolopaceus*
Common Snipe, *Gallinago gallinago*
Wilson's Phalarope, *Phalaropus tricolor*
**Laughing Gull, *Larus atricilla*
Franklin's Gull, *L. pipixcan*
**Ring-billed Gull, *L. delawarensis*
Herring Gull, *L. argentatus*
**Gull-billed Tern, *Sterna nilotica*
**Caspian Tern, *S. caspia*
Royal Tern, *S. maxima*
Common Tern, *S. hirundo*
**Forster's Tern, *S. forsteri*
**Least Tern, *S. antillarum*
Black Tern, *Chlidonias niger*
**Black Skimmer, *Rynchops niger*
**Mourning Dove, *Zenaida macroura*
**Common Nighthawk, *Chordeiles minor*
Chimney Swift, *Chaetura pelagica*
Belted Kingfisher, *Ceryle alcyon*
**Eastern Kingbird, *Tyrannus tyrannus*
Purple Martin, *Progne subis*
Tree Swallow, *Tachycineta bicolor*
N. Rough-winged Swallow, *Stelgidopteryx serripennis*
Bank Swallow, *Riparia riparia*
Cliff Swallow, *Hirundo pyrrhonota*
Barn Swallow, *H. rustica*
Sedge Wren, *Cistothorus platensis*
Marsh Wren, *C. palustris*
**Northern Mockingbird, *Mimus polyglottos*
Water Pipit, *Anthus spinoleta*
Loggerhead Shrike, *Lanius ludovicianus*

TABLE 1. Continued.

**Common Yellowthroat, *Geothlypis trichas*
**Dickcissel, *Spiza americana*
Savannah Sparrow, *Passerculus sandwichensis*
LeConte's Sparrow, *Ammodramus leconteii*
Sharp-tailed Sparrow, *A. caudacutus*
*Seaside Sparrow, *A. maritimus*
Swamp Sparrow, *Melospiza georgiana*
*Red-winged Blackbird, *Agelaius phoeniceus*
*Eastern Meadowlark, *Sturnella magna*
*Boat-tailed Grackle, *Quiscalus major*
**Brown-headed Cowbird, *Molothrus ater*
Orchard Oriole, *Icterus spurius*

* Evidence of breeding on the study plots.
** Breeding nearby on islands or freshwater wetlands.

a low ridge that trapped freshwater and reduced tidal inflow; it was typically the deepest zone (x = 12.3). The tidal vegetation zones showed the lowest mean variation during the period of study, but of course had daily water level changes that other zones did not have. No effort was made to standardize survey times in relation to tide, however, because time of day was deemed more important for the bird surveys, and predicting tide

TABLE 2. Incidence of birds of regular occurrence, 1990–1991.

Species	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Snow Goose	28	5	0	0	0	0	0	0	0	0	79	26
Water Pipit	18	19	47	0	0	0	0	0	0	0	0	0
Savannah Sparrow	10	47	63	60	4	0	0	0	0	0	0	1
Peeps	14	38	42	150	12	0	31	150	1	10	14	7
Dowitchers	7	14	44	131	10	0	15	30	0	11	19	2
Yellowlegs	0	24	98	441	90	0	63	61	3	39	31	11
B. W. Teal	0	0	39	154	32	0	2	8	13	23	24	0
Snowy Egret	0	0	1	11	22	1	5	17	25	9	7	1
Great Egret	0	0	1	0	13	25	12	46	19	33	10	19
W. F. Ibis	0	0	1	9	25	35	40	110	5	17	9	5
B. N. Stilt	0	0	5	27	126	48	66	50	10	1	1	0
Cattle Egret	0	0	0	2	4	20	17	37	100	9	5	0
Tricolored Heron	0	0	0	5	34	11	57	67	37	19	4	0
Least Bittern	0	0	0	1	6	25	19	35	1	0	0	0
Seaside Sparrow	0	1	11	57	78	23	48	31	1	1	2	6
Mottled Duck	0	5	34	24	20	4	7	14	6	24	10	4
R. W. Blackbird	10	38	169	225	246	173	181	91	29	23	13	2
B. T. Grackle	14	33	33	69	80	98	84	69	79	130	51	25
E. Meadowlark	41	63	61	41	28	16	27	9	1	17	21	17
G. B. Heron	1	0	1	1	6	8	5	9	5	9	8	2
L. B. Heron	3	0	1	1	1	5	7	14	3	10	59	0
White Ibis	2	1	6	3	41	84	69	155	8	89	23	20
Willet	1	10	23	71	65	37	12	7	2	12	38	2

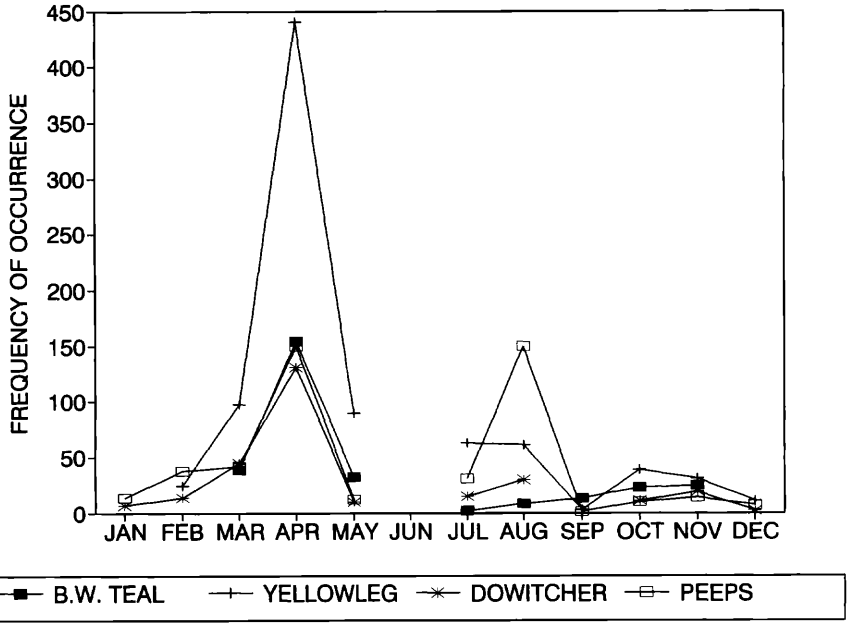

FIGURE 2. Frequency of occurrence of selected nonbreeding species that use the study area in migration, based on data from 1990 and 1991.

levels would have been impractical in a protected bay system where wind is more important than celestial influence.

Vegetation structure by zone.—Detailed analysis of vegetation composition and change are presented elsewhere, but dominants for which the zones were named constituted 48–95% of the vegetation. The following characteristics of vegetation structure consider plant height (based on means from 1991) and growth form of each plant zone potentially influencing bird use. (1) Gulf cordgrass is a tussock-forming grass, with stiff, upright (68.5 cm), blades, that usually occurs on high and saline ground temporarily flooded in winter or spring. Gulf cordgrass generally was attractive to the more terrestrial birds, but more shorebird species were found between clumps of vegetation when the zone was partially flooded. (2) Seashore paspalum was found on wet and often grazed sites, and was periodically flooded by rainfall and sheet flow, but still slightly saline (<6 ppt) water, due in part to salt concentration during drydowns. At the peak of its growth, this plant was tall (62.5 cm) but lacked the robustness essential for nests. When flooded, it was an ideal site for invertebrate feeders. (3) Olney three-square bulrush typically included the tallest vegetation (101 cm), and was commonly flooded with rainwater or fresh surface flow. It was flooded by seawater only during hurricane-level storms, but considerable evaporation occurred during warm summer

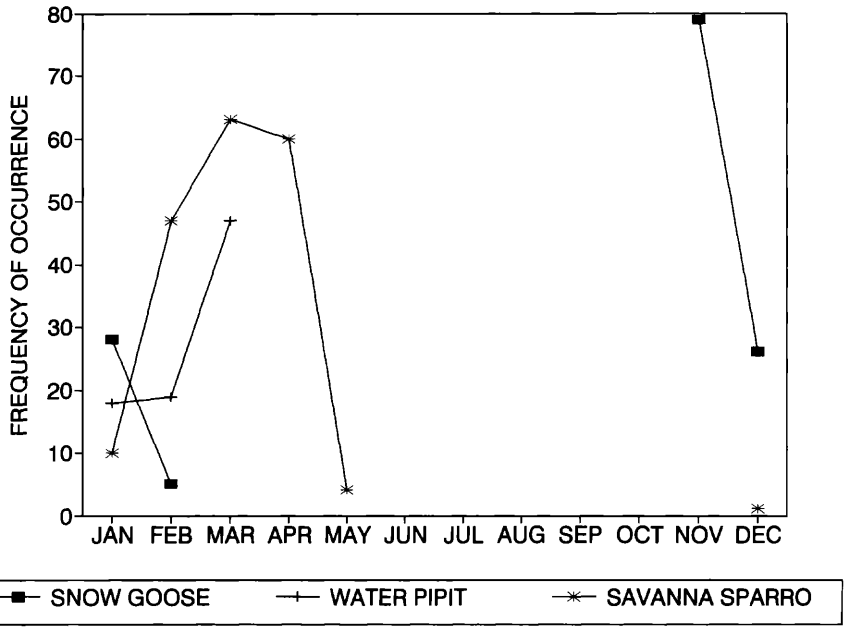

FIGURE 3. Frequency of occurrence of selected nonbreeding species that use the study area in winter, based on data from 1990 and 1991.

months; salinities varied greatly but typically were <10 ppt. An understory of seashore paspalum and marshhay cordgrass was common in shallow or periodically flooded areas. This habitat was attractive to feeding and roosting waders. Deeper pools contained widgeongrass (*Ruppia maritima*) favored by swimming aquatic herbivores. (4) Marshhay cordgrass was about the same mean height as Gulf cordgrass (69.5 cm vs. 68.5 cm), but the heights did not reflect the true difference in the two species because Gulf Cordgrass is clumped whereas marshhay cordgrass is continuous and overhanging. The growth form provides excellent cover for nests of smaller birds. This zone was separated from the *Scirpus olneyi* zone by a low ridge, and was more regularly flooded by brackish tidewater. Bird species that favored wet areas but low vegetation used this area in preference to the tall and dense *Scirpus olneyi*. Although salinity sometimes approached that of seawater, depth and hydroperiod probably were more important in maintenance of this plant species and attractiveness to birds. (5) Saltgrass was a salt-tolerant species usually located on somewhat higher ground in areas where extreme drying between tides increased salt levels. Often partially flooded by daily tides and sparsely vegetated, its patchy vegetation included a mix of salt-tolerant plants such as glasswort, marshhay cordgrass and smooth cordgrass, and occasionally saltwort (*Batis maritima*) as well as saltgrass. Mean height was the lowest of vegetated areas (49.7 cm).

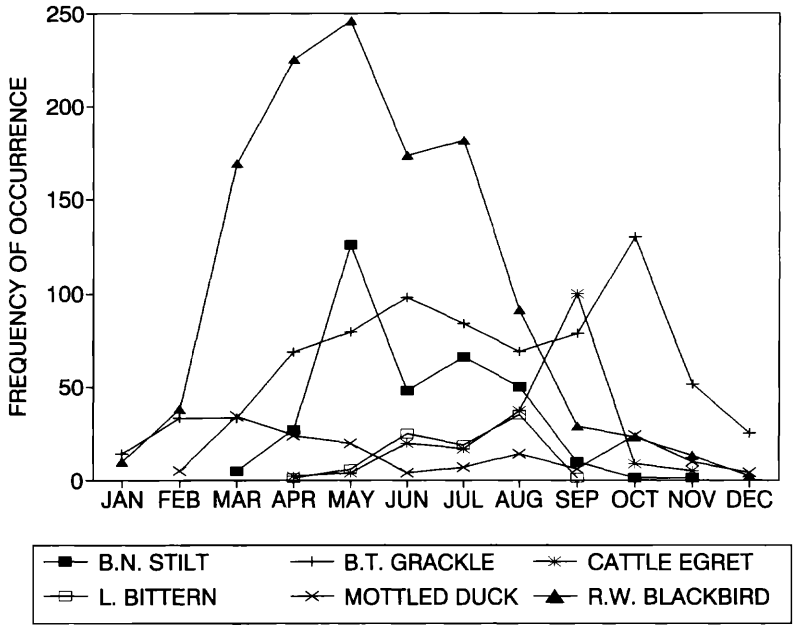

FIGURE 4. Frequency of occurrence of selected breeding species that use the study area all year, based on data from 1990 and 1991.

(6) Saline mud flats were sparsely vegetated with glasswort, and occasionally saltgrass, with widgeongrass in watered areas. Flats have many of the characteristics of saltgrass areas; they seem to form by vegetation kills due to excessive salinity or by sedimentation. Subsequently, they are gradually vegetated by glasswort and sometimes dwarf spikerush (*Eleocharis parvula*), followed by saltgrass and marshhay cordgrass. Plants were sparse and most were shorter than in other zones, but the taller smooth cordgrass increased population mean height (62.3 cm). Water salinity typically varied from 15–25 ppt but extremes ranged from 0–>35 ppt due to flushing and drying.

Seasonal use by birds.—As a measure of use or potential use of these brackish to saline zones, 121 species were recorded on or flying directly over the brackish vegetation plots during the entire study period (Table 1). Some species were migrants that rested temporarily after crossing the Gulf of Mexico, and were seen few times. Common passerine migrants that used trees around nearby ponds rarely occurred in the estuarine plots because there were no trees. Other species occurred regularly and often in large numbers, using the area for several months to most of the year. Some species were more common on adjacent freshwater areas and were seen in the saline areas only in the wet (and thus freshwater) years of 1990–1991.

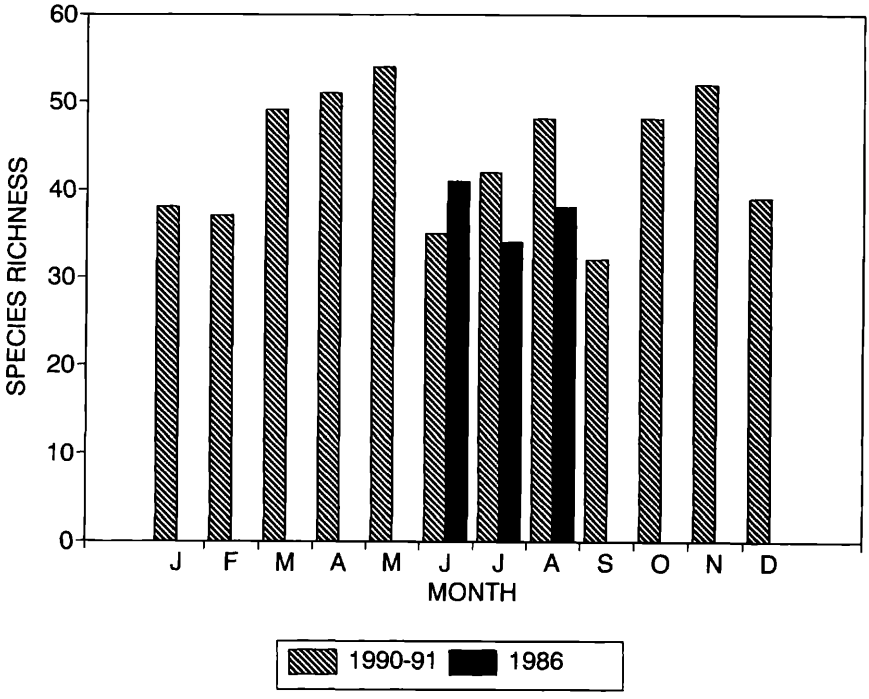

FIGURE 5. Species richness of birds observed on study plots by month, based on data from summers of 1986 and 1991, spring 1990, and fall 1991.

As a result of the geographic latitude of the study area, clarifying traditional seasons common to studies of more northerly areas was difficult. There was considerable overlap between late spring migrants and non-breeding summering and/or breeding birds. As a result of early breeding among colonial waders, those appearing on loafing and feeding areas could not be identified as breeders or non-breeders. Black Terns, yellowlegs, dowitchers and peeps were considered non-breeders, but some shorebirds present in July probably were early southward migrants. Many wintering ducks and some other birds did not reach the area until late December, making a separation from fall to winter difficult; hence data are shown by month in tables and figures.

Based on the presence in a series of consecutive months, only 23 species used this area on a regular basis (Table 2). Four species/groups that were dominantly migrants included yellowlegs, dowitchers, peeps and Blue-winged Teal (Fig. 2), although breeding was suspected in teal in several years and one nest was found in 1985 by B. Grand (U.S. Fish and Wildlife Service 1985). Three species were clearly wintering migrants: Lesser Snow Goose, Water Pipit and Savannah Sparrow (Fig. 3). The latter species

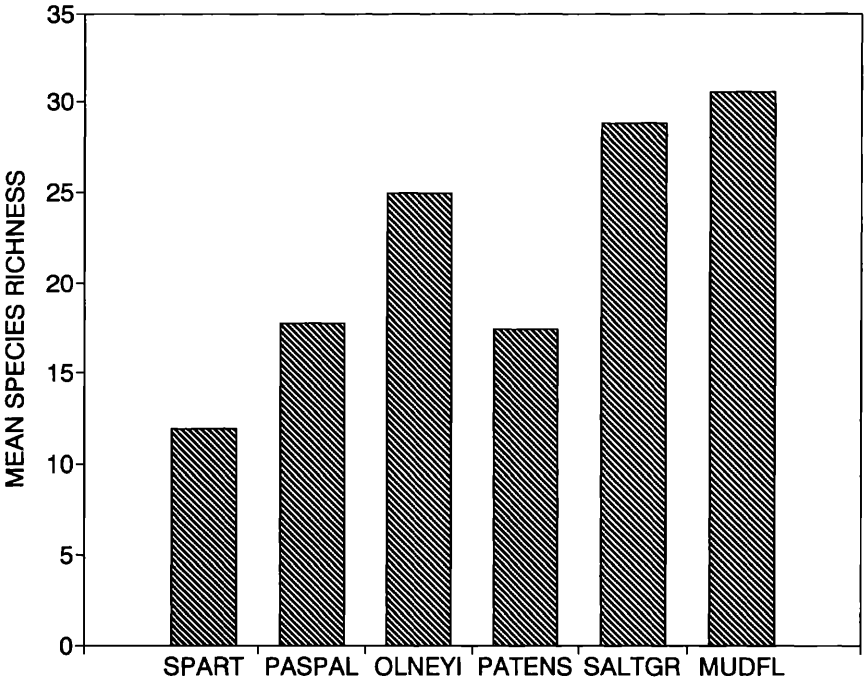

FIGURE 6. Mean species richness of birds by vegetation zone, based on maximal taxon richness recorded over all months and years.

arrived in December and was still present in small numbers in May, whereas the wintering periods for the other two were much shorter.

Among summering and permanent residents, some such as Least Bittern, Black-necked Stilt and Cattle Egret were present most of the summer but absent in winter (Fig. 4). Both stilts and bitterns nested in the marsh, but Cattle Egrets came to feed in the marsh after nesting or during fall migration, and often during drydown periods. Mottled ducks were permanent residents but became more visible in mid to late summer after breeding and during flocking periods. Other species were present at some level during all months, although not always recorded in study plots; some either nested on nearby islands (egrets and herons) or on the pond (Red-winged Blackbird and Boat-tailed Grackle). Occurrence of the latter two species differed seasonally with Red-winged Blackbirds nesting earlier and moving out of the plots, whereas grackles nested in early summer and then concentrated in late summer to feed in drying areas of the marsh (Fig. 4).

Bird species richness by month.—Seasonal variation in species richness reflects the importance of such coastal areas for migrants in spring (March, April and May) for most species, in July and August for shorebirds, and in October and November for waterfowl (Fig. 5), with lower

richness in winter months of December, January and February, and in June. Taxon richness for most months of the dry summer of 1986 was lower than those in the wet year of 1991 (Fig. 5), and involved more terrestrial species.

Bird species richness by vegetation zone.—Using the maximal index to taxon richness by including all categories by which data were recorded (rather than the grouping of dowitchers, yellowlegs, etc. mentioned above), richness generally was lowest in drier Gulf cordgrass and highest in the saltgrass and mudflat zones, which had variable water depths but short vegetation with an open profile (Fig. 6). The Olney's bulrush zone had consistently high usage and was characterized by the deepest and most regularly flooded water conditions. It also had the tallest vegetation, and served as nocturnal and daytime roosts for egrets and herons.

DISCUSSION

SBNWR was acquired mainly for its large winter populations of Lesser Snow Geese, which use several of these plant zones for feeding. The plant zonation resulting from water depth and salinity gradients, however, creates low profile but diverse habitat structure attractive to many other bird species. Seasonal and year-to-year water variation in tidal regimes and freshwater inflow further modified vegetation, resulting in constantly changing bird assemblages. Clearly the area serves many avian species for a wide variety of purposes such as nesting, resting, stopover and wintering. Its role for breeding is significant, but supports fewer bird species than do typical northern freshwater wetlands (Weller and Spatcher 1965) if only marsh-nesting species are considered. Its food support for locally nesting egrets and herons is still greater, however, but difficult to equate to that of northern marshes. Use by migratory shorebirds is significant in both spring and late summer, and other Neotropical migrants may use the area when conditions and timing allow. Passerine migrants were least sampled because shrub and forest zones were not included in the study.

Maintenance of habitat diversity is essential to avian diversity, which requires various natural water regimes and plant communities. Less-appreciated habitats such as mudflats and saltgrass proved especially attractive to a great diversity of birds (Fig. 6), some of which such as Reddish Egrets are quite rare. Such rarity must be a driving force and justification for preservation of such habitats if biodiversity is a major goal of refuges and preserves (Burger et al. 1982). Land management strategies or urban or industrial development that reduce this variation must be considered critically in relation to long-range goals for the area.

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