WADING BIRD TIME-ACTIVITY BUDGETS AND HABITAT USE DURING THE BREEDING SEASON IN MOIST SOIL WETLANDS AT RICHLAND CREEK WILDLIFE MANAGEMENT AREA

By

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ABSTRACT

Loss of wetland habitat has had drastic effects on waterbird species that are dependent upon wetlands to survive. Wading birds are excellent indicators of wetland function and overall health, where species such as wood stork (*Mycteria americana*) have severely declined due to increased loss of suitable habitat. Waterbirds consist of diverse taxonomic groups and their use and occurrence in moist soil managed wetlands may provide insight in quality moist soil wetland habitat that traditionally are managed for wintering waterfowl.

During the 2004 and 2005 breeding season, chronology of waterbird occurrence, wading bird behavior and habitat use of moist soil managed wetlands were studied at the Richland Creek Wildlife Management Area. Surveys were conducted for occurrence of waterbirds during spring and summer. Over 40 waterbird species were observed. Wading birds were the predominant group in both years with the highest abundance occurring in May-June.

Behavior was measured using time-activity budgets for seven focal species; cattle egrets (*Bubulcus ibis*), great egrets (*Ardea alba*), great blue herons (*A. herodias*), little blue herons (*Egretta caerula*), snowy egrets (*E. thula*), white ibis (*Eudocimus albus*) and wood stork. Over 4,000 focal samples were collected in both years. Behaviors varied among species ($P > 0.001$) and between years ($P > 0.001$). Resting and body maintenance were the

predominant behaviors among all species except white ibis which showed feeding (>60%) as the predominant behavior.

Microhabitat was measured within a 1-m^2 quadrat where data were collected on the following: distance to edge (m), water depth (cm), tallest emergent plant (cm), percent cover of open water, emergent vegetation, mudflat, and floating vegetation for used and random bird locations. Habitat use varied among species ($P > 0.001$) (i.e. cattle egret, great egret, snowy egret, white ibis) on moist soil wetlands. Data revealed wading birds utilized habitat consistent of water depths ranging from (4-27) cm in a mix of emergent vegetation and open water. Morphological differences among focal species revealed different habitat variables (i.e., open water, emergent, floating vegetation, mudflats) are required to provide suitable habitat for multiple species.

The results from this study have generated important data to further enhance what is known about foraging behaviors and techniques among wading birds as well their importance as indicators for wetland health. However, few studies have examined wading bird use of moist soil managed wetlands and due to the fact these wetlands were utilized by an endangered species (i.e., wood stork) then future management may include these birds.

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CHAPTER I

SPRING AND SUMMER WATERBIRD OCCURRENCE CHRONOLOGY AT THE RICHLAND CREEK WILDLIFE MANAGEMENT AREA

INTRODUCTION

Waterbirds (i.e., Charadriiformes, Ciconiiformes, Anseriformes) represent a group of birds as either facultative or obligate dependent upon open water or wetland habitats in search of food (Temple 2001) (Table 1.4). Waterbird migrations are characterized by long-distance flights, where fat accumulation occurs at suitable stopover habitats, given those habitats provide suitable quantities of prey (Weber et al. 1988). Inland wetland habitats are critical for waterbirds, where use of inland stopover sites is influenced by food availability and prey density (Evans and Dugan 1984), while indirectly related to wetland availability on the landscape (Burger 1984, Dahl 1990). Changes in habitat conditions may affect how, where, and when these birds select stopover sites during migration (Koford et al. 1994, Melvin et al. 1999). For example, migrating shorebirds (i.e., Charadriiformes) may skip suitable sites by storing more fat than necessary to fly to the next site (i.e., overloading) (Piersma 1987, Wilson 1988), as decreased flight time leads to greater migration success (Weber et al. 1994). However, if suitable stopover sites are not available or are widely separated, migration success may be compromised (Myers et al. 1987, Fredrickson and Reid 1988). Theoretically, as migration and energetic flight costs are high, and if wetland stopover sites are readily available, overloading should not regularly occur (Pennycuick 1975), whereby the importance of suitable wetland stopover sites present on the landscape becomes magnified (Fredrickson and Taylor 1982, Taft et al. 2002).

As continued development and degradation of wetland habitat occurs, loss of quality suitable stopover habitat also continues (Myers et al. 1987). Consequently, continued anthropogenic impacts on waterbird habitats, and resulting waterbird population declines has heightened conservation awareness of these species (Howe et al. 1989, Reed et al. 1997). As opposed to shorebirds, wading birds (i.e., Ciconiiformes) use three migration and dispersal strategies (i.e., seasonal, juvenile/dispersal, and intraregional) (Ryder 1967, Byrd 1978, Kushlan 1978a), which are driven by environmental conditions and prey abundance (Ogden et al. 1976). As wading bird movement (i.e., seasonal, juvenile/dispersal, or intraregional) is predicated by their ability to track food and habitat quality, those moving between widely separated sites may choose stopover habitats using different itineraries and corridors, depending upon season and environmental conditions (Piersma 1994). Moreover, migration success influences (1) timing of arrival on breeding grounds and (2) breeding success, where late arrival can compromise mate acquisition and reproductive success, and premature arrival may reduce reproductive success due to adverse environmental conditions encountered upon arrival (Green et al. 1977). Overall, biotic and abiotic changes in wetland habitat quality and availability, combined with unpredictable environmental conditions may drive migration timing, duration, departure, success, and general occupancy rates by waterbirds (Goss-Custard 1984).

Wetland location on the landscape, quality, size, prey density, and vegetative heterogeneity all combine to influence how waterbirds select stopover site wetlands during migration (Weller and Spatcher 1965, Page and Gill 1994), and increases in these habitat characteristics often positively influence species richness and abundance (Beecher 1942, Kaminski and Prince 1984, Nudds 1992). Although waterbirds will generally select natural wetlands, as more created wetlands become available (Ogden 1991, Velasquez 1992, Elphick and Oring 1998), their use by waterbirds becomes magnified in light of natural wetland decreasing availability (Lu 1990, Delphey and Dinsmore 1993, Kennish 2001). Created wetlands are often managed using moist soil management strategies, where when water control is possible, water depth is manipulated through drawdowns in spring and summer and flooding in fall, to increase annual plant and seed production and habitat suitability for nonbreeding waterfowl (Low and Bellrose 1944, Rundle and Fredrickson 1981, Twedt et al. 1998, Bowyer et al. 2005). Despite moist soil management strategies focus upon waterfowl, many waterbird species also use these wetlands, where managed wetlands with seasonal drawdowns have a positive impact on shorebirds and other waterbirds (Rundle and Fredrickson 1981, Hands 1991, Twedt et al. 1998, Bowyer 2002).

Understanding waterbird timing of occurrence is important from a management perspective (Deleon and Smith 1999), where presence or absence of waterbirds indicate wetland stopover site quality as well as prey quantity and quality (Kushlan 1979, Burger 1984, Colwell 1993, Colwell and Landrum 1993). Few data currently exist for shorebird and wading bird use and occurrence in created moist soil managed wetlands in Texas. Since few studies focus on timing and occurrence for both wading birds and shorebirds at inland wetland sites, chronology information is critical for wildlife biologists to create applicable management strategies (Davis and Smith 1998a). The objective of this portion of the study was to (1) quantify total shorebird and wading bird occurrence, (2) quantify weekly chronology of shorebird and wading bird occurrence, and (3) develop species richness and diversity estimates in moist soil managed wetlands at Richland Creek Wildlife Management Area (RCWMA) in east-central Texas.

METHODS

Study Area

The RCWMA contains a moist soil managed wetland complex in Freestone County, Texas (Figure 1.1). The WMA occurs in the Post Oak Savannah and Blackland Prairie ecoregion, within the Trinity River floodplain, which is the source of water for the created moist soil wetlands within RCWMA. The WMA is operated through a cooperative agreement between The Tarrant Regional Water District (TRWD) and the Texas Parks and Wildlife Department (TPWD). Within this agreement, the TRWD oversees construction, maintenance, and water control of the created moist soil managed wetlands to (1) compensate for habitat losses associated with the construction of the Richland-Chambers Reservoir and (2) improve water quality of water removed from the Trinity River. Similarly, TPWD is responsible for providing recreational waterfowl hunting opportunities and oversee habitat management within the moist soil wetlands to provide high quality wetland habitat(s) for wetland dependent waterbirds throughout the annual cycle. Combined, both agencies coordinate drawdown and flooding regimes to provide suitable wetland habitat and high quality water.

The four moist soil managed wetlands are located within the 1,938.5 ha North unit of the RCWMA, which were operational as of January 2003. These moist soil wetlands total 94.7 ha (i.e., 26.1, 27.6, 30.3 and 10.9 ha individually) and are arranged linearly (Figure 1.2). Water control is executed by a lift station located on the Trinity River (Figure 1.3), where water is pumped and moved into a settling pond, and remains for approximately two days. Water then moves via gravity into the first wetland, and traverses through each moist soil managed wetland until water reaches desired levels. In general, management currently favors nonbreeding waterfowl, where flooding occurs during August-March, where water levels average approximately 0.2 – 1.5 m, depending upon individual moist soil managed wetland. Drawdowns generally occur from March-August to provide seed bank expression for annual moist soil plant and seed production. Wetlands contain both aquatic submergent and emergent vegetation such as giant salvinia (*Salvinia molesta*), hydrilla (*Hydrilla verticillata*), delta duck potato (*Sagittaria platyphylla*), erect burhead (*Echinodorus rostratus*), frog fruit (*Phyla nodiflora*), water pepper (*Polygonum hydropiper*), lizard tail (*Saururus cernuus*), and water primrose (*Ludwigia hexapetala)* (D. Collins, unpublished data). Much of the remainder of the RCWMA contains bottomland hardwood forests dominated by cedar elm (*Ulmus crassifolia*), sugarberry (*Celtis laevigata*), and green ash (*Fraxinus pennsylvanica*). Other common species are honeylocust (*Gleditsia triacanthos*), boxelder (*Acer negundo*), black willow (*Salix

nigra), bur oak (*Quercus macrocarpa*), Shumard oak (*Q. shumardii*), overcup oak (*Q. lyrata*), water oak (*Q. nigra*), willow oak (*Q. phellos*), and native pecan (*Carya illinoinensis*) (C. Mason, personal communication).

Chronology of Occurrence

Each constructed wetland was surveyed weekly during spring and fall migration (i.e., April-August 2004, March-August 2005). All birds observed were identified using binoculars or spotting scopes where species and numbers of individuals were recorded into a tape recorder. Counts began at daybreak and continued until the entire study area had been observed. Counts in both years were conducted by the same observer to reduce bias. The order in which wetlands were surveyed was randomized weekly, but in a non repetitive fashion.

Data Analysis

The total number of birds observed in all wetlands was summed within year (i.e., 2004 or 2005) and month (i.e., 16 April - 15 May, 16 May - 15 June, etc.) and chronology of occurrence was developed for each species. This was accomplished by calculating the proportion (%) of each species observed within each month as compared to the total number of observations within a year (i.e., 2004 or 2005). Species richness and species diversity (Simpson's index) estimates were calculated for (1) each year and (2) each month (i.e., 16 March - 15 April, etc.) within each year.

RESULTS

A total of 41 and 46 waterbird species, representing 6 orders and 14 families were observed in 2004 and 2005, respectively (Table 1.1). Cattle egret (*Bulbulcus ibis*) was the most abundant species in both years, followed by great egrets (*Ardea alba*), wood storks (*Mycteria americana*), white ibises (*Eudocimus albus*), and snowy egrets (*Egretta thula*) in 2004 (Table 1.2), and great egrets, white ibises, snowy egrets, wood storks, little blue herons (*Egretta caerula*) and great blue herons (*Ardea herodias*) in 2005, respectively (Table 1.3). Each of these species were identified as focal species (Chapter II). Cattle egrets were most abundant between 16 August - 1 September in both years, while great egrets, wood storks, and white ibises were most abundant between 16 May - 15 June in both years. Snowy egrets reached peak abundance between 16 July - 15 August, 2004 and between 16 May - 15 June, 2005 (Figure 1.4). Occurrence of other waterbirds generally overlapped with focal species in 2004, but in 2005, focal species dominated observations after mid June (Figure 1.5). In both years, wading birds were the most abundant waterbird group, accounting for 81% and 55% of all observations in 2004 and 2005, respectively (Table 1.4). Shorebirds (13.3% and 15.9%) and waterfowl (0.9% and 11%) accounted for the majority of the remaining observations in both 2004 and 2005, respectively (Table 1.4). The remainder of observations (5% and 18%) consisted of a variety of gulls, terns, coots, kingfishers and cormorants (Table 1.4).

Average species richness per month was 23 species in 2004 and 24 species in 2005. Overall diversity indices were higher in 2004 (0.52) than 2005 (0.49). However indices were low among months for both years, on a Simpson's Index scale of 0-1, values were generally less than 0.5. In 2004, the highest diversity index (0.24) was during April-May, while in 2005 the highest index (0.37) was during June-July (Table 1.5).

DISCUSSION

Wading bird abundance was greater than any other group of waterbirds, and observations were dominated by five species within each year. Migration strategies vary among wading birds, where species such as white ibis and wood stork make intraregional movements in response to changes in water levels (Kushlan 1976a). Although wading birds consistently used study wetlands in both years, occurrence varied between years, where 30% more wading birds were observed in 2005 than in 2004. This variation is similar to other studies describing alterations in wading bird migration and movement strategies from year to year (Custer et al. 1980).

All of the observed wading bird species, except wood storks, are known to breed in the region (Obserholser and Kincaid 1974). Although no nests were discovered within the study area, these birds occupied study wetlands consistently through the study period, and are likely nesting locally, along the Trinity River or along the peripheries of Richland Chambers Reservoir. Despite the lack of specific data on breeding colony locations, several factors affect colony location and composition (Jenni 1969) and subsequent use of these wetlands by wading birds during the breeding season. For example, herons may destroy their nesting habitat through overfertilization by defecation (Jenni 1969, Wiese 1978). Moreover, colony size and location may shift due to changes in feeding habitat locations and quality, where wading birds wander prior to nest initiation and establish colonies near suitable foraging locations (Kushlan 1978a). Root (1988) observed population declines among wading birds due to prolonged drought, wetland degradation and hydrological changes in the Everglades.

Such movements may impact local population and community stability and structure, particularly if wetland suitability as feeding habitat varies annually. Nonetheless, wading birds used these moist soil managed wetlands as foraging and resting locations, and may provide important feeding and loafing habitats during the breeding season (Chapter II). Moreover, management strategies at RCWMA may provide more stable and suitable foraging habitat prior to, and during the breeding season, and increases in wading bird abundance may be observed over the next few years particularly as more created moist soil managed wetlands become functional at RCWMA. For example, habitat size may be linked to species abundance, particularly in a wetland complex setting (Paracuellos and Telleria 2004). As the number of moist soil managed wetlands increase, waterbird abundance and occurrence can be examined over time to quantify changes in assemblage structure as these wetlands mature. Further investigations on local wading bird population stability, dynamics, and survival during the breeding season may elucidate the impact of these created moist soil wetland habitats on local wading bird breeding ecology.

Few waterfowl (i.e., Anseriformes) were observed, which is not unexpected, as it would be highly unusual to observe large waterfowl flocks during the majority of the study period (Bellrose 1972). For example, wintering waterfowl would have already departed for northerly breeding areas, and the study period did not extend into months in which waterfowl are regularly observed returning to wintering regions. Moreover, as study site wetlands are managed specifically for nonbreeding waterfowl, habitats may not have been specifically suitable for waterfowl during spring and summer, as they were generally shallower than during winter, or dry altogether.

Conversely, the study period in both years generally overlapped shorebird migration and breeding periods (Skagen and Knopf 1994b, Davis and Smith 1998b). However, shorebird richness and abundance was generally low, despite generally suitable shallow water and mudflat habitats present during the study period. Low shorebird occurrence may be due to migration pressures to refuel and move on to the next stopover site, and these study wetlands may not be particularly suitable as shorebird migration stopover sites. Two migratory strategies have been described for shorebirds (i.e., jumping and hopping). The first is characterized as long distance flight with few stops, usually performed if stopover sites are limited or when shorebirds cross large bodies of water, while the latter refers to flying short distances with frequent refueling stops (Piersma 1987). In theory, if there is adequate wetland habitat available, birds should select towards “hopping”, as it is less energetically expensive (Skagen and Knopf 1994b). However, study site wetlands may occur outside of traditional migration corridors in Texas (e.g., the Playa Lakes Region), and are not extensively used by large numbers of migrating shorebirds. Nonetheless, several killdeer (*Charadrius vociferous*) nests were discovered around study wetlands, and although an omnipresent nesting shorebird, perhaps as (1) these moist soil managed wetlands mature and (2) additional moist soil managed wetlands are created, shorebirds may use this wetland complex more effectively during migration and for nesting.

Figure 1.1. Freestone County within Texas, location of Richland Creek Wildlife Management Area.

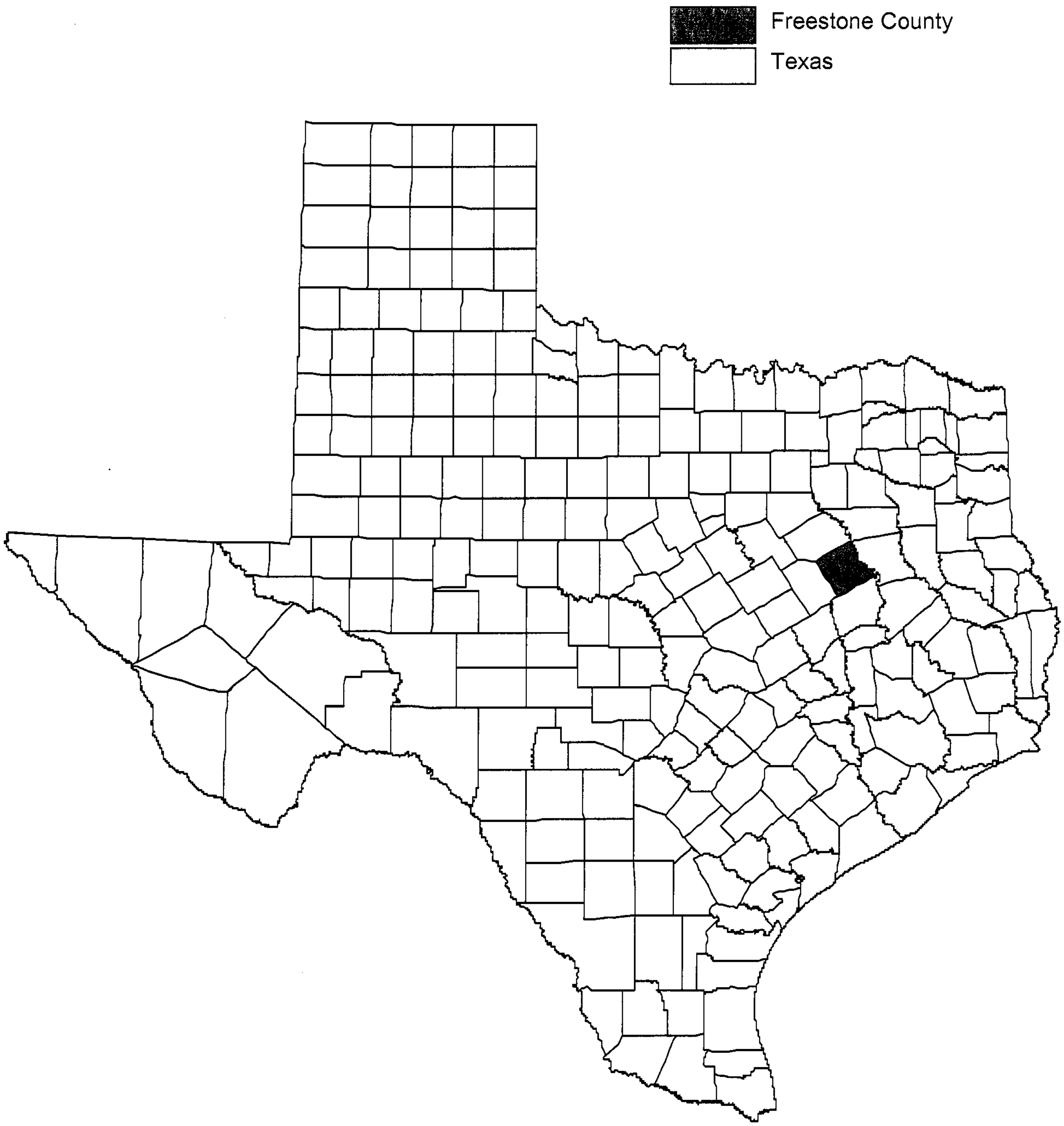


Figure1.2. Moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas.

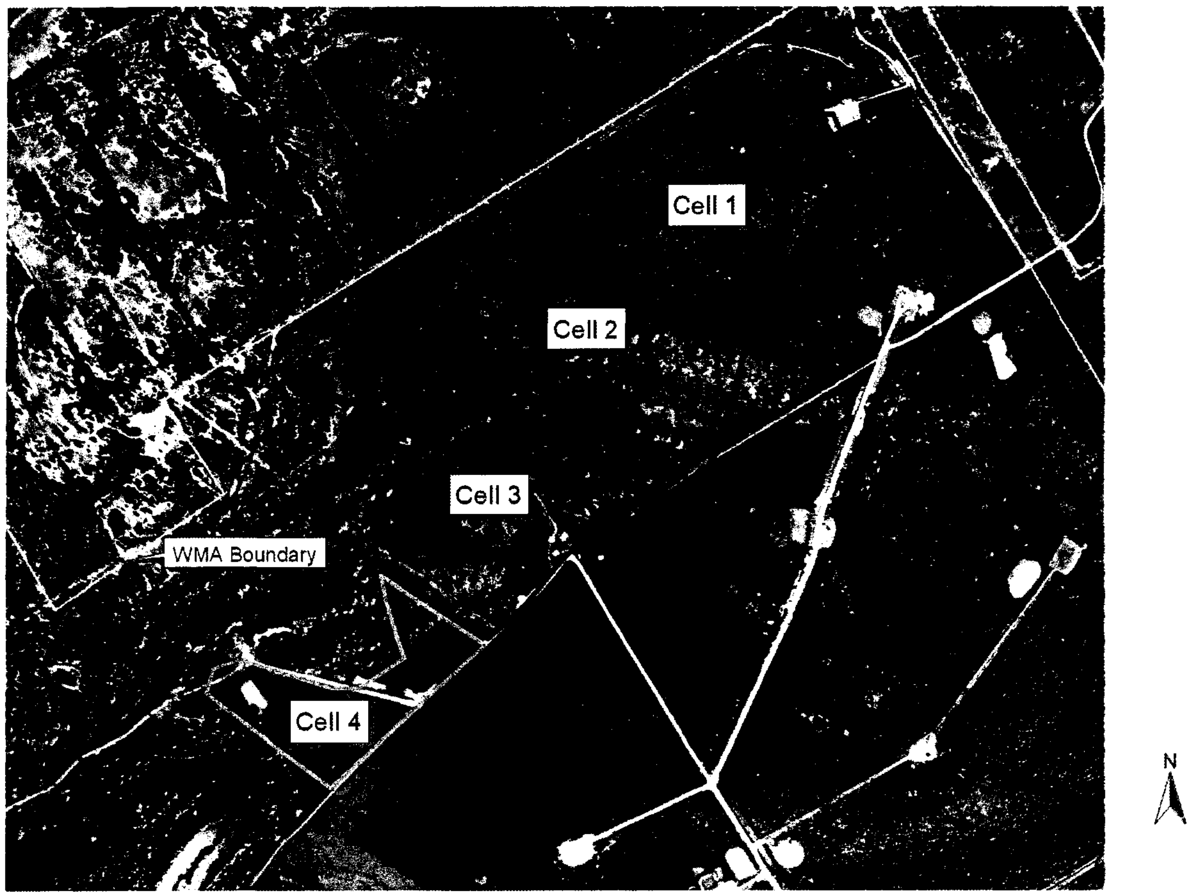


Figure1.3. Moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas in relation to the Trinity River.

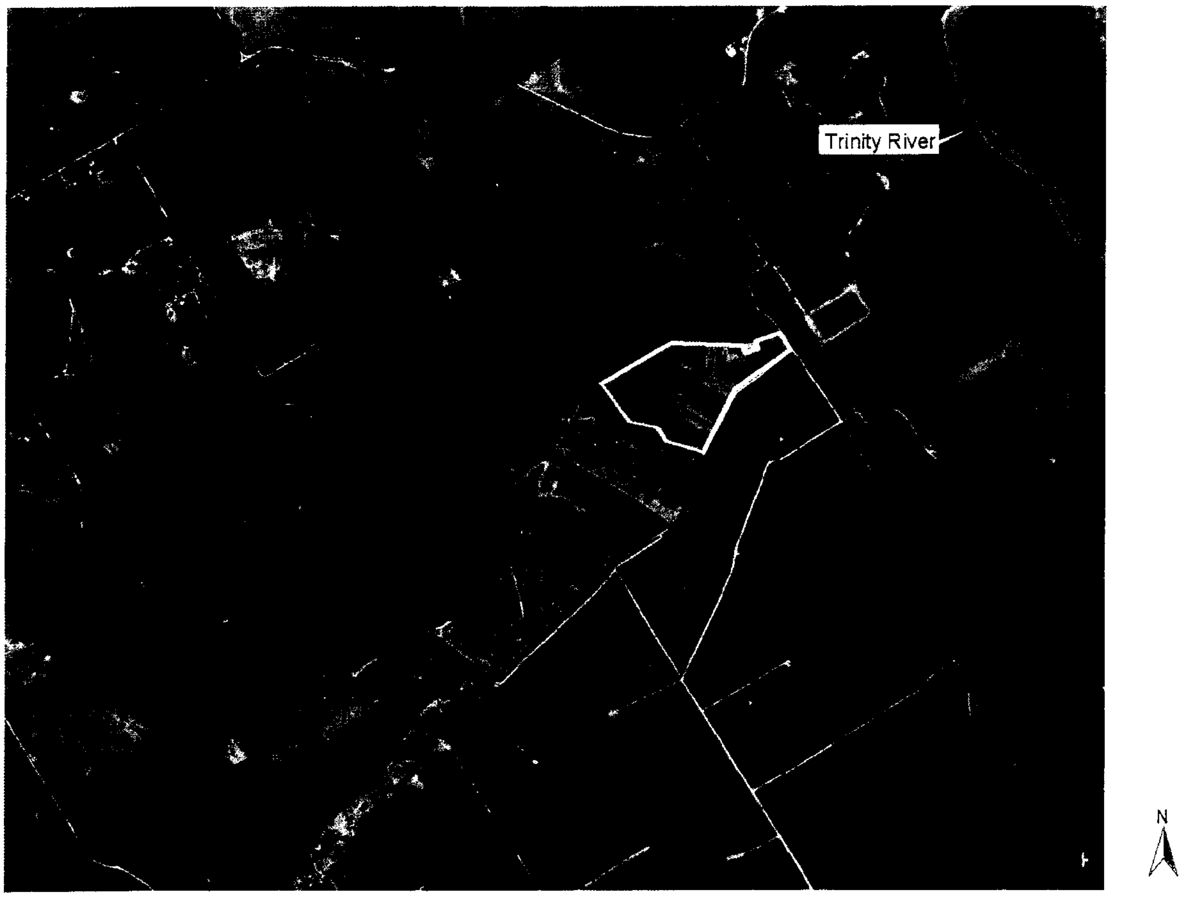


Figure 1.4. Chronology of occurrence for cattle egrets, great blue herons, great egrets, little blue herons, snowy egrets, white ibises and wood storks on moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

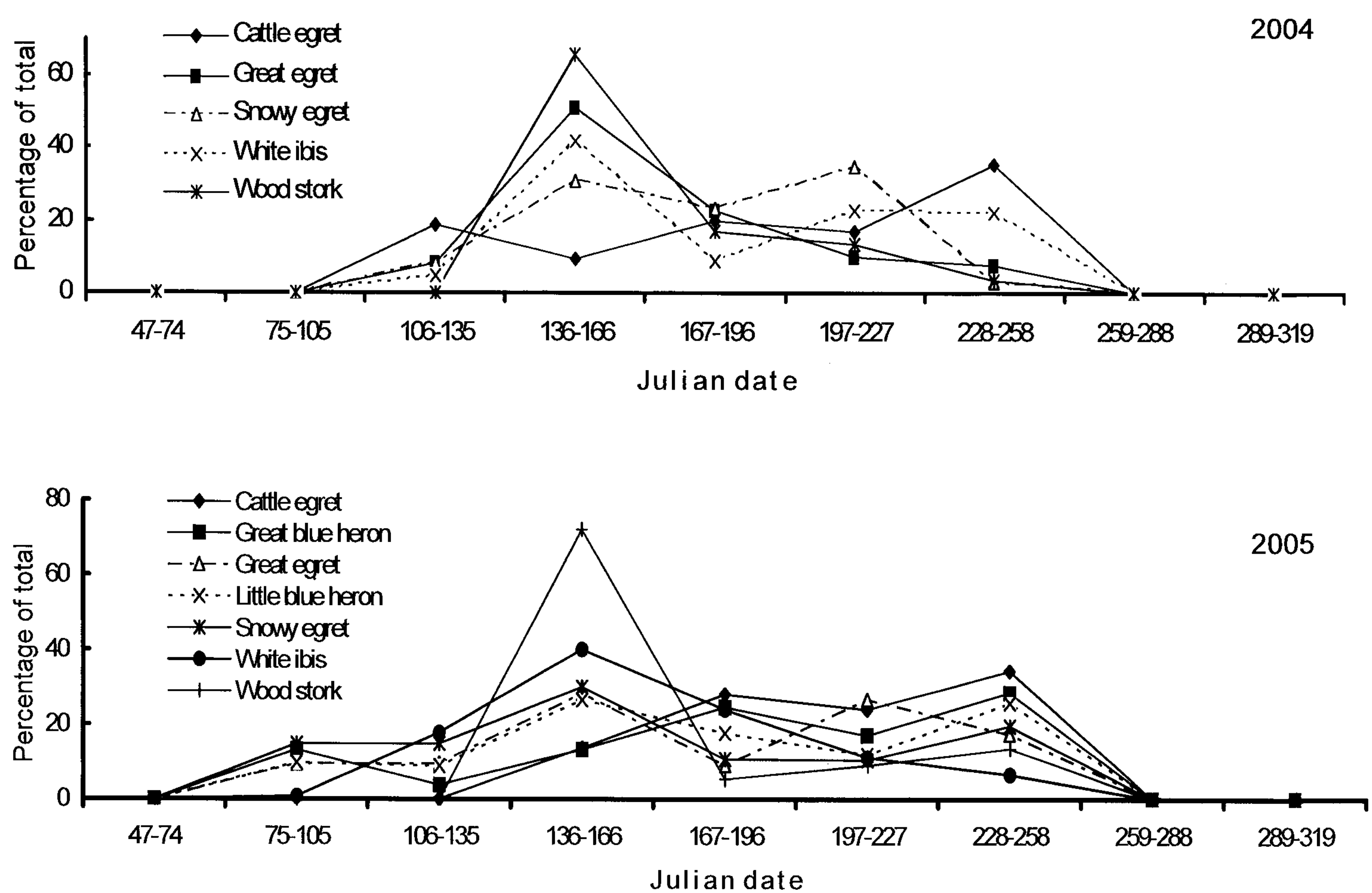


Table 1.1. Family, common names, scientific names, taxonomic grouping and occurrence by year of waterbirds observed on moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

Family	Common Name	Scientific Name	2004	2005	Taxonomic group[1]
Alcedinidae	Belted kingfisher	*Ceryle alcyon*	X		Other waterbird[2]
Anatidae	Black-bellied whistling-duck	*Dendrocygna autumnalis*		X	Waterfowl
Anatidae	Blue-wing teal	*Anas discors*	X	X	Waterfowl
Anatidae	Canada goose	*Branta canadensis*	X		Waterfowl
Anatidae	Gadwall	*Anas strepera*		X	Waterfowl
Anatidae	Green-wing teal	*Anas crecca*		X	Waterfowl
Anatidae	Northern pintail	*Anas acuta*		X	Waterfowl
Anatidae	Northern shoveler	*Anas clypeata*		X	Waterfowl
Anatidae	Wood duck	*Aix sponsa*	X	X	Waterfowl
Anhingidae	Anhinga	*Anhinga anhinga*	X		Other waterbird
Ardeidae	American bittern	*Botaurus lentiginosus*	X	X	Wading bird
Ardeidae	Black-crowned night-heron	*Nycticorax nycticorax*	X	X	Wading bird
Ardeidae	Cattle egret	*Bubulcus ibis*	X	X	Wading bird
Ardeidae	Great blue heron	*Ardea herodias*	X	X	Wading bird
Ardeidae	Great egret	*Ardea alba*	X	X	Wading bird
Ardeidae	Green heron	*Butorides virescens*	X	X	Wading bird
Ardeidae	Little blue heron	*Egretta caerulea*	X	X	Wading bird
Ardeidae	Snowy egret	*Egretta thula*	X	X	Wading bird
Ardeidae	Tricolored heron	*Egretta tricolor*	X	X	Wading bird
Ardeidae	Yellow-crowned night heron	*Nyctanassa violacea*	X	X	Wading bird
Charadriidae	American golden plover	*Pluvialis dominica*	X	X	Shorebird
Charadriidae	Killdeer	*Charadrius vociferus*	X	X	Shorebird
Charadriidae	Semipalmated plover	*Charadrius semipalmatus*		X	Shorebird
Ciconiidae	Wood stork	*Mycteria americana*	X	X	Wading bird
Laridae	Black tern	*Chlidonias niger*		X	Other waterbird
Laridae	Least tern	*Sterna antillarum*	X		Other waterbird
Laridae	Ring-billed gull	*Larus delawarensis*		X	Other waterbird
Pelecanidae	White pelican	*Pelecanus erythrorhynchos*	X	X	Other waterbird
Phalacrocoracidae	*Phalacrocorax* spp.	*Phalacrocorax spp.*	X	X	Other waterbird
Podicipedidae	Pied-billed grebe	*Podilymbus podiceps*		X	Other waterbird
Rallidae	American coot	*Fulica americana*		X	Other waterbird
Recurvirostridae	American avocet	*Recurvirostra americana*	X		Shorebird
Recurvirostridae	Black-necked stilt	*Himantopus mexicanus*	X	X	Shorebird
Scolopacidae	Baird's sandpiper	*Calidris bairdii*	X		Shorebird
Scolopacidae	*Calidris* spp.	*Calidris spp.*	X		Shorebird

Scolopacidae	Common snipe	*Gallinago gallinago*	X	X	Shorebird
Scolopacidae	Dunlin	*Calidris alpina*	X		Shorebird
Scolopacidae	Greater yellowlegs	*Tringa melanoleuca*	X	X	Shorebird
Scolopacidae	Lesser yellowlegs	*Tringa flavipes*	X	X	Shorebird
Scolopacidae	Least sandpiper	*Calidris minutilla*	X	X	Shorebird
Scolopacidae	*Limnodromus* spp.	*Limnodromus spp.*	X	X	Shorebird
Scolopacidae	Long-billed dowitcher	*Limnodromus scolopaceus*		X	Shorebird
Scolopacidae	Pectoral sandpiper	*Calidris acuminata*	X	X	Shorebird
Scolopacidae	Semipalmated sandpiper	*Calidris pusilla*	X	X	Shorebird
Scolopacidae	Short-billed dowitcher	*Limnodromus griseus*	X		Shorebird
Scolopacidae	Solitary sandpiper	*Tringa solitaria*	X	X	Shorebird
Scolopacidae	Spotted sandpiper	*Actitis macularia*	X	X	Shorebird
Scolopacidae	Stilt sandpiper	*Calidris himantopus*	X	X	Shorebird
Scolopacidae	*Tringa* spp.	*Tringa spp.*	X		Shorebird
Scolopacidae	Western sandpiper	*Calidris mauri*	X	X	Shorebird
Scolopacidae	White-rumped sandpiper	*Calidris fuscicollis*	X	X	Shorebird
Scolopacidae	Wilson's phalarope	*Phalaropus tricolor*	X	X	Shorebird
Threskiornithidae	Glossy ibis	*Plegadis falcinellus*	X	X	Wading bird
Threskiornithidae	*Plegadis* spp.	*Plegadis spp.*	X	X	Wading bird
Threskiornithidae	Roseate spoonbill	*Ajaia ajaja*	X	X	Wading bird
Threskiornithidae	White-faced ibis	*Plegadis chihi*		X	Wading bird
Threskiornithidae	White ibis	*Eudocimus albus*	X	X	Wading bird

[1]Taxonomic group as defined by foraging strategy and based on the Wetmore classification system.
[2]Other waterbird refers to species observed on moist soil wetlands but not defined as a wading bird, shorebird or waterfowl.

Table 1.2. Chronology (*n*) of occurrence for waterbirds observed on moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004.

Common name	16 Apr - 15 May	16 May - 15 June	16 June - 15 July	16 July- 15 Aug	16 Aug - 15 Sept
American avocet	0	0	3	0	0
American golden plover	0	1	0	0	0
American bittern	2	0	0	0	0
Anhinga	0	0	1	1	0
Baird's sandpiper	5	0	0	0	0
Belted kingfisher	0	1	0	0	0
Black-crowned night-heron	0	0	1	10	0
Black-necked stilt	0	2	0	5	0
Blue-wing teal	0	0	0	0	10
Calidris spp.	0	0	0	5	0
Canada goose	0	3	0	0	0
Cattle egret	165	82	180	150	320
Great blue heron	5	25	16	14	7
Glossy ibis	0	0	0	7	5
Great egret	51	308	138	60	46
Green heron	1	1	3	3	0
Greater yellowlegs	8	1	0	4	0
Killdeer	5	9	26	33	13
Lesser yellowlegs	0	0	2	2	0
Least sandpiper	8	0	0	25	6
Least tern	0	3	2	0	0
Limnodromus spp.	0	0	1	1	0
Little blue heron	12	35	22	45	21
Pectoral sandpiper	0	8	0	13	0
Phalacrocorax spp.	15	19	13	15	0
Plegadis spp.	0	3	3	0	0
Roseate spoonbill	0	11	14	7	0
Short-billed dowitcher	0	0	0	4	0

Semipalmated sandpiper	1	0	8	2	0
Snowy egret	32	124	93	139	12
Solitary sandpiper	1	0	0	3	2
Spotted sandpiper	1	1	0	5	2
Stilt sandpiper	0	4	0	30	0
Tricolored heron	0	2	3	4	0
Tringa spp.	30	6	1	0	0
Western sandpiper	0	0	0	15	0
White ibis	20	187	39	101	100
White pelican	0	52	60	65	0
White-rumped sandpiper	0	25	0	3	0
Wilson's phalarope	10	2	0	0	0
Wood duck	0	2	0	1	0
Wood stork	1	303	79	63	15
Yellow-crowned night heron	0	2	1	7	0

Table 1.3. Chronology (*n*) of occurrence for waterbirds observed on moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 March - 1 September, 2005.

Common name	16 Mar -15 Apr	16 Apr - 15 May	16 May - 15 June	16 June - 15 July	16 July- 15 Aug	16 Aug - 1 Sept
American golden plover	3	2	0	0	0	0
American bittern	0	4	0	0	0	0
American coot	100+	200+	4	0	0	0
Black-bellied whistling-duck	0	0	7	0	2	6
Black-crowned night-heron	0	0	1	0	1	0
Black tern	0	0	0	0	45	12
Black-necked stilt	2	1	2	0	0	0
Blue-wing teal	100+	0	1	0	0	0
Cattle egret	5	1	200	410	350	500
Common snipe	53	6	0	0	0	0
Gadwall	100+	0	2	0	0	0
Great blue heron	7	2	7	13	9	15
Glossy ibis	11	0	0	1	0	15
Great egret	72	72	212	68	200	130
Green heron	0	0	0	2	2	0
Greater yellowlegs	27	30	25	0	0	0
Green-wing teal	0	0	0	1	0	0
Killdeer	17	5	10	13	8	8
Lesser yellowlegs	13	26	0	0	1	1
Least sandpiper	40	44	5	0	1	1
Limnodromus spp.	20	0	0	0	0	0
Little blue heron	10	9	27	18	12	26
Long-billed dowitcher	0	40	0	0	0	0
Northern pintail	10	0	0	0	0	0
Northern shoveler	10	1	0	0	0	0
Pectoral sandpiper	35	20	30	0	0	16
Pied-billed grebe	0	3	0	2	0	11
Phalacrocorax spp.	8	24	29	21	21	8
Plegadis spp.	0	0	0	0	0	9
Ring-billed gull	50	0	0	0	0	0
Roseate spoonbill	0	0	6	2	3	15
Semipalmated plover	0	3	0	0	0	1
Semipalmated sandpiper	1	1	0	0	0	0
Snowy egret	57	57	115	41	40	75
Solitary sandpiper	3	3	0	2	3	3
Spotted sandpiper	3	3	3	0	6	0

Stilt sandpiper	0	10	0	0	0	0
Tricolored heron	1	2	2	1	1	0
Western sandpiper	8	3	20	0	0	0
White-faced ibis	13	40	6	0	0	0
White ibis	4	82	185	110	51	30
White pelican	82	35	50	0	0	0
White-rumped sandpiper	0	3	0	0	0	0
Wilson's phalarope	0	1	10	0	0	0
Wood duck	0	0	2	0	0	7
Wood stork	0	0	80	6	10	15
Yellow-crowned night heron	0	0	2	5	6	3

Table 1.4. Numbers of species, individuals, and percent abundance (%) of waterbird orders observed at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

		2004			2005		
Bird Group	Order*	Species (n)	Individuals (n)	%	Species (n)	Individuals (n)	%
Shorebirds	Charadriiformes	19	227	13.3	18	356	15.9
Wading birds	Ciconiiformes	15	1377	80.6	16	1229	54.9
Waterfowl	Anseriformes	3	15	0.9	8	248	11.8
Other waterbirds	Coraciiformes, Gruiformes, Pelicaniformes	4	86	5.0	4	406	18.1

*Denotes taxonomic group containing multiple families.

Table 1.5. Monthly waterbird species richness, number of individuals, and Simpson's diversity index at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

Month	2004			2005		
	Species Richness	Individuals (*n*)	Simpson's Index	Species Richness	Individuals (*n*)	Simpson's Index
March 16 - 15 April	0[1]	0	0.00	29	861	0.08
16 April – 15 May	19	372	0.24	31	733	0.12
16 May – 15 June	28	1222	0.17	28	1098	0.12
16 June – 15 July	23	709	0.15	17	1713	0.37
16 July – 15 August	31	841	0.10	21	962	0.22
16 August – 1 September	14	559	0.37	23	966	0.30

[1]Observations not performed during this month in 2004.

CHAPTER II

WADING BIRD TIME-ACTIVITY BUDGETS IN MOIST SOIL MANAGED WETLANDS AT RICHLAND CREEK WILDLIFE MANAGEMENT AREA

INTRODUCTION

Historically, wetlands in the U.S. were considered useless economically, and in some states nearly 90% of natural wetlands have been lost, primarily due to agriculture and urbanization (Farmer and Parent 1997). Wetlands have many natural values and functions, and when functioning properly, they provide wildlife habitat, act as filters to clean water and provide natural buffers to control flooding (Mitsch and Reeder 1991, 1992, Almendinger 1999). Due to current wetland protection laws, wetlands are created or restored when destroyed by humans (Mitsch et al. 1998, Kaiser 2001), where the overall goal of such restoration is to recreate natural wetland conditions, although success can be variable (Weinstein et al. 2001, Campbell et al. 2002).

Beyond restoration and creation focused upon recreating natural wetland functions and conditions after anthropogenic alteration, degradation, or destruction, wetlands are also created for habitat replacement, flood control, wildlife habitat, and water quality improvement (Ward 1989, Marble 1992). Although wetlands may be created or restored to replace natural ones, they often do not appear, nor function like, natural ones (Campbell et al. 2002). Although physical resemblance may lead to functional replacement over time, key wetland characteristics, such as hydric soils and hydrophytic plants, both evident in natural wetlands, may be lacking in created wetlands due to ecological immaturity (Erwin 1991, Bishel-Machung et al. 1996). Despite these problems, many created wetlands are managed specifically for wildlife using moist soil management techniques (Rundle and Frederickson 1981, Weber and Haig 1996) where providing suitable wildlife habitat is a primary management issue.

Moist soil management is commonly used to manipulate water levels through flooding and drawdowns to promote annual seed producing plants and invertebrates for nonbreeding waterfowl, migrant shorebirds, and other wetland dependent waterbirds, such as wading birds (Low and Bellrose 1944, Fredrickson and Reid 1988, Eldridge 1990, Safran et al. 2000). Beyond water manipulations, prescribed fire, grazing, mowing, disking, and herbicides are also used extensively to improve seed and invertebrate production in moist soil managed wetlands (Fredrickson 1991, Elphick and Oring 1998, Taylor and Smith 2003). Although waterbirds respond positively to hydrological manipulations, and creation of shallow water and mudflat habitats (Rundle and Fredrickson 1981, Fredrickson and Taylor 1982), their responses to traditional waterfowl management in moist soil managed wetlands are not fully understood (Boettcher et al. 1995) however wading birds are well adapted behaviorally to track spatially and temporally patchy prey items (Kushlan 1976b, Erwin 1983).

The broad range of water depths preferred by waterfowl and other waterbirds indicates that water depth manipulations can benefit a variety of waterbirds, including shorebirds and wading birds (Kushlan 1986, Skagen and Knopf 1994a), as different food items are available at different water depths (Ntiamoa-Baidu et al. 1998). As such, waterbird presence, abundance, and use of natural and/or created moist soil managed wetlands can be used to indicate general wetland function, habitat suitability, and overall productivity (Delphey and Dinsmore 1993, Reinecke and Loesch 1996, Reinecke and Hartke 2005). For example, white-faced ibis (*Plegadis chihi*) can indicate habitat quality, as habitat used by ibis also provides habitat for other waders and waterfowl (Safran et al. 2000). Beyond presence and use, waterbird time-activity budgets can provide indirect assessment of wetland functional value (Paulus 1988, Goss-Custard and Durell 1990) and provide useful information on an understudied wetland bird guild for development of comprehensive wetland conservation and management plans (Rundle and Fredrickson 1981, Hands et al. 1991).

Wading bird time-activity budgets developed within wetlands managed for waterfowl should help managers develop plans to (1) improve overall habitat quality, (2) potentially increase waterbird use, and (3) better understand how these birds use moist soil managed wetlands traditionally managed for waterfowl. The goal of this research was to develop spring and summer diurnal time-activity budgets of cattle egret (*Bubulcus ibis)*, great egret (*Ardea alba*), great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), wood stork (*Mycteria americana*), and white ibis (*Eudocimus ibis*) in created moist soil managed wetlands at Richland Creek Wildlife Management Area (RCWMA) in east-central Texas.

METHODS

Study Area

The RCWMA contains a moist soil managed wetland complex in Freestone County, Texas (Figure 1.1). The WMA occurs in the Post Oak Savannah and Blackland Prairie ecoregion, within the Trinity River floodplain, which is the source of water for the created moist soil wetlands within RCWMA. The WMA is operated through a cooperative agreement between The Tarrant Regional Water District (TRWD) and the Texas Parks and Wildlife Department (TPWD). Within this agreement, the TRWD oversees construction, maintenance, and water control of the created moist soil managed wetlands to (1) compensate for habitat losses associated with the construction of the Richland-Chambers Reservoir and (2) improve water quality of water removed from the Trinity River. Similarly, TPWD is responsible for providing recreational waterfowl hunting opportunities and oversee habitat management within the moist soil wetlands to provide high quality wetland habitat(s) for wetland dependent waterbirds throughout the annual cycle. Combined, both agencies coordinate drawdown and flooding regimes to provide suitable wetland habitat and high quality water.

The four moist soil managed wetlands are located within the 1,938.5 ha North unit of the RCWMA, which were operational as of January 2003. These moist soil managed wetlands total 94.7 ha (i.e., 26.1, 27.6, 30.3 and 10.9 ha individually) and are arranged linearly (Figure 1.2). Water control is executed by a lift station located on the Trinity River (Figure 1.3), where water is pumped and moved into a settling pond, and remains for approximately two days. Water then moves via gravity into the first wetland, and traverses through each moist soil managed wetland until water reaches desired levels. In general, management currently favors nonbreeding waterfowl, where flooding occurs during August-March, where water levels average approximately 0.2 – 1.5 m, depending upon individual moist soil managed wetland. Drawdowns generally occur from March-August to provide seed bank expression for annual moist soil plant and seed production. Wetlands contain both aquatic submergent and emergent vegetation such as giant salvinia (*Salvinia molesta*), hydrilla (*Hydrilla verticillata*), delta duck potato (*Sagittaria platyphylla*), erect burhead (*Echinodorus rostratus*), frog fruit (*Phyla nodiflora*), water pepper (*Polygonum hydropiper*), lizard tail (*Saururus cernuus*), and water primrose (*Ludwigia hexapetala)* (D. Collins, unpublished data). Much of the remainder of the RCWMA contains bottomland hardwood forests dominated by cedar elm (*Ulmus crassifolia*), sugarberry (*Celtis laevigata*), and green ash (*Fraxinus pennsylvanica*). Other common species are honeylocust (*Gleditsia triacanthos*), boxelder (*Acer negundo*), black willow (*Salix*

nigra), bur oak (*Quercus macrocarpa*), Shumard oak (*Q. shumardii*), overcup oak (*Q. lyrata*), water oak (*Q. nigra*), willow oak (*Q. phellos*), and native pecan (*Carya illinoinensis*) (C. Mason, personal communication).

Time-Activity Budgets

Time-activity budgets were developed using the focal individual sampling technique (Altmann 1974, Bergan et al. 1989, Davis and Smith 1998a, DeLeon and Smith 1999) during two diurnal periods: (i.e., 08:00-15:00 (early-midday) and 15:00-21:00 (midday-late), Bryan et al. 2001), for cattle egrets, great egrets, snowy egrets, white ibises and wood storks from 16 April - 31 August 2004 and for cattle egrets, great egrets, snowy egrets, white ibises, wood storks, great blue herons, and little blue herons 16 March -1 September 2005, on five moist soil managed wetlands. Moist soil managed wetlands were surveyed randomly and numbered as follows: wetlands one through four were created moist-soil managed wetlands, and wetland five which was defined as including the Ducks Unlimited Marsh and any other non-managed wetland on site or non-wetland areas (i.e., upland grasses or roads) (Figure 1.2). Surveys in 2004 were conducted by one primary observer and two assistants. However field assistant sampling days totaled less than a week over the entire season. Surveys in 2005 were conducted by two observers consistently over the entire study period.

Individuals were randomly selected and the following behaviors were continuously recorded for 3 min. into a tape recorder: (1) feeding (i.e., handling and consumption of prey), (2) standing (i.e., waiting or stalking), (3) resting (i.e., crouched position or asleep), (4) body maintenance (i.e., preening or bathing), (5) aggression, (6) locomotion (i.e., walking, wading, swimming or running), (7) alert (i.e., stationary or scanning), (8) comfort movements (i.e., shaking or fluffing feathers), (9) foot stirring (i.e., stirring prey up to surface with foot), and (10) nesting (i.e., manipulating or carrying branches) (Rooth 1976, Laubhan et al. 1991, DeLeon and Smith 1999).

In flocks of < 20 birds, individuals were scanned for 3 min. per bird until all individuals of the flock were sampled (Colwell and Landrum 1993, Davis et al. 1989). In flocks of > 20 birds, individuals were randomly sampled by directing the spotting scope toward the center of the flock, and selecting an individual in the center field of view (Bergan et al. 1989, Davis et al. 1998). Individuals were sampled by shifting the scope back and forth across the range of birds to ensure all portions of the flock were equally sampled (Davis et al. 1989). Individuals observed < 30 s and those in which the bird was out of sight were discarded (DeLeon and Smith 1999).

Data Analysis

Time-activity budgets were developed by calculating the proportion (%) of time spent in each behavior for each 3 min. focal sample. Focal species (i.e., cattle egrets, great egrets, snowy egrets, white ibises, wood storks, great blue herons, and little blue herons) were the replicates where a factorial multivariate analysis of variance (MANOVA) was used to examine differences in proportion of time spent in specific behaviors among focal species, between time periods (i.e., 0800-1500, early-midday, 1500-2100, midday-late), between years (i.e., 2004 and 2005), among months (i.e., 16 March - 15 April, 16 April - 15 May, 16 May - 15 June, etc.), and among moist soil managed wetlands. Multivariate normality was not assessed as satisfactory tests are lacking for greater than two dependent variables (Johnson and Wichern 1988: 146). Normality does not affect the MANOVA test criterion (i.e., Wilks' lambda) (Olson 1976) and MANOVA is robust to heterogeneity in dispersion matrices (i.e., variance-covariance matrix) (Ito and Schull 1964, Ito 1969). If differences occurred ($P < 0.05$) in MANOVA, univariate analysis of variance (ANOVA) was used to examine the effects of the independent variables on the dependent variables (i.e, behaviors). Least squares mean separation was used to examine differences ($P < 0.05$) occurring during ANOVAs (DeLeon and Smith 1999).

RESULTS

Focal Species: 2004 and 2005

A total of 4,002 focal samples were collected in 2004 and 2005 for cattle egrets (n = 935), great egrets (n = 1250), snowy egrets (n = 736), white ibises (n = 826), wood storks (n = 255), and great blue (n = 129, 2005 only) and little blue (n = 207, 2005 only) herons. Behaviors varied among species (Wilks' $\lambda = 0.50$; 44, 15,236; $P < 0.001$), between years (Wilks' $\lambda = 0.97$; 11, 3,982; $P < 0.001$), and a species x year interaction occurred (Wilks' $\lambda = 0.93$; 44, 15,236; $P < 0.001$). Data for little blue and great blue herons were only used in analyses performed within 2005, as no focal samples were collected for these species in 2004. White ibises and snowy egrets spent the most time feeding, great egrets spent the most time standing, while cattle egrets and wood storks spent the most time resting (Table 2.1). Behaviors, irrespective of species, varied between 2004 and 2005, where resting and body maintenance were the dominant behaviors in 2004 and standing/waiting and feeding were the dominant behaviors in 2005 (Table 2.2). Because of the species x year interaction, subsequent analyses were performed within years and among species to examine differences in behaviors between diurnal periods, among months, and among moist soil managed wetlands.

Focal species: 2004

In 2004, 1,210 focal samples were collected for the five focal species (i.e., cattle egret, great egret, snowy egret, white ibis, and wood stork). In general, focal sample data coincided with each individual species proportional occurrence on study site wetlands (Figure 2.1). Behaviors varied among species (Wilks' λ = 0.60; 36, 4,356; $P < 0.001$) (Table 2.3), among months (Wilks' λ = 0.89; 36, 4,356; $P < 0.001$) (Table 2.4), among moist soil managed wetlands (Wilks' λ = 0.91; 36, 4,356; $P < 0.001$) (Table 2.5), but not between diurnal periods (Wilks' λ = 0.98; 36, 4,356; $P = 0.108$) (Table 2.6). There was a species x month (Wilks' λ = 0.88; 90, 7,891; $P < 0.002$), species x diurnal period (Wilks' λ = 0.94; 36, 4,356; $P < 0.001$), and species x moist soil managed wetland (Wilks' λ = 0.87; 36, 4,356; $P < 0.001$) interaction. White ibis spent the most time feeding and wood storks spent the most time resting, while cattle, great and snowy egrets spent considerable time in standing/waiting, resting, and maintenance behaviors in 2004 (Table 2.3). Irrespective of individual species differences, all five focal species spent time standing/waiting and resting more during the first two months, and spent time in body maintenance and resting during the latter months (Table 2.4). Focal species tended to spend time in body maintenance and resting more in moist soil managed wetland two, three and four, and tended to stand/wait and locomote in moist soil managed wetlands one and five (Table 2.5). In general, focal species spent time in body maintenance and resting more during the early-midday period, whereas more time was spent in standing/waiting and resting during the midday-late diurnal period (Table 2.6). Due to interactions, subsequent analyses within 2004 were performed within each species to examine differences in time spent in different behaviors, among months, between time periods, and among moist soil managed wetlands.

Focal species: 2005

In 2005, 3,128 focal samples were collected for seven focal species (i.e., cattle egret, great blue heron, great egret, little blue heron, snowy egret, white ibis, and wood stork). In general, focal sample data coincided with each individual species proportional occurrence on study site wetlands (Figure 2.2). Behaviors varied among species (Wilks' $\lambda = 0.50$; 66, 16,390; $P < 0.001$) (Table 2.7), among months (Wilks' $\lambda = 0.89$; 55, 14,177; $P < 0.001$) (Table 2.8), between diurnal periods (Wilks' $\lambda = 0.99$; 11, 3,062; $P = 0.001$) (Table 2.9), and among moist soil managed wetlands (Wilks' $\lambda = 0.95$; 44, 11,716; $P < 0.001$) (Table

2.10). There was a species x month (Wilks' λ = 0.83; 187, 28,474; $P < 0.001$), species x diurnal period (Wilks' λ = 0.96, 66, 16,390; $P = 0.006$) and a species x moist soil managed wetland (Wilks' λ = 0.87; 176, 27,926; $P < 0.001$) interaction. Great and snowy egrets, and little and great blue herons spent a considerable amount of time standing, while white ibis fed more than any species, and wood storks spent the most time resting (Table 2.7). Irrespective of species differences, focal species spent time in locomotion and standing/waiting more during the first two months, and standing/waiting and feeding during the latter months during 2005 (Table 2.8). In general, focal species spent more time standing/waiting and resting during both the early-midday and midday-late diurnal period (Table 2.9). Finally, focal species tended to feed more in moist soil managed wetlands three and four, and tended to stand/wait in moist soil managed wetlands one, two and five (Table 2.10). Due to interactions, subsequent analyses within 2005 were performed within each species to examine differences in time spent in different among months, between time periods, and among moist soil managed wetlands.

Cattle Egret

A total of 935 cattle egret focal samples were collected in 2004 and 2005 combined. Behaviors varied among months (Wilks' λ = 0.89; 36, 3,416; $P <$

0.001) (Table 2.11), between diurnal periods (Wilks' λ = 0.97; 9, 911; P = 0.012) (Table 2.12), among moist soil managed wetlands (Wilks' λ = 0.76; 36, 3,416; P < 0.001) (Table 2.13), and between years (Wilks' λ = 0.96; 9, 911; P = 0.004) (Table 2.14). There was a month x year (Wilks' λ = 0.96; 18, 1,822; P = 0.007) and a diurnal period x year (Wilks' λ = 0.97; 9, 911; P = 0.004) interaction, but not a moist soil managed wetland x year (Wilks' λ = 0.97; 18, 1,822; P = 0.229) interaction. Regardless of year, cattle egrets spent time in body maintenance and resting more during the first and fourth months, standing/waiting and locomotion during the second month, and standing/waiting, resting and maintenance behaviors during latter months (Table 2.11). Although behaviors varied (P = 0.012) among diurnal periods in MANOVA, subsequent analyses revealed no variability (P > 0.05), and cattle egrets generally spent equal amounts of time standing/waiting, resting, and maintenance behaviors during both diurnal periods (Table 2.12). Finally, cattle egrets tended to spend time in body maintenance, standing/waiting and locomotion more in moist soil managed wetlands one and five, and spend time in body maintenance and resting more in moist soil managed wetlands two, three, and four (Table 2.13). Regardless of month, moist soil managed wetland or diurnal period, cattle egrets spent more time in body maintenance in 2004 and resting in 2005 (Table 2.14). Due to interactions, subsequent analyses were performed within year for cattle egrets to examine differences in time spent in different among months, between diurnal time periods, and among moist soil managed wetlands.

In 2004, 232 cattle egret focal samples were collected (Figure 2.1). Behaviors varied among months (Wilks' λ = 0.78; 24, 604; P = 0.007) (Table 2.15), between diurnal periods (Wilks' λ = 0.87; 8, 208; P = 0.005) (Table 2.16), and among moist soil managed wetlands (Wilks' λ = 0.61; 24, 604; P < 0.001) (Table 2.17). There was a diurnal period x month (Wilks' λ = 0.77; 24, 604; P = 0.006) and a moist soil managed wetland x month (Wilks' λ = 0.61; 48, 1,028; P < 0.001) interaction. Cattle egrets spent more time standing/waiting and locomoting and feeding in the second month, while they spent more time in body maintenance and resting in the first and last two months (Table 2.15). In general, cattle egrets spent similar amounts of time in body maintenance and resting during both diurnal periods, but spent considerably more time feeding during the midday-late period (Table 2.16). Finally, cattle egrets tended to stand/wait and locomote more in moist soil managed wetlands one and five, and spent more time in body maintenance and resting more in moist soil managed wetlands two and four, and were not observed in moist soil managed wetland three (Table 2.17).

In 2005, 703 cattle egret focal samples were collected (Figure 2.2). Behaviors varied among months (Wilks' λ = 0.91; 27, 1,978; P < 0.002) (Table

2.18), between diurnal periods (Wilks' $\lambda = 0.94$; 9,677; $P < 0.001$) (Table 2.19), and among moist soil managed wetlands (Wilks' $\lambda = 0.78$; 27, 1,978; $P < 0.001$) (Table 2.20). There was a diurnal period x month (Wilks' $\lambda = 0.91$; 27, 1,978; $P < 0.001$) and a moist soil managed wetland x month (Wilks' $\lambda = 0.81$; 63, 3,819; $P < 0.001$) interaction. Cattle egrets were not observed during the first two months. However, they spent more time locomoting in first month of arrival and standing/waiting in the last month, while resting and maintenance behaviors were also greater in the latter months (Table 2.18). In general, cattle egrets spent more time in resting and maintenance behaviors during the early-midday, and standing/waiting during the midday-late diurnal period (Table 2.19). Finally, cattle egrets tended to stand/wait and locomote more in moist soil managed wetlands three and five, and spent more time in body maintenance and resting more in moist soil managed wetlands two and four (Table 2.20). They were never observed in moist soil managed wetland one (Table 2.20).

Great Egret

A total of 1,250 great egret focal samples were collected in 2004 and 2005 combined. Behaviors varied among months (Wilks' $\lambda = 0.83$; 50, 5,577; $P < 0.001$) (Table 2.21), moist soil managed wetlands (Wilks' $\lambda = 0.89$; 40, 4,636; $P <$

0.001) (Table 2.22), and between years (Wilks' λ = 0.94; 10, 1,222; P < 0.001) (Table 2.23), but not between diurnal periods (Wilks' λ = 0.98; 10, 1,222; P = 0.119) (Table 2.24). There was a moist soil managed wetland x year (Wilks' λ = 0.91; 30, 3,588; P < 0.001) and a month x year (Wilks' λ = 0.94, 30, 3,588; P < 0.001) but not a diurnal period x year (Wilks' λ = 0.99; 10, 1,222; P < 0.440) interaction. Regardless of year, great egrets more spent time locomoting during the first two months, body maintenance during the mid-summer months, and standing/waiting during the latter months (Table 2.21). Great egrets tended to stand/wait and locomote more in moist soil managed wetlands four and five, and spent time in body maintenance and resting more in moist soil managed wetlands one, two, and three (Table 2.22). Regardless of month, moist soil managed wetland or diurnal period, great egrets spent more standing/waiting in 2005 than in 2004 (Table 2.23). In general, great egrets spent similar amounts of time in body maintenance and standing/waiting between diurnal periods (Table 2.24). Due to interactions, subsequent analyses were performed within year to examine differences in time spent in different among months, between diurnal time periods, and among moist soil managed wetlands.

In 2004, 355 great egret focal samples were collected (Figure 2.1). Behaviors varied among months (Wilks' λ = 0.80; 24, 952; P < 0.001) (Table 2.25) and among moist soil managed wetlands (Wilks' λ = 0.75; 24, 952; P <

0.001) (Table 2.26), but not between diurnal periods (Wilks' λ = 0.96, 8, 328; P = 0.182) (Table 2.27). There was a diurnal period x month (Wilks' λ = 0.89; 24, 952; P = 0.049) and a moist soil managed wetland x month (Wilks' λ = 0.64; 72, 2,003; P < 0.001) interaction. Great egrets spent more time feeding during April and May, and more time resting from June through August (Table 2.25). Great egrets were not observed in moist soil managed wetland one, but they fed more in moist soil managed wetland two, tended to stand/wait more in moist soil managed wetland five, and rested more in moist soil managed wetland three (Table 2.26). Finally, great egret behaviors were consistent between diurnal periods (Table 2.27).

In 2005, 895 great egret focal samples were collected (Figure 2.2). Behaviors varied among months (Wilks' λ = 0.66; 50, 3,880; P < 0.001) (Table 2.28) and among moist soil managed wetlands (Wilks' λ = 0.62; 40, 3,225; P < 0.001) (Table 2.29), but not between diurnal periods (Wilks' λ = 0.99; 10, 850; P = 0.766) (Table 2.30). There was a period x month (Wilks' λ = 0.91; 50, 3,880; P = 0.012) and moist soil managed wetland x month (Wilks' λ = 0.40; 200, 7,663; P < 0.001) interaction. During the first two months, great egrets spent more time locomoting, and more time standing/waiting and resting from June through August (Table 2.28). In general, great egrets tended to stand/wait evenly throughout each wetland, but rested more in moist soil managed wetland one, and spent more time locomoting in moist soil managed wetlands four and five (Table 2.29). Finally, great egret behaviors were similar between diurnal periods (Table 2.30).

Snowy Egret

A total of 736 snowy egret focal samples were collected in 2004 and 2005 combined. Behaviors varied among months (Wilks' $\lambda = 0.76$; 50, 3,228; $P < 0.001$) (Table 2.31), between diurnal periods (Wilks' $\lambda = 0.96$; 10, 707; $P = 0.005$) (Table 2.32), among moist soil managed wetlands (Wilks' $\lambda = 0.89$; 40, 2,683; $P = 0.004$) (Table 2.33), but not between years (Wilks' $\lambda = 0.98$; 10, 707; $P = 0.345$) (Table 2.34). There was a moist soil managed wetland x year (Wilks' $\lambda = 0.90$; 40, 2,683; $P = 0.001$), a month x year (Wilks' $\lambda = 0.85$; 30, 2,076; $P = 0.001$) but not a diurnal period x year (Wilks' $\lambda = 0.99$; 10, 707; $P = 0.846$) interaction. Regardless of year, snowy egrets spent more time locomoting more during the first two months, resting during mid-June through mid August, feeding during the second half of summer, and considerable time standing/waiting during July and August (Table 2.31). In general, snowy egrets spent more time feeding later in the day, and more time in maintenance and resting behaviors early in the day (Table 2.32). Finally, snowy egrets tended to stand/wait, locomote and feed more in moist soil managed wetlands one, two, and three and resting more in moist soil managed wetlands four and five (Table 2.33). Regardless of month, moist soil managed wetland, or diurnal period, snowy egret time-activity budgets were generally similar between 2004 and 2005 (Table 2.34). Finally, snowy egret was the only species observed engaged in footstirring behaviors during this study. Due to interactions, subsequent analyses were performed within year for snowy egrets to examine differences in time spent among months, between diurnal time periods, and among moist soil managed wetlands.

In 2004, 294 snowy egret focal samples were collected (Figure 2.1). Behaviors were similar among months (Wilks' λ = 0.89; 24, 764; P = 0.178) (Table 2.35) and among diurnal periods (Wilks' λ = 0.98; 8, 263; P = 0.813) (Table 2.36), but varied among moist soil managed wetlands (Wilks' λ = 0.82; 32, 972; P = 0.020) (Table 2.37). There was a moist soil managed wetland x month (Wilks' λ = 0.62; 96, 1,782; P = 0.012) interaction, but not a diurnal period x month (Wilks' λ = 0.88; 24, 764; P = 0.104) interaction. Snowy egrets behaviors were generally similar throughout the study period (Table 2.35) and were similar regardless of diurnal period (Table 2.36). Snowy egrets tended to stand/wait and locomote more in moist soil managed wetlands one and five, and spent more time in body maintenance and resting more in moist soil managed wetlands three and four (Table 2.37).

In 2005, 442 snowy egret focal samples were collected (Figure 2.2). Behaviors varied among months (Wilks' λ = 0.77; 50, 1,841; P < 0.001) (Table 2.38), but were similar among diurnal periods (Wilks' λ = 0.97; 10, 403; P = 0.519) (Table 2.39) and among moist soil managed wetlands (Wilks' λ = 0.91; 40, 1,530; P = 0.559) (Table 2.40). There was a moist soil managed wetland x month (Wilks' λ = 0.58; 140, 3,324; P < 0.001) and a diurnal period x month (Wilks' λ = 0.78; 50, 1,841; P < 0.001) interaction. During the first two months, snowy egrets spent more time in body maintenance and resting, while standing/waiting and feeding was higher during the latter months (Table 2.38). In general, snowy egret time-activity budgets were similar between diurnal periods (Table 2.39) and among moist soil managed wetlands (Table 2.40).

White Ibis

A total of 826 white ibis focal samples were collected in 2004 and 2005 combined. Behaviors varied among months (Wilks' λ = 0.91; 27, 2,343; P < 0.001) (Table 2.41), between years (Wilks' λ = 0.91; 9, 802; P < 0.001) (Table 2.42), and between diurnal periods (Wilks' λ = 0.96; 9, 802; P < 0.008) (Table 2.43), but were similar among moist soil managed wetlands (Wilks' λ = 0.96; 27, 2,343; P = 0.275) (Table 2.44). There was a month x year (Wilks' λ = 0.91; 27, 2,343; $P < 0.001$), a diurnal period x month (Wilks' $\lambda = 0.96$; 9, 802; $P = 0.002$) but not a moist soil managed wetland x month (Wilks' $\lambda = 0.96$; 27, 2,343; $P = 0.270$) interaction. White ibis were not observed during the first two months, but spent considerable time feeding throughout the entire season in both years (Table 2.41). Regardless of month, moist soil managed wetland or diurnal period, white ibis spent more time resting in 2004 and almost twice as much time feeding in 2005 (Table 2.42). In general, white ibis fed consistently during both diurnal periods (Table 2.43). White ibis were not observed in moist soil managed wetland one, but time-activity budgets were similar among moist soil managed wetlands, irrespective of year (Table 2.44). Due to interactions, subsequent analyses were performed within year for white ibis to examine differences in time spent among months, between diurnal time periods, and among moist soil managed wetlands.

In 2004, 152 white ibis focal samples were collected (Figure 2.1). Behaviors were similar among months (Wilks' $\lambda = 0.82$; 18, 369; $P = 0.127$) (Table 2.45), between diurnal periods (Wilks' $\lambda = 0.91$; 6, 130; $P = 0.063$) (Table 2.46), and among moist soil managed wetlands (Wilks' $\lambda = 0.91$; 18, 369; $P = 0.837$) (Table 2.47). There was no moist soil managed wetland x month (Wilks' $\lambda = 0.71$; 36, 574; $P = 0.151$) nor a diurnal period x month (Wilks' $\lambda = 0.87$; 18, 369;

$P = 0.455$) interaction. White ibis, irrespective of month, diurnal period, or moist soil managed wetland, spent most of their time feeding (Tables 2.45, 2.46, 2.47)

In 2005, 674 white ibis focal samples were collected (Figure 2.2). Behaviors varied among months (Wilks' $\lambda = 0.93$; 27, 1,887; $P = 0.027$) (Table 2.48), and moist soil managed wetlands (Wilks' $\lambda = 0.93$; 27, 1,887; $P = 0.024$) (Table 2.49), but was similar among diurnal periods (Wilks' $\lambda = 0.99$; 9, 646; $P = 0.755$) (Table 2.50). There was a moist soil managed wetland x month (Wilks' $\lambda = 0.81$; 81, 4,184; $P < 0.004$) interaction, but not a diurnal period x month (Wilks' $\lambda = 0.96$; 27, 1,887; $P = 0.608$) interaction. White ibis were not observed in the first two months, but fed considerably during entire summer season (Table 2.48). In general, white ibis tended to feed more in moist soil managed wetland three, and rest more in moist soil managed wetlands four and five (Table 2.49). They were not observed in moist soil managed wetland one (Table 2.49). Finally, white ibis time activity budgets were similar between diurnal periods (Table 2.50).

Wood Stork

A total of 255, wood stork focal samples were collected in 2004 and 2005 combined. Behaviors were similar among months (Wilks' $\lambda = 0.91$; 16, 478; $P = 0.150$) (Table 2.51), between diurnal periods (Wilks' $\lambda = 0.96$; 8, 239; $P = 0.452$)

(Table 2.52), and between years (Wilks' λ = 0.97; 8, 239; P = 0.613) (Table 2.53), but varied among moist soil managed wetlands (Wilks' λ = 0.85; 24, 697; P = 0.028) (Table 2.54). There was no period x year (Wilks' λ = 0.93; 8, 239; P = 0.053) interaction. As no interactions occurred, no within year analyses were performed for wood storks. Regardless of month, diurnal period, and year, wood storks spent most (32-77%) of their time resting. Wood storks were only observed in moist soil managed wetlands two-five, but spent the most time resting in moist soil managed wetland four, and fed most in moist soil managed wetland five (Table 2.54).

Great Blue Heron: 2005

In 2005, 129 great blue heron focal samples were collected (Figure 2.2). Behaviors were similar among months (Wilks' λ = 0.82; 24, 296; P = 0.652) (Table 2.55), among moist soil managed wetlands (Wilks' λ = 0.85; 24, 296 P = 0.867) (Table 2.56), and between diurnal periods (Wilks' λ = 0.92; 8, 102; P = 0.412) (Table 2.57). There was no moist soil managed wetland x month (Wilks' λ = 0.54; 72, 628; P = 0.667) nor diurnal period x month (Wilks' λ = 0.75; 24, 296; P = 0.186) interaction. Great blue herons were not observed in the first two months, but spent most of the time either resting or in standing/waiting behaviors, irrespective of month, moist soil managed wetland, or diurnal period (Tables 2.55, 2.56, 2.57).

Little Blue Heron: 2005

In 2005, 207 little blue heron focal samples were collected (Figure 2.2). Behaviors varied among months (Wilks' $\lambda = 0.71$; 21, 523; $P < 0.001$) (Table 2.58) and between diurnal periods (Wilks' $\lambda = 0.91$; 7, 182; $P = 0.020$) (Table 2.59), but were similar among moist soil managed wetlands (Wilks' $\lambda = 0.84$; 21, 523; $P = 0.074$) (Table 2.60). There was a moist soil managed wetland x month (Wilks' $\lambda = 0.60$; 56, 985; $P = 0.001$) interaction but not a diurnal period x month (Wilks' $\lambda = 0.87$; 21, 523; $P = 0.292$) interaction. Little blue herons were not observed in the first two months, but spent more time in maintenance behaviors during May through mid July, and more time standing/waiting and feeding from July and August (Table 2.58). Little blue herons spent more time locomoting, standing/waiting and feeding during the early-midday diurnal period, and more time resting during the midday-late diurnal period (Table 2.59). In general, little blue heron time-activity budgets were similar among moist soil managed wetlands (Table 2.60).

DISCUSSION

Wading Bird Behavior: General Patterns

Wading bird time-activity budgets generated during this study can be characterized into two dominant behavioral categories, (1) feeding and feeding related behaviors (i.e., feeding, standing/waiting, or searching for food), and (2) resting and body maintenance behaviors (Table 2.1). Irrespective of years and species, when these two general categories are combined, they accounted for > 80% of the total time-activity budgets for each focal species (Tables 2.3, 2.7). However, this generalization masks interspecific differences in time spent in food acquisition behaviors and size and/or morphology-related foraging strategies among herons, egrets, and ibis, as well as the little time wood storks foraged or actively fed during this study (Tables 2.3, 2.7). For example, many wading birds forage by using stand and wait behaviors before striking at prey items (i.e., green heron, great egret, great blue heron), while others walk slowly and strike at prey while moving (i.e., little blue heron, cattle egret), and specifically snowy egrets often use footstirring to bring prey to the water surface (Meyerriecks 1959, Kushlan 1972). These interspecific differences in foraging strategies among herons, egrets, and ibis observed in this study, seem to generally reflect basic differences in foraging strategies observed in other studies (Meyerriecks 1959, Kahl and Peacock 1963, Kushlan 1979, Kushlan 1981).

Waders such as great and snowy egrets, and little blue and great blue herons are visual feeders and consequently spend more time searching for prey, either by stalking or as sit-and-wait stationary hunters (Kushlan 1978a). For example, all of these species spent considerable time (i.e., 20-55%) standing and waiting, and little time (i.e., 1-14%) actually feeding. These strategies may be used to compensate for higher energy expenditure during more active foraging bouts in larger waders. Conversely, smaller waders, like snowy egrets and little blue herons may conserve energy when water is too deep by feeding from perches above the water (Kushlan 1978a) or footstirring (observed only in snowy egrets in this study), slow wading, and moving in shallow water. For example, Willard (1977) revealed snowy egrets catch higher numbers of prey when footstirring in shallow water/mudflats than either little blue herons or tricolored herons (*Egretta tricolor*), which use slow wading or open wing behaviors. Furthermore, Brzorad et al. (2004) demonstrated that intake was higher than expenditure for snowy egrets, which balanced the energetic cost of walking and foraging strikes with foraging success, whereas great egrets spent twice the energy actively foraging than slow wading. Overall, foraging and food acquisition behaviors exhibited by waders in moist soil managed wetlands are similar to earlier studies on egret and heron feeding behavior (Meyerriecks 1959, Kushlan 1979, Kushlan 1981).

As opposed to egrets and herons, white ibis are more active, tactile feeders and spend little time in search for prey, as they do not rely upon vision for food acquisition (Kushlan 1978a, 1979). This foraging strategy was generally reflected in white ibis behaviors observed during this study, as they were observed actively feeding > 60% of the time (Table 2.1), and infrequently (< 6%) engaged in sit and wait hunting behaviors. Other tactile foragers, such as Caribbean flamingos (*Phoenicopterus ruber*) also engage in continuous feeding and moving behaviors, much like white ibis in this study (Espino-Barros and Baldassarre 1989). The other tactile forager observed, wood storks, did not use these moist soil wetlands for feeding despite similar foraging and moving tactics as white ibis (Kahl 1964).

As opposed to the egrets, herons, and ibis, wood storks used the moist soil managed wetlands primarily for resting and maintenance behaviors. For both years combined, they spent nearly 80% of the time in these two behaviors, and < 15% of the time feeding or in stand and wait behaviors (Table 2.1). Resting and body maintenance behaviors (i.e., > 30%) have also been reported as dominant wader behaviors in other studies (i.e., Gawlik and Sklar 2000, Traut and Hostetler 2003), but wood storks engaged in these behaviors nearly twice as much as any other focal species during this study. Most wading birds roost nocturnally and forage diurnally, but wood storks have been documented to forage at night as well as day (Bryan et al. 2001). As wood storks use tactile foraging (much like white ibis) they are more likely to feed nocturnally since they are not visual hunters (Kahl 1964, Kushlan 1978a), and nocturnal foraging may be a behavioral adaptation to avoid or escape interspecific competition with other diurnal tactile foragers such as white ibis (i.e., Watmough 1978). Other wading birds that have been documented foraging nocturnally are yellow crowned night herons (*Nycticorax violaceus*) and roseate spoonbills (*Ajaia ajaja*) (Rojas et al. 1999), both of which were observed performing bill jabbing and bill sweeping behaviors during this study (Appendices D and E). To determine if wood storks were foraging nocturnally, attempts were made to develop nocturnal time activity budgets for wood storks in 2005. However, they were largely unsuccessful due to equipment failure, but data that were collected indicated that wood storks still used snags for resting at night with little time devoted to feeding. Nesting behaviors usually were also prevalent at night (Appendix F.1).

Wading Bird Behavior: Seasonal, Diurnal and Moist Soil Wetland Effects

Although time-activity budgets as previously characterized were dominated by (1) feeding and food acquisition and (2) resting and maintenance behaviors, there were distinct changes in time spent in these behaviors over time in both years. In 2004, for all species combined, time spent in resting and body maintenance behaviors were consistent (i.e., 43-53%) from mid April to mid August, but jumped to nearly 90% during the last two weeks of August (Table 2.4). During the same time, feeding related behaviors were fairly consistent (i.e., 30-48%, mid April to mid August), and dropped to <10% of the time in late August (Table 2.4). In 2005, no drastic switch between time spent resting or feeding was observed, but time spent actually feeding, not necessarily in food acquisition behaviors increased over time, a direct contrast to 2004 (Table 2.8). This pattern has been observed in other studies, where time spent feeding in one season may be the inverse of resting in another (Morrier and McNeil 1991). As this study overlapped the end of spring migration, summer, and the beginning of fall migration, it is not unexpected that distinct shifts in feeding and resting behaviors occurred. For example, cattle and great egrets, and wood storks spent more time actually feeding upon arrival (i.e., April-May) than later in the summer, where they tended to spend more time in stand and wait behaviors (Tables 2.15, 2.18, 2.25, 2.28, 2.51). Conversely, little blue herons and snowy egrets fed and engaged in stand and wait behaviors more during July and August than during May and June (Table 2.58), and great blue herons tended (non-significant) to follow the same pattern (Table 2.55). Finally, white ibises tended to feed consistently throughout the study period in both years, although in late August 2005, they spent nearly 90% of their time in resting and maintenance behaviors

(Tables 2.45, 2.48), however sample sizes (n = 18) were low for this period in 2005.

Despite the generalized patterns for all species combined as related to year, there appears to be two time-related feeding patterns for wading birds observed during this study. Focal species tended to either (1) feed more upon arrival (i.e. April-May) to study site wetlands or (2) feed more prior to departure (late August). These patterns were generally consistent within species among years, despite observations starting earlier in 2005. Moreover, time spent locomoting declined for all species in both years, which may indicate a general familiarity of the study site wetlands by the focal species over time, where birds may not have to move as much to find suitable foraging, feeding, or resting locations (Yodor et al. 2004, Snell-Rood and Cristol 2005). The first strategy fits a generalized pattern of refueling upon arrival after migration (Pienkowski et al. 1984, Myers et al. 1987), where declines in feeding over time could be a response to decreased food quantity and quality during summer as wading birds will select habitats based on prey abundance (Goss-Custard 1970, Colwell and Landrum 1993). The second strategy tends to fit a generalized strategy of increased energy intake prior to migration, a behavior observed in other migrant passerines, shorebirds, and waterfowl (Fredrickson and Drobney 1979, Karasov and Pinshow 2000, Landys et al. 2005).

Species specific feeding patterns (i.e., upon arrival or prior to departure) may also be correlated with general migration strategies as there are two primary energetic demands on wading birds during migration: (1) refueling at stopover sites during migration and (2) fat accumulation in preparation for migration (Myers and McCaffery 1984). More time spent feeding upon arrival and prior to departure among herons and egrets, and constant feeding observed among white ibis, may not indicate greater amounts of available prey items but perhaps a lack of sufficient suitable prey to sustain over time. Migration patterns and strategies often depend upon the dynamics of energy reserve and deposition, which may be correlated to availability of stopover sites (Alerstam and Lindstrom 1990). Although short-flight migration strategies provide potentially more feeding opportunities, this strategy may not always be feasible due to drying or loss of wetland habitat (Iverson et al. 1996). Migration pressures are energetically costly to large species such as whooping cranes (*Grus americana*), a species of concern, which breeds on the Texas coast and winters in the arctic (Faanes 1992, Skagen and Knopf 1993). Migration strategies among many wading bird species involve selecting foraging habitat based on available suitable breeding habitat, where species such as white ibis, white-faced ibis and wood stork often are philopatric from year to year depending upon predictable wetland habitats (Ryder 1967, Frederick and Ogden 1997). Due to such great migration distances among many species, higher rates of feeding should be expected upon arrival and departure at stopover wetlands, which did occur at RCWMA.

Changes in general patterns did not seem to be affected by time of day among species in 2004, but did in 2005. However, cattle egret was the only species in which behavior selection seemed to be correlated with time of day. In 2004 cattle egrets fed more or less depending upon time of day (Table 2.16). Furthermore there was an inverse correlation in prey search time and prey consumption. Earlier in the day prey search time was higher, while feeding time was lower. In the afternoon prey search time was lower while feeding was higher (Table 2.16), which is contrary to other species resting in midday (Rave and Cordes 1993). In 2005, cattle egrets were more selective about search time (i.e., stand and wait) and spent more time searching rather than actual food consumption, where food items may not have been as abundant. Furthermore search time was overall much higher than consumption time in both years (Table 2.19). The versatile foraging ecology of this species allows greater adaptability to searching and feeding in multiple habitats (Meyerriecks 1960, Siegfried 1971).

Despite interspecific variability in foraging strategies upon arrival and prior to departure from study site wetlands, there were distinct differences in time spent feeding between 2004 and 2005 for all species combined. In general, time spent feeding increased over time in 2005 and decreased in 2004. This may be a direct result of differences in moist soil managed wetland drawdown timing between years. For example, in 2004, drawdowns were performed in late spring early summer and flooded in late summer early fall, where much of the available foraging habitat was located in isolated pools within moist soil managed wetlands. This is a typical drawdown regime, practiced to promote annual plant and seed production for wintering waterfowl (Low and Bellrose 1944), not necessarily to provide habitat during summer for wading birds. Conversely, in 2005, drawdowns were performed much later (i.e., June/July) and some (wetland numbers one, four) were either drawn down early, but reflooded soon or not drawn down at all. This is not a typical moist soil management practice, and was a result of different management priorities between TRWD and TPWD. Nonetheless, yearly differences in time spent feeding for all species combined are likely a response to these changes in drawdown strategies.

Timing of moist soil management water manipulations will influence habitat structure and prey availability and quality (Severson 1987, Murkin and Kadlec 1984, Colwell and Landrum 1993) which likely impacted time-activity budgets of the focal species. For example, prey availability may have been stable or even increased in 2005 as more water was present on moist soil managed wetlands, whereas in 2004, prey availability likely declined over time due to foraging pressures on isolated pools within moist soil managed wetlands by a suite of wading bird predators. Richardson and Taylor (2003) revealed wading bird abundance in rice fields declined over time as higher quality vertebrate prey declined and birds were forced to feed on lower quality invertebrates.

Despite yearly differences in flooding regimes on study site wetlands, there were also distinct differences in utilization rates of individual moist soil managed wetlands by focal species. For example, < 4% of all focal samples were generated from moist soil managed wetland one for both years combined. No observations of great egrets, white ibis and wood storks were made in wetland one in 2004 and in 2005 no cattle egrets, white ibis, wood stork, nor great and little blue herons were observed in wetland one (Figure 1.2). As white ibis were most frequently observed feeding, their absence from this particular wetland likely indicates either a general lack of suitable prey items or a lack of suitable foraging habitat (i.e., increased water depths), as does the lowest amount of time (< 3 %, in 2005) spent feeding for all species combined (Tables 2.6, 2.10). Wetland three was the most frequently used (i.e., 36% of all focal samples) in 2005, particularly for cattle and snowy egrets and wood storks. This wetland contains many snags in which cattle egrets and wood storks spent considerable time resting and in maintenance behaviors. During the latter months of 2005 this wetland was flooded and provided pockets of flooded emergent vegetation for snowy egrets to opportunistically search for prey and feed. Resting and maintenance behaviors were consistently higher in wetlands two and four in 2004 while in 2005, wading birds primarily fed in wetland four while resting and loafing in wetland two, which also contained snags for resting. Overall, yearly differences in water levels within and among moist soil managed wetlands dramatically altered wading bird utilization rates and subsequent behaviors observed within each wetland. Therefore cost/benefit analyses of management schemes can be examined by looking at the response of indicator species at different trophic levels as habitat changes.

Wading Bird Behavior: Flocking, Nesting, and Rare Observations

All focal species spent time in large flocks (> 20) feeding, resting, or in body maintenance behaviors (Appendix B). Flocking behavior in wading birds is not unusual, as aggregations (either single or multiple species) are often formed to aid in prey discovery, decrease predation, and increase the probability of prey disturbance by others within the flock for an individual's advantage (Rand 1954, Lack 1968, Krebs 1973), although some species may "parasitize" flocks, using them to locate food and feed near them, but not within the flock itself (Kushlan 1977a). Foraging in flocks has advantages over foraging alone, as it decreases search time between food patches, and increases the likelihood of foraging in suitable habitats (Kushlan 1981). Foraging success may be impacted by flock size, where success is higher in larger flocks (Nota 2003), although in dense flocks, prey detection decreases and increased flock density may reduce food availability (Kushlan 1977a), and dense flocks may eventually disband, making individuals more prone to predation (Kushlan 1976b). Many species, like the great egret and snowy egret, have white plumage, which aid in attracting other birds to flocks (Kushlan 1978). For example, Krebs (1974) and Kushlan (1977b) found wading birds are attracted to white decoys rather than blue decoys, which indicates that white wading birds (i.e., white ibis, snowy egrets, great egrets, etc.) may be used to indicate high habitat quality or prey abundance. For example, wading birds will form feeding associations specifically with white ibis, and as white ibis was observed to consistently feed at high rates throughout this study, they are likely a good indicator of habitat with high prey abundance (Courser and Dinsmore 1975).

Nesting behaviors (i.e., carrying twigs or other nest materials) were infrequently observed in this study (i.e., < 3 %, depending upon species) and in other studies involving multiple waterbird species (i.e., 10%, Traut and Hostetler 2003). In 2004, only cattle and great egrets were observed in nesting behaviors (Table 2.1), but in 2005 only little blue herons did not engage in any nesting behaviors (Table 2.7). Of these, wood storks spent nearly 3% of the time in nesting behaviors, the most of any species, and some storks were observed pulling and carrying branches at night (Appendix F.1). This is particularly interesting as wood storks are a species of concern, and no wood stork nests have been documented in Texas, although they are suspected to have nested along the Texas coast in the early 1900's (Palmer 1962, Oberholser and Kincaid 1974, C. Frentress, personal communication). Additionally flocks of > 750 have been observed at RCWMA during previous summers (C. Frentress, personal communication). Although optimal breeding locations for wading birds should be close to suitable feeding areas, prevent or discourage potential predators, and contain both nest sites and nesting materials (i.e., branches, snags, etc.) (Jenni 1969), RCWMA contains these elements for wood storks (and other focal species), however no nests were discovered on RCWMA despite the time frame of the study period occurring during the breeding season (i.e., March - July, or possibly through October for renesting attempts). The nearby Trinity River corridor and Richland Chambers reservoir also possess these habitat elements, and future surveys need to be performed to locate breeding colonies for wood storks. If wood storks are selecting nearby habitats for nesting they could most likely be located on a yearly basis as they are philopatric and some individuals may return if hydrological regimes are adequate (Ogden 1994, Frederick and Ogden 1997).

Infrequent or lack of use of an area for breeding may be affected by overall wetland quality (Kushlan 1978a). Moreover, fluctuating water levels may cause a shift in breeding locations between years (Kushlan 1978a, Custer at al. 1980). General behavior prior to breeding often consists of feeding away from the colony and roosting in the colony at night (Wiese 1976). Although cattle egrets occasionally roosted in large numbers (>200) in snags throughout the day, individuals generally left RCWMA in early evening, with only a few species remaining on wetlands at night, such as great blue heron, yellow-crowned night heron and wood stork. Comfort movements (i.e., shaking or fluffing feathers) and aggressive behaviors were infrequently observed (<1%) although these aggressive behaviors were considered feeding or roosting disputes, not nest site defense behaviors (Wiese 1976).

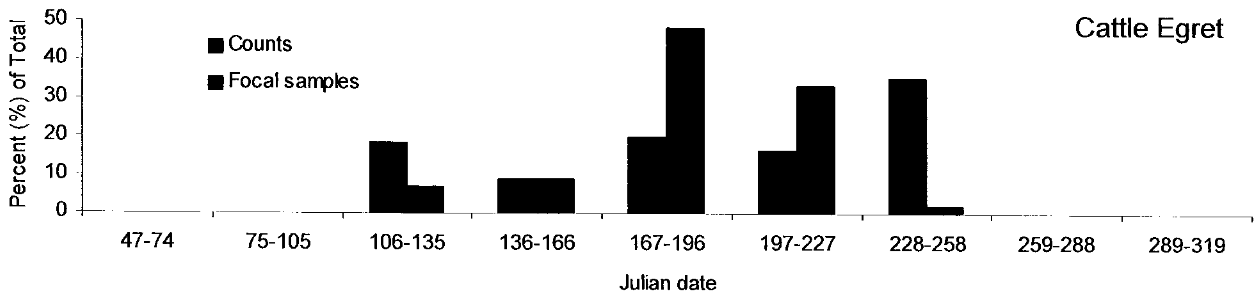
Management Implications

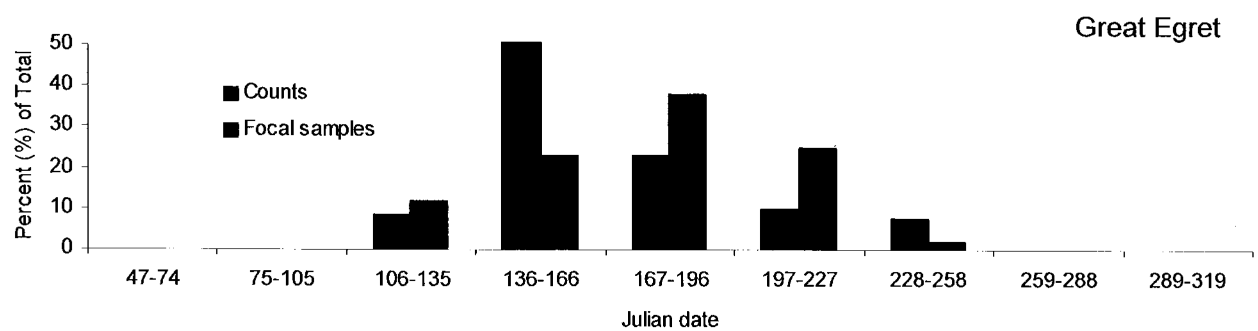
Knowledge of activity patterns has important consequences for wetland conservation, protection and management, as they provide insight into the functional role of wetland habitats for waterbirds (Caraco 1979, Espino-Barros and Baldassarre 1989). This study provides an initial description of behavioral patterns of wading birds during the breeding season on moist soil managed wetlands. In general, wading birds engaged in (1) feeding and food acquisition behaviors and (2) resting and body maintenance behaviors, both of which are generally related to physiology, energy conservation strategies, and migration strategies. As few studies have examined wading bird behavior on moist soil managed wetlands, knowledge of behavioral responses to such management is essential. Although waterbird diversity increases, in response to moist soil management strategies, have been documented in natural wetlands (i.e., playas, Anderson and Smith 1999) and in created wetlands (Stewart and Kantrud 1973), how they use those wetlands is equally important, as those data will indicate relative habitat quality.

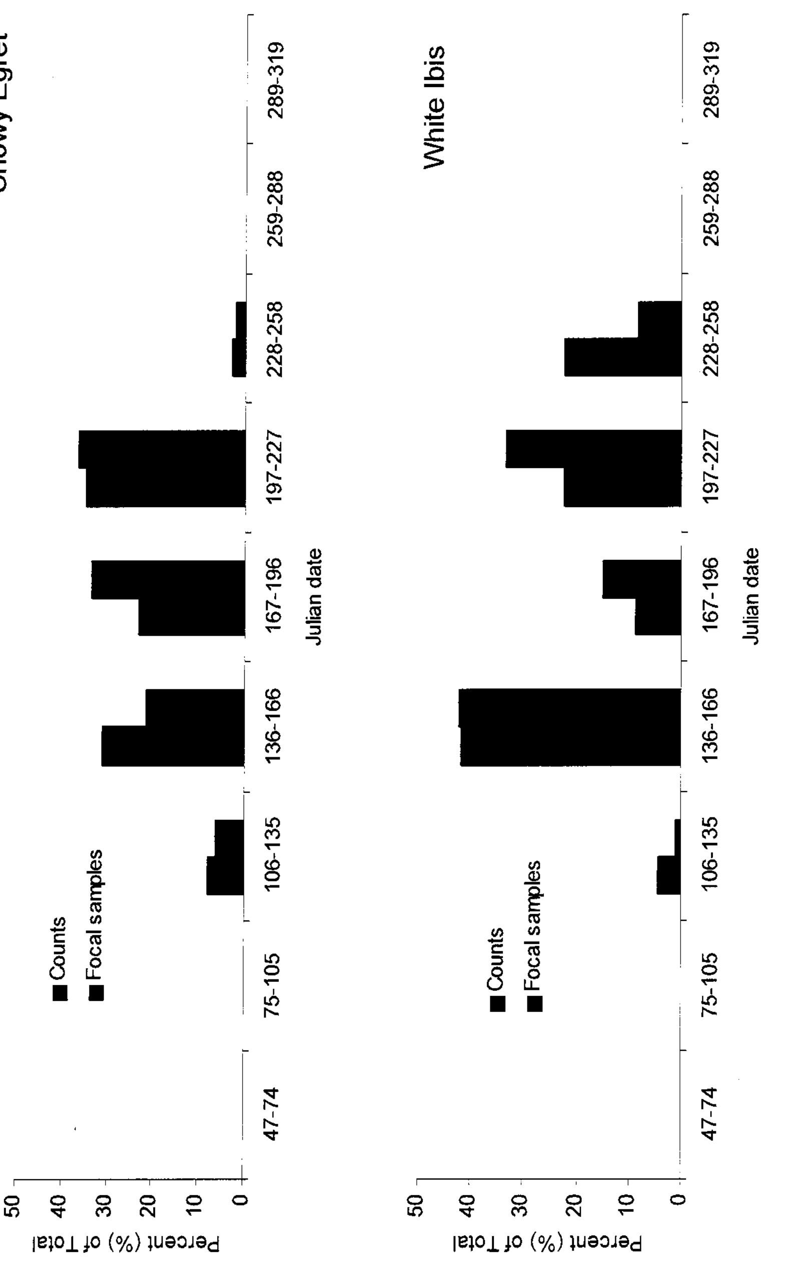
Moist soil management can be beneficial as it may create pools with high prey densities (Bryan et al. 2000), which are critical for foraging wading birds. As such, increased time feeding, as opposed to increased time resting, would indicate high prey availability, and therefore high foraging habitat quality. Because of the differences in water depths, drawdown regimes, and overall management strategies within each moist soil managed wetland at RCWMA, the WMA operates in a "wetland complex". In general, wading birds benefit from moist-soil management in a wetland complex, which provides diverse habitat for a diversity of waterbirds (Voigts 1976, Fredrickson and Reid 1986, Bowyer 2001, Bowyer 2002). However, dramatic hydrological changes (i.e., water levels too low or too high) may alter behavioral responses among wetland dependent species. For example, wood storks are sensitive to water level changes, where large colonies will abandon a site, even during the breeding season (Kushlan et al. 1975). As such, future moist soil management strategies may consider potential impacts on species of concern, such as wood storks. Although increased flooding over most of the annual cycle may benefit larger wading birds, other morphologically different waterbirds may not respond (i.e., shorebirds, small waders). If wetlands are not drawn down where decomposition and seed germination do not occur at some point during the annual cycle, as observed in wetland one, then the hydrophytic composition may be altered and submergent vegetation becomes more dominant rather than emergent seed producing plants. As such, as waterfowl migrate through and winter at RCWMA, these wetlands may only attract diving ducks and nonmigratory wading birds, thus limiting the potential for greater waterbird diversity.

The Texas coast is a key wintering area for many wading birds (Mikuska et al. 1998) and the RCWMA is an ideal stopover site during migration and during summer. As wading birds specifically select wetlands suitable for breeding, rather than arbitrary chosen sites (Hestbeck 1995, Niemuth and Solberg 2003), current management practices should consider wading bird migration and breeding. When moist soil management techniques are implemented, various habitats become available. For example, flooded agricultural fields may provide a rich food supply, open water habitats create new edge habitat, and when water levels decline, exposed shallow water and mudflats allow waders to walk and readily search for fish, reptiles, amphibians, and large invertebrates (Weller 1999). As additional wetlands are created at RCWMA, wading bird abundance should increase. However, beyond just abundance, time spent in different behaviors should provide insight into the functionality and overall quality of created moist soil managed wetlands.

Figure 2.1. Chronology of occurrence (%) for observations and focal individual samples of cattle egrets, great egrets, snowy egrets, white ibises, and wood storks on moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004.







Snowy Egret
White Ibis
Counts
Focal samples
Percent (%) of Total
0
10
20
30
40
50
47-74
75-105
106-135
136-166
167-196
197-227
228-258
259-288
289-319
Julian date

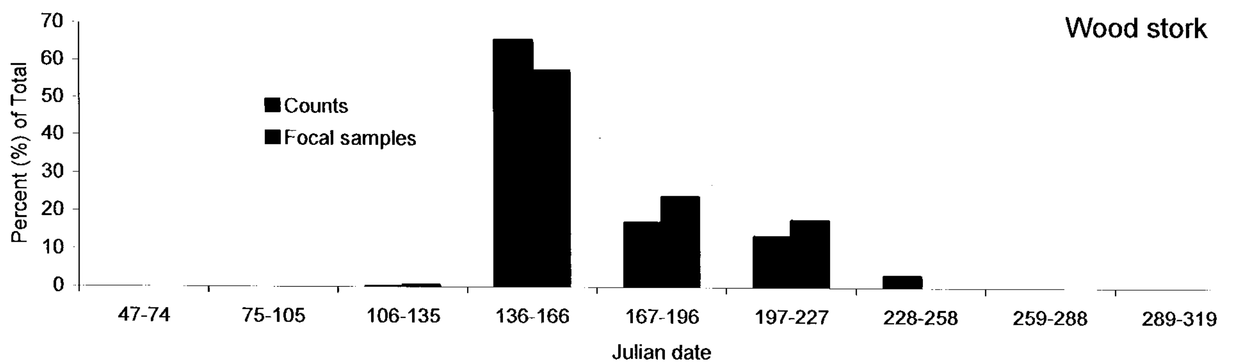
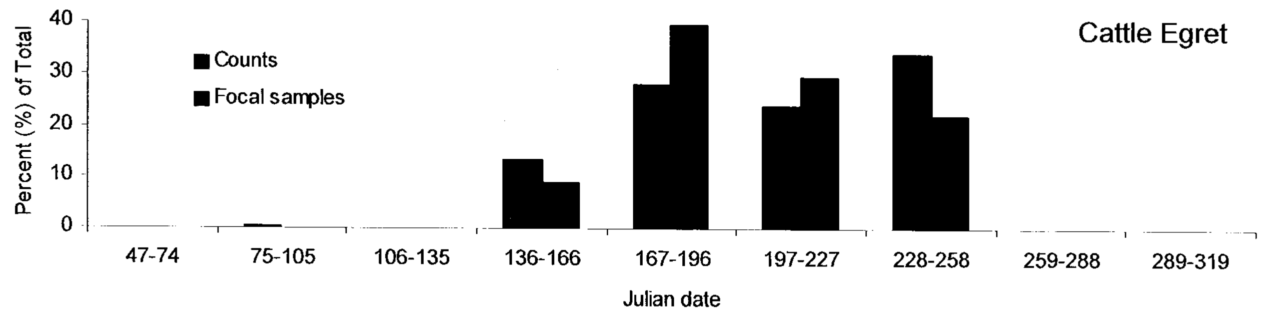
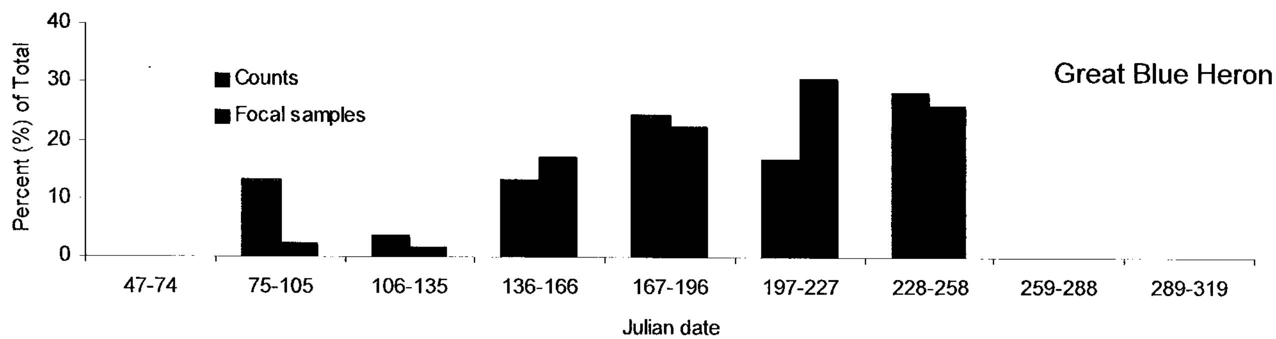
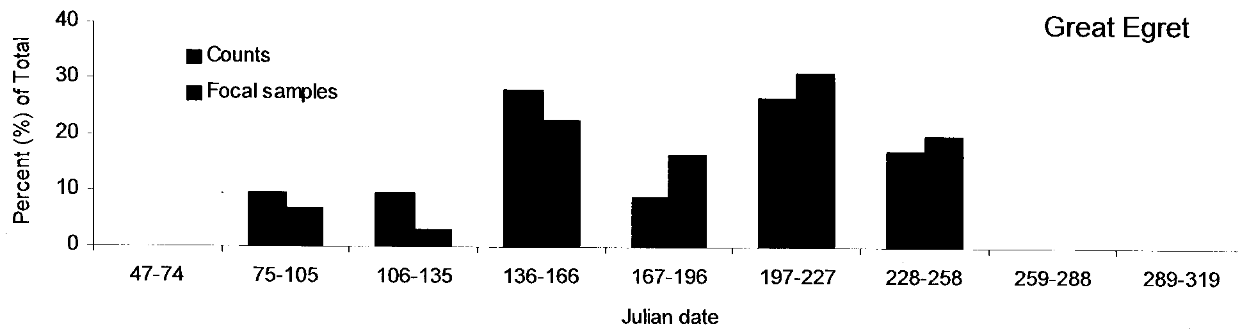
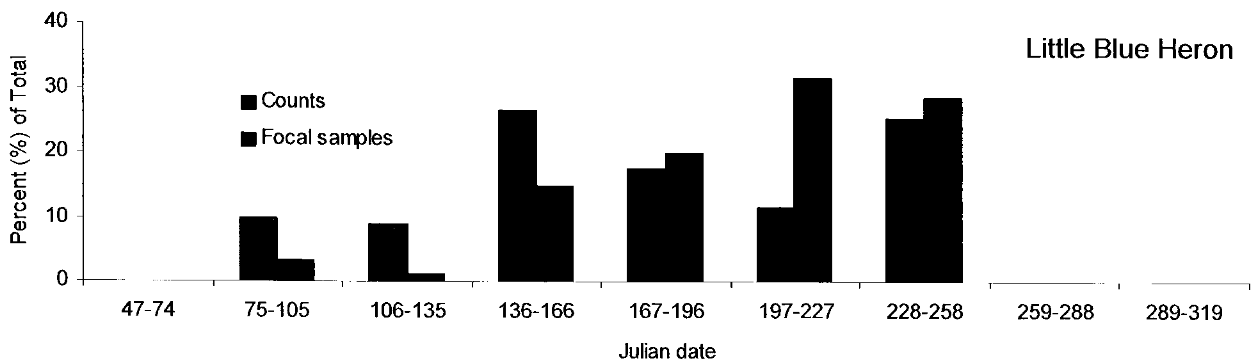

Wood stork
Counts
Focal samples
Percent (%) of Total
0
10
20
30
40
50
60
70
47-74
75-105
106-135
136-166
167-196
197-227
228-258
259-288
289-319
Julian date

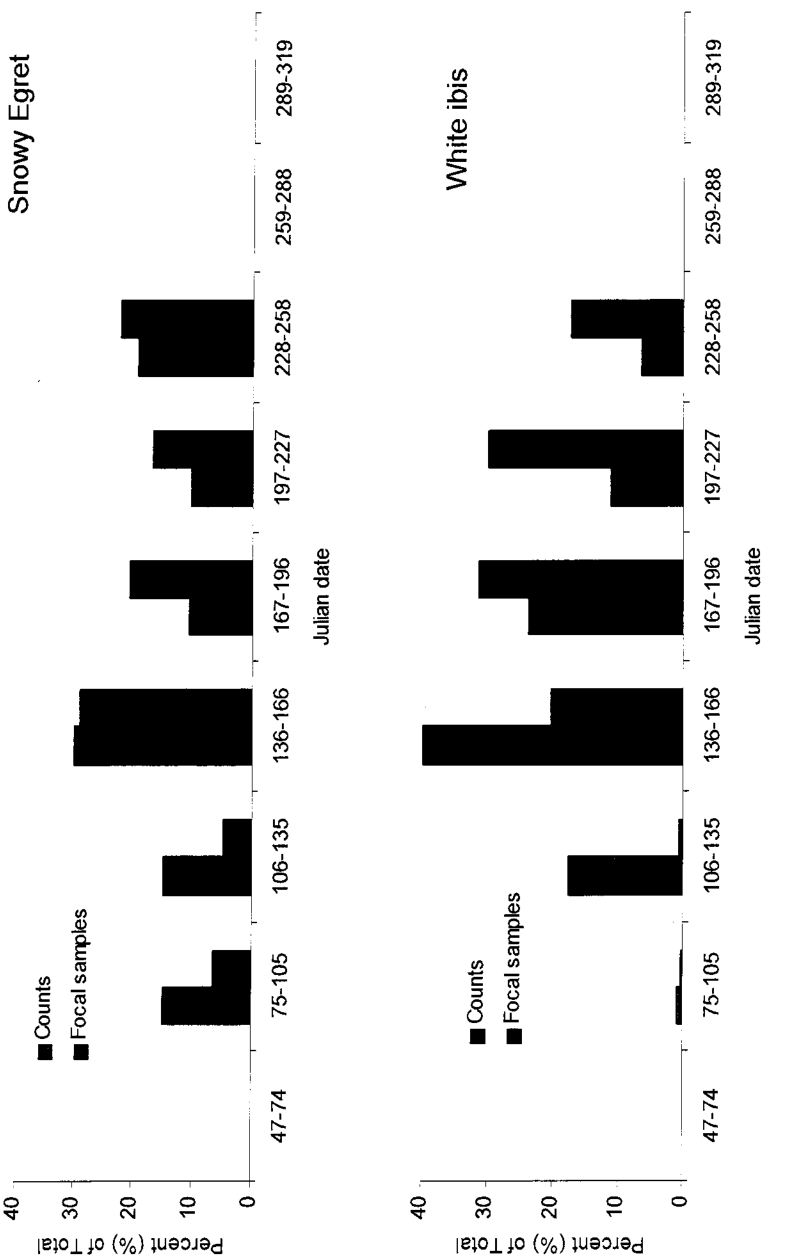
Figure 2.2. Chronology of occurrence (%) for observations and focal individual samples of cattle egrets, great egrets, snowy egrets, white ibises, and wood storks on moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 March - 1 September, 2005.

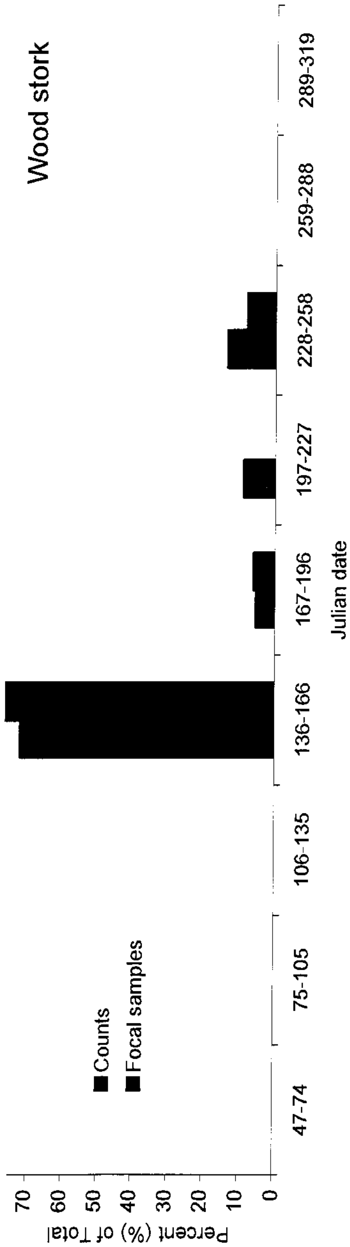





Great Egret
Counts
Focal samples
Percent (%) of Total
40
30
20
10
0
47-74
75-105
106-135
136-166
167-196
197-227
228-258
259-288
289-319
Julian date


Little Blue Heron
Counts
Focal samples
Percent (%) of Total
40
30
20
10
0
47-74
75-105
106-135
136-166
167-196
197-227
228-258
259-288
289-319
Julian date


Snowy Egret
Counts
Focal samples
Percent (%) of Total
0
10
20
30
40
47-74
75-105
106-135
136-166
167-196
197-227
228-258
259-288
289-319
Julian date
White ibis
Counts
Focal samples
Percent (%) of Total
0
10
20
30
40
47-74
75-105
106-135
136-166
167-196
197-227
228-258
259-288
289-319
Julian date



Wood stork
Counts
Focal samples
Percent (%) of Total
70
60
50
40
30
20
10
0
47-74
75-105
106-135
136-166
167-196
197-227
228-258
259-288
289-319
Julian date

Table 2.1. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for wading bird behaviors measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Species											
	Cattle Egret (n = 935)		Great Egret (n = 1250)		Snowy Egret (n = 736)		White Ibis (n = 826)		Wood Stork (n = 255)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	13.36 b[1]	0.75	13.42 b	0.59	18.15 a	0.86	4.85 c	0.41	5.38 c	0.87	44.97	< 0.001
Standing (%)	22.61 b	1.11	46.78 a	1.17	13.94 c	0.73	5.43 d	0.50	8.68 c	1.56	194.69	< 0.001
Feeding (%)	2.99 d	0.29	2.37 d	0.21	37.21 b	1.31	62.08 a	1.46	6.74 c	1.42	494.56	< 0.001
Footstirring (%)	0.00 b	0.00	0.00 b	0.00	1.51 a	0.28	0.00 b	0.00	0.00 b	0.00	29.50	< 0.001
Aggression (%)	0.03 b	0.01	0.06 b	0.01	0.27 a	0.05	0.05 b	0.01	0.14 b	0.07	13.31	< 0.001
Alert (%)	0.05 a	0.02	0.05 a	0.03	0.03 a	0.01	0.01a	0.01	0.08 a	0.06	1.12	0.343
Maintenance (%)	28.68 a	1.21	18.26 b	0.91	14.65 c	1.15	12.05 c	0.94	15.71 c	1.81	27.66	< 0.001
Resting (%)	31.35 b	1.24	18.69 c	0.93	14.11 d	1.15	15.28 d	1.13	62.37 a	2.61	93.00	< 0.001
Comfort (%)	0.17 a	0.03	0.09 b	0.02	0.11 a	0.04	0.08 b	0.01	0.13 a	0.03	3.49	0.007
Nesting (%)	0.73 a	0.20	0.19b	0.09	0.01 b	0.01	0.15 b	0.12	0.77 a	0.44	7.16	< 0.001

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.2. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for wading bird behaviors measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Year					
	2004 (*n* = 1210)		2005 (*n* = 2792)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	13.52 a[1]	0.64	11.33 b	0.37	6.34	0.011
Standing (%)	20.92 a	0.93	25.52 a	0.68	1.00	0.317
Feeding (%)	14.38 a	0.81	24.62 b	0.71	63.99	< 0.001
Footstirring (%)	0.34 a	0.09	0.25 a	0.06	0.10	0.751
Aggression (%)	0.13 a	0.03	0.08 a	0.01	0.17	0.679
Alert (%)	0.05 a	0.03	0.04 a	0.01	0.16	0.689
Maintenance (%)	22.95 a	1.01	16.69 b	0.59	13.34	0.003
Resting (%)	27.25 a	1.09	20.99 b	0.67	4.85	0.027
Comfort (%)	0.16 a	0.03	0.09 a	0.01	3.52	0.060
Nesting (%)	0.29 b	0.12	0.32 a	0.08	5.72	0.016

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.3. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for wading bird behaviors measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Species											
	Cattle egret (n = 232)		Great egret (n = 355)		Snowy egret (n = 294)		White ibis (n = 152)		Wood stork (n = 177)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	14.40 b[1]	1.63	13.53 b	1.09	21.74 a	1.49	4.77 c	1.07	6.24 c	1.18	15.04	< 0.001
Standing (%)	19.58 c	2.09	39.47 a	2.11	27.70 b	1.88	5.65 d	1.34	11.41 d	2.17	20.18	< 0.001
Feeding (%)	3.08 c	0.61	4.08 c	0.53	13.18 b	1.09	38.33 a	3.59	7.19 c	1.77	72.25	< 0.001
Footstirring (%)	0.00 a	0.00	0.00 a	0.00	1.39 a	0.36	0.00 a	0.00	0.00 a	0.00	7.17	< 0.001
Aggression (%)	0.02 a	0.02	0.05 a	0.02	0.34 a	0.10	0.09 a	0.03	0.12 a	0.09	1.43	0.222
Alert (%)	0.03 a	0.02	0.09 a	0.08	0.02 a	0.01	0.00	0.00	0.07 a	0.07	1.83	0.120
Maintenance (%)	35.67 a	2.57	24.44 b	1.89	19.14 c	2.03	19.83 c	2.69	12.29 c	1.88	7.52	< 0.001
Resting (%)	25.73 b	2.21	18.00 bc	1.64	16.30 c	1.91	31.19 b	3.36	62.58 a	3.16	52.21	< 0.001
Comfort (%)	0.32 a	0.11	0.08 a	0.02	0.19 a	0.09	0.14 a	0.04	0.11 a	0.04	2.15	0.072
Nesting (%)	1.17 a	0.58	0.25 b	0.19	0.00 b	0.00	0.00 b	0.00	0.00 b	0.00	3.04	0.016

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.4. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for wading bird behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004.

	Month											
	16 Apr - 15 May (n = 78)		16 May - 15 June (n = 307)		16 June - 15 July (n = 424)		16 July- 15 Aug (n = 383)		16 Aug - 1 Sept (n = 18)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	17.21 a[1]	2.29	16.94 a	1.41	14.42 ab	1.15	9.65 c	0.94	0.37 bc	0.33	6.98	< 0.001
Standing (%)	27.54 b	3.60	19.97 b	1.77	23.06 b	1.63	30.06 a	1.99	0.64 b	0.52	3.44	0.008
Feeding (%)	11.14 a	2.08	15.39 a	1.66	7.45 b	0.91	11.03 b	1.29	8.81 c	6.09	15.38	< 0.001
Footstirring (%)	0.06 a	0.04	0.54 a	0.21	0.23 a	0.11	0.36 a	0.19	0.00 a	0.00	0.36	0.838
Aggression (%)	0.14 a	0.06	0.12 a	0.06	0.20 a	0.07	0.59 ab	0.02	0.06 a	0.06	0.39	0.812
Alert (%)	0.11 a	0.07	0.05 a	0.04	0.00 a	0.00	0.09 a	0.08	0.00 a	0.00	0.43	0.790
Maintenance (%)	18.06 ab	3.28	20.12 a	1.96	27.44 a	1.82	21.21 a	1.75	23.77 a	7.95	2.21	0.066
Resting (%)	25.33 b	3.99	26.28 c	2.21	26.53 b	1.79	27.38 b	1.99	66.28 a	9.69	10.21	< 0.001
Comfort (%)	0.32 a	0.13	0.21 a	0.09	0.09 a	0.03	0.17 a	0.06	0.07 a	0.07	0.97	0.422
Nesting (%)	0.00 a	0.00	0.39 a	0.29	0.57 a	0.29	0.00 a	0.00	0.00 a	0.00	1.73	0.141

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.5. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for wading bird behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Moist Soil Managed Wetland											
	Wetland 1 (n = 53)		Wetland 2 (n = 252)		Wetland 3 (n = 120)		Wetland 4 (n = 148)		Wetland 5 (n = 637)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	19.86 a[1]	3.30	17.84 a	1.71	11.07 ab	1.91	7.30 ab	1.37	13.20 a	0.82	5.28	0.003
Standing (%)	28.76 a	4.53	14.79 b	1.60	12.89 b	2.45	15.46 b	2.47	32.17 a	1.51	11.77	< 0.001
Feeding (%)	10.14 a	2.18	12.71 a	1.55	14.85 a	2.73	7.88 ab	1.86	10.12 a	0.93	3.63	0.006
Footstirring (%)	1.34 a	0.87	0.59 a	0.24	0.64 a	0.39	0.08 a	0.06	0.15 a	0.10	0.48	0.747
Aggression (%)	0.51 a	0.32	0.19 a	0.08	0.04 a	0.03	0.03 a	0.02	0.11 a	0.04	2.01	0.090
Alert (%)	0.02 a	0.02	0.13 a	0.12	0.00	0.00	0.08 a	0.08	0.02 a	0.01	1.83	0.120
Maintenance (%)	27.14 a	5.42	27.53 a	2.38	23.07 a	3.15	29.62 a	3.06	19.21 ab	1.31	2.68	0.030
Resting (%)	11.86 b	3.53	25.25 b	2.30	37.04 a	3.81	38.98 a	3.32	24.75 a	1.49	10.59	< 0.001
Comfort (%)	0.37 a	0.17	0.14 a	0.06	0.17 a	0.07	0.13 a	0.04	0.16 a	0.05	0.17	0.954
Nesting (%)	0.00 a	0.00	0.81a	0.47	0.24 a	0.24	0.45 a	0.45	0.09 a	0.09	1.50	0.200

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.6. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for wading bird behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Diurnal Period					
	Early-Midday (*n* =751)		Midday-Late (*n* = 459)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	13.06 a[1]	0.80	14.29 a	1.05	1.01	0.315
Standing (%)	24.29 a	1.27	24.70 a	1.19	0.22	0.641
Feeding (%)	10.01 a	0.85	12.24 a	1.19	3.61	0.057
Footstirring (%)	0.27 a	0.10	0.44 a	0.17	0.93	0.335
Aggression (%)	0.15 a	0.04	0.09 a	0.04	0.49	0.482
Alert (%)	0.08 a	0.04	0.00 a	0.00	2.43	0.119
Maintenance (%)	24.05 a	1.31	21.14 a	1.59	0.16	0.685
Resting (%)	27.51 a	1.40	26.83 a	1.78	2.98	0.084
Comfort (%)	0.12 a	0.04	0.23 a	0.06	3.88	0.049
Nesting (%)	0.46 a	0.20	0.03 a	0.02	1.44	0.229

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.7. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for wading bird behaviors measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Species															
	Cattle egret (*n* = 703)		Great blue heron (*n* = 129)		Great egret (*n* = 895)		Little blue heron (*n* = 207)		Snowy egret (*n* = 442)		White ibis (*n* = 674)		Wood stork (*n* = 78)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	13.01 b[1]	0.84	11.70 b	1.83	13.37 b	0.69	27.99 a	2.03	15.75 b	1.00	4.87 c	0.43	3.41 c	0.86	19.64	< 0.001
Standing (%)	23.60 d	1.30	54.20 a	3.79	49.68 a	1.39	32.60 c	2.31	43.53 b	1.72	5.37 e	0.52	2.48 e	1.04	77.96	< 0.001
Feeding (%)	2.97 c	0.32	1.08 c	0.51	1.69 c	0.19	11.77 b	1.11	14.44 b	0.97	67.44 a	1.52	5.71 c	2.31	301.07	< 0.001
Footstirring (%)	0.00 b	0.00	0.00 b	0.00	0.00 b	0.00	0.00 b	0.00	1.59 a	0.39	0.00 b	0.00	0.00 b	0.00	7.34	< 0.001
Aggression (%)	0.03 ab	0.01	0.02 ab	0.01	0.07 ab	0.018	0.11 a	0.046	0.22 a	0.05	0.04 ab	0.01	0.18 a	0.07	7.33	< 0.001
Alert (%)	0.06 a	0.02	0.00 a	0.00	0.03 a	0.01	0.00 a	0.00	0.03 a	0.01	0.01 a	0.01	0.11 a	0.11	0.53	0.787
Maintenance (%)	26.37 a	1.35	7.37 c	1.74	15.80 b	1.01	18.27 b	2.40	11.66 bc	1.33	10.29 c	0.96	23.46 b	3.97	12.84	< 0.001
Resting (%)	33.20 b	1.47	25.54 c	3.53	18.95 d	1.13	9.12 e	1.62	12.64 e	1.44	11.69 e	1.11	61.89 a	4.64	43.32	< 0.001
Comfort (%)	0.12 a	0.02	0.02 a	0.01	0.10 a	0.01	0.06 a	0.02	0.06 a	0.01	0.06 a	0.01	0.18 a	0.06	1.09	0.363
Nesting (%)	0.58 b	0.18	0.01 bc	0.01	0.17 c	0.10	0.00	0.00	0.01 c	0.01	0.18 c	0.15	2.53 a	1.41	6.57	< 0.001

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.8. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for wading bird behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Month													
	16 Mar – 15 Apr (n = 89)		16 Apr - 15 May (n = 50)		16 May - 15 June (n = 665)		16 June - 15 July (n = 811)		16 July- 15 Aug (n = 875)		16 Aug - 1 Sept (n = 638)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	28.19 a[1]	3.06	22.60 b	4.01	13.88 b	0.81	11.67 bc	0.73	10.51 c	0.66	11.59 c	0.74	10.54	< 0.001
Standing (%)	38.33 bc	3.68	29.55 c	5.11	26.78 b	1.35	25.45 b	1.27	29.80 b	1.30	44.57 a	1.61	13.69	< 0.001
Feeding (%)	3.45 a	0.82	4.73 a	1.54	21.01 a	1.34	17.48 ab	1.17	20.27 a	1.20	18.84 a	1.28	5.06	< 0.001
Footstirring (%)	1.24 a	0.70	0.92 a	0.44	0.69 a	0.22	0.05 ab	0.05	0.001 ab	0.001	0.06 ab	0.06	11.92	< 0.001
Aggression (%)	0.53 a	0.19	0.14 b	0.09	0.11 b	0.02	0.04 b	0.01	0.05 b	0.01	0.06 b	0.01	10.06	< 0.001
Alert (%)	0.08 a	0.05	-	-	0.06 a	0.02	0.05 a	0.02	0.01 a	0.006	0.01 a	0.01	1.05	0.384
Maintenance (%)	14.13 b	3.06	26.86 a	5.61	18.68 b	1.28	21.21 b	1.18	14.17 bc	0.97	10.51 bc	1.02	12.18	< 0.001
Resting (%)	13.10 ab	2.87	13.69 a	4.02	17.86 ab	1.28	23.79 a	1.25	24.91 a	1.30	14.05 ab	1.24	4.42	< 0.005
Comfort (%)	0.04 ab	0.02	0.03 ab	0.03	0.14 a	0.02	0.11 a	0.01	0.04 b	0.009	0.07 b	0.01	1.16	0.327
Nesting (%)	-	-	1.37 a	1.18	0.70 a	0.23	0.06 b	0.03	0.19 ab	0.11	0.19 ab	0.15	1.86	0.098

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.9. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for wading bird behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (*n* = 1836)		Midday-Late (*n* = 1292)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	13.24 a[1]	0.51	11.30 b	0.53	8.07	0.004
Standing (%)	30.37 a	0.87	32.57 a	1.08	3.38	0.066
Feeding (%)	18.19 b	0.76	19.39 a	0.95	4.13	0.042
Footstirring (%)	0.18 a	0.07	0.27 a	0.08	0.41	0.524
Aggression (%)	0.07 a	0.01	0.09 a	0.01	0.36	0.549
Alert (%)	0.04 a	0.01	0.01 a	0.01	0.09	0.767
Maintenance (%)	17.89 a	0.75	14.30 b	0.80	4.88	0.027
Resting (%)	19.53 b	0.80	21.62 a	1.00	9.35	0.002
Comfort (%)	0.08 a	0.009	0.09 a	0.01	0.05	0.831
Nesting (%)	0.29 a	0.08	0.27 a	0.12	0.00	0.947

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.10. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for wading bird behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Moist Soil Managed Wetland											
	Wetland 1 (n = 109)		Wetland 2 (n = 667)		Wetland 3 (n = 1120)		Wetland 4 (n = 649)		Wetland 5 (n = 583)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	9.83 c[1]	1.74	9.79 c	0.75	10.88 b	0.57	9.60 b	0.70	22.15 a	1.05	12.05	< 0.001
Standing (%)	40.68 a	4.05	34.65 a	1.63	28.66 a	1.10	25.32 a	1.40	37.35 a	1.50	1.89	0.110
Feeding (%)	2.66 b	0.62	5.12 b	0.65	25.84 a	1.12	30.61 bc	1.63	10.18 b	0.91	4.35	0.001
Footstirring (%)	0.08 b	0.04	0.17 b	0.07	0.30 a	0.13	0.06 b	0.06	0.33 a	0.11	9.41	< 0.001
Aggression (%)	0.28 a	0.14	0.06 ab	0.01	0.07 ab	0.01	0.03 ab	0.01	0.12 a	0.03	2.66	0.031
Alert (%)	0.00 a	0.00	0.05 a	0.02	0.03 a	0.01	0.01 a	0.01	0.05 a	0.02	0.95	0.435
Maintenance (%)	16.69 a	2.97	21.61 a	1.32	16.21 a	0.94	15.52 a	1.20	11.79 b	1.05	4.24	0.002
Resting (%)	29.12 a	3.88	28.18 b	1.49	17.46 c	0.99	18.45 b	1.34	17.64 bc	1.35	5.87	< 0.001
Comfort (%)	0.06 a	0.02	0.09 a	0.01	0.11 a	0.01	0.07 a	0.01	0.07 a	0.01	0.46	0.763
Nesting (%)	0.53 a	0.53	0.23 a	0.12	0.38 a	0.13	0.28 a	0.17	0.10 a	0.08	0.31	0.871

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.11. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for cattle egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March -1 September, 2005.

	Month											
	16 Apr - 15 May (n = 17)		16 May - 15 June (n = 83)		16 June - 15 July (n = 394)		16 July- 15 Aug (n = 287)		16 Aug - 1 Sept (n = 154)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	10.43 b[1]	4.88	22.71 a	3.05	15.26 a	1.26	8.87 b	1.06	12.10 b	1.73	8.30	< 0.001
Standing (%)	14.94 a	6.54	25.68 a	3.48	21.79 a	1.67	19.07 a	1.92	30.47 a	3.09	2.12	0.076
Feeding (%)	9.08 a	5.22	5.99 a	1.35	2.62 b	0.36	2.17 b	0.44	3.22 b	0.77	6.06	< 0.001
Footstirring (%)	-	-	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.13 a	0.09	0.04 a	0.02	0.02 a	0.01	0.01 a	0.01	0.07 a	0.04	1.42	0.225
Alert (%)	0.05 a	0.05	0.02 a	0.02	0.08 a	0.04	0.03 a	0.02	0.00 a	0.00	0.67	0.612
Maintenance (%)	31.87 a	8.65	22.47 a	3.79	28.92 a	1.84	31.65 a	2.23	25.46 a	3.00	0.82	0.511
Resting (%)	32.64 a	8.39	19.24 a	3.31	30.54 a	1.85	37.43 a	2.35	28.45 a	3.15	2.10	0.079
Comfort (%)	0.82 a	0.49	0.20 a	0.11	0.18 a	0.04	0.14 a	0.07	0.11 a	0.03	0.77	0.542
Nesting (%)	0.00 a	0.00	3.57 a	1.45	0.51 a	0.26	0.59 a	0.33	0.07 a	0.05	5.40	0.092

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.12. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for cattle egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (*n* =610)		Midday-Late (*n* = 325)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	13.01 a[1]	0.93	14.00 a	1.27	1.71	0.191
Standing (%)	21.23 a	1.33	25.19 a	1.96	0.30	0.585
Feeding (%)	2.71 a	0.30	3.53 a	0.60	3.44	0.063
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.01 a	0.007	0.05 a	0.02	1.65	0.198
Alert (%)	0.06 a	0.03	0.03 a	0.02	1.00	0.317
Maintenance (%)	31.14 a	1.54	24.05 a	1.89	3.49	0.061
Resting (%)	30.69 a	1.52	32.58 a	2.13	0.12	0.733
Comfort (%)	0.12 b	0.02	0.26 a	0.07	9.19	0.002
Nesting (%)	0.97 a	0.29	0.25 a	0.16	2.45	0.118

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.13. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for cattle egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Moist Soil Managed Wetland											
	Wetland 1 (*n* = 24)		Wetland 2 (*n* = 314)		Wetland 3 (*n* = 196)		Wetland 4 (*n* = 90)		Wetland 5 (*n* = 311)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	22.04 a	5.55	3.70 bc	0.58	10.23 b	1.46	5.82 b	1.65	26.58 a	1.60	42.37	< 0.001
Standing (%)	24.21 a	6.06	12.74 b	0.58	20.18 b	2.34	15.91 ab	3.43	35.90 a	1.97	21.26	< 0.001
Feeding (%)	3.95 ab	1.20	1.78 ab	0.40	3.29 a	0.75	0.74 b	0.22	4.61 a	0.56	6.54	< 0.001
Footstirring (%)	-	-	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.13 a	0.13	0.01 a	0.007	0.02 a	0.01	0.01 a	0.01	0.05 a	0.02	1.67	0.153
Alert (%)	0.03 a	0.03	0.06 a	0.03	0.08 a	0.07	0.00 a	0.00	0.03 a	0.02	0.53	0.712
Maintenance (%)	31.60 a	8.19	38.05 a	2.21	32.90 a	2.81	35.06 a	3.80	14.46 ab	1.58	20.59	< 0.001
Resting (%)	17.42 b	6.12	42.35 a	2.24	32.27 b	2.72	40.99 a	3.94	17.94 bc	1.79	14.11	< 0.001
Comfort (%)	0.58 a	0.35	0.18 a	0.04	0.17 a	0.05	0.10 a	0.04	0.15 a	0.06	0.44	0.780
Nesting (%)	0.00 b	0.00	1.07 a	0.45	0.80 a	0.38	1.33 a	0.93	0.20 b	0.16	3.36	0.009

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.14. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for cattle egret behaviors between years measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Year					
	2004 (*n* = 232)		2005 (*n* = 703)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	14.40 a[1]	1.63	13.01 a	0.84	1.34	0.248
Standing (%)	19.58 b	2.09	23.60 a	1.30	4.40	0.036
Feeding (%)	3.07 a	0.60	2.97 a	0.32	1.86	0.172
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.02 a	0.01	0.03 a	0.10	2.44	0.118
Alert (%)	0.02 a	0.02	0.06 a	0.02	0.03	0.867
Maintenance (%)	35.66 a	2.56	26.37 b	1.35	9.42	0.002
Resting (%)	25.73 b	2.20	33.20 a	1.47	5.13	0.023
Comfort (%)	0.31 a	0.10	0.12 b	0.02	5.50	0.019
Nesting (%)	1.17 a	1.17	0.58 a	0.18	0.69	0.407

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.15. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for cattle egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Month									
	16 Apr - 15 May (n = 17)		16 May - 15 June (n = 22)		16 June - 15 July (n = 111)		16 July- 15 Aug (n = 82)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	10.43 ab[1]	4.88	30.96 a	7.04	15.79 a	2.56	8.90 b	1.91	4.52	0.004
Standing (%)	14.95 a	6.54	24.03 a	7.41	15.45 a	2.60	24.93 a	4.06	0.73	0.535
Feeding (%)	9.08 a	5.22	9.72 a	3.70	1.92 b	0.42	1.61 b	0.52	9.02	< 0.001
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.13 a	0.09	0.00 a	0.00	0.03 a	0.03	0.00 a	0.00	1.52	0.211
Alert (%)	0.05 a	0.05	0.00 a	0.00	0.00 a	0.00	0.06 a	0.06	0.07	0.975
Maintenance (%)	31.87 a	8.65	20.31 a	8.01	37.92 a	3.73	37.51 a	4.37	1.81	0.146
Resting (%)	32.64 a	8.39	10.43 a	5.01	27.04 a	3.22	26.62 a	3.83	1.55	0.203
Comfort (%)	0.82 a	0.49	0.41 a	0.41	0.20 a	0.09	0.33 a	0.23	0.70	0.553
Nesting (%)	0.00 a	0.00	4.12 a	3.85	1.62 a	0.94	0.00 a	0.00	1.33	0.265

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.16. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for cattle egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Diurnal Period					
	Early-Midday (*n* = 158)		Midday-Late (*n* = 74)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	13.00 a[1]	1.82	17.38 a	3.32	0.04	0.839
Standing (%)	21.24 a	0.45	4.66 a	1.62	1.73	0.189
Feeding (%)	2.33 b	2.61	16.01 a	3.42	22.40	< 0.001
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.02 a	0.02	0.01 a	0.01	0.55	0.458
Alert (%)	0.03 a	0.03	0.00 a	0.00	0.75	0.388
Maintenance (%)	36.54 a	3.12	33.79 a	4.53	0.13	0.722
Resting (%)	25.02 a	2.61	27.23 a	4.09	0.66	0.417
Comfort (%)	0.15 a	0.06	0.66 a	0.30	2.38	0.124
Nesting (%)	1.61 a	0.85	0.21 a	0.12	0.85	0.357

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.17. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for cattle egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Moist Soil Managed Wetland									
	Wetland 1 (n = 24)		Wetland 2 (n = 68)		Wetland 4 (n = 36)		Wetland 5 (n = 104)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	22.04 a[1]	5.55	2.67 b	1.48	7.33 b	3.21	22.75 a	2.78	10.63	< 0.001
Standing (%)	24.21 a	6.06	2.24 b	1.58	11.57 b	4.54	32.61 a	3.55	8.74	< 0.001
Feeding (%)	3.95 b	1.20	0.12 b	0.07	0.76 b	0.39	5.60 a	1.26	18.62	< 0.001
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.13 a	0.13	0.00 a	0.00	0.02 a	0.02	0.01 a	0.01	0.52	0.668
Alert (%)	0.03 a	0.03	0.00 a	0.00	0.00 a	0.00	0.04 a	0.04	0.13	0.940
Maintenance (%)	31.60 ab	8.19	50.46 a	4.67	47.90 a	6.01	22.69 b	3.52	3.91	0.009
Resting (%)	17.42 ab	6.12	41.12 a	4.40	30.44 a	4.90	15.95 b	2.94	9.57	< 0.001
Comfort (%)	0.58 a	0.35	0.35 a	0.19	0.09 a	0.07	0.30 a	0.18	0.94	0.420
Nesting (%)	0.00 b	0.00	3.01 a	1.71	1.83 a	1.83	0.00 b	0.00	5.01	0.002

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.18. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for cattle egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Month									
	16 May - 15 June (*n* = 61)		16 June - 15 July (*n* = 283)		16 July- 15 Aug (*n* = 205)		16 Aug - 1 Sept (*n* = 154)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	19.74 a[1]	3.24	15.05 a	1.44	8.86 b	1.28	12.10 ab	1.73	3.83	0.009
Standing (%)	26.27 a	3.95	24.28 a	2.09	16.72 a	2.13	30.47 a	3.09	1.53	0.205
Feeding (%)	4.65 a	1.24	2.89 a	0.48	2.39 a	0.58	3.22 a	0.77	0.40	0.753
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.06 a	0.02	0.01 ab	0.01	0.01 ab	0.01	0.07 a	0.04	5.41	0.001
Alert (%)	0.03 a	0.03	0.12 a	0.07	0.02 a	0.02	0.00 a	0.00	1.11	0.344
Maintenance (%)	23.24 a	4.31	25.40 a	2.08	29.31 a	2.58	25.46 a	3.00	1.51	0.209
Resting (%)	22.42 b	4.08	31.91 ab	2.25	41.76 a	2.86	28.45 b	3.15	4.38	0.004
Comfort (%)	0.13 a	0.05	0.17 a	0.04	0.06 a	0.02	0.11 a	0.03	1.58	0.193
Nesting (%)	3.37 a	1.44	0.07 a	0.04	0.82 a	0.46	0.07 a	0.05	1.21	0.306

Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.19. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for cattle egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (*n* = 452)		Midday-Late (*n* = 251)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	13.01 a[1]	1.08	13.00a	1.33	0.56	0.455
Standing (%)	21.22 b	1.55	27.91 a	2.31	11.25	0.008
Feeding (%)	2.84 a	0.37	3.19 a	0.61	1.57	0.210
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.01 b	0.006	0.06 a	0.02	15.56	< 0.001
Alert (%)	0.07 a	0.03	0.04 a	0.03	0.27	0.605
Maintenance (%)	29.25 a	1.77	21.18 b	2.02	6.58	0.010
Resting (%)	32.67 a	1.82	34.15 a	2.48	0.91	0.339
Comfort (%)	0.11 a	0.02	0.14 a	0.01	0.05	0.829
Nesting (%)	0.75 a	0.26	0.26 b	0.21	6.31	0.012

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.20. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for cattle egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Moist Soil Managed Wetland									
	Wetland 2 (*n* = 246)		Wetland 3 (*n* = 196)		Wetland 4 (*n* = 54)		Wetland 5 (*n* = 207)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	3.98 c[1]	0.62	10.23 b	1.46	4.82 c	1.73	28.50 a	1.95	34.01	< 0.001
Standing (%)	15.65 b	2.08	20.18 b	2.34	18.79 b	4.85	37.56 a	2.37	15.56	< 0.001
Feeding (%)	2.24 ab	0.51	3.29 a	0.75	0.73 b	0.26	4.11 a	0.56	2.98	0.030
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.01 a	0.009	0.02 a	0.01	0.00 a	0.00	0.07 a	0.03	1.76	0.153
Alert (%)	0.08 a	0.04	0.08 a	0.07	0.00 a	0.00	0.02 a	0.01	0.28	0.842
Maintenance (%)	34.62 a	2.47	32.90 a	2.81	26.50 a	4.60	10.33 b	1.52	14.85	< 0.001
Resting (%)	42.70 a	2.59	32.27 b	2.72	48.02 a	5.53	18.94 c	2.25	14.67	< 0.001
Comfort (%)	0.13 a	0.03	0.17 a	0.05	0.11 a	0.05	0.08 b	0.02	2.65	0.048
Nesting (%)	0.53 a	0.33	0.80 a	0.38	1.00 a	0.96	0.30 a	0.24	2.56	0.054

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.21. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for great egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March -1 September, 2005.

	Month													
	16 Mar – 15 Apr (*n* = 61)		16 Apr - 15 May (*n* = 70)		16 May - 15 June (*n* = 285)		16 June - 15 July (*n* = 288)		16 July- 15 Aug (*n* = 369)		16 Aug - 1 Sept (*n* = 177)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	27.06 a	3.88	22.41 a	2.80	15.63 b	1.32	12.33 c	1.18	10.49 c	0.93	9.42 c	1.20	11.83	< 0.001
Standing (%)	34.78 c	4.52	37.00 c	4.11	39.93 c	2.29	41.04 c	2.44	50.43 b	2.23	67.52 a	2.89	11.32	< 0.001
Feeding (%)	1.74 b	0.42	7.22 a	1.57	3.06 b	0.41	1.90 bc	0.40	1.31 bc	0.21	2.48 b	0.75	8.15	< 0.001
Footstirring (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.17 a	0.09	0.10 a	0.04	0.06 a	0.02	0.08 a	0.04	0.04 a	0.01	0.01 a	0.01	0.89	0.484
Alert (%)	0.01 a	0.01	0.06 a	0.06	0.10 a	0.05	0.01 a	0.01	0.07 a	0.07	0.01 a	0.01	1.18	0.318
Maintenance (%)	18.03 a	4.03	17.31 ab	3.75	24.94 a	2.18	25.03 a	2.12	14.13 ab	1.47	5.51 c	1.29	10.13	< 0.001
Resting (%)	16.89 a	3.75	14.76 b	3.49	15.70 ab	1.75	19.27 a	1.85	23.42 a	1.94	14.84 b	2.47	2.41	0.034
Comfort (%)	0.03 a	0.03	0.12 a	0.07	0.17 a	0.05	0.08 a	0.02	0.06 a	0.01	0.08 a	0.03	0.35	0.879
Nesting (%)	0.00 b	0.00	0.98 a	0.84	0.33 a	0.25	0.22 a	0.21	0.00	0.00	0.07 b	0.07	2.36	0.037

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.22. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for great egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Moist Soil Managed Wetland											
	Wetland 1 (n = 83)		Wetland 2 (n = 298)		Wetland 3 (n = 235)		Wetland 4 (n = 226)		Wetland 5 (n = 408)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	5.99 c	1.38	12.20 b	1.25	10.70 bc	1.23	18.54 a	1.54	14.53 b	1.00	7.20	< 0.001
Standing (%)	38.28 b	4.74	51.88 a	2.50	44.52 b	2.76	48.22 a	2.57	45.28 ab	1.98	4.10	0.002
Feeding (%)	1.66 b	0.59	2.58 a	0.53	2.03 b	0.33	2.02 b	0.33	2.73 a	0.39	8.84	< 0.001
Footstirring (%)	-	-	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.00 a	0.00	0.04 a	0.02	0.06 a	0.02	0.03 a	0.01	0.11 a	0.03	1.57	0.179
Alert (%)	0.00 b	0.00	0.12 a	0.10	0.01 a	0.01	0.00 b	0.00	0.06 a	0.03	6.15	< 0.001
Maintenance (%)	19.97 a	3.64	15.17 b	1.73	22.19 a	2.23	16.76 b	2.15	18.71 ab	1.59	3.98	0.003
Resting (%)	33.26 a	4.57	17.79 b	1.90	19.84 b	2.15	14.29 bc	1.97	18.14 b	1.59	6.66	< 0.001
Comfort (%)	0.07 a	0.03	0.07 a	0.02	0.19 a	0.06	0.09 a	0.02	0.06 a	0.01	1.70	0.146
Nesting (%)	0.70 a	0.70	0.07 a	0.05	0.40 a	0.30	0.02 a	0.02	0.14 a	0.14	1.38	0.237

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.23. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for great egret behaviors between years measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Year					
	2004 (*n* = 355)		2005 (*n* = 895)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	13.52 a[1]	1.09	13.37 a	0.69	0.14	0.703
Standing (%)	39.47 b	2.10	49.68 a	1.39	10.45	0.001
Feeding (%)	4.07 a	0.53	1.69 b	0.19	49.72	< 0.001
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.04 a	0.02	0.07 a	0.01	1.25	0.263
Alert (%)	0.09 a	0.08	0.03 b	0.01	5.82	0.016
Maintenance (%)	24.44 a	1.89	15.80 a	1.01	1.97	0.160
Resting (%)	18.00 a	1.63	18.95 a	1.13	0.99	0.320
Comfort (%)	0.07 a	0.02	0.10 a	0.01	0.05	0.831
Nesting (%)	0.25 a	0.18	0.17 a	0.10	2.84	0.092

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.24. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for great egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (n =723)		Midday-Late (n = 527)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	12.63 a	0.77	14.49 a	0.89	0.34	0.561
Standing (%)	45.80 a	1.56	48.12 a	1.76	1.85	0.173
Feeding (%)	2.12 a	0.27	2.70 a	0.31	1.49	0.222
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.05 a	0.01	0.07 a	0.02	0.00	0.964
Alert (%)	0.08 a	0.04	0.01 a	0.005	4.75	0.029
Maintenance (%)	20.68 a	1.26	14.92 a	1.27	7.09	0.007
Resting (%)	18.18 a	1.20	19.38 a	1.47	0.17	0.679
Comfort (%)	0.08 a	0.01	0.11 a	0.02	1.99	0.158
Nesting (%)	0.22 a	0.12	0.15 a	0.12	0.35	0.551

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.25. Means ($\bar{x}$), Standard Errors (SE) and F and P values resulting from univariate analysis of variance for great egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Month									
	16 April-15 May (n = 42)		16 May-15 June (n = 84)		16 June-15 July (n = 139)		16 July-15 August (n = 90)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	22.04 a[1]	3.10	19.93 a	2.80	11.06 b	1.60	7.38 b	1.56	6.92	0.002
Standing (%)	35.13 a	4.94	31.05 a	3.69	38.28 a	3.45	51.19 a	4.63	0.29	0.832
Feeding (%)	11.06 a	2.42	4.90 b	1.13	2.98 bc	0.80	1.73 c	0.44	4.91	0.002
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.11 a	0.06	0.03 a	0.03	0.07 a	0.05	0.00 a	0.00	0.07	0.975
Alert (%)	0.10 b	0.10	0.00 b	0.00	0.00 b	0.00	0.32 a	0.32	10.62	< 0.001
Maintenance (%)	13.08 a	3.72	29.14 a	4.27	28.64 a	3.20	18.86 a	3.36	2.22	0.085
Resting (%)	18.24 a	4.85	14.53 b	3.06	18.43 a	2.55	20.45 a	3.58	4.00	0.008
Comfort (%)	0.20 a	0.13	0.04 a	0.03	0.07 a	0.03	0.04 a	0.03	1.21	0.305
Nesting (%)	0.00 a	0.00	0.33 a	0.33	0.43 a	0.43	0.00 a	0.00	0.09	0.965

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.26. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for great egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Moist Soil Managed Wetland									
	Wetland 2 (n = 34)		Wetland 3 (n = 44)		Wetland 4 (n = 27)		Wetland 5 (n = 250)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	24.24 a[1]	5.19	10.48 b	3.06	15.85 b	4.41	11.96 b	1.14	7.21	< 0.001
Standing (%)	23.36 b	2.96	21.61 b	5.15	38.31 a	2.20	44.94 a	2.57	2.73	0.043
Feeding (%)	12.11 a	4.71	2.48 b	1.12	4.32 b	7.60	3.23 b	0.53	7.24	< 0.001
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.03 a	0.03	0.06 a	0.06	0.00 a	0.00	0.05 a	0.03	0.16	0.925
Alert (%)	0.85 a	0.85	0.00 b	0.00	0.00 b	0.00	0.01 b	0.01	12.49	< 0.001
Maintenance (%)	27.86 a	6.96	34.21 a	5.41	18.74 a	6.73	22.87 a	2.20	1.21	0.305
Resting (%)	8.50 b	3.72	30.23 a	5.08	22.65 a	6.91	16.63 ab	1.91	2.95	0.032
Comfort (%)	0.00 b	0.00	0.24 a	0.14	0.11 a	0.08	0.05 ab	0.01	4.05	0.007
Nesting (%)	0.00 a	0.00	0.64 a	0.64	0.00	0.00	0.24 a	0.24	0.06	0.981

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.27. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for great egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Diurnal Period					
	Early-Midday (*n* = 204)		Midday-Late (*n* = 151)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	12.26 a[1]	1.41	15.22 a	1.72	0.22	0.636
Standing (%)	40.01 a	2.84	38.74 a	3.13	0.20	0.657
Feeding (%)	3.08 a	0.59	5.41 a	0.95	5.41	0.020
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.06 a	0.03	0.02 a	0.02	0.30	0.586
Alert (%)	0.16 a	0.14	0.00 a	0.00	0.60	0.440
Maintenance (%)	26.31 a	2.55	21.91 a	2.81	0.72	0.390
Resting (%)	17.60 a	2.09	18.54 a	2.61	1.65	0.020
Comfort (%)	0.04 a	0.01	0.12 a	0.04	0.75	0.388
Nesting (%)	0.43 a	0.32	0.00 a	0.00	0.45	0.505

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.28. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for great egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Month													
	16 Mar – 15 Apr (n = 61)		16 Apr - 15 May (n = 28)		16 May - 15 June (n = 201)		16 June - 15 July (n = 149)		16 July- 15 Aug (n = 279)		16 Aug - 1 Sept (n = 177)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	27.06 a[1]	3.88	22.96 a	5.30	13.84 b	1.45	13.53 b	1.73	11.50 b	1.11	9.42 c	1.20	8.54	< 0.001
Standing (%)	34.78 c	4.52	39.81 bc	7.21	43.64 b	2.82	43.61 b	3.45	50.18 b	2.55	67.52 a	2.89	6.02	< 0.001
Feeding (%)	1.74 ab	0.42a	1.46 ab	0.60	2.29 a	0.32	0.89 b	0.20	1.18 ab	0.23	2.48 a	0.75	3.48	0.004
Footstirring (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.17 a	0.09	0.09 a	0.06	0.08 a	0.04	0.10 a	0.07	0.05 a	0.02	0.01 a	0.01	0.59	0.706
Alert (%)	0.01 b	0.01	0.00 b	0.00	0.14 a	0.07	0.01 b	0.01	0.00 b	0.00	0.01 b	0.01	3.63	0.002
Maintainence (%)	18.03 a	4.03	23.65 a	7.48	23.19 a	2.52	21.66 a	2.80	12.60 ab	1.62	5.51 c	1.29	4.24	0.008
Resting (%)	16.89 a	3.75	9.55 b	4.78	16.19 ab	2.13	20.05 a	2.69	24.37 a	2.29	14.84 ab	2.47	2.38	0.036
Comfort (%)	0.04 a	0.03	0.00 a	0.00	0.22 a	0.07	0.08 a	0.03	0.06 a	0.02	0.08 a	0.03	1.44	0.206
Nesting (%)	0.00 b	0.00	2.46 a	2.10	0.33 b	0.32	0.02 b	0.02	0.00 b	0.00	0.07 b	0.07	48.08	< 0.001

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.29. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for great egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Moist Soil Managed Wetland											
	Wetland 1 (n = 83)		Wetland 2 (n = 264)		Wetland 3 (n = 191)		Wetland 4 (n = 199)		Wetland 5 (n = 158)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	6.00 b[1]	1.38	10.26 b	1.19	10.75 b	1.34	18.90 a	1.65	18.64 a	1.83	5.69	< 0.002
Standing (%)	38.28 a	4.74	55.56 a	2.67	49.79 a	3.07	49.56 a	2.73	45.83 a	3.13	1.27	0.281
Feeding (%)	1.66 a	0.59	1.36 a	0.41	1.93 a	0.32	1.71 a	0.23	1.93 a	0.57	0.53	0.712
Footstirring (%)	-	-	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.00 a	0.00	0.04 a	0.02	0.06 a	0.03	0.03 b	0.01	0.20 a	0.08	2.34	0.053
Alert (%)	0.00 a	0.00	0.03 a	0.02	0.01 a	0.01	0.00 a	0.00	0.15 a	0.08	1.40	0.231
Maintenance (%)	19.97 a	3.64	13.54 ab	1.71	19.42 a	2.42	16.49 a	2.27	12.14 b	2.07	3.94	0.003
Resting (%)	33.26 a	4.57	18.99 a	2.08	17.44 a	2.34	13.15 a	2.02	20.52 a	2.78	1.22	0.302
Comfort (%)	0.07 a	0.03	0.08 a	0.02	0.18 a	0.07	0.08 a	0.02	0.08 a	0.02	0.03	0.997
Nesting (%)	0.70 a	0.70	0.08 b	0.05	0.35 a	0.34	0.02 b	0.02	0.00b	0.00	104.10	< 0.001

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.30. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for great egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (n = 519)		Midday-Late (n = 376)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	12.78 a[1]	0.92	14.19 a	1.05	0.10	0.747
Standing (%)	48.08 a	1.85	51.88 a	2.10	0.52	0.470
Feeding (%)	1.74 a	0.29	1.61 a	0.19	0.03	0.871
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.04 a	0.01	0.09 a	0.03	0.20	0.656
Alert (%)	0.05 a	0.02	0.01 a	0.008	0.22	0.638
Maintenance (%)	18.47 a	1.43	12.12 a	1.36	2.07	0.150
Resting (%)	18.41 a	1.46	19.71 a	1.78	0.09	0.767
Comfort (%)	0.10 a	0.02	0.11 a	0.03	0.07	0.795
Nesting (%)	0.13 a	0.11	0.21 a	0.17	0.44	0.505

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.31. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for snowy egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Month													
	16 Mar – 15 Apr (n = 28)		16 Apr - 15 May (n = 41)		16 May - 15 June (n = 193)		16 June - 15 July (n = 192)		16 July- 15 Aug (n = 184)		16 Aug - 1 Sept (n = 98)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	30.66 a	4.91	17.87 b	3.94	24.23 a	1.69	17.77 b	1.75	14.46 b	1.69	10.33 b	1.31	6.89	< 0.001
Standing (%)	46.08 b	6.16	19.07 d	4.72	33.31 bc	2.26	29.63 bc	2.50	35.83 b	2.72	67.37 a	2.72	12.15	< 0.001
Feeding (%)	7.16 b	2.32	10.87 b	2.83	15.80 a	1.30	11.39 ab	1.33	16.36 a	1.88	13.94 ab	1.41	3.89	0.001
Footstirring (%)	3.96 a	2.16	1.23 ab	0.54	3.25 a	0.81	0.73 b	0.32	0.76 b	0.40	0.42 b	0.42	5.18	< 0.001
Aggression (%)	1.33 a	0.54	0.19 b	0.13	0.23 b	0.07	0.40 b	0.14	0.10 bc	0.04	0.08 b	0.03	2.75	0.018
Alert (%)	0.24 a	0.17	0.07 b	0.07	0.01 b	0.01	0.03 b	0.02	0.02 b	0.01	0.00b	0.00	3.72	0.002
Maintenance (%)	5.65 b	3.80	24.35 a	5.65	14.26 ab	2.26	20.39 a	2.53	14.08 ab	2.27	3.68 b	1.54	3.21	0.007
Resting (%)	4.84 ab	3.73	26.13 a	5.80	8.59 b	1.84	19.54 a	2.51	18.27 a	2.62	4.08 b	1.83	6.14	< 0.001
Comfort (%)	0.04 a	0.04	0.10 a	0.05	0.23 a	0.13	0.05 a	0.02	0.09 a	0.03	0.06 a	0.03	1.60	0.158
Nesting (%)	0.00 a	0.00	0.00 a	0.00	0.00 a	0.00	0.03 a	0.03	0.00 a	0.00	0.00 a	0.00	0.98	0.426

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.32. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for snowy egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March -1 September, 2005.

	Diurnal Period					
	Early-Midday (*n* =465)		Midday-Late (*n* = 271)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	18.72 a	1.09	17.15 a	1.35	0.54	0.462
Standing (%)	36.03 a	1.63	39.22 a	2.18	1.29	0.256
Feeding (%)	12.13 b	0.79	17.04 a	1.42	16.68	< 0.001
Footstirring (%)	1.18 a	0.32	2.06 a	0.49	2.01	0.156
Aggression (%)	0.25 a	0.06	0.28 a	0.09	0.00	0.960
Alert (%)	0.04 a	0.01	0.00 a	0.00	2.55	0.110
Maintenance (%)	16.17 a	1.49	12.03 b	1.76	4.41	0.036
Resting (%)	15.27 a	1.49	12.10 a	1.80	1.99	0.158
Comfort (%)	0.13 a	0.05	0.08 a	0.02	0.36	0.549
Nesting (%)	0.01 a	0.01	0.00 a	0.00	0.32	0.571

[1]Means followed by the same letter within the same row are not different (*P* > 0.05).

Table 2.33. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for snowy egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Moist Soil Managed Wetland											
	Wetland 1 (n = 55)		Wetland 2 (n = 157		Wetland 3 (n = 238)		Wetland 4 (n = 68)		Wetland 5 (n = 218)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	19.95 b	3.21	28.31 a	2.27	12.55 b	1.14	11.38 b	2.44	18.58 b	1.52	5.13	< 0.004
Standing (%)	40.01 a	5.08	28.60 b	2.49	45.15 a	2.34	28.58 b	4.37	36.71 ab	2.36	3.55	0.007
Feeding (%)	10.80 ab	2.14	14.01 a	1.51	17.92 a	1.53	7.10 b	1.90	12.45 ab	1.14	2.68	0.030
Footstirring (%)	1.44 a	0.83	1.68 a	0.49	1.75 a	0.63	0.80 a	0.62	1.34 a	0.41	1.41	0.228
Aggression (%)	0.99 a	0.40	0.40 a	0.13	0.10 a	0.03	0.01 a	0.01	0.23 a	0.08	2.38	0.050
Alert (%)	0.00 a	0.00	0.06 a	0.03	0.03 a	0.01	0.00 a	0.00	0.02 a	0.01	1.46	0.211
Maintenance (%)	15.31 a	4.38	14.69 a	2.50	9.82 a	1.68	25.68 a	4.73	16.26 a	2.17	1.45	0.214
Resting (%)	11.33 a	3.75	12.14 a	2.34	12.53 a	1.99	26.33 a	4.79	14.11 a	2.06	2.02	0.090
Comfort (%)	0.12 a	0.06	0.06 a	0.02	0.06 a	0.02	0.07 a	0.04	0.21 a	0.12	1.08	0.364
Nesting (%)	0.00 a	0.00	0.00 a	0.00	0.02 a	0.02	0.00 a	0.00	0.00 a	0.00	0.22	0.925

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.34. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for snowy egret behaviors between years measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Year					
	2004 (*n* = 294)		2005 (*n* = 442)			
	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	21.73 a	1.49	15.75 a	1.00	0.41	0.523
Standing (%)	27.70 a	1.87	43.53 a	1.72	4.95	0.026
Feeding (%)	13.18 a	1.09	14.44 a	0.97	0.92	0.338
Footstirring (%)	1.38 a	0.36	1.59 a	0.39	0.20	0.653
Aggression (%)	0.33 a	0.10	0.22 a	0.05	0.10	0.756
Alert (%)	0.02 a	0.01	0.03 a	0.01	1.32	0.251
Maintenance (%)	19.13 a	2.02	11.66 a	1.33	0.45	0.504
Resting (%)	16.30 a	1.90	12.64 a	1.44	0.30	0.586
Comfort (%)	0.19 a	0.09	0.06 a	0.01	0.55	0.457
Nesting (%)	0.00 a	0.00	0.01 a	0.01	0.13	0.714

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.35. Means ($\bar{x}$), Standard Errors (SE) and F and P values resulting from univariate analysis of variance for snowy egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Month									
	16 April-15 May (n = 19)		16 May-15 June (n = 64)		16 June-15 July (n = 101)		16 July-15 August (n = 110)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	12.19 a[1]	4.35	30.02 a	3.36	24.82 a	2.60	15.61 a	2.23	4.26	0.005
Standing (%)	22.04 a	7.32	24.93 a	3.52	23.42 a	2.71	34.21 a	1.20	0.58	0.626
Feeding (%)	13.15 a	4.87	15.21 a	2.16	17.16 a	2.30	8.34 a	3.56	3.31	0.020
Footstirring (%)	0.23 a	0.17	2.60 a	0.96	0.96 a	0.46	1.26 a	0.66	0.78	0.504
Aggression (%)	0.19 a	0.19	0.13 a	0.10	0.72 a	0.26	0.12 a	0.07	1.11	0.345
Alert (%)	0.15 a	0.15	0.04 a	0.04	0.00 a	0.00	0.00 a	0.00	0.16	0.920
Maintenance (%)	16.71 a	6.88	19.44 a	4.55	19.85 a	3.51	18.72 a	3.29	0.51	0.674
Resting (%)	34.44 a	9.57	7.05 a	2.87	12.99 a	2.83	21.57 a	3.55	1.82	0.144
Comfort (%)	0.13 a	0.09	0.53 a	0.41	0.04 a	0.02	0.13 a	0.06	0.75	0.523
Nesting (%)	-	-	-	-	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.36. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for snowy egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Diurnal Period					
	Early-Midday (n = 196)		Midday-Late (n = 98)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	22.09 a[1]	1.86	21.02 a	2.48	0.01	0.939
Standing (%)	26.70 a	2.26	29.69 a	2.33	0.53	0.466
Feeding (%)	11.14 a	1.12	17.26 a	3.33	1.02	0.313
Footstirring (%)	1.05 a	0.38	2.05 a	0.77	0.22	0.636
Aggression (%)	0.38 a	0.12	0.24 a	0.17	0.36	0.551
Alert (%)	0.03 a	0.02	0.00 a	0.00	2.25	0.135
Maintenance (%)	21.39 a	2.58	14.62 a	3.19	0.75	0.387
Resting (%)	16.95 a	2.38	14.99 a	3.16	0.10	0.753
Comfort (%)	0.23 a	0.13	0.10 a	0.04	0.07	0.798
Nesting (%)	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.37. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for snowy egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Moist Soil Managed Wetland											
	Wetland 1 (n = 29)		Wetland 2 (n = 91)		Wetland 3 (n = 32)		Wetland 4 (n = 40)		Wetland 5 (n = 102)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	18.05 b[1]	3.96	32.87 a	3.01	20.33 b	4.44	8.03 bc	2.52	18.66 b	2.29	3.57	0.007
Standing (%)	35.52 a	6.59	26.06 a	2.87	11.60 a	3.95	16.57 a	4.60	37.21 a	3.52	2.23	0.066
Feeding (%)	15.25 a	3.61	17.59 a	2.18	15.65 a	3.86	6.69 a	2.48	10.42 a	1.51	2.07	0.085
Footstirring (%)	2.44 a	1.56	1.65 a	0.64	2.38 a	1.43	0.29 a	0.22	0.95 a	0.60	0.64	0.637
Aggression (%)	0.82 a	0.57	0.49 a	0.22	0.00 a	0.00	0.00 a	0.00	0.29 a	0.13	0.68	0.605
Alert (%)	0.00 a	0.00	0.03 a	0.03	0.00 a	0.00	0.00 a	0.00	0.02 a	0.02	1.65	0.163
Maintenance (%)	23.44 a	7.27	15.41 a	3.32	21.74 a	6.47	33.04 a	6.59	14.96 a	3.12	0.91	0.457
Resting (%)	7.25 b	3.87	5.78 b	1.94	28.24 a	7.31	35.21 a	6.69	17.09 b	3.34	4.57	0.001
Comfort (%)	0.19 a	0.10	0.08 a	0.03	0.03 a	0.03	0.13 a	0.08	0.36 a	0.26	0.67	0.611
Nesting (%)	-	-	-	-	-	-	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.38. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for snowy egret behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	16 Mar – 15 Apr (n = 28)		16 Apr - 15 May (n = 22)		16 May - 15 June (n = 129)		16 June - 15 July (n = 91)		16 July- 15 Aug (n = 74)		16 Aug - 1 Sept (n = 98)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	30.66 a[1]	4.91	22.15 a	6.26	21.36 a	1.86	9.94 b	2.03	12.76 b	2.58	10.33 b	1.31	5.40	< 0.001
Standing (%)	46.08 b	6.16	16.50 c	6.22	37.47 b	2.84	36.51 b	4.23	38.23 b	4.22	67.37 a	2.72	3.00	0.011
Feeding (%)	7.16 bc	2.32	8.90 b	3.24	16.10 b	1.64	4.98 c	0.79	28.27 a	3.94	13.94 b	1.41	3.07	0.009
Footstirring (%)	3.96 a	2.16	2.10 a	0.96	3.57 a	1.13	0.47 b	0.46	0.01 b	0.01	0.42 b	0.42	2.66	0.022
Aggression (%)	1.33 a	0.54	0.19 b	0.19	0.28 b	0.10	0.06 b	0.05	0.07 b	0.03	0.08 b	0.03	3.27	0.006
Alert (%)	0.24 a	0.17	0.00 a	0.00	0.00 a	0.00	0.06 a	0.04	0.05 a	0.03	0.00 a	0.00	1.43	0.211
Maintenance (%)	5.65 b	3.80	30.95 a	8.60	11.70 b	2.50	21.00 a	3.69	7.19 b	2.67	3.68 b	1.54	2.92	0.013
Resting (%)	4.84 bc	3.73	18.96 ab	6.79	9.36 b	2.36	26.80 a	4.15	13.35 b	3.78	4.08 a	1.83	3.47	0.004
Comfort (%)	0.04 a	0.04	0.07 a	0.08	0.08 a	0.03	0.05 a	0.02	0.02 a	0.02	0.06 a	0.03	0.06	0.997
Nesting (%)	0.00 a	0.00	0.00 a	0.00	0.00 a	0.00	0.06 a	0.06	0.00 a	0.00	0.00 a	0.00	0.09	0.993

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.39. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for snowy egret behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (*n* = 269)		Midday-Late (*n* = 173)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	16.26 a[1]	1.31	14.96 a	1.57	0.56	0.456
Standing (%)	42.83 a	2.19	44.62 a	2.77	0.00	0.988
Feeding (%)	12.85 a	1.10	16.92 a	1.80	1.59	0.208
Footstirring (%)	1.29 a	0.49	2.06 a	0.63	0.02	0.884
Aggression (%)	0.16 a	0.05	0.30 a	0.10	0.07	0.791
Alert (%)	0.06 a	0.02	0.00 a	0.00	1.55	0.214
Maintenance (%)	12.37 a	1.73	10.55 a	2.08	0.74	0.389
Resting (%)	14.04 a	1.90	10.46 a	2.18	0.95	0.330
Comfort (%)	0.05 a	0.01	0.07 a	0.02	0.23	0.628
Nesting (%)	0.02 a	0.02	0.00 a	0.00	0.16	0.691

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.40. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for snowy egret behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

Behavior	Wetland 1 (*n* = 26)		Wetland 2 (*n* = 66)		Wetland 3 (*n* = 206)		Wetland 4 (*n* = 28)		Wetland 5 (*n* = 116)		*F*	*P*
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE		
Locomotion (%)	22.07 a	5.22	22.03 a	3.34	11.34 a	1.11	16.17 a	4.63	18.50 a	2.03	3.19	0.013
Standing (%)	48.37 a	7.66	32.11 a	4.39	50.36 a	2.45	45.75 a	7.27	36.27 a	3.20	0.47	0.755
Feeding (%)	5.84 a	1.67	9.08 a	1.83	18.28 a	1.67	7.70 a	3.00	14.25 a	1.67	1.27	0.281
Footstirring (%)	0.34 a	0.17	1.72 a	0.76	1.66 a	0.70	1.52 a	1.48	1.69 a	0.57	0.94	0.437
Aggression (%)	1.19 a	0.56	0.27a	0.11	0.12 a	0.04	0.04 a	0.04	0.18 a	0.09	0.36	0.839
Alert (%)	0.00 a	0.00	0.10 a	0.07	0.03 a	0.02	0.00	0.00	0.02 a	0.02	0.28	0.891
Maintenance (%)	6.23 a	3.90	13.71 a	3.81	7.97 a	1.64	15.18 a	6.22	17.40 a	3.03	1.34	0.252
Resting (%)	15.89 a	6.63	20.91 a	4.70	10.09 a	1.96	13.64 a	5.99	11.49 a	2.52	0.70	0.591
Comfort (%)	0.04 a	0.04	0.03 a	0.02	0.06 a	0.02	0.00 a	0.00	0.08 a	0.03	0.29	0.883
Nesting (%)	0.00 a	0.00	0.00 a	0.00	0.03 a	0.03	0.00 a	0.00	0.00a	0.00	0.05	0.995

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.41. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for white ibis behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Month									
	16 May - 15 June (n = 173)		16 June - 15 July (n = 246)		16 July- 15 Aug (n = 273)		16 Aug - 1 Sept (n = 134)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	5.58 a	0.92	4.05 a	0.64	5.16 a	0.73	4.72 a	1.08	2.04	0.106
Standing (%)	2.44 b	0.54	5.81 a	1.01	7.03 a	0.99	5.27 a	1.04	5.13	0.001
Feeding (%)	70.91 a	2.94	54.13 b	2.81	62.24 a	2.51	64.94 a	3.55	6.79	0.002
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.04 a	0.02	0.03 a	0.01	0.07 a	0.01	0.04 a	0.02	2.14	0.093
Alert (%)	0.01 a	0.004	0.01 a	0.01	0.00 a	0.00	0.00 a	0.00	0.15	0.930
Maintenance (%)	13.11 a	2.22	15.33 a	1.86	9.16 b	1.42	10.51 ab	2.19	6.99	< 0.001
Resting (%)	7.75 b	1.78	20.39 a	2.26	16.23 b	2.03	13.67 b	2.76	8.43	< 0.001
Comfort (%)	0.10 a	0.02	0.09 a	0.02	0.06 a	0.02	0.05 a	0.02	1.24	0.293
Nesting (%)	0.00 a	0.00	0.09 a	0.09	0.00 a	0.00	0.74 a	0.74	0.29	0.830

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.42. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for white ibis behaviors between years measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March -1 September, 2005.

	Year					
	2004 (*n* =152)		2005 (*n* = 674)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	4.76 a	1.06	4.87 b	0.43	11.52	0.007
Standing (%)	5.65 a	1.34	5.37 a	0.52	2.10	0.147
Feeding (%)	38.33 b	3.58	67.44 a	1.52	39.15	< 0.001
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.08 a	0.31	0.04 a	0.01	1.31	0.252
Alert (%)	0.00 a	0.00	0.01 a	0.01	0.00	0.983
Maintenance (%)	19.83 a	2.68	10.29 b	0.96	12.90	0.003
Resting (%)	31.19 a	3.35	11.69 b	1.11	48.49	< 0.001
Comfort (%)	0.13 a	0.04	0.06 a	0.01	3.81	0.051
Nesting (%)	0.00 a	0.00	0.18 a	0.15	0.16	0.693

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.43. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for white ibis behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March -1 September, 2005.

	Diurnal Period					
	Early-Midday (*n* =461)		Midday-Late (*n* = 365)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	5.18 a[1]	0.54	4.43 a	0.60	1.42	0.233
Standing (%)	5.61 a	0.68	5.18 b	0.70	4.15	0.042
Feeding (%)	63.03 a	1.94	60.88 a	2.21	0.05	0.822
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.05 a	0.01	0.04 a	0.01	2.72	0.099
Alert (%)	0.01 a	0.01	0.00 a	0.00	0.32	0.568
Maintenance (%)	10.91 a	1.19	13.49 a	1.49	3.52	0.061
Resting (%)	15.07 a	1.50	15.54 a	1.70	0.00	0.957
Comfort (%)	0.05 b	0.01	0.11 a	0.02	18.96	< 0.001
Nesting (%)	0.05 a	0.05	0.27 a	0.27	0.10	0.754

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.44. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for white ibis behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Moist Soil Managed Wetland									
	Wetland 2 (*n* = 49)		Wetland 3 (*n* = 317)		Wetland 4 (*n* = 333)		Wetland 5 (*n* = 127)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	5.67 a	1.93	5.10 a	0.68	3.41 a	0.44	7.66 a	1.41	3.88	0.009
Standing (%)	1.99 a	0.76	4.20 a	0.65	6.71 a	0.88	6.40 a	1.46	1.41	0.238
Feeding (%)	57.76 a	6.38	72.41 a	2.11	59.76 a	2.33	44.04 a	3.84	1.13	0.337
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.09 a	0.05	0.05 a	0.01	0.03 a	0.01	0.06 a	0.02	0.77	0.509
Alert (%)	0.00 a	0.00	0.01 a	0.01	0.01 a	0.01	0.00 a	0.00	0.13	0.940
Maintenance (%)	17.33 a	4.43	10.27 a	1.44	11.59 a	1.44	15.65 a	2.58	0.10	0.961
Resting (%)	17.01 a	4.64	7.82 a	1.31	18.02 a	1.93	26.05 a	3.49	1.47	0.222
Comfort (%)	0.05 a	0.04	0.09 a	0.02	0.05 a	0.01	0.10 a	0.04	0.74	0.531
Nesting (%)	0.00 a	0.00	0.00 a	0.00	0.37 a	0.30	0.00 a	0.00	0.08	0.971

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.45. Means ($\bar{x}$), Standard Errors (SE) and F and P values resulting from univariate analysis of variance for white ibis behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Month									
	16 May-15 June (n = 34)		16 June-15 July (n = 31)		16 July-15 Aug (n = 69)		16 Aug- 1 Sept (n = 18)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	7.39 a[1]	2.98	0.55 a	0.23	6.51 a	1.76	0.36 a	0.33	0.21	0.888
Standing (%)	1.68 a	0.75	0.22 a	0.14	11.35 a	5.23	0.64 a	0.52	2.05	0.110
Feeding (%)	55.49 a	7.75	24.62 a	7.63	43.73 a	2.78	8.08 a	6.09	2.82	0.041
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.08 a	0.08	0.00 a	0.00	0.12 a	0.05	0.06 a	0.06	0.85	0.470
Alert (%)	-	-	-	-	-	-	-	-	-	-
Maintenance (%)	14.13 a	5.22	35.15 a	7.07	14.72 a	3.53	23.77 a	7.95	3.66	0.014
Resting (%)	21.04 a	6.40	39.37 a	7.45	23.36 a	4.62	66.27 a	9.69	1.70	0.170
Comfort (%)	0.15 a	0.10	0.05 a	0.05	0.18 a	0.07	0.06 a	0.06	0.33	0.803
Nesting (%)	-	-	-	-	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.46. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for white ibis behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Diurnal Period					
	Early-Midday (n = 101)		Midday-Late (n = 51)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	5.42 a[1]	1.37	3.48 a	1.65	1.01	0.317
Standing (%)	7.43 a	4.35	2.11 a	0.69	0.04	0.849
Feeding (%)	37.13 a	1.96	40.69 a	6.36	0.47	0.099
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.04 a	0.02	0.16 a	0.07	1.22	0.272
Alert (%)	-	-	-	-	-	-
Maintenance (%)	18.84 a	3.23	21.78 a	4.84	2.67	0.104
Resting (%)	31.06 a	4.13	31.44 a	5.81	1.04	0.308
Comfort (%)	0.05 a	0.03	0.31 a	0.10	6.07	0.015
Nesting (%)	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.47. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for white ibis behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004.

	Moist Soil Managed Wetland									
	Wetland 2 (n = 23)		Wetland 3 (n = 22)		Wetland 4 (n = 26)		Wetland 5 (n = 81)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	1.04 a[1]	0.34	7.62 a	4.42	2.08 a	0.72	5.90 a	1.56	0.58	0.631
Standing (%)	0.64 a	0.29	2.62 a	1.14	6.67 a	4.22	7.56 a	2.07	0.52	0.666
Feeding (%)	49.84 a	10.20	53.24 a	9.87	28.99 a	8.53	34.01 a	4.61	2.13	0.099
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.10 a	0.07	0.07 a	0.07	0.11 a	0.11	0.07 a	0.04	0.27	0.848
Alert (%)	-	-	-	-	-	-	-	-	-	-
Maintenance (%)	24.31 a	7.62	13.98 a	6.43	18.69 a	6.20	20.51 a	3.74	0.64	0.587
Resting (%)	23.96 a	7.81	22.33 a	8.18	43.27 a	8.84	31.77 a	4.63	0.77	0.513
Comfort (%)	0.07 a	0.07	0.12 a	0.12	0.16 a	0.11	0.15 a	0.06	0.56	0.644
Nesting (%)	-	-	-	-	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.48. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for white ibis behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Month									
	16 May - 15 June (*n* = 139)		16 June - 15 July (*n* = 215)		16 July- 15 Aug (*n* = 204)		16 Aug - 1 Sept (*n* = 116)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	5.13 a[1]	0.89	4.56 a	0.72	4.71 a	0.77	5.40 a	1.24	1.54	0.202
Standing (%)	2.63 a	0.65	6.61 a	1.15	5.58 a	0.93	5.99 a	1.19	0.23	0.872
Feeding (%)	74.68 a	3.06	58.39 a	2.91	68.50 a	2.73	73.65 a	3.32	2.06	0.104
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.03 b	0.01	0.04 a	0.01	0.05 a	0.01	0.03 b	0.02	3.90	0.008
Alert (%)	0.01 a	0.01	0.01 a	0.01	0.00 a	0.00	0.00 a	0.00	0.02	0.997
Maintenance (%)	12.87 a	2.46	12.48 a	1.80	7.29 b	1.46	8.46 ab	2.16	3.88	0.009
Resting (%)	4.50 b	1.45	17.66 a	2.31	13.82 a	2.21	5.51 b	1.93	3.01	0.029
Comfort (%)	0.03 a	0.02	0.09 a	0.03	0.02 a	0.01	0.05 a	0.02	0.99	0.396
Nesting (%)	0.00 a	0.00	0.11 a	0.11	0.00 a	0.00	0.86 a	0.86	0.33	0.801

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.49. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for white ibis behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Moist Soil Managed Wetland									
	Wetland 2 (*n* = 26)		Wetland 3 (*n* = 295)		Wetland 4 (*n* = 307)		Wetland 5 (*n* = 46)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	9.77 a[1]	3.46	4.92 b	0.66	3.52 c	0.47	10.75 a	2.74	3.79	0.010
Standing (%)	3.18 a	1.38	4.32 a	0.70	6.71 a	0.89	4.35 a	1.71	0.08	0.969
Feeding (%)	64.77 ab	7.88	73.84 a	2.13	62.36 b	2.36	61.72 b	6.02	4.60	0.003
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.08 a	0.08	0.05 a	0.01	0.02 a	0.01	0.06 a	0.04	1.76	0.153
Alert (%)	0.00 a	0.00	0.01 a	0.01	0.01 a	0.01	0.00 a	0.00	0.02	0.997
Maintenance (%)	11.17 a	4.76	10.00 a	1.47	10.99 a	1.48	7.09 b	2.27	4.41	0.004
Resting (%)	10.86 a	5.22	6.74 a	1.25	15.88 a	1.91	15.97 a	4.86	2.60	0.051
Comfort (%)	0.04 a	0.04	0.09 a	0.02	0.04 a	0.01	0.02 a	0.02	0.79	0.497
Nesting (%)	0.00 a	0.00	0.00 a	0.00	0.40 a	0.33	0.00 a	0.00	0.03	0.992

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.50. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for white ibis behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (*n* = 360)		Midday-Late (*n* = 314)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	5.12 a[1]	0.57	4.58 a	0.65	0.01	0.943
Standing (%)	5.10 a	0.68	5.68 a	0.81	0.00	0.990
Feeding (%)	70.30 a	2.02	64.16 a	2.31	2.54	0.111
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.05 a	0.01	0.02 a	0.01	0.85	0.355
Alert (%)	0.01 a	0.01	0.00 a	0.00	0.84	0.360
Maintenance (%)	8.68 a	1.20	12.14 a	1.53	2.77	0.096
Resting (%)	10.58 a	1.45	12.96 a	1.70	0.30	0.586
Comfort (%)	0.05 a	0.01	0.07 a	0.02	0.73	0.393
Nesting (%)	0.06 a	0.06	0.31 a	0.31	0.95	0.331

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.51. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for wood stork behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Month							
	16 May - 15 June (*n* = 181)		16 June - 15 July (*n* = 42)		16 July- 15 Aug (*n* = 32)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	5.17 a[1]	0.90	7.17 a	3.09	4.15 a	2.29	0.34	0.713
Standing (%)	8.46 a	1.79	8.77 a	4.01	9.75 a	4.96	0.09	0.913
Feeding (%)	9.30 a	0.09	0.78 a	0.75	0.01 a	0.01	5.33	0.005
Footstirring (%)	-	-	-	-	-	-	-	-
Aggression (%)	0.19 a	0.09	0.00 a	0.00	0.00 a	0.00	1.01	0.365
Alert (%)	0.11 a	0.08	0.00 a	0.00	0.00 a	0.00	0.53	0.591
Maintenance (%)	18.70 a	2.33	8.26 a	3.30	8.51 a	3.10	0.80	0.452
Resting (%)	56.79 a	3.13	75.01 a	5.97	77.35 a	6.32	4.53	0.011
Comfort (%)	0.15 a	0.04	0.00 a	0.00	0.20 a	0.10	1.38	0.253
Nesting (%)	1.09 a	0.61	0.00 a	0.00	0.00 a	0.00	0.00	1.000

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.52. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for wood stork behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005

	Diurnal Period					
	Early-Midday (n = 127)		Midday-Late (n = 128)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	3.88 a[1]	1.06	6.85 a	1.35	1.53	0.217
Standing (%)	6.97 a	2.04	10.37 a	2.35	0.40	0.526
Feeding (%)	8.10 a	2.21	5.38 b	1.78	4.30	0.039
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.19 a	0.12	0.07 a	0.04	1.34	0.248
Alert (%)	0.09 a	0.09	0.07 a	0.68	0.02	0.879
Maintenance (%)	13.67 a	2.44	17.72 a	2.65	0.00	0.963
Resting (%)	66.22 a	3.64	58.54 a	3.71	0.16	0.689
Comfort (%)	0.12 a	0.04	0.14 a	0.04	0.07	0.791
Nesting (%)	0.72 a	0.58	0.82 a	0.65	0.01	0.937

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.53. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for wood stork behaviors measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	Year					
	2004 (n = 177)		2005 (n = 78)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	6.24 a	1.18	3.41 a	0.86	0.35	0.555
Standing (%)	11.40 a	2.16	2.48 a	1.04	0.45	0.503
Feeding (%)	7.18 a	1.77	5.71 a	2.31	0.23	0.634
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.11 a	0.09	0.18 a	0.07	0.08	0.772
Alert (%)	0.06 a	0.06	0.11 a	0.11	0.02	0.901
Maintenance (%)	12.28 a	1.87	23.46 a	3.97	2.33	0.128
Resting (%)	32.58 a	3.16	61.89 a	4.64	2.01	0.157
Comfort (%)	0.10 a	0.03	0.18 a	0.06	0.15	0.695
Nesting (%)	0.00 s	0.00	2.53 a	1.41	2.08	0.150

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.54. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for wood stork behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 April - 31 August, 2004 and 16 March-1 September, 2005.

	Moist Soil Managed Wetland									
	Wetland 2 (n = 36)		Wetland 3 (n = 100)		Wetland 4 (n = 19)		Wetland 5 (n = 100)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	10.33 a[1]	4.16	3.14 ab	0.74	0.64 b	0.57	6.72 a	1.39	2.68	0.047
Standing (%)	10.96 a	4.75	3.61 a	1.42	0.00 a	0.00	14.57 a	3.19	2.48	0.061
Feeding (%)	0.94 b	0.87	4.45 ab	1.82	0.00 b	0.00	12.38 a	3.02	4.22	0.006
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.00 a	0.00	0.14 a	0.06	0.00 a	0.00	0.20 a	0.16	0.36	0.782
Alert (%)	0.00 a	0.00	0.09 a	0.08	0.62 a	0.62	0.00 a	0.00	2.43	0.065
Maintenance (%)	16.58 a	4.85	20.89 a	3.36	18.17 a	5.86	9.73 a	2.27	0.83	0.479
Resting (%)	61.10 b	7.00	65.47 b	4.04	80.39 a	5.69	56.30 c	4.43	4.64	0.003
Comfort (%)	0.06 a	0.06	0.20 a	0.05	0.16 a	0.13	0.07 a	0.04	0.74	0.530
Nesting (%)	0.00 a	0.00	1.97 a	1.10	0.00	0.00	0.00 a	0.00	0.00	1.000-

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.55. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for great blue heron behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Month									
	16 May - 15 June (n = 22)		16 June - 15 July (n = 31)		16 July- 15 Aug (n = 42)		16 Aug - 1 Sept (n = 34)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	13.13 a[1]	5.00	20.32 a	4.83	7.75 a	2.67	7.77 a	2.38	2.42	0.069
Standing (%)	60.85 a	8.89	50.65 a	7.33	48.27 a	7.10	60.46 a	7.31	1.58	0.198
Feeding (%)	0.47 a	0.31	0.37 a	0.16	1.15 a	0.87	2.04 a	1.62	0.21	0.889
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.00	0.00	0.03 a	0.04	0.02 a	0.02	0.04 a	0.04	0.07	0.978
Alert (%)	-	-	-	-	-	-	-	-	-	-
Maintenance (%)	6.65 a	3.76	7.43 a	3.20	5.81 a	2.55	9.72 a	4.48	0.80	0.497
Resting (%)	18.83 a	7.57	21.08 a	6.49	36.87 a	7.04	19.94 a	6.46	1.85	0.142
Comfort (%)	0.04 a	0.04	0.00 a	0.00	0.06 a	0.04	0.00 a	0.00	1.19	0.316
Nesting (%)	0.00 a	0.00	0.00 a	0.00	0.03 a	0.03	0.00 a	0.00	0.26	0.855

[1]Means followed by the same letter within the same row are not different (P > 0.05).

Table 2.56. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for great blue heron behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Moist Soil Managed Wetland									
	Wetland 2 (n = 36)		Wetland 3 (n = 39)		Wetland 4 (n = 20)		Wetland 5 (n = 34)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	9.95 a[1]	3.55	12.13 a	2.99	7.78 a	4.57	15.35 a	3.94	1.03	0.383
Standing (%)	42.29 a	7.46	64.00 a	6.41	66.88 a	9.96	48.10 a	7.03	0.76	0.521
Feeding (%)	0.33 a	0.61	0.34 a	0.20	0.24 a	0.22	3.22 a	1.90	0.66	0.576
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.06 a	0.04	0.04 a	0.04	0.00 a	0.00	0.00 a	0.00	0.16	0.920
Alert (%)	-	-	-	-	-	-	-	-	-	-
Maintenance (%)	14.36 a	4.36	7.31 a	3.54	0.35 a	0.25	4.18 a	1.99	2.21	0.091
Resting (%)	32.91 a	6.86	16.16 a	5.55	24.64 a	9.79	29.02 a	7.23	0.11	0.954
Comfort (%)	0.03 a	0.03	0.00 a	0.00	0.07 a	0.07	0.03 a	0.03	1.00	0.394
Nesting (%)	0.04 a	0.04	0.00 a	0.00	0.00 a	0.00	0.00 a	0.00	0.13	0.939

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.57. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for great blue heron behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (n = 66)		Midday-Late (n = 63)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	14.90 a[1]	3.01	8.34 a	1.96	4.57	0.034
Standing (%)	53.53 a	5.12	54.90 a	5.65	0.86	0.354
Feeding (%)	1.37 a	0.84	0.77 a	0.58	0.31	0.576
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.04 a	0.02	0.01 a	0.01	0.48	0.488
Alert (%)	-	-	-	-	-	-
Maintenance (%)	8.75 a	2.72	5.93 a	2.14	0.09	0.769
Resting (%)	21.31 a	4.61	29.96 a	5.36	0.14	0.710
Comfort (%)	0.03 a	0.02	0.04 a	0.04	0.03	0.865
Nesting (%)	0.02 a	0.02	0.00 a	0.00	0.22	0.640

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.58. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance for little blue heron behaviors among months measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Month									
	16 May - 15 June (n = 35)		16 June - 15 July (n = 42)		16 July- 15 Aug (n = 71)		16 Aug - 1 Sept (n = 59)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Locomotion (%)	34.93 a[1]	5.75	15.97 a	3.78	27.35 a	3.68	33.22 a	3.19	0.64	0.591
Standing (%)	20.05 b	4.39	22.72 b	4.96	37.40 a	4.06	41.31 a	4.33	6.33	0.004
Feeding (%)	9.05 a	1.62	5.00 a	1.26	11.29 a	2.02	18.78 a	2.51	0.71	0.546
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.04 a	0.04	0.00 a	0.00	0.12 a	0.08	0.22 a	0.11	0.07	0.973
Alert (%)	-	-	-	-	-	-	-	-	-	-
Maintenance (%)	30.54 a	7.09	46.77 a	6.79	8.60 b	2.81	2.34 b	1.37	12.55	< 0.001
Resting (%)	5.23 a	2.02	9.26 a	2.56	15.19 a	3.91	4.03 a	2.10	2.36	0.072
Comfort (%)	0.02 a	0.02	0.19 a	0.08	0.01 a	0.01	0.04 a	0.03	0.82	0.483
Nesting (%)	-	-	-	-	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.59. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for little blue heron behaviors between two diurnal periods measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Diurnal Period					
	Early-Midday (n = 135)		Midday-Late (n = 72)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	33.21 a[1]	2.51	18.21 b	3.14	6.93	0.009
Standing (%)	30.97 a	2.58	35.67 a	4.54	3.12	0.078
Feeding (%)	14.14 a	1.52	7.32 b	1.29	4.28	0.039
Footstirring (%)	-	-	-	-	-	-
Aggression (%)	0.16 a	0.06	0.02 a	0.02	0.76	0.385
Alert (%)	-	-	-	-	-	-
Maintenance (%)	15.63 a	2.83	23.23 a	4.37	0.01	0.906
Resting (%)	5.76 b	1.59	15.43 a	3.48	5.02	0.026
Comfort (%)	0.05 a	0.02	0.06 a	0.03	0.38	0.540
Nesting (%)	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 2.60. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for little blue heron behaviors among moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east- central Texas, 16 March - 1 September, 2005.

	Moist Soil Managed Wetland									
	Wetland 2 (*n* = 29)		Wetland 3 (*n* = 115)		Wetland 4 (*n* = 41)		Wetland 5 (*n* = 22)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Locomotion (%)	26.62 a[1]	6.40	31.30 a	2.62	12.61 a	3.35	41.20 a	6.41	2.77	0.042
Standing (%)	29.93 a	6.92	37.34 a	3.04	21.31 a	4.88	32.42 a	6.50	0.77	0.511
Feeding (%)	7.24 a	3.00	16.72 a	1.63	3.02 a	0.93	8.14 a	2.18	3.11	0.027
Footstirring (%)	-	-	-	-	-	-	-	-	-	-
Aggression (%)	0.09 a	0.06	0.12 a	0.06	0.14 a	0.14	0.00 a	0.00	0.20	0.895
Alert (%)	-	-	-	-	-	-	-	-	-	-
Maintenance (%)	21.03 a	6.76	11.20 a	2.69	37.93 a	6.51	14.96 a	6.99	2.74	0.044
Resting (%)	15.03 a	5.69	3.21 a	1.20	24.76 a	5.50	3.08 a	1.70	2.12	0.098
Comfort (%)	0.03 a	0.03	0.04 a	0.02	0.17 a	0.08	0.00 a	0.00	0.33	0.806
Nesting (%)	-	-	-	-	-	-	-	-	-	-

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

CHAPTER III

HABITAT USE OF WADING BIRDS AT THE RICHLAND CREEK WILDLIFE MANAGEMENT AREA

INTRODUCTION

In recent decades, an increased awareness of wetland loss, loss of wetland functions (i.e., flood control, water quality, wildlife habitat), and declines of waterbird species, has emphasized the importance of wetland habitat conservation and restoration efforts at landscape scales (Myers et al. 1987, Smith et al. 1989, Skagen and Knopf 1993). Conservation efforts for wetlands and waterbirds rely on knowledge of habitat use and availability, where understanding of waterbird habitat use and requirements is critical for wetland restoration or creation (Taft and Haig 2003). However, wildlife habitat value has often been viewed as ancillary compared with other created wetland management goals (i.e., flood control, wastewater treatment, etc.) (Cole 1998). Created wetlands can contribute to increases in wetland faunal diversity if different wetland types are available or created wetlands are arranged as moist soil managed wetland complexes (Porej 2004). In addition, created wetland complexes may further attract multiple waterbird species and provide habitat for area-sensitive or endemic species (Delnicki and Rienecke 1986, Weller 1999). as waterbird distribution and density is positively influenced by suitable habitat conditions (Smith 1970, Stewart and Kantrud 1973).

Despite the aforementioned generalities about conservation and management of both natural and created wetlands, wading bird habitat use patterns are not well documented. Many studies have emphasized nesting behaviors and nest site selection (Jenni, 1969, Kushlan and Robertson 1977), or foraging and flock aggregation behavior (Krebs 1974, Smith 1995), and from these studies, basic generalizations about habitat use have emerged. For example, cattle egrets (*Bubulcus ibis*) will use wetlands, grasslands, and agricultural fields (Mora 1992, Seedikkoya et al. 2005), snowy egrets (*Egretta thula*) generally prefer open water habitats for foraging, little blue herons (*E. caerula*) prefer vegetated areas, and longer legged species (i.e., white ibis (*Eudocimus albus*), great egret (*Ardea alba*), etc.) generally select deeper water habitats than shorter legged species (Jenni 1969, Kushlan and Kushlan 1975), thus taking advantage of feeding niches that smaller wading birds may not use (Schlorff 1978). However, more specific habitat use data are generally lacking, and understanding waterbird microhabitat use within wetlands should be useful from a conservation and management perspective (Deleon 1996). For example, beyond documenting presence, abundance, and behavior within a given wetland, microhabitat data can provide managers with information to more successfully manipulate water levels and wetland habitat structure targeted at wading birds, outside the normal parameters of wetland management for nonbreeding waterfowl and shorebirds. The objective of this portion of the study was to (1) quantify waterbird microhabitat use of created moist soil managed wetlands, (2) compare used microhabitat with randomly selected nonused habitat within created moist soil managed wetlands, and (3) correlate focal species microhabitat and behaviors (Chapter II).

METHODS

Study Area

The RCWMA contains a moist soil managed wetland complex in Freestone County, Texas (Figure 1.1). The WMA occurs in the Post Oak Savannah and Blackland Prairie ecoregion, within the Trinity River floodplain, which is the source of water for the created moist soil wetlands within RCWMA. The WMA is operated through a cooperative agreement between The Tarrant Regional Water District (TRWD) and the Texas Parks and Wildlife Department (TPWD). Within this agreement, the TRWD oversees construction, maintenance, and water control of the created moist soil managed wetlands to (1) compensate for habitat losses associated with the construction of the Richland-Chambers Reservoir and (2) improve water quality of water removed from the Trinity River. Similarly, TPWD is responsible for providing recreational waterfowl hunting opportunities and oversee habitat management within the moist soil wetlands to provide high quality wetland habitat(s) for wetland dependent waterbirds throughout the annual cycle. Combined, both agencies coordinate drawdown and flooding regimes to provide suitable wetland habitat and high quality water.

The four moist soil managed wetlands are located within the 1,938.5 ha North unit of the RCWMA, which were operational as of January 2003. These moist soil managed wetlands total 94.7 ha (i.e., 26.1, 27.6, 30.3 and 10.9 ha individually) and are arranged linearly (Figure 1.2). Water control is executed by a lift station located on the Trinity River (Figure 1.3), where water is pumped and moved into a settling pond, and remains for approximately two days. Water then moves via gravity into the first wetland, and traverses through each moist soil managed wetland until water reaches desired levels. In general, management currently favors nonbreeding waterfowl, where flooding occurs during August-March, where water levels average approximately 0.2 – 1.5 m, depending upon individual moist soil managed wetland. Drawdowns generally occur from March-August to provide seed bank expression for annual moist soil plant and seed production. Wetlands contain both aquatic submergent and emergent vegetation such as giant salvinia (*Salvinia molesta*), hydrilla (*Hydrilla verticillata*), delta duck potato (*Sagittaria platyphylla*), erect burhead (*Echinodorus rostratus*), frog fruit (*Phyla nodiflora*), water pepper (*Polygonum hydropiper*), lizard tail (*Saururus cernuus*), and water primrose (*Ludwigia hexapetala)* (D. Collins, unpublished data). Much of the remainder of the RCWMA contains bottomland hardwood forests dominated by cedar elm (*Ulmus crassifolia*), sugarberry (*Celtis laevigata*), and green ash (*Fraxinus pennsylvanica*). Other common species are honeylocust (*Gleditsia triacanthos*), boxelder (*Acer negundo*), black willow (*Salix

nigra), bur oak (*Quercus macrocarpa*), Shumard oak (*Q. shumardii*), overcup oak (*Q. lyrata*), water oak (*Q. nigra*), willow oak (*Q. phellos*), and native pecan (*Carya illinoinensis*) (C. Mason, personal communication).

Microhabitat Data Collection

Microhabitat data were collected for randomly selected cattle egret, great egret, snowy egret, and white ibis from 16 March - 1 September 2005. Microhabitat data were collected from randomly selected individuals, so as to not disturb flocks or impact individual bird behavior during the behavioral sampling portion of this study (see Chapter II). At each bird location, the following habitat variables were measured in a 1-m^2 quadrat: water depth (cm), emergent vegetation (%), percent open water (%), exposed mudflat (%), floating vegetation (%), presence/absence of submergent vegetation, and height (cm) of tallest emergent vegetation. Distance to the nearest road (i.e., hard edge along each moist soil managed wetland (Figure 1.2) was also measured. These same data were collected at a random location < 5 m from each bird location.

Beyond specific microhabitat data collected on the four aforementioned species, qualitative habitat descriptions were also made during focal sampling in 2005 (see Chapter II). At the beginning of each focal sample, habitat in which birds occupied was recorded into the following categories: (1) tree (i.e., dead or alive), (2) vegetation (i.e., non-woody), (3) open water (i.e., no emergent vegetation visible), (4) mudflat (i.e., no surface water), and (5) other (i.e., road or levee separating moist soil managed wetland). If located in water, each focal individual was visually examined to determine water depth, where water intersected each individual's leg was estimated. Water depth was extrapolated, based upon published leg lengths for focal species (i.e., 11.7 cm for cattle egrets, 21.7 cm for great egrets, 26.7 cm for great blue herons, 13.3 cm for little blue herons; 14.5 cm for snowy egrets, 13.8 cm for white ibis, and 33.3 cm for wood storks (Kahl 1962, Palmer 1962).

Data Analysis

One-way univariate analysis of variance was used to examine differences in microhabitat measured at 1- m^2 quadrats (i.e., distance to edge (m), water depth (cm), tallest emergent plant (cm), percent cover of open water, emergent vegetation, mudflat, and floating vegetation), (1) among species (i.e., cattle egret, great egret, snowy egret, and white ibis), (2) between wading birds and random locations, irrespective of species, and (3) between wading bird species and random locations, within individual species. Least squares mean separation was used to examine differences ($P < 0.05$) occurring during ANOVAs. Frequency data generated from focal samples were generated using only those samples in which either resting related or feeding related behaviors were the first observation. No statistical comparisons were made using these data, but were used to generalize habitat occurrence in these two behaviors among all focal species (i.e., cattle egret, great egret, great blue heron, little blue heron, snowy egret, white ibis, and wood stork).

RESULTS

Microhabitat data were collected at > 300 bird and random locations for cattle egret (*n* = 86), great egret (*n* = 98), snowy egret (*n* = 68) and white ibis (*n* = 83). Microhabitat varied (P < 0.001) among species for all measured variables (Table 3.1). White ibises used habitat farthest from hard edges, with the most floating vegetation, while great egrets used habitat consisting of the deepest and some conditions (Table 3.1). Conversely, cattle egrets used the shallowest, most vegetated aquatic habitats, with the least amount of floating vegetation (Table 3.1). Finally, snowy egrets also used fairly shallow most open water habitats, with the highest proportion of mudflats (Table 3.1). Irrespective of species, wading bird microhabitat rarely varied (*P* > 0.05) from random habitats, except that wading birds used (*P* = 0.036) habitats with a slightly greater percentage of emergent vegetation coverage than random plots (Table 3.2). In general, focal species, as a group, used microhabitats in water approximately 50 m from a hard edge, with nearly 50% cover of emergent vegetation, approximately 25% open water, with < 5% mudflat (Table 3.2). Most birds used habitat with < 50% open water, > 50% emergent vegetation, < 50% floating vegetation, and < 50% mudflat coverage (Table 3.3). Microhabitat also rarely varied between used and random habitats within individual species. Cattle egrets used habitats with less floating vegetation ($P = 0.024$) and open water ($P = 0.035$), but more ($P = 0.003$) emergent vegetation than random plots (Table 3.4). There were no differences ($P > 0.05$) between great egrets and random habitat for any measured microhabitat variable (Table 3.5). Snowy egrets tended use habitats with more ($P > 0.05$) mudflat coverage, but snowy egret and random microhabitat did not vary ($P > 0.05$) for any other habitat variable (Table 3.6). There were no differences ($P > 0.05$) between white ibis and random habitat for any measured microhabitat variable (Table 3.7).

Qualitative habitat characterization revealed that most of the focal species either fed or rested in emergent vegetation > 50% of the time, except for wood storks, which spent > 80% of their time in snags (Table 3.8). Moreover, focal species spent most of their time in water nearly as deep as possible, as related to leg lengths (Table 3.8). For wood storks in which these habitat frequencies were recorded, they spent > 90% of their time resting, and < 8% of their time feeding, usually in very shallow water (i.e., < 1 cm deep) with large percentages of emergent vegetation (Table 3.8). Conversely, great egrets tended to rest in water with vegetation (i.e., > 62%), and spent the least amount of time in snags of all focal species (Table 3.8). For all species combined, when resting, they spent between 6% and 83% of the time in snags. These qualitative data highlight the importance of snags currently present in moist soil managed wetlands at RCWMA that would have likely been masked by previous quantitative analyses of bird habitat use.

DISCUSSION

Wading bird microhabitat use patterns should provide information as related to overall wetland health, because understanding habitat relationships will allow managers to assess potential wetland value for wading birds, as habitat selection in these birds are dependent upon several factors. Other studies have demonstrated that wading birds recognize vegetative structural features as related to foraging success and prey availability (Weller 1999), although few studies have focused on microhabitat use by wading birds (Custer and Galli 2002). Consequently, even coarse assessments of habitat use by wading birds may deliver relative habitat quality evaluations of potentially suitable wetland habitats.

In this study, vegetative cover and open water appeared to be important habitat features for wading bird occupancy. However, vegetation further characterized into submergent, emergent, or floating provides more discrimination, as each of these vegetative cover types provides different structure and possible prey availability (Fleury and Sherry 1995, Safran et al. 1997, Safran et al. 2000). In general, water habitats with emergent vegetation were frequently used by wading birds at RCWMA, either for resting or feeding, as focal species used open water habitats about half as frequently as aquatic emergent vegetative habitat. In general, wetland habitat with increased emergent vegetative cover should provide habitat/cover (1) for vertebrate and invertebrate prey for wading birds (Balcombe et al. 2005) and (2) from potential competitors for wading birds, especially among darker colored waders (i.e., little blue herons, tricolored herons, etc.). For example, little blue herons may be less successful than snowy egrets at acquiring prey in open water as opposed to aquatic emergent vegetative habitats, suggesting darker plumage does not contribute to higher feeding success in open water habitats (Green and Leberg 2005). Moreover, open water habitats may be less productive than aquatic habitats with emergent vegetation when hydroperiods are short (MacArthur and Wilson 1967, Anderson and Smith 1999b).

In general, microhabitat use consisted largely of emergent vegetation in water, suggesting that the moist soil managed wetlands at RCWMA do provide suitable habitat for a suite of wading birds during spring and summer. For example, hemi-marsh wetland complexes are considered highly productive and inhabited by a diversity of waterbirds (Weller and Spatcher 1965, Smith et al. 2004), which are often used as indicator species, as they are conspicuous, easy to survey, and occur in large numbers (Kushlan 1979, 1993). Moreover, frequent use of floating vegetation may be related to prey availability (Weller 1999), as species such as white ibis tended to use such habitats frequently throughout the study. However, for slow moving, visual foraging waders large amounts of floating vegetation may be disadvantageous (Weller 1999), but as white ibis are tactile foragers, floating vegetation should not disrupt its feeding strategy. Therefore, habitat use and selection patterns are important in moist soil wetland management decision, particularly if threatened or endangered species use those habitats (i.e., wood stork) (Kushlan 1978a, Coulter and Bryan 1995).

Focal species tended to generally occur in water within the general range of water depths for wading birds (10-20 cm) (Taft et al. 2002). For example, great egrets, one of the taller focal species, tended to use deeper waters when resting or in food acquisition related behaviors, and frequently used both emergent and open water habitat. Conversely, snowy egret tended to use more shallow, open water habitats than taller wading birds, although they also frequently used aquatic emergent habitat as well (Table 3.1). Snowy egrets use of footstirring (Chapter II) may allow this species to forage more successfully in open water when disturbing prey for food acquisition (Kushlan 1976b). Social cues (i.e., flock feeding), along with possible spatial memory of recently exploited patches may also contribute to microhabitat use patterns by snowy egrets (Krebs 1974, Menzel and Wyers 1981).

Moist soil managed wetlands at RCWMA provide varying water depths and habitats useful for numerous morphologically and physiologically different species. An ideal moist soil wetland complex should consist of submergents, emergents, open water, unvegetated shallow water and mudflats (Fredrickson and Reid 1988, Fredrickson 1991, Weller 1999). Although mudflat use was low among all species (4%), and shorebirds are more frequently observed in such habitats (Capen and Low 1980), smaller wading birds may also exploit mudflats if prey are available (Maccarone and Bzorad 2002), which was observed in snowy egrets which used mudflats more than other species. In addition, the importance of available snags as resting posts was apparent, however generally not considered a significant management issue for wading birds. Finally, since used and random locations did not vary, this may be an indicator of overall wetland quality and given that previous studies have shown a positive correlation between invertebrate biomass and dense emergent vegetation (Streever et al. 1995), birds may have not needed to go far to locate adequate food sources, since RCWMA contains vast amounts of emergent vegetation.

Table 3.1. Means ($\bar{x}$) and Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance for microhabitat variables measured at randomly selected wading birds of the focal species (i.e., cattle egret, great egret, snowy egret, and white ibis) observed in moist soil managed wetlands at Richland Creek Wildlife Management Area in east-central Texas, 16 March - 1 September, 2005.

	Species									
	Cattle egret (n = 86)		Great Egret (n = 98)		Snowy egret (n = 68)		White ibis (n = 83)			
Habitat	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Distance to edge (m)	20.89 c[1]	3.88	36.04 b	3.73	42.38 b	5.92	78.28 a	7.98	19.89	< 0.001
Water depth (cm)	4.37 c	1.20	27.48 a	1.73	16.46 b	1.86	17.89 b	1.17	41.90	< 0.001
Open Water (%)	4.90 c	1.66	34.48 a	3.61	39.73 a	4.87	24.75 b	3.76	18.60	< 0.001
Emergent Vegetation (%)	92.86 a	2.18	39.46 b	3.42	33.92 bc	4.38	27.34 c	4.01	73.38	< 0.001
Mudflat (%)	2.05 b	1.05	0.91 b	0.35	13.48 a	3.27	3.67 b	1.46	11.09	< 0.001
Floating (%)	0.17 d	0.12	25.12 b	3.26	12.85 c	2.86	44.21 a	4.59	34.48	< 0.001
Tallest Emergent Plant (cm)	30.90 b	2.54	51.80 a	3.45	31.16 b	3.55	27.70 b	2.89	13.62	< 0.001

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 3.2. Means ($\bar{x}$), Standard Errors (SE) and *F* and *P* values resulting from univariate analysis of variance for microhabitat variables measured between wading bird and random locations measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Bird Habitat (*n* = 335)		Random Habitat (*n* = 335)			
Habitat	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Distance to edge (m)	44.06 a[1]	2.96	44.35 a	2.95	0.00	0.945
Water depth (cm)	16.93 a	0.89	17.69 a	0.92	0.34	0.559
Open water (%)	25.54 a	1.89	28.46 a	1.98	1.13	0.289
Emergent vegetation (%)	49.04 a	2.26	42.44 b	2.17	4.43	0.036
Mudflat (%)	4.44 a	0.84	3.50 a	0.77	0.67	0.412
Floating (%)	20.95 a	1.81	25.59 a	1.95	3.02	0.083
Tallest emergent plant (cm)	36.27 a	1.66	36.19 a	1.55	0.00	0.973

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 3.3. Proportion (%) of focal wading birds (i.e., cattle egret, great egret, snowy egret, and white ibis) microhabitat use measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Bird Location (*n* = 335)	
	< 50 % coverage	> 50 % coverage
Open Water (%)	73 %	27 %
Emergent Vegetation (%)	55 %	44 %
Mudflat (%)	98 %	2 %
Floating (%)	75 %	25 %

Table 3.4. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance between cattle egret and random microhabitat measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

Habitat	Bird location (n = 86)		Random location (n =86)			
	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Distance to edge	20.89 a[1]	3.88	21.63 a	4.02	0.02	0.883
Water depth (cm)	4.37 a	1.20	7.20 a	1.51	2.15	0.144
Open water (%)	4.90 b	1.66	11.83 a	2.80	4.53	0.035
Emergent vegetation (%)	92.86 a	2.18	80.38 b	3.48	9.19	0.003
Mudflat (%)	2.05 a	1.05	4.40 a	1.73	1.34	0.249
Floating (%)	0.17 b	0.12	3.37 a	1.39	5.19	0.024
Tallest emergent plant (cm)	30.90 a	2.54	30.73 a	2.33	0.01	0.960

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 3.5. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance between great egret and random microhabitat measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Bird location (n = 98)		Random location (n = 98)			
Habitat	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Distance to edge	36.04 a[1]	3.73	36.51 a	3.78	0.01	0.930
Water depth (cm)	27.48 a	1.73	27.39 a	1.98	0.01	0.972
Open water (%)	34.48 a	3.61	33.81 a	3.75	0.02	0.897
Emergent vegetation (%)	39.46 a	3.42	36.24 a	3.73	0.40	0.526
Mudflat (%)	0.91 a	0.35	3.74 a	1.46	3.50	0.063
Floating (%)	25.12 a	3.26	26.19 a	3.40	0.05	0.821
Tallest emergent plant (cm)	51.80 a	3.45	44.53 a	3.08	2.46	0.119

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 3.6. Means ($\bar{x}$), Standard Errors (SE), and F and P values resulting from univariate analysis of variance between snowy egret and random microhabitat measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Bird location (*n* = 68)		Random location (*n* = 68)			
Habitat	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Distance to edge	42.26 a[1]	5.92	42.75 a	5.73	0.01	0.950
Water depth (cm)	16.46 a	1.86	18.51 a	1.80	0.63	0.434
Open water (%)	39.73 a	4.87	50.48 a	4.70	2.56	0.112
Emergent vegetation (%)	33.92 a	4.38	24.61 a	3.50	2.75	0.099
Mudflat (%)	13.48 a	3.27	5.04 b	1.96	4.89	0.029
Floating (%)	12.85 a	2.86	19.85 a	3.48	2.41	0.123
Tallest emergent plant (cm)	31.16 a	3.55	31.25 a	3.21	0.00	0.984

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 3.7. Means ($\bar{x}$), Standard Errors (SE), and *F* and *P* values resulting from univariate analysis of variance between white ibis and random microhabitat measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas, 16 March - 1 September, 2005.

	Bird location (n = 83)		Random location (n = 83)			
Habitat	$\bar{x}$	SE	$\bar{x}$	SE	*F*	*P*
Distance to edge	78.28 a[1]	7.94	78.47 a	7.94	0.00	0.987
Water depth (cm)	17.89 a	1.17	16.40 a	0.93	0.98	0.324
Open water (%)	24.75 a	3.76	21.33 a	3.54	0.44	0.509
Emergent vegetation (%)	27.34 a	4.01	25.02 a	3.41	0.19	0.659
Mudflat (%)	3.67 a	1.46	1.02 a	0.91	2.35	0.127
Floating (%)	44.21 a	4.59	52.61 a	4.55	1.69	0.196
Tallest emergent plant (cm)	27.70 a	2.89	36.06 a	3.44	3.46	0.065

[1]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 3.8. Frequency (%) of occurrence by wading birds in different habitats as related to time spent in feeding and resting behaviors measured in moist soil managed wetlands at the Richland Creek Wildlife Management Area, in east-central Texas 16 March - 1 September, 2005.

	Species						
	Cattle egret	Great blue heron	Great egret	Little blue heron	Snowy egret	White ibis	Wood stork
Habitat	(*n* =714)	(*n* =139)	(*n* =896)	(*n* =234)	(*n* =442)	(*n* =684)	(*n* =102)
Tree[1] (%)	46.00	15.80	5.69	25.64	11.99	12.71	83.30
Vegetation (%)	51.00	61.87	62.90	65.81	60.85	60.67	12.12
Open Water (%)	0.70	18.00	13.18	5.12	22.39	26.00	1.01
Mudflat (%)	1.10	-	0.89	0.43	2.48	0.59	3.03
Road (%)	0.70	2.15	2.90	2.99	2.26	-	-
Feeding (%)	8.49	3.77	8.19	52.70	53.67	86.60	7.50
Resting (%)	91.51	96.22	91.80	47.30	46.32	13.39	91.37
Water depth (cm)	9.75	21.58	18.11	9.77	8.81	10.42	0.11

[1]For all observations, when birds were located in trees (i.e., alive or dead (snags), birds were engaged in resting behaviors.

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APPENDIX A

LITERATURE REVIEW OF WATERBIRD BEHAVIOR, HABITAT USE, AND RESPONSES TO MOIST SOIL MANAGED WETLANDS

INTRODUCTION

Created Wetland Ecology

Due to anthropogenic impacts upon natural wetlands (Mitsch et al. 1998), created or restored wetlands have become important alternative habitat and food sources for wetland dependent wildlife, including waterbirds (Shuwen et al. 2001), as created wetlands provide suitable invertebrate habitats and ultimately suitable habitat for waterbirds (Stevens et al. 2003). As such, the ecological value of created wetlands may be evaluated by examining behavior of, and use by, wetland dependent wildlife, as well as monitoring potential food (i.e., invertebrates and vertebrates) resources (Ashley et al. 2000). Wading birds are good bioindicators of wetland health (Kushlan 1993), as their presence/absence or condition can signal changes occurring at lower trophic levels (Kushlan 1993). For example, the result of eggshell thinning from DDT/DDE contamination, documented waterbirds as bioindicators (Blus et al. 1972).

New wetland construction can be a result of mitigation or replacement of wetlands lost elsewhere, where mitigation projects often either have not been successful or success was subjectively determined (Mitsch et al. 1998). In some instances, improper hydrological conditions in constructed wetlands can cause mitigation failure (Erwin 1991). However, many mitigation wetland projects have been documented as successful based upon plant and wildlife composition and diversity, or if the desired goal for that site, such as clean water, was achieved (Shuwen et al. 2001).

As created wetlands are monitored during construction and subsequent stages of maturation, over time they can function much like natural wetlands. Important variables such as soil matrix chroma, organic matter content, rock fragment content, soil bulk density, vegetative species richness, total plant cover, and average wetland indicator status can all be used to assess function (Campbell et al. 2002). These variables often vary among natural wetlands, mature created wetlands, and immature created wetlands, where created wetland function improves over time, as they mature towards natural wetland conditions (Edinger 1999). Therefore, over time created constructed wetlands can be as functional as natural wetlands depending upon goals and objectives.

Faunal biodiversity in local regions may increase due to wetland creation or restoration. The snail kite (*Rostruhamus sociabilis*) is an example of a species that has responded positively to wetland restoration efforts (Toland 1994). Additionally, restoration in the St. John's River floodplain, has not only improved wildlife habitat, but also provided better water quality and flood protection. Borrow pits and managed impoundments were found to be important nesting sites for many species, including the federally endangered wood stork, in The

Upper St. John's Basin. The area was the sole breeding site of this species in Florida (Bryan et al. 2003).

Larger created wetland complexes create diverse habitats, attractive to multiple bird species rather than a single species (Delnicki and Reinecke 1986, Frederickson and Reid 1986). As habitat requirements vary among species, different created wetland types are necessary to maintain or increase bird diversity (Twedt et al. 1998). For example, waterfowl use more open water habitats, and certain management practices such as dredging and flooding, can manipulate habitats (Elphick 2000).

Shorebird and Wading Bird Ecology

CHARADRIIFORMES

Shorebirds, including plovers, sandpipers, and curlews, are fully migratory, and some can travel 12,000 to 25,000 km yearly. During spring and fall migration, some shorebirds migrate north to the Arctic tundra and south to the southern tip of South America (Myers 1983), while many others pass along the Atlantic and Pacific coasts, the western Gulf of Mexico, and through the Great Plains of North America (Myers et al. 1987). As these migrations cannot be completed in a single flight, most migrant shorebirds use wetlands as stopover sites to rest and feed (Skagen and Knopf 1993). Therefore, conservation of stopover sites is critical to shorebird migration success and population survival (Myers 1983).

In interior North America, wetlands tend to be temporally and spatially dynamic (Skagen and Knopf 1993), making habitat conservation difficult. Migrant species utilizing networks, such as playas, small patches of mudflats, grasslands, and marshes (Myers 1983, Davis and Smith 1998a) may be the most difficult to manage and protect. Critical to both habitat and shorebird conservation is identification and preservation of the most predictably available and heavily used sites, on landscape scales (Skagen and Knopf 1994b).

Wetlands offer a wide range of habitats for foraging, roosting, and protection from predation, due to increased flock size, which will enhance shorebird survival (Page and Gill 1994). Shorebirds require habitat that will maximize food intake, especially during migration when fat accumulation is critical (Skagen and Knopf 1993, Davis and Smith 1998b). Most shorebirds prefer areas with sparse vegetation (25% cover), adequate mudflat (10-15%), and shallow water (< 4 cm depth) habitats with high amounts of invertebrate densities (Davis and Smith 1998b). However, when natural wetlands are lost or otherwise unavailable or unsuitable, created wetlands can provide suitable alternative habitats for shorebirds, as they can be managed for different water levels and provide these required habitat patterns (Evans 1976, Connors et al. 1981, Burger 1984).

CICONIIFORMES

Wading birds differ in feeding behavior and strategies from shorebirds. They are typically active near dawn and dusk, and rest in midday, while feeding mainly on larger invertebrates and fish (Myers and McCaffery 1984, Morrier and McNeil 1991, McNeil et al. 1993). Food intake rates vary, depending on time of day and year. Day length also influences wading bird prey availability, as fish move toward the water surface when water conditions are anoxic in early morning (Kersten et al. 1991). This movement leads to higher capture rates and feeding success for wading birds (Kersten et al. 1991). Foraging may also be impacted by flock size, where success is higher in larger flocks in warmer water (Nota 2003). Additionally, some species may "parasitize" flocks of birds, by using them to locate food patches and feed near them, but not within the flock (Kushlan 1977a). However, bird density is nearly as important as flock size, because in dense flocks, prey detection decreases (Kushlan 1977a). However, when it is no longer advantageous for dense flocks they must spread out to find additional food sources, making them more prone to predation (Kushlan 1976b).

Migration Ecology

There are three main energetic demands on shorebirds and wading birds during migration: (1) refueling at stopover sites, (2) molting, and (3) fat accumulation in preparation for migration (Myers and McCaffery 1984). Therefore, conservation and management of freshwater wetland stopover sites in interior North America is critical for successful shorebird and wading bird migration (Davis and Smith 1998b). The use of stopover sites by shorebirds and wading birds can be divided into two types. Traditional stopovers are aligned along migration routes and used yearly and occupied for extended periods. Nontraditional stopovers are opportunistic sites, which are not used annually, where stopover duration is usually short (Melvin and Temple 1982). Migration patterns vary among species and geographically, where different regions are unique and conservation and management must be regionally and sometimes species specific. For example, shorebirds in coastal areas use ecologically predictable sites (i.e., traditional stopovers) with abundant food sources, but in the interior U.S., shorebirds use nontraditional wetlands more opportunistically and must adapt to unpredictable habitat conditions (Skagen and Knopf 1993).

There are few differences in migration ecology between shorebirds and wading birds. Both migrate long distances between breeding and wintering grounds, mainly located in the Arctic and north temperate regions (Morrison 1984), and both use stopover wetlands to replenish fat reserves during migration (Myers et al. 1987). Wading birds also appear to be somewhat more immune to inclement weather than shorebirds due to their comparatively larger size (Kushlan 1981). However, the primary difference between shorebird and wading bird migration ecology revolves around food habits and general habitat selection (Kushlan 1979, Warnock et al. 2002). Whereas shorebirds primarily consume invertebrates and use wetlands with shallow water and exposed mudflat habitats, wading birds rely upon wetlands with abundant and reliable vertebrate food sources such as fish and amphibians (Ogden et al. 1976, Kushlan 1979). Despite these food habit differences, wading bird populations face similar threats from habitat loss (Goss-Custard 1980, Frederick 2002).

Behavioral Ecology

Time-activity budgets are important to assess functional wetland habitat value for shorebirds and wading birds (Davis and Smith 1998a). Knowledge of species composition, migration chronology, habitat selection, and feeding ecology during migration is also essential for developing conservation strategies at local and landscape scales (Davis and Smith 1998b). As different species occupy different habitats and exploit multiple food sources, behavioral data can provide managers with detailed information needed to manage wetlands for target species.

During migration, shorebirds and wading birds form dense aggregations as compared to the breeding season. Similarly, species composition changes, where mixed flocks are often observed, and species that are generally geographically or ecologically isolated become concentrated (Recher 1966). Behavioral patterns may change within and among seasons, depending upon dietary requirements, habitat condition, and bird age (Rompre and McNeil 1994). For example, time spent feeding in one season may be the inverse of resting in another season (Morrier and McNeil 1991). Additionally, migrant shorebirds feeding in inland areas will behave differently from those in coastal wintering and breeding grounds (O'Reilly and Wingfield 1995, Davis and Smith 1998b), as different habitats provide different food items. Finally, bird behavior, in northern temperate regions may differ from that in the south, as will habitat and vegetation types (Davis and Smith 1998b).

There are three primary foraging categories shared among shorebirds, which vary by species, water depth, and general prey searching behavior (Battley et al. 2003) and are generally dictated by bill and leg length (Baker 1979). First, there are visual-surface foragers, where birds spot prey items in shallow water, such as grey plovers (*Pluvialis squatarola*), common sandpipers (*Actitis hypoleucos*), and whimbrels (*Limosa phaeopus*). Second, tactile-surface foragers use their bill to locate prey in shallow water, such as bar-tailed godwits (*Limosa lapponica*), curlews (*Numenius arquata*), and sanderlings (*Calidris alba*). Finally, pelagic-foragers forage in deeper, more open water, and may be visual or tactile foragers, such as American avocets (*Recurvirostra americana*), black-necked stilts (*Himantopus himantopus*) and greenshanks (*Tringa nebularia*).

Beyond the three general categories, they can be further divided. First, pelagic foragers can scythe, or sweep the bill from side to side. Second, tactile and pelagic foragers can plow while running with the bill partially immersed at an angle in the water. Third, they can peck at the surface with quick jabs into the water, or probe the substrate or water.

Wading bird feeding ecology and behavior generally differs from shorebirds, where waders are stalkers, using sight and slow movements to take prey items in deep or shallow water (Ntiamoa-Baidu et al. 1998). Wading birds mainly feed on large invertebrates, amphibians and fish, whereas shorebirds are faster foragers, feeding on smaller invertebrates like chironomid larva and oligocheate worms (Higgins and Smith 1999). Like shorebirds, wading bird prey capture techniques vary among species and morphology. First, some wading birds may stand and wait, stand upright and wait, crouch and wait, or vibrate their bill in the water column before striking at prey items. Second, wading birds often walk slowly and strike at prey while moving. Third, wading birds may use foot stirring and bill vibrating to bring prey to the water surface for easier prey capture (Meyerriecks 1959, Kushlan 1972). Fourth, reddish egrets (*Egretta rufescens*) and tricolored herons (*Egretta tricolor*) may extend their wings over the water column to reduce the surface glare, and the movements of the shadow may stir up potential prey (Meyerriecks 1962). Additional movements include swaying head back and forth in an arc with bill pointed in one spot right before striking, mudflat feeding, and sandpiper style pecking. Some waders may actively pursue prey, using open wing techniques, but are rarely used except by smaller herons such as snowy egrets (*Egretta thula*) (Willard 1977). Finally, aerial hunting may be used where birds dive and hover, such as snowy egrets and little blue herons (*Egretta caerulea*) (Willard 1977).

Wading bird population size and amount of available habitat are positively correlated, and both will affect foraging behaviors. Selection of foraging sites is not random and is usually correlated with food abundance (Kushlan 1981). For example, wading birds will forage alone or in flocks, where larger flocks will be concentrated in areas with more abundant food sources (Kushlan 1976). Foraging in flocks has advantages over foraging alone, as it decreases search time between food patches, increases the likelihood of foraging in suitable habitats, and more food may be available (Kushlan 1981), although increased flock density may quickly reduce food availability. Many species, like the great egret and snowy egret, have white plumage, which aid in attracting other birds to flocks (Kushlan 1978). A change in prey distribution and behavior affects availability to little egrets *(Egretta garzetta)* which appears to be an explanation for the formation of feeding aggregations (Kersten et al. 1991)

Nocturnal Behavior

Diurnal feeding may not fulfill the energetic needs of migratory birds, and both diurnal and nocturnal foraging may be required to meet energy demands during migration (Robert and McNeil 1989). Therefore nocturnal habits are also ecologically important (Davis and Smith 1998a), as there are potentially important behavioral differences between day and night. Nocturnal feeding supplements nutritional demands and may provide waterbirds with more profitable prey items while reducing predation risk (Bryan et al. 2001).

Most wading birds generally roost at night and forage during the day. However, wood storks have been documented foraging more at night than any time of day (Bryan et al. 2001). In addition, wood storks use tactile foraging, and are more likely to feed nocturnally since they do not rely on vision to search for prey (Kahl 1964, Kushlan 1978). Other wading birds that have been documented to forage at night are the yellow crowned night heron (*Nycticorax violaceus*), a crepuscular and nocturnal feeder, great blue heron (*Ardea herodias*), a mainly crepuscular, but also diurnal and nocturnal feeder, and roseate spoonbill (*Ajaia ajaja*), a mainly crepuscular feeder which forages at night (Rojas et al. 1999). Furthermore, some heron species will forage at night in the same feeding grounds as diurnal heron species, potentially avoiding competition for limited food resources (Watmough 1978). Specific prey capture techniques also vary between day and night. Wood stork, however, are tactile foragers, regardless of diurnal period. In addition, behaviors vary from day to night and are modified accordingly, with slower movements, fewer steps and longer search time at night compared to day (Goss-Custard 1970, Hulscher 1976, Robert and McNeil 1989, Turpie and Hockey 1993).

APPENDIX B

ESTIMATED FLOCK SIZE FOR WADING BIRDS AND SHOREBIRDS IN MOIST SOIL MANAGED WETLANDS AT THE RICHLAND CREEK WILDLIFE MANAGEMENT AREA IN EAST-CENTRAL TEXAS

Appendix B. Estimated flock size (i.e., > or < 20 individuals) for wading birds and shorebirds in moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004 and 16 March - 1 September, 2005.

	2004		2005	
Species	< 20	> 20	< 20	> 20
Baird's sandpiper	X			
Black-necked stilt	X		X	
Cattle egret[1]		X		X
Glossy ibis	X		X	
Great blue heron[1]	X		X	
Great egret[1]		X		X
Greater yellowlegs	X			X
Green heron	X		X	
Killdeer	X		X	
Limnodromus spp.	X			X
Little blue heron[1]		X		X
Least sandpiper		X	X	
Lesser yellowlegs	X		X	
Pectoral sandpiper		X	X	
Plegadis spp.	X		X	
Roseate spoonbill		X	X	
Snowy egret[1]		X		X
Solitary sandpiper	X		X	
Spotted sandpiper	X		X	
Stilt sandpiper		X	X	

Tricolored heron	X		X	
Western sandpiper		X	X	
White ibis[1]		X		X
Wilson's phalarope	X			X
White-rumped sandpiper	X		X	
Wood stork[1]		X		X
Yellow-crowned night heron	X		X	

[1]Focal species.

APPENDIX C

OBSERVATIONS OF AERIAL FORAGING BY GREAT AND SNOWY EGRETS AT THE RICHLAND CREEK WILDLIFE MANAGEMENT AREA

INTRODUCTION

Ciconiiformes are known for their dexterity and diversity of foraging behaviors and techniques (Kushlan 1978a, Chapter II). For example, > 30 different foraging behaviors have been recorded for nine different species within the order (Meyerriecks 1962, Kushlan 1976b, Willard 1977). Smaller waders such as snowy egrets (*Egretta thula*), little blue (*E. caerula*) and tricolored (*E. tricolor*) herons tend to utilize a wider diversity of foraging techniques than larger waders such as great egrets (*Ardea alba*) and great blue herons (*A. herodias*) (Kushlan 1976b). This size-related difference in foraging repertoires among waders is hypothesized to be physiologically based, where the energetic costs of active prey pursuit during the breeding season may be too great for some species, and limit those to energetically less expensive stand and wait or stalking approaches (Kushlan 1978b). Conversely, during non-breeding periods, when energetic costs of prey pursuit are lower, these larger waders may incorporate more active, albeit less cost efficient, foraging techniques (Kushlan 1978b). However, irrespective of season, some species may learn and evolve individual feeding specializations in order to maximize foraging efficiency (Kushlan 1972).

One of the more infrequently used, and rarely documented, wader foraging behavior is aerial foraging, documented primarily for snowy egrets, great egrets, and great blue herons (Rogers 1974, Morey and Smits 1987). These behaviors have been described as (1) hovering and plunging to catch live prey at water's surface, (2) hovering to disturb prey caught in submergent vegetation, (3) hovering to feed on dead floating fish, or (4) hovering while dragging feet at the surface (Bond 1934, Meyerriecks 1959, Kushlan 1972). Because of its relative rarity, few studies have focused upon aerial foraging in waders. This is the first report of these behaviors, in at least 10 years, among waders using moist soil managed wetlands.

During part of a larger study examining wading bird behavior during spring and summer in moist soil managed wetlands at Richland Creek Wildlife Management Area in east central Texas (Chapter II), great and snowy egrets were observed aerially foraging on two separate occasions on 12 August and 1 September, 2005. The rarity of aerial foraging is evident as this behavior was observed on only two occasions in two years, despite nearly 2,000 individual focal samples, representing approximately 100 hours of detailed observations collected for great egret (n = 1,250) and snowy egret (n = 736) during this study (Chapter II).

Aerial foraging was observed between 07:00 and 10:00, over open water in moist soil managed wetlands two and three (i.e., 27.6, 30.3 ha respectively) (Figure 1.2), both of which contained pools of water deeper than in which birds could stand. Emergent herbaceous vegetation surrounded those pools and was used as resting locations between aerial foraging bouts. Of the aforementioned behaviors, both species used (1) hovering and plunging and (2) foot dragging techniques, often performed simultaneously among individuals of both species. During these behaviors the frequency of aggressive encounters, which were rarely observed (i.e., < 1 % of the time for both species) during all other observations (Table 2.1), within and between species increased. On both occasions, aerial foraging by snowy and great egrets occurred within mixed flocks (i.e., > 100 individuals) of cattle egrets, (*Bubulcus ibis*), great and snowy egrets, and an occasional great blue heron. After birds had completed a plunging attempt, most floated/rested at the water's surface for a few seconds before taking flight again directly from the water, a behavior also observed in great blue herons (Morey and Smits 1987). Often attempts were futile as individuals expended a great deal of energy hovering and flying with unsuccessful foraging attempts, therefore intake may not sufficiently fulfill energy requirements. It is unknown whether birds were actively pursuing disturbed prey or were feeding upon dead floating fish. As morning passed, birds diminished the frequency and intensity of aerial foraging, and eventually switched to more typical stand and wait foraging behaviors.

These observations may support earlier hypotheses of facultative foraging behavior switches, where wading birds change from less successful foraging techniques to those that maximize feeding success (Meyerriecks 1962). These observations also corroborate previous documentation of egrets utilizing hovering and foot dragging in conjunction with aerial diving (i.e., plunging) (Kushlan 1972, Rodgers 1974). Also, the timing of these observations (i.e., post breeding) also give support to the hypothesis that such aerial foraging behaviors are performed when energetic costs are lower. Since lack of quantitative data exists regarding this rare behavior, it is still unclear whether it is a response of decreased food quantity or quality elsewhere on wetlands, thus forcing these species to attempt foraging in habitat and water levels not normally utilized by these birds. Finally, because of the extreme infrequency in which these behaviors were documented, these observations further substantiate the rarity of aerial foraging in wading birds.

APPENDIX D

OCCURRENCE OF FORAGING RELATED BEHAVIORS OBSERVED FOR WADING BIRDS AND SHOREBIRDS IN MOIST SOIL MANAGED WETLANDS AT THE RICHLAND CREEK WILDLIFE MANAGEMENT AREA IN EAST-CENTRAL TEXAS, 16 APRIL - 31 AUGUST, 2004

Appendix D. Occurrence of foraging related behaviors[1] observed for wading birds and shorebirds in moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 April - 31 August, 2004.

Species	Behavior													
	Stand/wait	Stalking	Running	Hopping	Footstirring	Head tilt	Head sway	Bill vibrate	Bill sweep	Quick jabs	Bill probe	Dipping	Spinning	Open-wing feed	Head bob
Baird's sandpiper	-	-	X	-	-	-	-	-	-	X	X	-	-	-	-
Black-necked stilt	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
Cattle egret	X	X	X	-	-	X	X	-	-	X	-	-	-	-	-
Glossy ibis	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Great blue heron	X	X	-	-	-	-	-	-	-	X	-	-	-	-	-
Great egret	X	X	-	-	-	X	X	-	X	X	-	-	-	-	-
Greater yellowlegs	-	-	-	-	-	-	-	-	-	X	X	-	-	-	X
Green heron	X	-	-	-	-	-	-	-	-	X	-	-	-	-	
Killdeer	-	-	X	-	X	-	-	-	-	X	-	X	-	-	X
Limnodromus spp.	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Little blue heron	X	X	-	-	-	X	X	-	-	X	-	-	-	-	-
Least sandpiper	-	-	X	-	-	-	-	-	-	X	X	-	-	-	-
Lesser yellowlegs	-	-	-	-	-	-	-	-	-	X	X	-	-	-	X
Pectoral sandpiper	-	-	-	-	-	-	-	-	-	X	X	-	-	-	X
Plegadis spp.	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Roseate spoonbill	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Snowy egret	X	X	X	X	X	-	X	X	X	X	-	X	-	-	-
Solitary sandpiper	-	-	-	-	-	-	-	-	-	X	-		-	-	X
Spotted sandpiper	-	-	-	-	-	-	-	-	-	X	X	X	-	-	X
Stilt sandpiper	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
Tricolored heron	X	X	-	-	-	-	-	-	-	X	-	-	-	X	-

Western sandpiper	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
Wilson's phalarope	-	-	-	-	-	-	-	-	X	X	-	-	X	-	-
White-rumped sandpiper	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
Wood stork	X	-	-	-	X	-	-	-	X	-	X	-	-	-	-
Yellow-crowned night heron	-	X	-	-	-	-	-	-	-	X	-	-	-	-	-

[1]Foraging behaviors as defined by Meyerriecks (1962).

APPENDIX E

OCCURRENCE OF FORAGING RELATED BEHAVIORS OBSERVED FOR WADING BIRDS AND SHOREBIRDS IN MOIST SOIL MANAGED WETLANDS AT THE RICHLAND CREEK WILDLIFE MANAGEMENT AREA IN EAST-CENTRAL TEXAS, 16 MARCH - 1 SEPTEMBER, 2005.

Appendix E. Occurrence of foraging related behaviors[1] observed for wading birds and shorebirds in moist soil managed wetlands at the Richland Creek Wildlife Management Area in east-central Texas, 16 March - 1 September, 2005.

	Behavior														
Species	Stand/wait	Stalking	Running	Hopping	Footstirring	Head tilt	Head sway	Bill vibrate	Bill sweep	Quick jabs	Bill probe	Dipping	Spinning	Open-wing feed	Head bob
Cattle egret	X	X	-	X	-	-	-	X	-	-	X	-	-	-	-
Common snipe	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Great blue heron	X	X	X	-	-	-	X	-	-	-	X	-	-	-	-
Glossy ibis	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Great egret	X	X	X	-	-	-	X	X	-	-	X	-	-	-	-
Greater yellowlegs	-	-	-	-	-	-	-	-	-	X	X	X	-	-	X
Green heron	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Killdeer	-	-	-	X	-	X	X	-	-	-	X	-	-	-	X
Limnodromus spp.	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Little blue heron	X	X	-	-	-	-	-	X	-	-	X	-	-	-	-
Least sandpiper	-	-	-	X	-	-	-	-	-	-	X	-	-	-	-
Lesser yellowlegs	-	-	-	-	-	-	-	-	-	X	X	X	-	-	X
Pectoral sandpiper	-	-	-	X	-	-	-	-	-	-	X	X	-	-	-
Roseate spoonbill	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
Snowy egret	X	X	X	X	X	X	X	X	X	-	X	-	-	-	-
Solitary sandpiper	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X
Spotted sandpiper	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X
Stilt sandpiper	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X
Tricolored heron	X	X	-	-	-	-	-	-	-	-	X	-	-	X	-
Western sandpiper	-	-	-	X	-	-	-	-	-	-	X	-	-	-	-
White-faced ibis	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

White ibis	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-
Wilson's phalarope	-	-	-	-	-	-	-	-	-	X	-	X	X	-	-
White-rumped sandpiper	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Wood stork	X	-	-	-	-	X	-	-	-	X	-	X	-	-	-
Yellow-crowned night heron	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-

[1] Foraging behaviors as defined by Meyerriecks (1962).

APPENDIX F

NOCTURNAL OBSERVATIONS OF WOOD STORKS DURING SUMMER AT THE RICHLAND CREEK WILDLIFE MANAGEMENT AREA

INTRODUCTION

Wood storks (*Mycteria americana*) are a wetland dependent wading bird that require wetland habitats with specific water depths for foraging, nesting, and loafing (Frederick and Collopy 1989), but due to wetland losses, wood storks have suffered severe population declines since the early 1900's (Ogden 1980, Bryan 2000). Changes in water management in Florida during the breeding season have attributed to this decline, as wood storks are highly sensitive to water level changes within and between years (Kushlan et al. 1975, Ogden 1994). For example, when Everglade wetlands become dry during summer, wood storks migrate to wetlands with higher prey availability in Georgia and South Carolina (Kahl 1964). However, wetlands in these areas are generally smaller and food supplies are not as concentrated (Depkin 1992), and wood storks change foraging strategies by feeding on lower density larger prey in small flocks or solitarily, rather than in large colonial flocks (Coulter and Bryan 1993, Coulter and Bryan 1995).

This within season northward migration is unusual in North American birds, and their presence on Richland Creek Wildlife Management Area (RCWMA) during June and July may suggest that these birds are also moving in response to declining foraging or wetland habitat quality, locally or regionally.

However, the origin of wood storks appearing at RCWMA remains unknown. Wood stork occurrence in Texas is not well documented and few studies report use of moist soil managed wetlands during summer, despite potentially suitable habitat in such wetlands with water level control. Since wood storks prefer wetland habitats with small pools and high prey concentration (Kahl 1964, Gaines et al. 1998, Bryan et al. 2002) moist soil management may be an effective technique for providing suitable foraging habitat for this species (Chapter II).

Wood storks primarily forage by tactilocation rather than relying upon vision to search for prey (Kahl 1964), a behavior used by few other wading birds (i.e., white ibis (*Eudocimus albus*) (Chapter II). Tactile foraging may also allow waders, such as wood storks, to forage nocturnally (Bryan et al. 2001), as locating prey at night is not dependent upon vision. Nocturnal foraging has been theorized to supplement normal diurnal feeding, which may not meet energy requirements for many species (Kostecke and Smith 2001). Moreover, feeding at night may also aid in search of prey through smaller flock sizes, offer protection from predation (Goss-Custard 1969, Willard 1977, Kushlan 1978a), and allow birds to avoid interspecific competition with diurnal foragers employing similar foraging strategies (i.e., white ibis, Chapter II). Because of the (1) overall lack of consistent observations of diurnal foraging by wood storks (Table 2.1), and (2) and documented reports of nocturnal foraging by wood storks in other studies (Bryan et al. 2001), attempts were made to develop nocturnal time activity budgets for wood storks at RCWMA in 2005

METHODS

Between 16 April and 1 September, 2005, several (> 15) attempts were made to conduct nocturnal observations on wood storks in order to develop - nocturnal time-activity budgets using the focal individual sampling technique on moist soil managed wetlands at RCWMA (Chapter II). Observations were made using night vision optics or spotlight and spotting scope from 17:00-05:00, where moist soil managed wetlands were surveyed randomly. When wood storks were observed, attempts were made to observe randomly selected individuals where following behaviors were continuously recorded for 3 min. into a tape recorder: (1) feeding (i.e., handling and consumption of prey), (2) standing (i.e., waiting or stalking), (3) resting (i.e., crouched position or asleep), (4) body maintenance (i.e., preening or bathing), (5) aggression, (6) locomotion (i.e., walking, wading, swimming or running), (7) alert (i.e., stationary or scanning), (8) comfort movements (i.e., shaking or fluffing feathers), (9) foot stirring (i.e., stirring prey up to surface with foot), and (10) nesting (i.e., manipulating or carrying branches) (Rooth 1976, Laubhan et al. 1991, DeLeon and Smith 1999).

RESULTS

As many as 30 wood storks were counted after dark on a given survey night, however, due to difficulty locating and observing wood storks at night, only nine focal samples could be collected (Table F.1). There were observations of feeding for individuals in which focal samples were not generated, but for the nine focal samples, resting comprised > 70% of their nocturnal time budgets (Table F.1), which is very similar to the amount of diurnal time spent resting (Table 2.1). Moreover, for those nine samples, no feeding was observed, nor was any stand and wait behaviors (i.e., foraging related behaviors, Chapter II). Although a very small sample size, six of nine birds engaged in nesting behaviors (i.e., carrying twigs or other nest materials), at rates (i.e., $\bar{x}$ = 13 %) (Table F.1) nearly five times that observed for wood storks during diurnal periods (Table 2.1).

DISCUSSION

Although nocturnal feeding is documented in the literature (Bryan et al. 2001), data generated during this portion of the study revealed nocturnal feeding to be an infrequently observed activity for wood stork on these moist soil managed wetlands. Previous research reporting nocturnal foraging in wood storks have also presented few quantitative results, where birds were observed feeding diurnally and nocturnally with higher rates during diurnal periods (Kahl 1964). Additionally, Bryan et al. (2001) also examined nocturnal behavior of wood stork on inland impoundments and revealed larger numbers foraging at night however when compared to other times of the day, foraging rates were similar. Although not well documented or understood, wood storks may have an advantage to feed nocturnally, as they are tactile foragers which may (1) lead to selection of higher quality prey and (2) avoid competition for food resources at night from other wading birds. Future research clearly needs to focus on nocturnal behaviors in wood storks since there is little known information to substantiate which foraging habitats provide for maximum prey intake at night. Understanding how wood storks utilize moist soil wetlands in relation to other species and as an endangered species can offer management implications which aid in conservation and protection of wetlands and wood storks.

Despite limited data, observations of nesting behaviors during both diurnal (Table 2.1) and nocturnal periods (Table F.1) are potentially important from a conservation and management standpoint. As wood storks are known to move northward during poor habitat conditions, wood stork presence and frequency of nesting behaviors potentially indicate that wood storks maintain nesting colonies within the region surrounding RCWMA. However, to date, no wood stork nests have been documented in Texas (C. Frentress, personal communication), and results from this study may lead to further investigations into the presence and location of wood stork nesting colonies near RCWMA, potentially within the Trinity River basin. Use of satellite telemetry may be useful to (1) further explore movement patterns of wood storks in Texas, (2) locate and identify wood stork nesting colonies, and (3) monitor nest success and examine nesting ecology in wood storks.

Table F.1. Individual nocturnal time-activity budgets (i.e., proportion (%) of time spent in individual behaviors) for nine wood storks collected during late June and early September 2005 at the Richland Creek Wildlife Management Area, in east-central Texas.

	Individuals										
Behavior	One	Two	Three	Four	Five	Six	Seven	Eight	Nine	$\bar{x}$	SE
Locomotion (%)	18.03	30.05	5.41	12.90	0.00	0.00	0.00	5.56	0.00	7.99	3.49
Feeding (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aggression (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.12	0.12
Standing (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alert (%)	0.00	8.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.97
Maintenance (%)	7.65	9.84	5.41	2.69	2.72	0.00	0.00	0.00	0.00	3.14	1.24
Resting (%)	74.32	42.62	78.38	79.03	14.13	100.00	100	87.78	96.11	74.08	9.60
Comfort (%)	0.00	2.19	0.00	0.00	0.00	0.00	0.00	1.11	0.00	0.36	0.26
Nesting (%)	0.00	6.56	10.81	5.38	83.15	0.00	0.00	5.56	2.78	12.69	8.89

VITA

After completing her work at Nolan Catholic High School, Fort Worth, Texas, in 1997, Angela Mangiameli entered The University of Texas at Arlington. She graduated in December of 2001 with a Bachelor of Science in Biology. During the following year she worked at the Westcliff Animal Hospital as a veterinary assistant. In February 2003 she was employed as an intern for Fossil Rim Wildlife Center working with Attwater's Prairie Chickens. In the fall of 2003 she entered Stephen F. Austin State University, studying Wildlife Management, and received the degree of Master of Science in August 2006.

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