USE OF NEWLY CONSTRUCTED WETLANDS BY WINTERING WATERFOWL AND WATERBIRDS

THESIS

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ABSTRACT

Texas coastal wetlands have been declining since the 1950s. Waterfowl and waterbirds, in particular, have been greatly affected by the loss of wetlands because these areas provide wintering habitat. In an effort to combat the loss of wetlands, landowners, non-governmental agencies, and governmental agencies have combined resources to create and restore wetlands. One such effort was a newly constructed wetland near La Ward, Jackson County, in the Gulf Coast region of Texas. In this study of the constructed wetlands, I determined occupancy of and behaviors exhibited by waterfowl and waterbirds using the wetlands at seven quadrats. I conducted 10-minute visual scans every 30 minutes to determine presence or absence and behavior of waterfowl and waterbirds in quadrats. Sixteen waterfowl species as well as American coot and grebe species used the wetlands with varying frequency. Quadrat 6A had the greatest occupancy with 10,294 birds of 19 species. Only two birds used Quadrat 6C.

Waterfowl and waterbirds primarily rested on quadrats (50% of observations). Foraging was a secondary behavior (29% of observations). Geese in particular tended to rest in quadrats. Further investigation may determine which characteristics of these quadrats make them particularly suited for resting and foraging, and should provide additional information for habitat managers to create or enhance their areas for winter waterfowl resting and foraging.

Abiotic data were also collected during the study to determine if factors such as wind direction and time of day had any effect on occupancy by waterfowl. All abiotic factors affected species presence with site location, wind direction, and air temperature

being the most significant ($p < 0.0001$). Other abiotic factors had a highly significant effect on occupancy. Time of day and wind speed, time of day and humidity, wind speed and humidity, time of day and air temperature, and wind speed and air temperature all combined to significantly impact pond occupancy by waterfowl ($p < 0.0001$).

Overall, these newly constructed wetlands were immediately occupied by waterfowl and waterbirds and used for resting and foraging during winter along the Gulf Coast of Texas.

INTRODUCTION

Texas has some of the most abundant and diverse wetlands in the world (Moulton and Jacobs 2000). Ecologically, wetlands increase the earth's water quality, provide nurseries for fish and shellfish, decrease damage during severe flooding, reduce erosion by creating vegetated buffers along shorelines, increase revenue to communities from fishing and wildlife watching opportunities, and create viable, diverse wildlife habitat (Moulton and Jacobs 2000). Each winter thousands of waterfowl and other birds migrate into Texas. Many of these birds winter along the Texas coast before migrating north in spring to breed and reproduce.

Unfortunately, Texas coastal wetlands have declined at a rate of 2,300 ha per year since the 1950s (Moulton and Jacobs 2000). Several factors, including changing weather patterns, changing agricultural practices, and human encroachment contributed to the decline and loss of habitat for wintering waterfowl (Moulton et al. 1997, Baccus and Koo 1998). Specifically, a reduction in the abundance of ducks became apparent through the 1980s and early 1990s, causing concern for the continued existence of duck populations (Ringelman 1992). While regulations of hunting seasons and bag limits as well as regulations on the use of chemicals to control insects and vegetation have helped to stabilize waterfowl populations, the continuing loss of habitat is a concern of wildlife managers (Baldassarre and Bolen 1994). Habitat loss not only causes direct mortality through the loss of feeding, resting, and nesting areas, it changes waterfowl behavior in the remaining smaller, more concentrated waterfowl populations (Kelley et al. 1993).

Since the mid-1950s, over 202,000 ha of wetland habitat has been lost to urban sprawl. Construction of houses, businesses, industrial complexes, and roads are substantial contributors to wetland loss in the major metropolitan areas of Houston, San Antonio, Dallas/Fort Worth, and Austin (Moulton et al. 1997). Because of the burgeoning human population and high property values, it is unlikely that urban sprawl will slow in these areas. The solution to this problem may be the restoration of wetlands on private lands by individuals or organizations or the purchase and restoration of suitable lands by the state or federal government.

Loss of waterfowl habitat in the Texas Gulf Coast has reduced the size of one of the major waterfowl wintering grounds in North America (Graziano and Cross 1993). Additionally, the decline in waterfowl hunting has caused economic loss in many rural communities. Hunters, wildlife watchers, and antihunters have expressed concern for the decline in waterfowl and have asked habitat managers to ensure the sustainability of waterfowl for future generations (Baldassarre and Bolen 1994). The North American Waterfowl Management Plan was a response by waterfowl managers to the decline of duck and goose species as documented by field surveys from 1950 through 1980. The plan calls for the restoration of habitat for waterfowl and waterfowl populations to 1970s population levels (Graziano and Cross 1993). Under this plan, Texas became a state in the Gulf Coast Joint Venture.

To accomplish this restoration, state, federal and local governments, as well as private industry and landowners, must step forward to identify and restore suitable areas for waterfowl habitat. It also is important to maximize the value of remaining habitat by tailoring habitat to the needs of waterfowl. In order to provide suitable habitat for wintering waterfowl and waterbirds, it is necessary to determine which wetlands are being used by waterfowl and waterbirds and what behaviors are exhibited while on wetlands. Behavioral data should indicate which needs are being fulfilled by wetlands. The patterns of use combined with the behaviors exhibited by waterfowl and waterbirds should indicate the needs of wintering waterfowl.

The objectives of this study were to determine the extent of waterfowl use of newly constructed ponds and behavioral activities of waterfowl while on ponds. To address these objectives, I tested the following hypotheses:

1: Waterfowl and waterbirds used all quadrats with equal frequency,

2: Quadrat did not affect waterbird and waterfowl behavior, and

3: Species diversity was equal across all ponds.

By determining patterns of use and behaviors exhibited by waterfowl in the newly constructed wetland, I will provide information for understanding the benefits these constructed wetlands provide to wintering waterfowl. Based on these findings, future studies will be able to isolate specific characteristics of the wetlands for study. Additionally, by determining how wintering waterfowl use these particular wetlands, wildlife managers and landowners will be able to better direct wetlands construction to provide winter waterfowl habitat.

STUDY AREA

There are several thousand hectares of industrial and agricultural land in the central Texas coastal plains in Calhoun and Jackson counties near Port Lavaca that border Texas Highway 172 between Lake Texana and Port Lavaca. A 120-ha tract of this land was set aside for wetland restoration in compliance with terms established in a mitigation agreement between a chemical company that owns the land and local environmental groups (Fig. 1). Dikes and levees were constructed to enclose four sections of this land. Five ponds were created as habitat for migratory and resident waterfowl. Water control devices diverted water into impoundments and enabled drawdown management or seasonal removal of water from the ponds allowing cattle grazing after the spring waterfowl migration.

The ponds varied in size (Fig.1). The largest pond was unit six (38.0 ha). Unit one (8 ha) had emergent vegetation and is the smallest pond. Unit one served as a control pond in the study. Rattle bush (*Sesbania drummondii*) and Macartney rose (*Rosa bracteata*) dominated the vegetation associated with ponds. Macartney rose formed dense thickets and made observation of birds very difficult. Unit three had extremely dense thickets of Macartney rose along its eastern border, which prevented the use of the border in this study. Macartney rose thickets precluded the use of unit two in this study. Rattle bush aggregations also were numerous, but the relatively open, deciduous plant allowed waterfowl movement around its branches. It also did not obscure observers' lines of sight for data collection. Otherwise vegetation in or around the ponds did not impede observations.

Soil samples of this area indicate that a clay "pan" exists 64-100 cm below the surface. Below the pan lies 102 cm of sandy clay loam. In all, there is 140 cm of soil capable of sustaining water at desired levels (Jackson County Soil Survey 1997).

Filling of ponds began in October 1999 and was completed by November 1999. Water remained in these impoundments until the completion of waterfowl migration in Spring 2000. These ponds will be filled annually on this schedule in a continuing effort to supply migratory waterfowl with wintering habitat.

MATERIALS AND METHODS

In this study, I assessed habitat use patterns by migratory and resident waterfowl populations on these newly constructed wetlands. Criteria for individual waterfowl behaviors were defined and data were collected on behaviors exhibited by waterfowl. Data were also used to determine whether behaviors occurred in equal frequencies. If behaviors do not occur in equal frequency, the analysis should indicate which species-specific behaviors occurred more or less frequently. By establishing whether ponds had an effect on behaviors, I determined how these constructed wetlands were used by waterfowl. For example, since food is a major requirement for waterfowl, I expected that adequate wintering habitat would include feeding opportunities. If particular species of birds exhibited feeding behavior in a pond more often than expected (and therefore to the exclusion of other behaviors), I concluded that the pond provided more feeding opportunities than expected and therefore the pond could not be rejected as unsuitable waterfowl habitat.

Data also indicated species diversity and relative distribution of waterfowl using ponds for the period in which migratory waterfowl inhabited the area. Additionally, ponds were compared individually and as a group to determine if there are significant differences in use between them.

Three ponds (units three, four, and six) were identified as the study area. To determine waterfowl use of ponds, one to three permanent, elongated quadrats were established in the ponds. One quadrat was placed in a pre-existing emergent wetland directly north of unit two (Fig. 1). Quadrats were randomly placed in areas of potential waterfowl use. Criteria for use included (1) areas without water but with vegetation (dry land), (2) areas with water and emergent vegetation, and (3) areas with open water and no vegetation. These criteria were used to increase the internal validity of the study (Altmann 1973).

Quadrats were marked using 5 cm x 189 cm polyvinyl chloride (PVC) pipe. One pipe was placed in each corner to demark a 50 m by 200 m quadrat with a total area of 10,000 m^2. Because of the length of quadrats, two additional pipes were placed between the corner markers along the 200 m axis at 100 m to more accurately delineate the quadrat boundaries during data collection. Individual quadrats were identified by painting the tops of each pipe; yellow identified quadrat A, blue identified quadrat B, and quadrat C in unit six was left unpainted, as were pipes that outlined the single quadrat in the existing emergent wetland. Additionally, all PVC posts that delineated the boundaries of a quadrat were plotted with a Garmin 12XL global positioning system (GPS unit) to identify boundaries while preparing maps of the study area. All GPS information was downloaded into 3-D Topo Quads (DeLorme), a mapping program used to generate preliminary digital raster graphic (DRG) or topographic maps of the study site. Aerial maps or Digital Ortho Quarter Quads (DOQQs) were also prepared and used.

Quadrats were visually scan sampled for waterfowl 10 times during each of 8 counts: four morning and four evening counts were conducted at each quadrat. Morning counts were conducted between 0700 to 1130 h. The data collector changed locations and counted different quadrats in the afternoon. Data collection in the afternoon occurred from 1200 to 1630 h. Environmental data collected during sampling included wind speed, wind direction, relative humidity, cloud cover, and ambient temperature. Cloud cover data were based on terminology such as overcast, clear, partly cloudy, etc. A Kestrel 2000 (Nielson-Kellerman Company, Chester, PA) was used to collect wind speed and ambient temperature. The humidity was derived with the use of a pen-type thermo-hygrometer (Control Company, Friendswood, TX).

Data collection began on 21 December 1999 and was concluded by 20 February 2000. The beginning date was chosen to insure that the majority of waterfowl species typically wintering along the coast of Texas had completed migration and were utilizing the ponds. The ending date for the study insured migration north had not begun prior to the completion of data collection.

Use of ponds by waterfowl was defined as waterfowl being on ponds and within quadrat boundaries at the time of a survey. Data were additive in the evaluation of each quadrat. Quadrats were visually scanned at 30-minute intervals using a Swift Searcher 20x and 40x spotting scope (Model 839). The 20x lens was used by observers to visually scan the area of a quadrat, while the 40x lens was used to identity individual waterfowl when initial identification was questionable. In addition, *A Guide to Field Identification of North American Birds* by Robbins et al. (1983) and the *Field Guide to the Birds of North America, Third Edition* (Dickinson 1999) were used to confirm bird identifications.

Scan sampling (Martin and Bateson 1993) was used to determine behavior of birds within quadrats. Waterfowl within a quadrat were surveyed every 30 minutes. A survey lasted a maximum of 10 minutes. A 10-minute visual scan was chosen based on preliminary data collected on 20 December 1999, when I attempted to take data at 2, 3, 5, 7 and 10-minute intervals in mock surveys at quadrats 5A and 3A. I determined that large numbers of waterfowl could be present during a scan (one mock survey included over 760 individual birds) and a ten-minute scan was the only survey method that allowed enough time for an observer to count individual birds, identify species, and determine behavior. If a quadrat contained few birds, then the count only lasted long enough to record all birds. This was an attempt to make counts as instantaneous as possible and lower the bias involved with scan sampling (Altmann 1973). Only one scan for each species occurred during the 10-minute period.

There were eight data collections for each quadrat with four morning and four afternoon counts. During each count, scans were conducted every 30 minutes over a period of five hours for a total of 10 scans per count per quadrat. This resulted in 80 scans for each quadrat and 560 scans or 5600 minutes of observation for all quadrats during the study. Counts for each quadrat were scheduled randomly, but some opportunistic scans occurred during the study period.

New birds arriving in a quadrat after the beginning of a 10-minute scan were not counted as part of that data set. If counted birds left the quadrat and returned prior to the end of a 10-minute scan, these birds were not recounted. This reduced confusion for data collectors and avoided counting birds twice.

Five individual categories of behaviors described the actions of waterfowl: (1) foraging, (2) preening, (3) resting, (4) movement, and (5) conflict. I defined each behavior in detail (see below). For the purpose of this study, it was necessary to categorize behaviors as discreet actions independent of one another. Each of the behavior categories may be composites of multiple behaviors. The category name indicated the primary function of the behavior.

1. Foraging: The primary purpose of foraging was to seek, find, and consume material. Waterfowl did this while partially or completely submerged, while swimming or floating along the surface of water, or while on land. Movement can occur during foraging, however the act of retrieving materials from the water or land indicated that the primary purpose of movement was to seek, find, and consume material.
2. Preening: Preening was active movement for the primary purpose of feather maintenance in the form of "rearranging and oiling" feathers (Ehrlich et al. 1988). Preening behavior included drawing individual feathers or clumps of feathers through the beak, using the beak to "scratch" or "nip" at feathers, or diving briefly, sometimes repeatedly, and shaking water from feathers immediately after surfacing. This behavior also included "dust baths," when an individual retracted the legs and occupied a dry, dusty substrate. To "bathe," the bird shook and fluttered its wings and body, distributing the dust evenly over the body. The bird then rose, shook the body, fluttered the wings, and moved feathers through the bill.
3. Resting: Resting was a passive behavior that lacked directional movement. The physical state of the bird took several forms and the actor could be awake or asleep. While on land, a standing position was taken with one leg extended and the other pulled against the body with the foot dangling relaxed. The head could be extended or pulled against the body. The eyes could be opened or closed. A resting pose

could also be taken with both feet positioned on the ground, the head extended or retracted, and the eyes opened or closed. While on water, ducks and geese rested while floating with head forward and eyes opened or closed. Either on land or on water, the actor's head was turned toward the tail and placed on the back or under feathers of the back or wing. While at rest, the actor did not engage the legs and feet or wings in active, directional movement.

4. Movement: The primary purpose of movement was to shift the bird's position from one place to another or to shift from certain behaviors to another behavior. Movement occurred on land or in water, in any direction, and either directed or non-directed. Movement on land occurred when the bird's body was upright with legs extended and the bird engaged the feet and legs in active, directional movement (as in walking). Generally the head was forward and faced the direction of the intended destination. Movement on land also occurred when the bird was prepared to take flight from a resting behavior. The standing bird increased the angle of the body, extended the wings, and bent the legs in preparation for leaving the ground. If in water, the bird might prepare for flight by stretching the wings, changing the angle of the body, and engaging the feet and legs in rapid, directional movement. Movement while remaining in water occurred when paddling of feet underwater propelled the bird. It could be directed or non-directed.
5. Conflict: The primary purpose of conflict behavior was to bring the bird in physical contact with another animal in an aggressive manner. Conflict was any interaction between two animals that consisted of physical contact that subsequently displaces

one or both participants by their rapid movement. Typically the bird will initiate movement reaction by the adversarial animal(s) with a biting or "nipping" motion to one or more additional participants. Additionally, the rapid flapping of wings with subsequent physical contact between two or more individuals was construed as conflict.

Observers determined behavior by reviewing the behavior definitions carefully before collecting data (Bakeman and Gottman 1986). This allowed counts to remain consistent throughout data collection.

Observations and identifications of species were recorded on data sheets in order of observation. "Tick" marks recorded each behavior observed for each species. Additional scans or sweeps were used, as needed, to count individual birds of each species and record behaviors exhibited by each bird. The number of species present within the quadrat determined the number of times the area was scanned.

Additional information concerning waterfowl outside the quadrats also was noted. This included the species and sex of individuals, if possible. This information was considered incidental and was not used for analysis.

In order to establish whether waterfowl used quadrats with equal frequency, the data were analyzed using an analysis of variance (ANOVA) test (Zarr 1984). Statistical Analysis Software (SAS) was used to conduct the ANOVA (SAS Institute, Inc. 1988). The ANOVA was used to determine correlations or differences between aspects of general use by waterfowl by pond (Table 4).

A Pearson correlation coefficients procedure was used to determine whether individual atmospheric conditions, time, and date were linearly correlated to one another (Zarr 1984). A general linear model (GLM) ANOVA was used to determine whether weather, time, and date factors had a significant effect on use of ponds by waterfowl (Zarr 1984). Type III sum of squares tests were used to avoid bias due to the order in which the factors were tested.

The GLM test also was used to compare ponds and their differences in use. A Tukey's studentized range (HSD) test for sum also was used to more specifically determine which quadrats had similar overall use (Zarr 1984; Bart et al. 1998). To determine whether there was an overall difference in use concerning all ponds, the GLM ANOVA was used again (Table 4).

The Shannon-Weiner (H') Index of Species Diversity analysis was used to establish species diversity for individual ponds (Table 6). In addition, species diversity was determined for all ponds by a Shannon-Weiner index. The data used for these calculations were reduced to the highest number of birds of each species observed each day. This was because birds may have been observed and counted in several scans during one overall count. Using cumulative data could increase bias.

Evenness (J') of species in quadrats also was calculated. Evenness reflects similarities in abundance among the species using ponds. Overall species diversity and evenness also were calculated for all quadrats.

To determine the probability of each pond influencing behavior, a Chi-square analysis was calculated. Fisher's exact test using a Monte Carlo simulation was used to ensure that the Chi-square was valid (Zarr 1984). Validity is only in question when greater than 20% of the cells (behavior by quadrat) used in the Chi-square have a value of < 5. Statistical Analysis Software (SAS) was used to calculate the Chi-square and the Fisher's exact test with Monte Carlo simulation P-values.

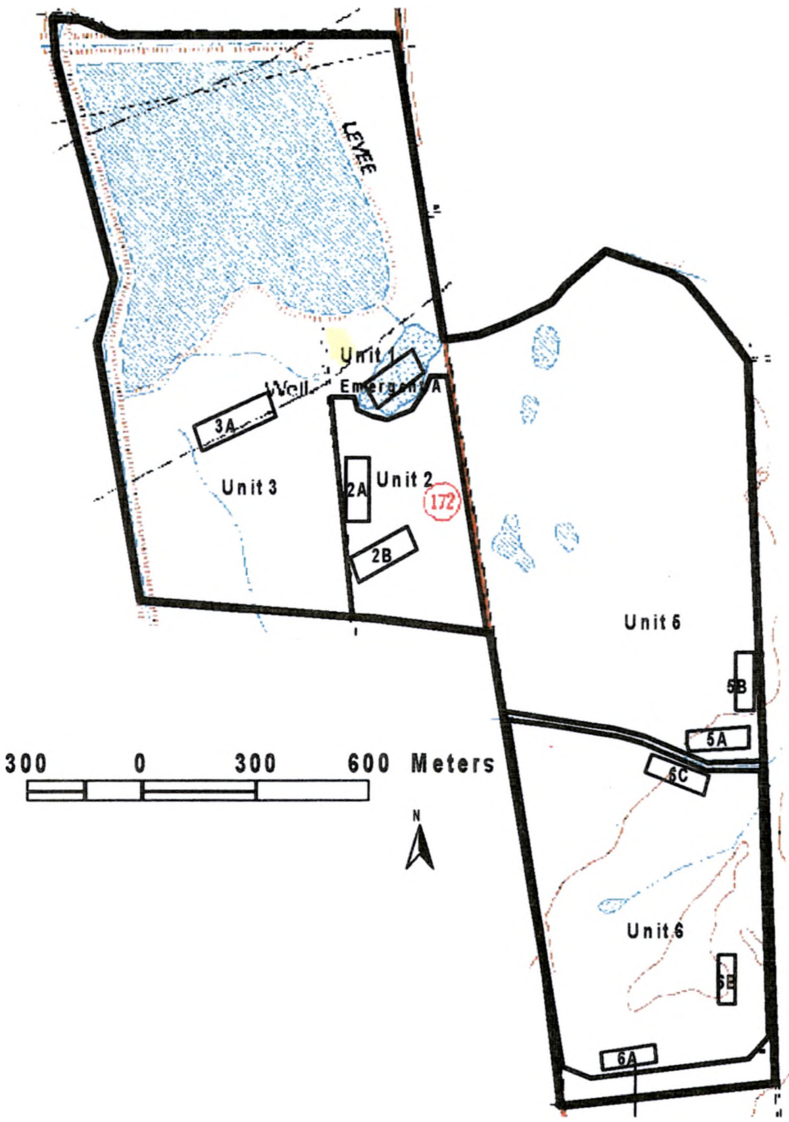

Figure 1. Topographical map of the study site including ponds 2, 3, 5, 6, and an existing emergent pond north of pond 2. The map delineates quadrats 3A, 5A, 5B, 6A, 6B, 6C, and Emergent A. The project site is located in the Gulf Coast region along Highway 172 south of La Ward, Texas in Jackson County.

RESULTS

Use

Sixteen species of waterfowl were observed within quadrats on the ponds. Data also were collected on three additional waterbird species including two species of grebe, least grebe (*Tachbabtus dominicus*) and pied-billed grebe (*Podilymbus podiceps*), and American coot (*Fulicana americana*).

The maximum number of birds counted for one species during a 10-minute visual scan was 850 (Table 1). The minimum counted was zero. No sightings of any waterfowl were made in over 40% (226) of 560 visual scans. The mean number of birds counted per visual scan was 13.8. Of the duck species using the ponds, the green-winged teal (*Anas crecca*) was the most prevalent with 1,329 individual sightings recorded during the study. The northern pintail (*Anas acuta*) and northern shoveler (*Anas cypeata*) had similar abundance. Pintails were counted 1,334 times in 105 scans during the study and occurred in all quadrats except 5A and 6C. The mean number of pintails (13.3) counted throughout the study was higher than northern shovelers (6.8).

Five species were rare on the ponds observed during the study: No more than two American wigeons (*Anas americana*) were counted during each of two scans. No more than two redheads (*Aythya americana*) were counted during each of three scans. One lesser scaup (*Aythya affinis*) was sighted during one scan. No more than four cinnamon teal (*Anas cyanoptera*) were sighted during each of four scans. One bufflehead (*Bucephala albeola*) was sighted during one scan.

Three species of geese occurred in quadrats during the study. The snow goose (*Chen caerulescens*) had the greatest abundance with 4,542 individuals counted on all ponds. The greatest number of birds of any species counted during one scan was snow geese on 23 January, with 850 individuals were counted in quadrat 6A (Table 1). Three additional counts yielded over 500 birds during each scan. Of the 560 total scans, snow geese appeared in 58. Of the seven quadrats sampled, snow geese occurred in all quadrats except 6C and Emergent A.

Canada geese (*Branta canadensis*) occurred less often (27 scans) than snow geese, however, a large number of individual birds were present. There were 3,868 sightings of Canada geese with 510 birds being the greatest gathering recorded in one scan. Canada geese occurred in quadrats 3A, 6A, and 6B. The greater white-fronted goose (*Anser albifrons*) was the third goose species counted during this study. While greater white-fronted geese were not as common (697) as Canada geese, they did occur in almost as many scans (25) and in the same quadrats as Canada geese. Ross' geese (*Chen rossii*) landed on ponds, however they never occurred inside quadrats during a scan. Thus, the species was recorded as incidental.

Of the waterbird species, American coots were the most prevalent on ponds (Table 1). There were 2,298 individuals counted during the study with birds occurring in every quadrat except 6C. Of 560 scans, American coots were counted in 205. Grebes were counted in 104 scans with eight being the largest number recorded during one scan.

The seven quadrats established in different ponds had varying use. Quadrat 6A had waterfowl. There were 10,294 birds of 17 species of waterfowl and waterbirds counted in 80 scans. Snow geese and Canada geese were the most common waterfowl. Eleven species constituted ≤ 2 % each of the total and other species ranged from 8% to 12 %.

Quadrat 3A (Fig. 3) had the second highest use and number of species (11). I counted 4,415 birds on this quadrat. Snow geese again made up the highest percentage (29%) of individuals counted. Grebes were the only species represented by < 1% of the total individuals counted.

A greater number of species (13) used Quadrat 6B (Fig. 4) than Quadrat 3A, but fewer birds (946) actually used the pond. American coots and green-winged teal made up the greatest percentage of individuals using the quadrat. The remaining 11 species ranged from < 1% to 13% of the total birds counted.

Quadrat Emergent A had a total of 602 birds counted during scans. By far, the American coot was the most common species (Fig. 5). Northern shovelers made up 26%. Each of the remaining species accounted for 7% or less of the total. Both quadrats 5A and 5B had 338 birds each (Fig. 6, 7). Fifty-three percent of quadrat 5B's 225 individuals were grebes, while 39% of the 113 individuals counted on quadrat 5A were northern shovelers. Few waterfowl species used quadrat 6C during the study. Only two northern shovelers were observed in the quadrat.

All abiotic factors that might influence waterfowl use of quadrats correlated with one another with the exception of wind speed and date ($p = 0.0516$). Several factors were highly significant (Table 2). All abiotic factors had an effect on waterfowl and waterbird use of the ponds (Table 3).

Several quadrats had similar use. Quadrat 3A was dissimilar in use to all quadrats except 6B (Table 4). Quadrat 6A was dissimilar in use to any other ponds ($p < 0.0001$ in all comparisons). Quadrat 5A was similar to all quadrats except 3A and 6A. There were statistical differences ($p = 0.0024$) in use of the ponds by waterfowl when all ponds were compared.

Behavior

All three species of geese typically exhibited resting behavior on ponds. Regardless of the pond, at least 79% of all Canada geese were observed resting (Fig. 8). Otherwise, Canada geese preened or exhibited movement or foraging behaviors. Greater white-fronted geese primarily rested in all quadrats where they were observed (Fig. 9). Foraging and preening were secondary behaviors. Snow geese were observed resting the majority of the time with > 55% of all observations in quadrat 3A and > 71% of all other observations in other quadrats (Fig. 10). A greater amount of preening occurred in quadrat 3A with movement being the second most dominant behavior in quadrats 5B and 6A.

Mallards used five of the seven quadrats and exhibited three dominant behaviors (Fig. 11). In quadrats 3A and Emergent A the dominant behavior was foraging. In Emergent A, mallards foraged 68.2% of the time. Similarly, mallards foraged 64% of the time in quadrat 3A. In quadrats 5B and 6A, mallards exhibited three individual behaviors. The dominant behavior (57.1%) was movement. In quadrat 5B, preening was the second most common behavior (28.6%), while resting was the second most common behavior in quadrat 6A (28.6%). Foraging was the third most common behavior in 5B and preening was the third most common behavior in 6A with both occurring 14.3% of the time.

All mottled duck observations occurred in Quadrat 6A, on the same day (Fig. 12). Of 35 individuals, 51.4% were foraging. Resting and movement occurred 22.9% of the time. Preening occurred 2.9% of the time.

Gadwalls used quadrats 3A, 6A, and Emergent A (Fig. 13). They exhibited foraging, preening, and resting behaviors in all quadrats but Emergent A. In quadrat Emergent A, the dominant behavior was movement. The dominant behavior in quadrat 6A was foraging and the dominant behavior in 3A was preening. The other two behaviors noted on each pond were movement and resting which occurred <11% of the time for each behavior.

Green-winged teals occurred in quadrats 3A, 6A, and 6B (Fig. 14). In quadrats 3A and 6B, resting was the dominant behavior. In quadrat 6B, green-winged teals overwhelmingly preferred to rest (82%), while foraging was the dominant behavior (68.8%) in quadrat 6A. Green-winged teals preened and moved in all three quadrats. Each of these behaviors occurred less than 25% of the time.

Northern pintails foraged most often in quadrats. On quadrats 3A, 6A, and Emergent A, northern pintails foraged in greater than 70% of observations (Fig. 15). On pond 5B foraging was also the dominant behavior (44.4%). On pond 6B the dominant behavior was resting (57.5%). Otherwise northern pintails preened and moved. No conflicts were recorded.

The northern shoveler was the only species to use all quadrats. On all quadrats except 5B, foraging behavior was dominant with a range of 51.9% to 100% (Fig. 16). On quadrat 5B, the dominant behavior was movement. Preening and resting occurred less than 15% of the time.The dominant behavior of blue-winged teal was foraging. The exception was quadrat 5A where they moved 33% more often than foraging (Fig. 17). Otherwise, blue-winged teals were observed resting and preening.

Movement was the dominant behavior of cinnamon teals in quadrats 5B and 6B (Fig. 18), while foraging was the dominant behavior in quadrat 5A (75%). Cinnamon teal occurred twice in quadrat Emergent A; both birds were resting. Cinnamon teals also preened on quadrats 5B and 6B (< 20%).

Four additional species of ducks were observed. Nine observations of redheads occurred on three separate dates at quadrats 6A, 6B, and Emergent A. Redheads moved five times, rested three times, and foraged once. American wigeons occurred on quadrats 6A and 6B on three different occasions. These birds moved and foraged. Lesser scaups were observed preening and moving twice on quadrat 6A. One bufflehead was observed moving in quadrat 6A.

Grebe species occurred on all quadrats except 6C and exhibited all behaviors (Fig. 19). The dominant behavior on 5B, 6A, and Emergent A was movement, while in quadrats 3A and 5A movement occurred in equal frequency to foraging. On quadrat 6B the dominant behavior was foraging. Grebes species also exhibited conflict behavior on quadrat 3A (22 January 2000). Two incidents of American coots exhibiting conflict behavior also occurred on 11 January 2000 on quadrat Emergent A (Fig. 20). Otherwise, American coots typically foraged. On quadrats 3A, 5A, 6A, and 6B American coots foraged > 80% of the time. Foraging also dominated behavior for coots on quadrat Emergent A (58%). On quadrat 5B, American coots generally moved. All other individual behaviors accounted for less than 7% of total observations. For all species, resting was exhibited at a greater frequency than all other behaviors combined. Resting accounted for 50% of the recorded behaviors for all species. Conflict accounted for < 1% (Fig. 21).

Because greater than 20% of behaviors in the quadrats occurred less frequently than generally acceptable for the Chi-square analysis ($f = 5$), the Fisher's exact test using a Monte Carlo simulation was necessary. This analysis indicates that waterfowl and waterbirds' behaviors were significantly different among different quadrats in all but three species (Table 5). American wigeon, redhead, and white-fronted geese displayed behaviors as expected in quadrats.

Species diversity also differed among quadrats. Quadrats 3A and 6A had the highest species diversity, while quadrat 6C had the lowest (Table 6). Diversity for all quadrats was relatively high. Species richness was highest on quadrat 6A (n = 17) and lowest on pond 6C (n = 1). Waterfowl and waterbirds were most evenly distributed on quadrat 3A (E = 1.730), while the least evenly distributed quadrats were 5A and 5B (E = 0.212 and 0.213, respectively). Species diversity for all quadrats was higher than any individual quadrat (H = 1.834). The overall evenness value was also higher (E = 1.491) for all quadrats except 3A.

Table 1. Wintering waterfowl and waterbird use of newly constructed wetlands in the Gulf Coast region along Highway 172 south of La Ward, Texas in Jackson County. Sum, mean, and standard error of each species in all quadrats are reported. Total number of scans including each species and the ranges of birds in each quadrat are also described.

Species	N	$\bar{x}$	SE	Total # in scans	Range
Waterbirds					
American Coot	2298	11.2	0.70	205	1 - 55
Grebe	210	2.0	0.15	104	1 - 8
Waterfowl					
American Wigeon	5	1.3	0.25	4	1 - 2
Blue-winged Teal	103	3.4	0.83	31	1 -19
Bufflehead	1	1.0	~	~	1
Canada Goose	3868	145.5	27.04	27	1 - 510
Cinnamon Teal	40	2.9	0.25	14	1- 4
Gadwall	149	3.9	0.33	38	1 - 10
Green-winged Teal	1527	18.6	2.06	82	1 - 71
Lesser Scaup	2	1.0	0.00	0	1 - 2
Mallard	149	2.8	0.41	52	1 - 12
Mottled Duck	35	7.0	1.18	5	3 - 10
Northern Pintail	1334	13.3	1.59	105	1 - 65
Northern Shoveler	1329	6.8	0.56	200	1 - 60
Redhead	9	1.3	0.18	7	1 - 2
Ruddy Duck	37	2.6	0.45	14	1 - 6
Snow Goose	4542	79.7	23.48	58	1 - 850
Greater White-fronted Goose	697	28.0	9.46	25	1 - 210
Total	16335	13.8	1.51	560	0 - 850

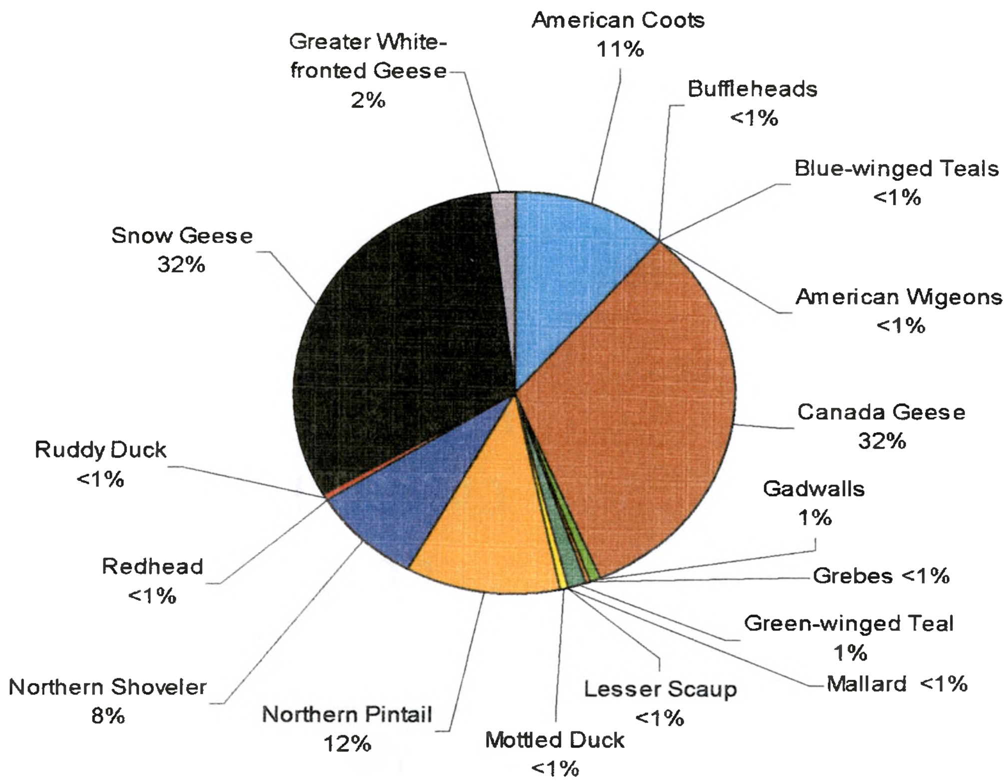

Figure 2. Use of Quadrat 6A by waterfowl and waterbird species. Ten-minute scan samples were conducted every 30 minutes from 21 December 1999 through 20 February 2000. Use is expressed as a percentage of the total number of birds observed (n = 10,294). Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

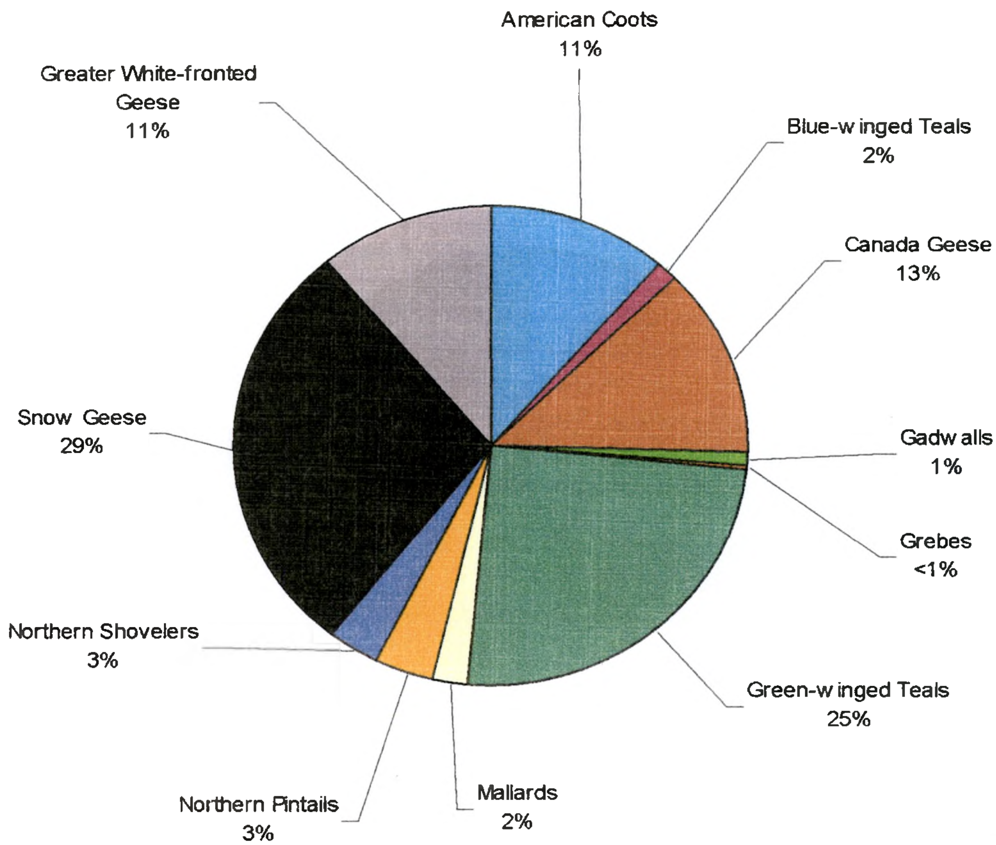

Figure 3. Use of Quadrat 3A by waterfowl and waterbird species. Ten-minute scan samples were conducted every 30 minutes from 21 December 1999 through 20 February 2000. Use is expressed as a percentage of the total number of birds observed (n = 4,415). Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

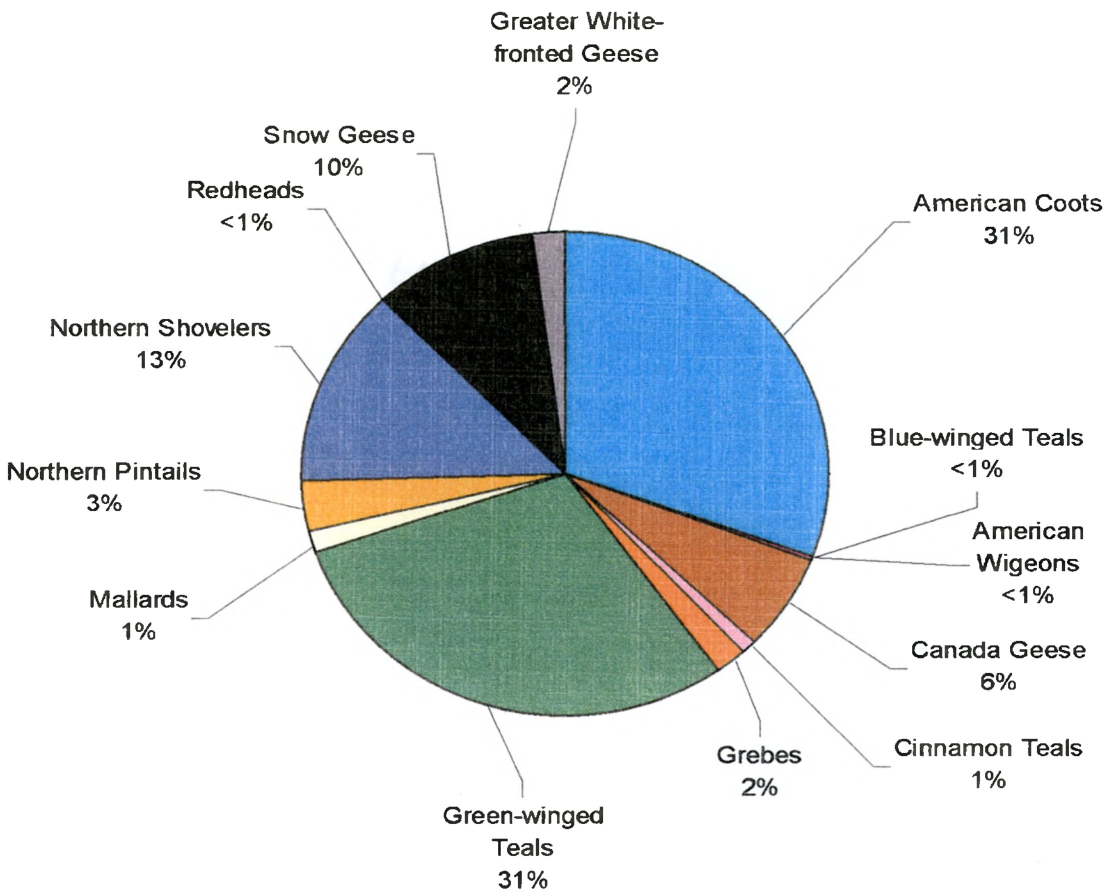

Figure 4. Use of Quadrat 6B by waterfowl and waterbird species. Ten-minute scan samples were conducted every 30 minutes from 21 December 1999 through 20 February 2000. Use is expressed as a percentage of the total number of birds observed (n = 946). Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

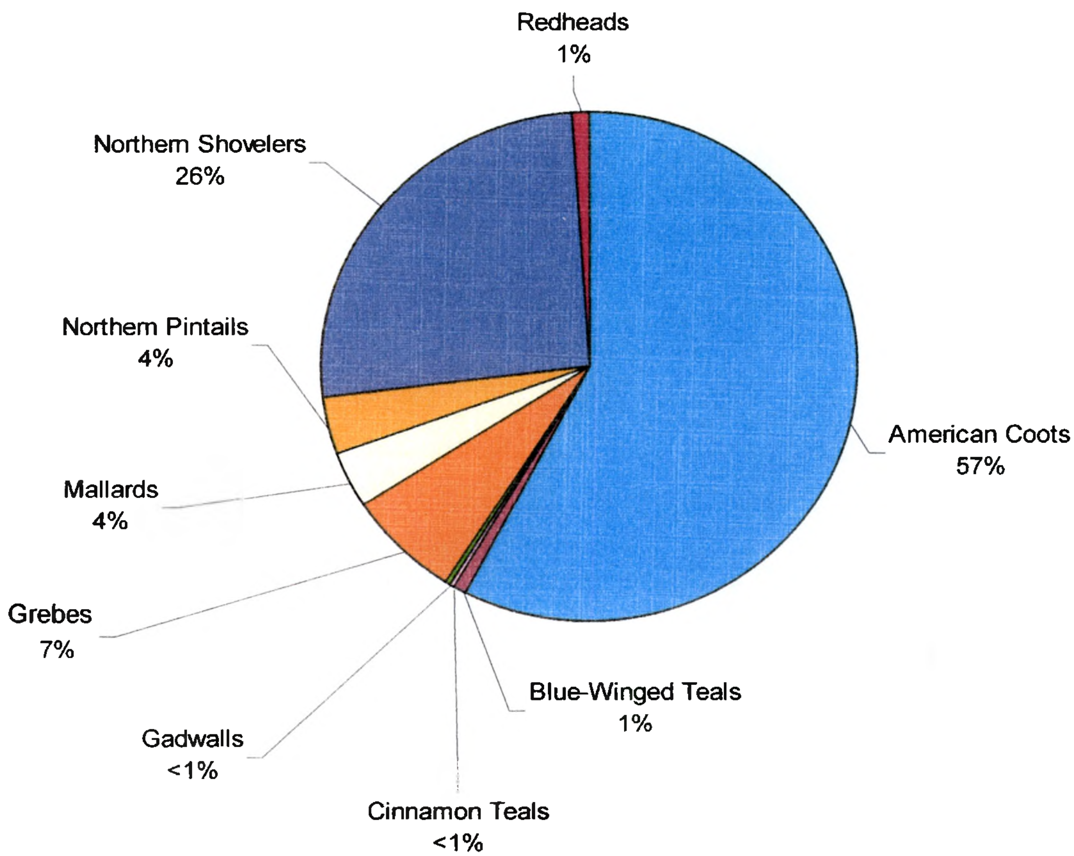

Figure 5. Use of Quadrat Emergent A by waterfowl and waterbird species. Ten-minute scan samples were conducted every 30 minutes from 21 December 1999 through 20 February 2000. Use is expressed as a percentage of the total number of birds observed (n = 602). Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

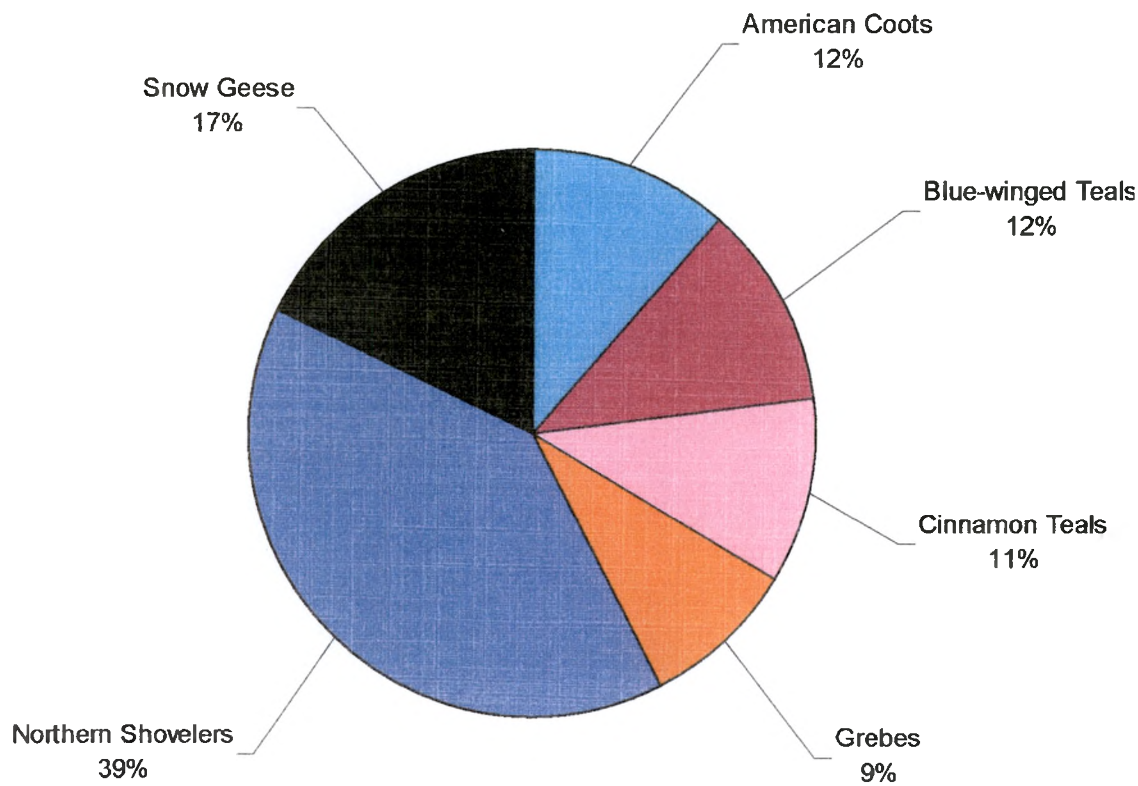

Figure 6. Use of Quadrat 5A by waterfowl and waterbird species. Ten-minute scan samples were conducted every 30 minutes from 21 December 1999 through 20 February 2000. Use is expressed as a percentage of the total number of birds observed (n = 113). Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

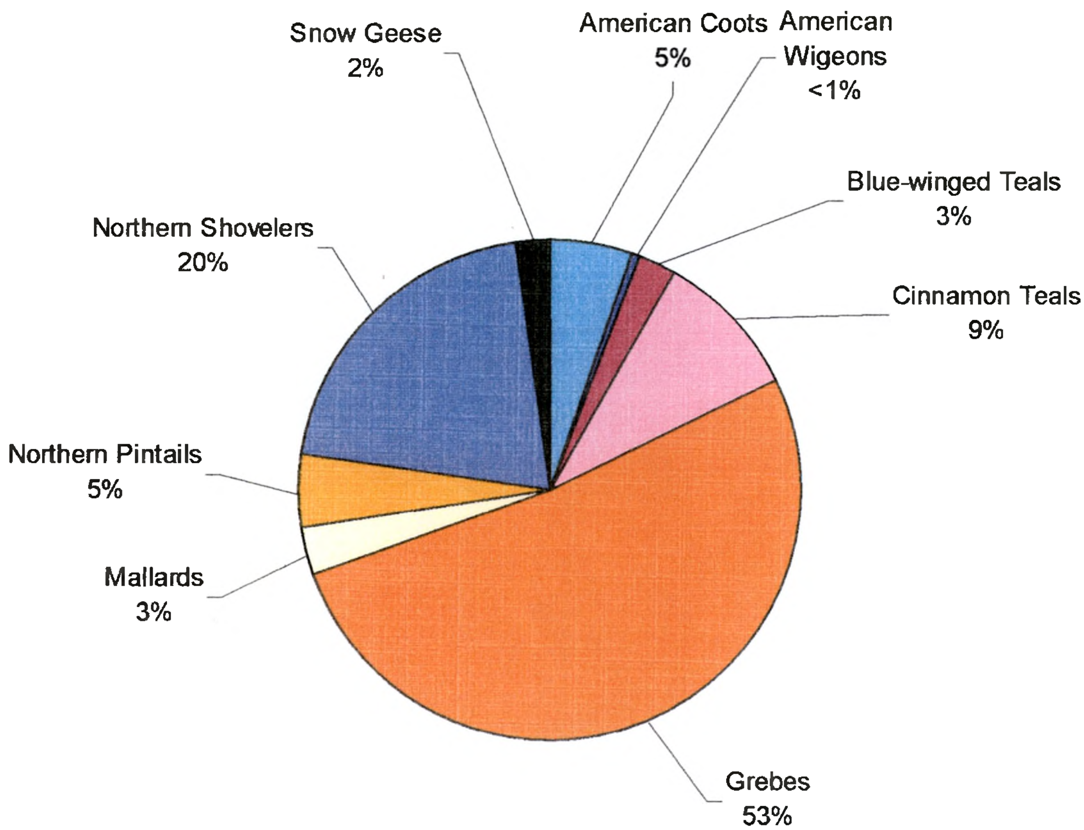

Figure 7. Use of Quadrat 5B by waterfowl and waterbird species. Ten-minute scan samples were conducted every 30 minutes from 21 December 1999 through 20 February 2000. Use is expressed as a percentage of the total number of birds observed (n = 225). Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

Table 2. Pearson correlation coefficients indicating correlation between 560 observations of waterfowl and waterbird use and abiotic factors of date, time, wind speed, humidity, and air temperature among quadrats in newly constructed wetlands in the Gulf Coast region along Highway 172 south of La Ward, Texas in Jackson County. Lower p-values indicate increased correlation and are the upper diagonal set. R^2 values are presented in the loer diagonal set. All abiotic factors correlated except wind speed and date.

	Date	Time	Wind speed	Humidity	Air Temperature
Date		0.0003	0.0516	0.0063	0.0099
Time	0.1541		< 0.0001	< 0.0001	< 0.0001
Wind speed	-0.0823	0.4394		< 0.0001	< 0.0001
Humidity	0.1152	-0.3527	-0.3449		0.0008
Air Temperature	0.1090	0.6132	0.1819	0.1409	

Table 3. A single type III sum of squares ANOVA indicating the effect of abiotic factors on use of quadrats by waterfowl and waterbird species in newly constructed wetlands in the Gulf Coast region along Highway 172 south of La Ward, Texas in Jackson County. Abiotic factors of site, date, time, wind speed, wind direction, humidity, cloud cover, and air temperature were tested. $r^2 = 0.3693$, $p < 0.0001$

	DF	F	p
Site	6	21.53	< 0.0001
Date	1	15.00	0.0001
Time	1	9.93	0.0017
Wind speed	1	6.11	0.0138
Wind Direction	14	4.05	< 0.0001
Humidity	1	4.21	0.0406
Cloud cover	6	2.32	0.0317
Air Temperature	1	26.25	< 0.0001

Table 4. Comparison of 560 observations of quadrat use by wintering waterfowl and waterbird species in newly constructed wetlands in the Gulf Coast region along Highway 172 south of La Ward, Texas in Jackson County. Comparison was made with general linear model (GLM) analysis of variance (ANOVA). Lower p-values indicate decreased similarity of use by waterfowl and waterbird species between quadrats.

Quadrats	3A	5A	5B	6A	6B	6C	Emergent A
3A		0.0012	< 0.0001	< 0.0001	0.1025	0.0020	0.0011
5A			0.1437	< 0.0001	0.0896	0.7947	0.7493
5B				< 0.0001	0.0035	0.0811	0.1500
6A					< 0.0001	< 0.0001	< 0.0001
6B						0.1299	0.2493
6C							0.8929
Emergent A							

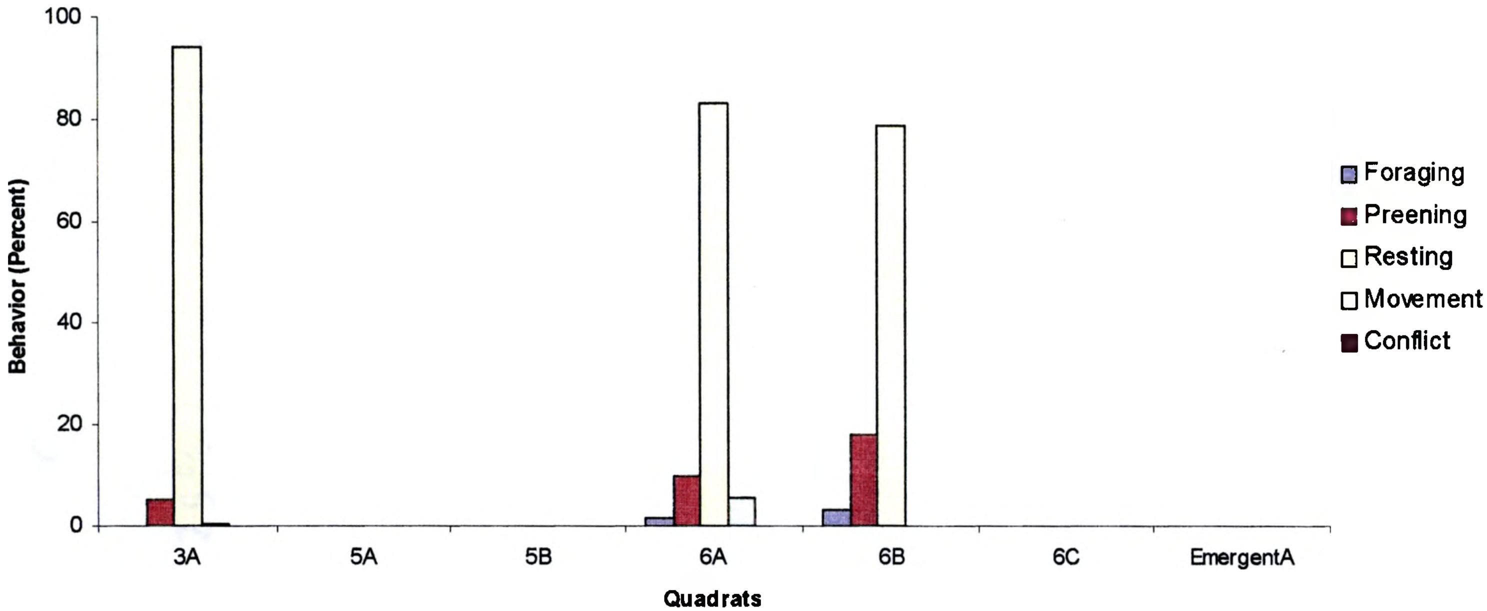

Figure 8. Behaviors of Canada geese by quadrat expressed as a percentage of total behaviors observed (n = 3,868). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes Quadrats located in constructed wetlands near La Ward, Texas in Jackson County.

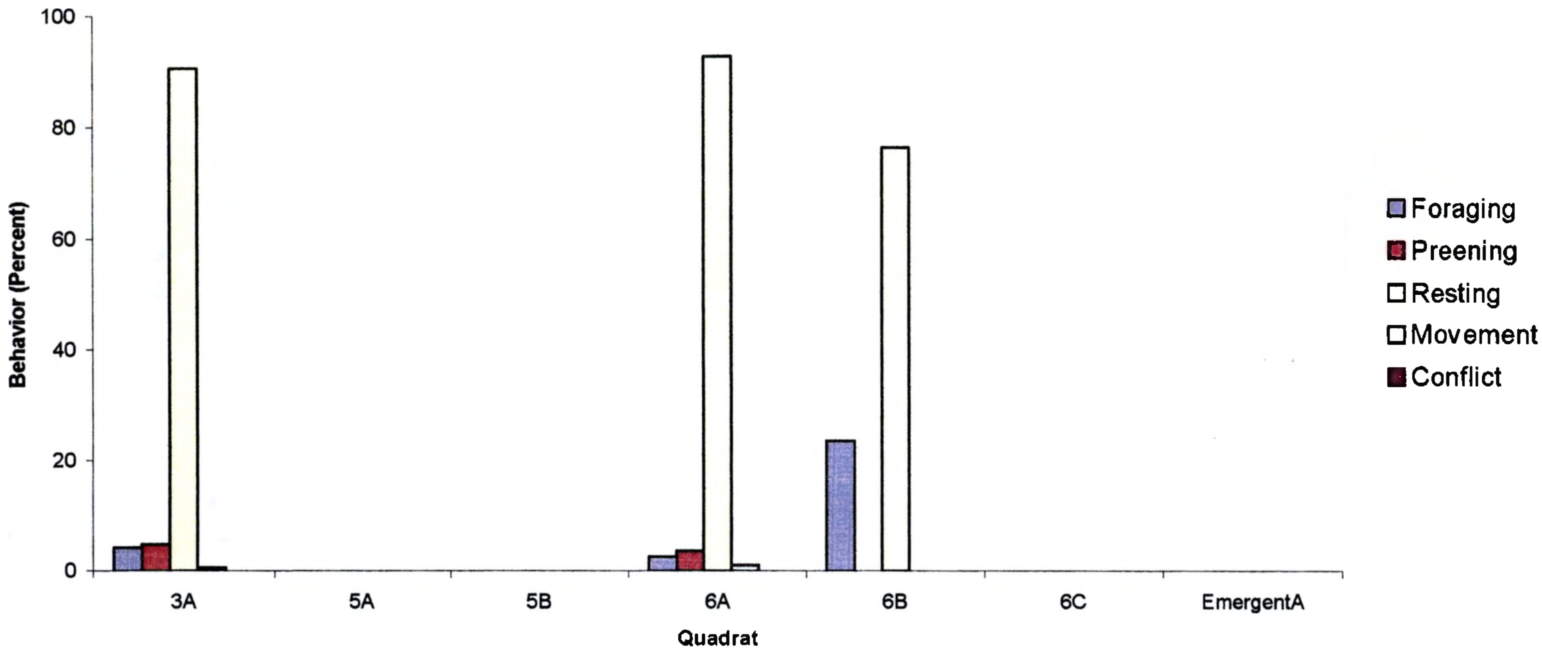

Figure 9. Behaviors of greater white-fronted geese by quadrat expressed as a percentage of behaviors observed (n = 697). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

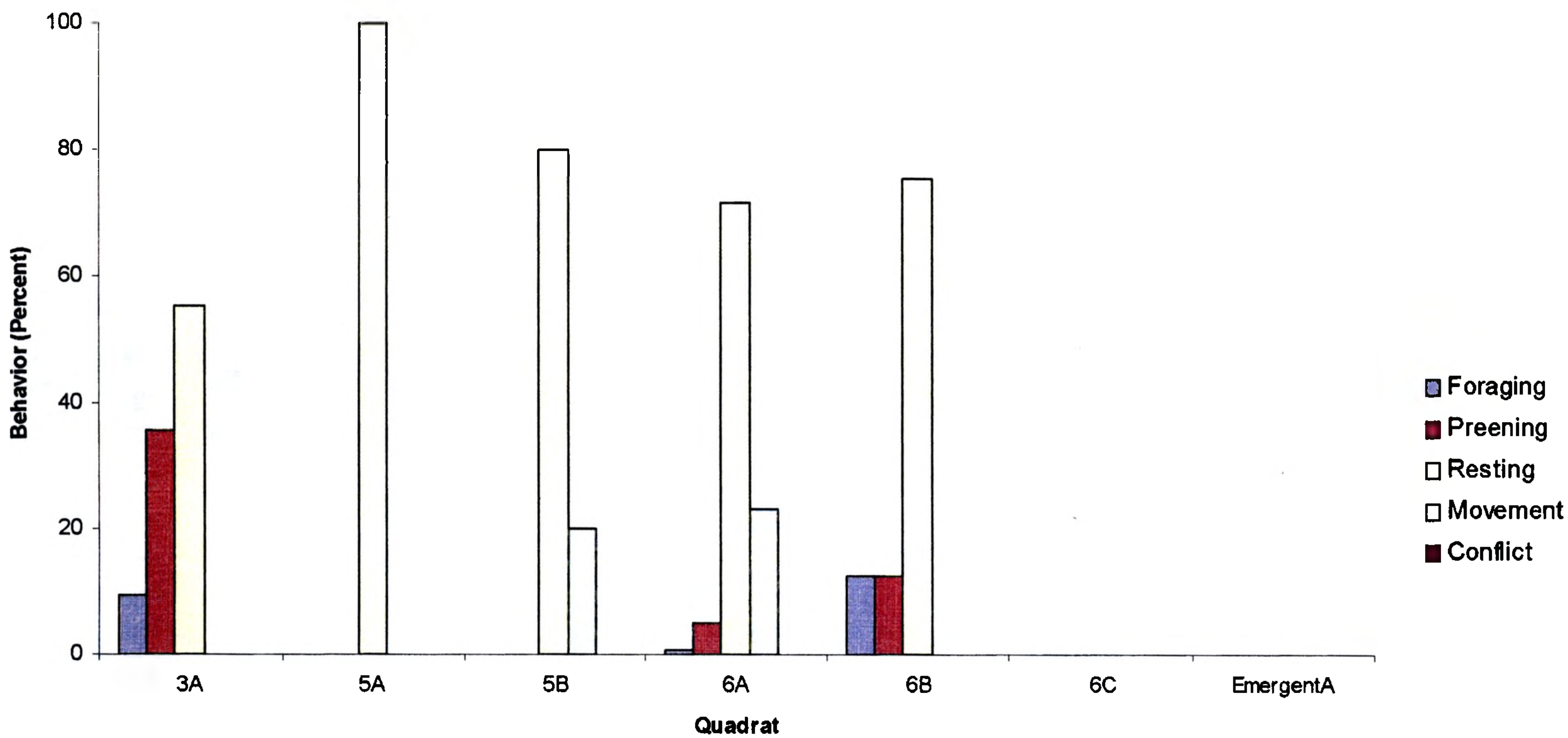

Figure 10. Behaviors of snow geese by quadrat expressed as a percentage of behaviors observed (n = 4,542). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

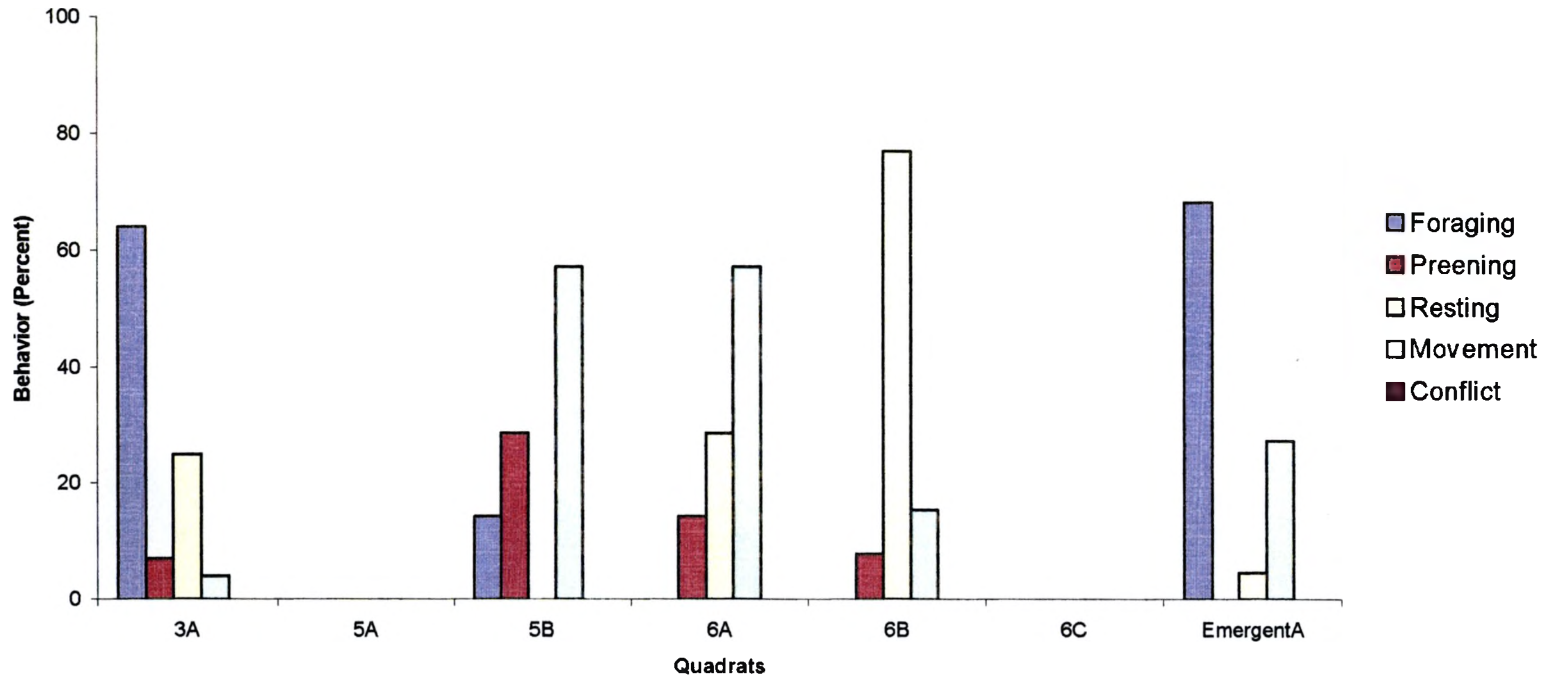

Figure 11. Behaviors of mallards by quadrat expressed as a percentage of behaviors observed (n = 149). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

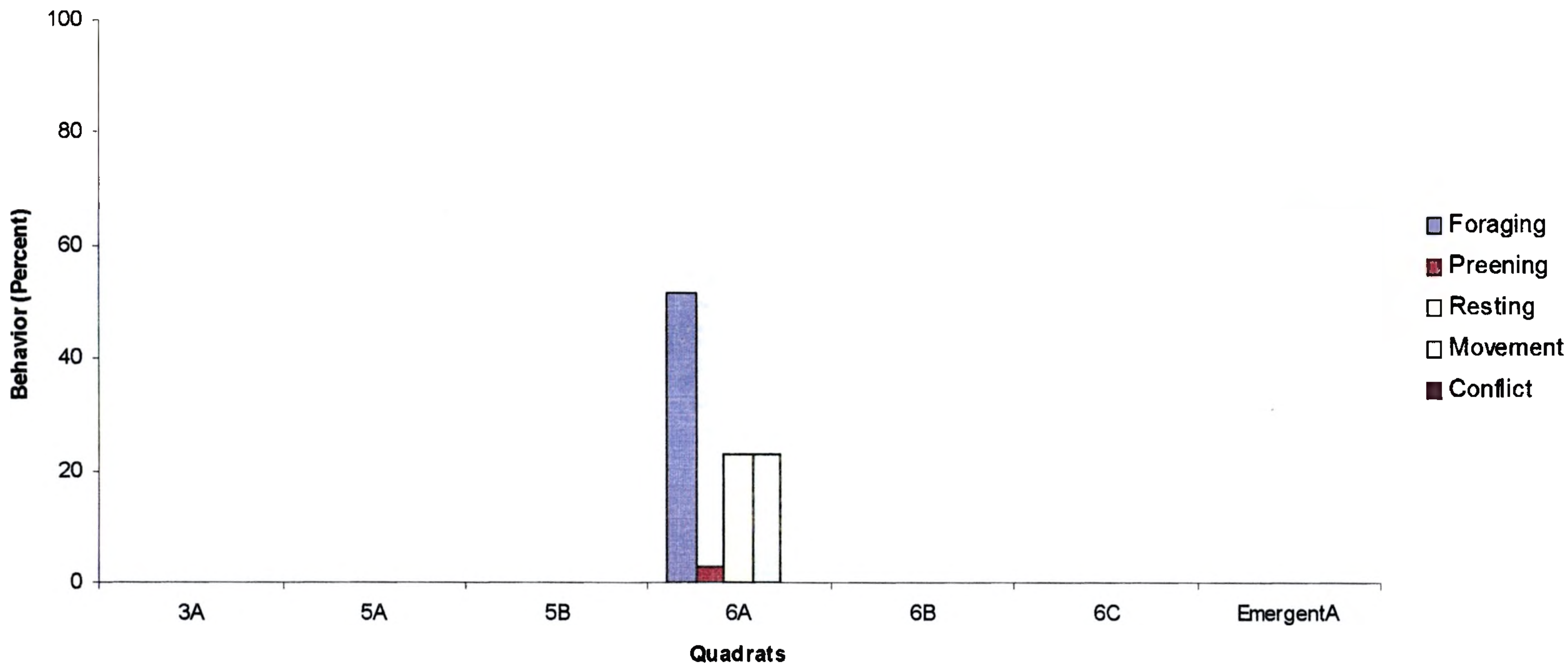

Figure 12. Behaviors of mottled ducks by quadrat expressed as a percentage of behaviors observed (n = 35). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

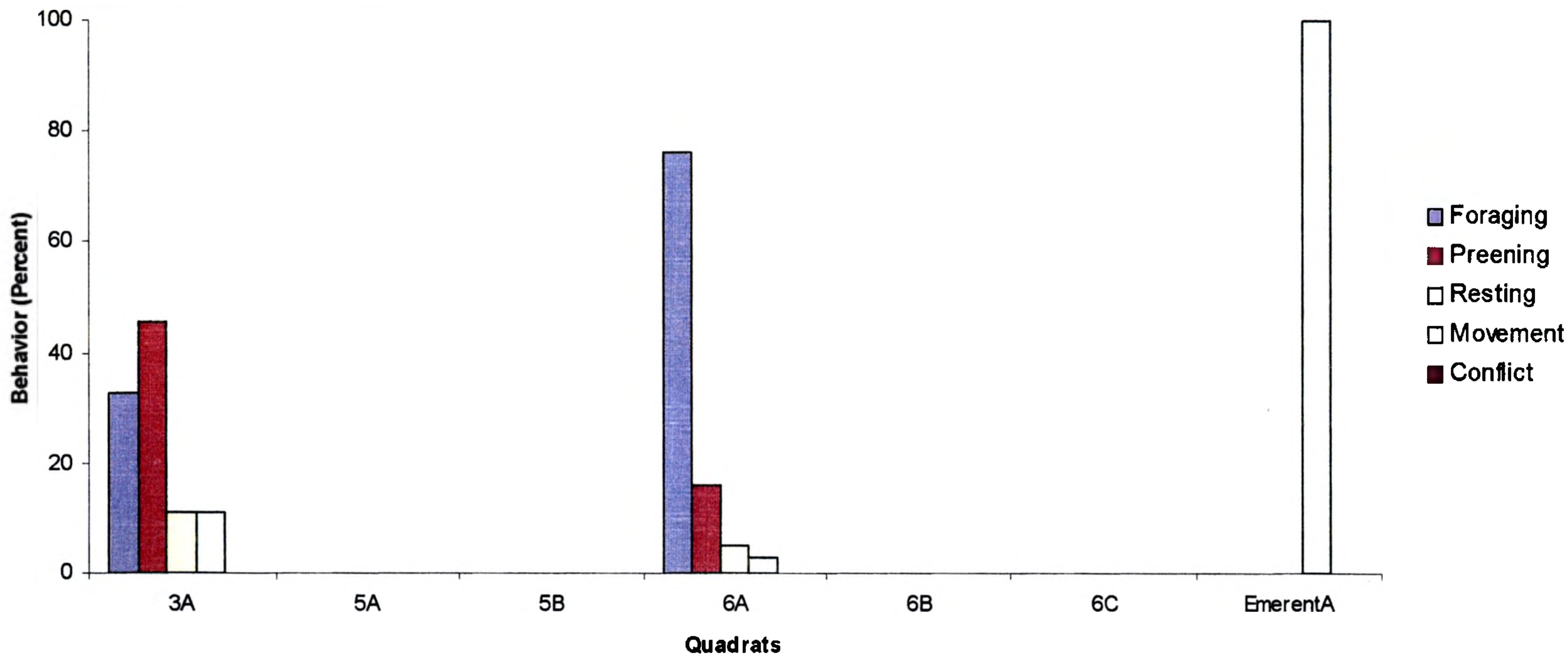

Figure 13. Behaviors of gadwalls by quadrat expressed as a percentage of behaviors observed (n = 149). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats located in constructed wetlands near La Ward, Texas in Jackson County.

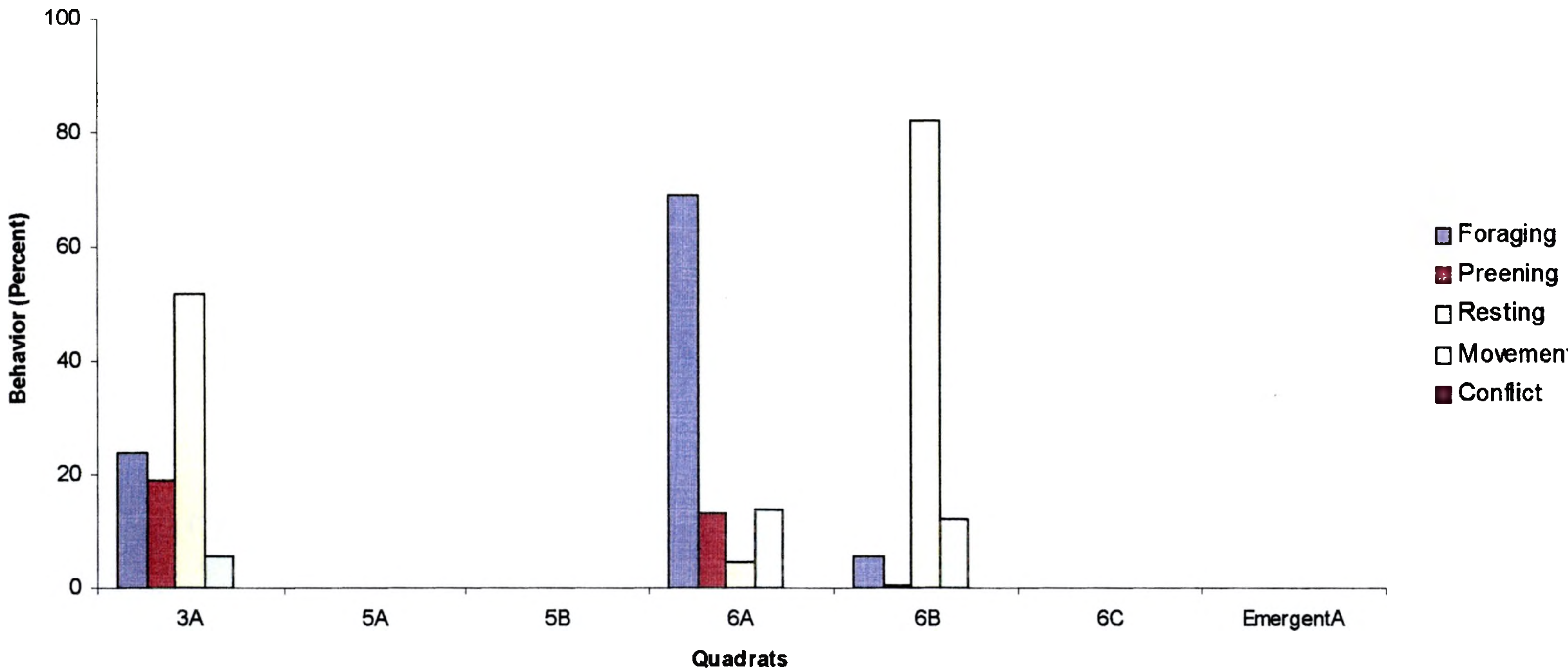

Figure 14. Behaviors of green-winged teal by quadrat expressed as a percentage of behaviors observed (n = 1,527). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

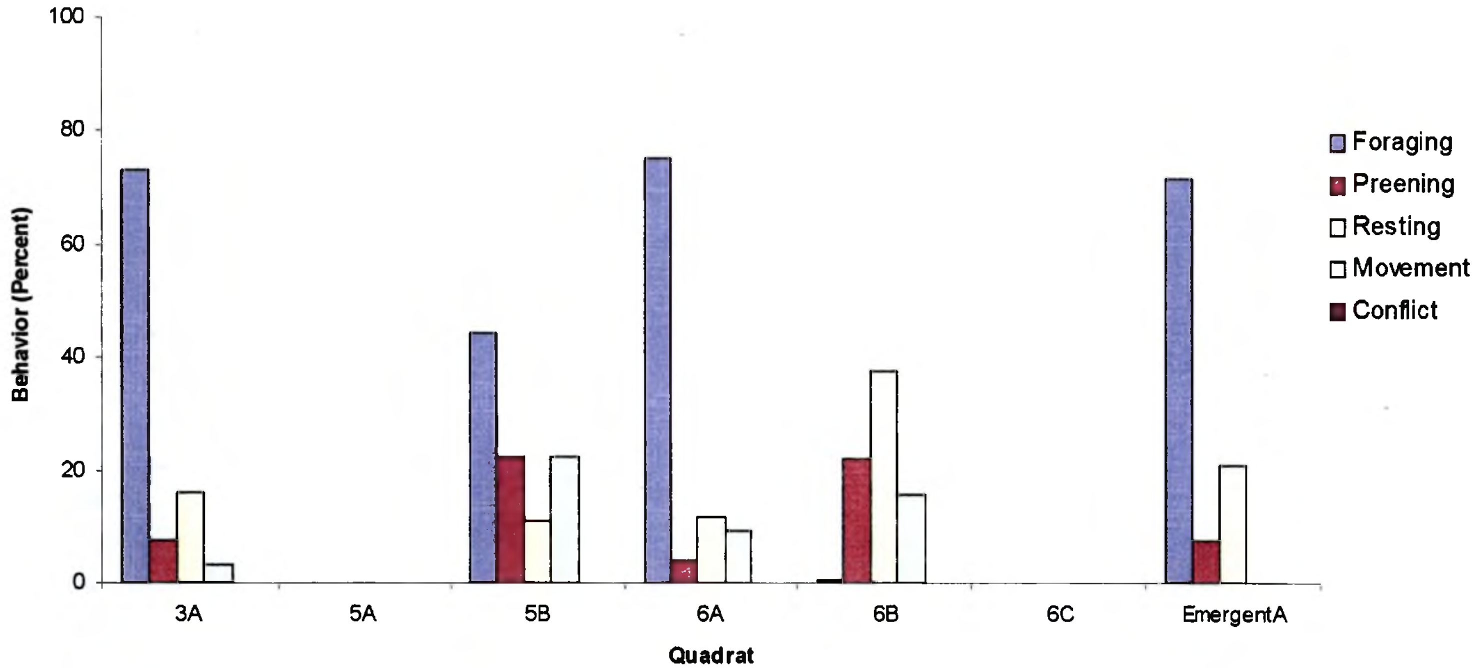

Figure 15. Behaviors of northern pintails by quadrat expressed as a percentage of behaviors observed (n = 1,334). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

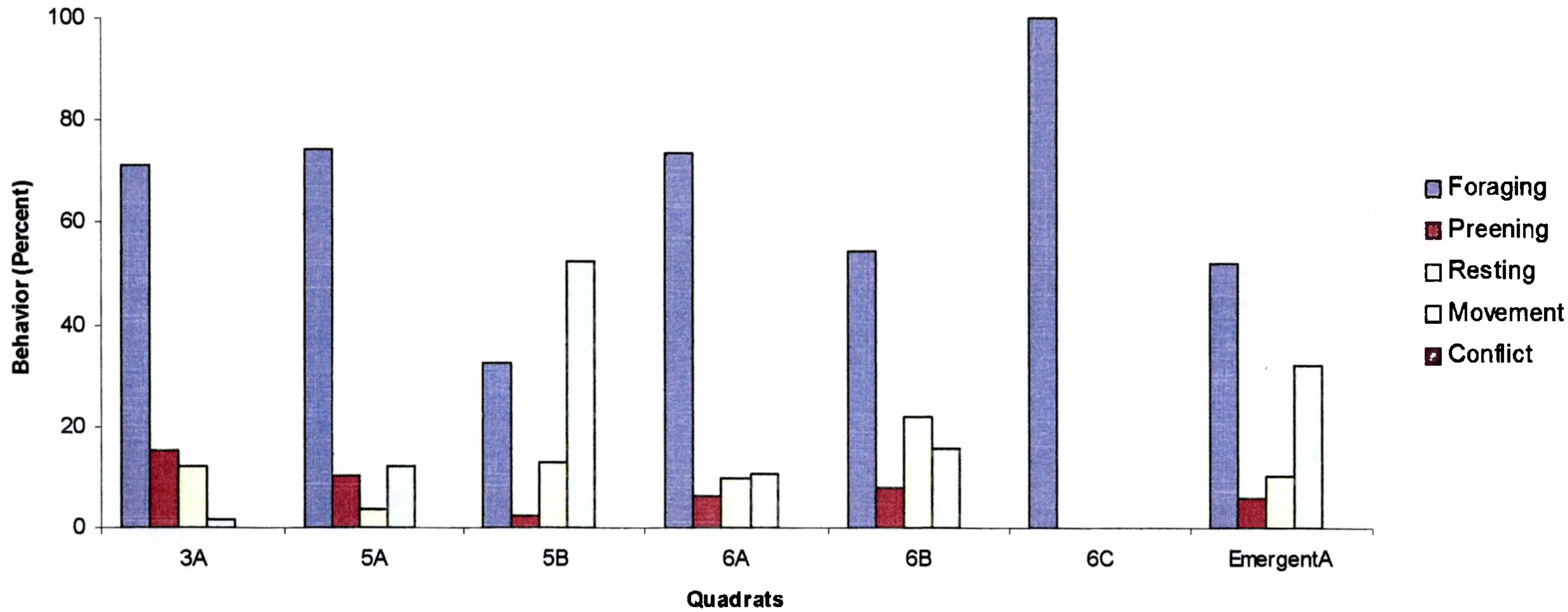

Figure 16. Behaviors of northern shovelers by quadrat expressed as a percentage of behaviors observed (n = 1,329). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

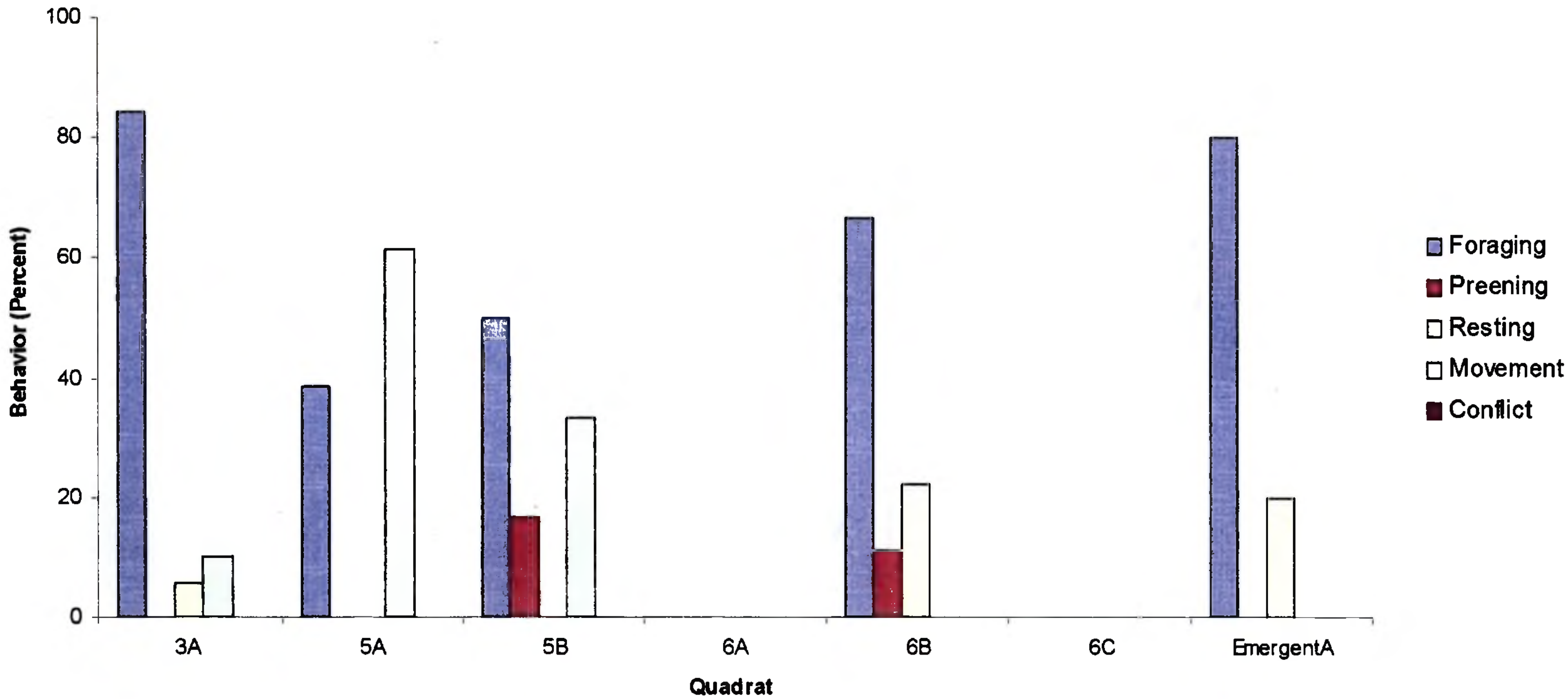

Figure 17. Behaviors of blue-winged teal by quadrat expressed as a percentage of behaviors observed (n = 103). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

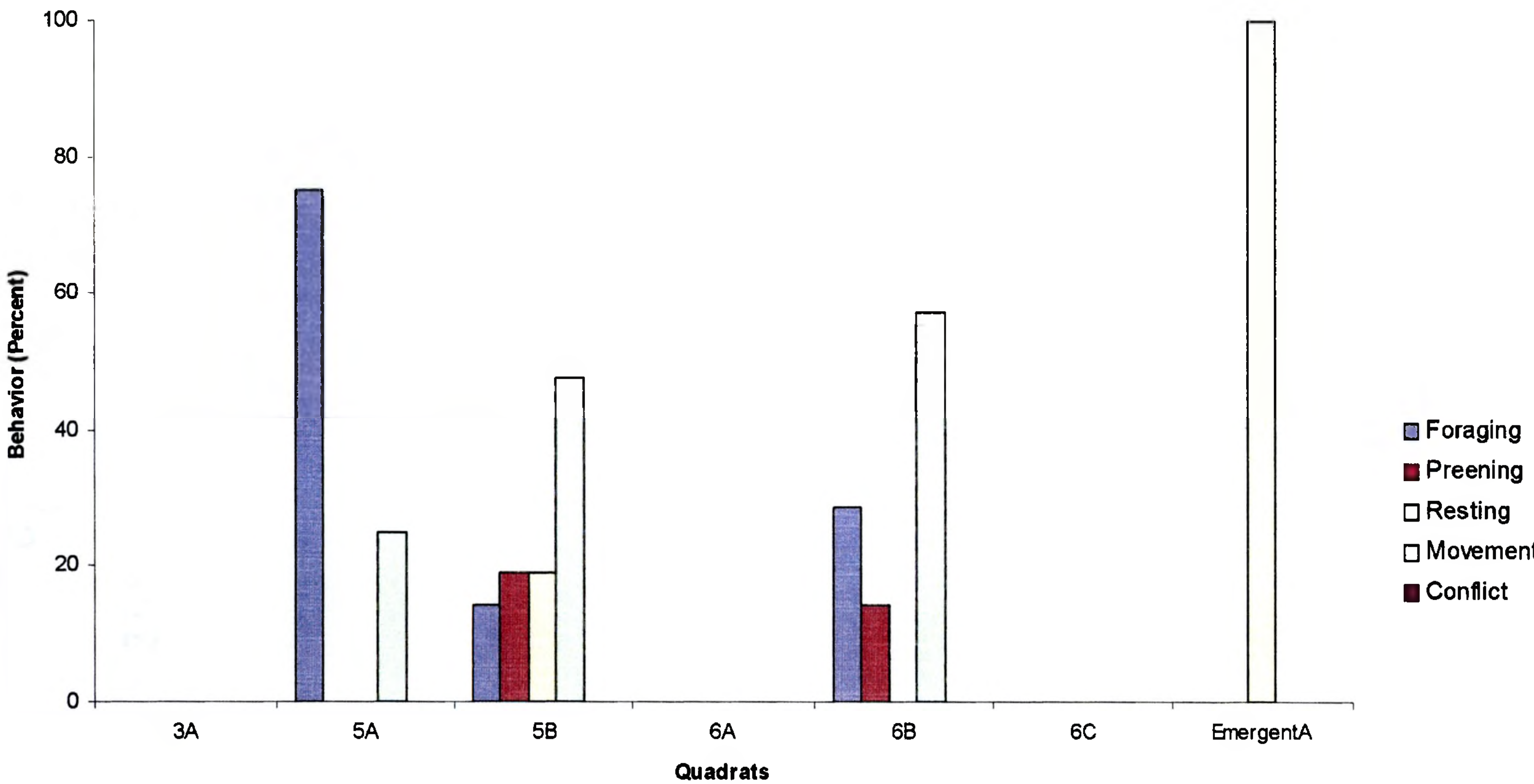

Figure 18. Behaviors of cinnamon teal by quadrat expressed as a percentage of behaviors observed (n = 42). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

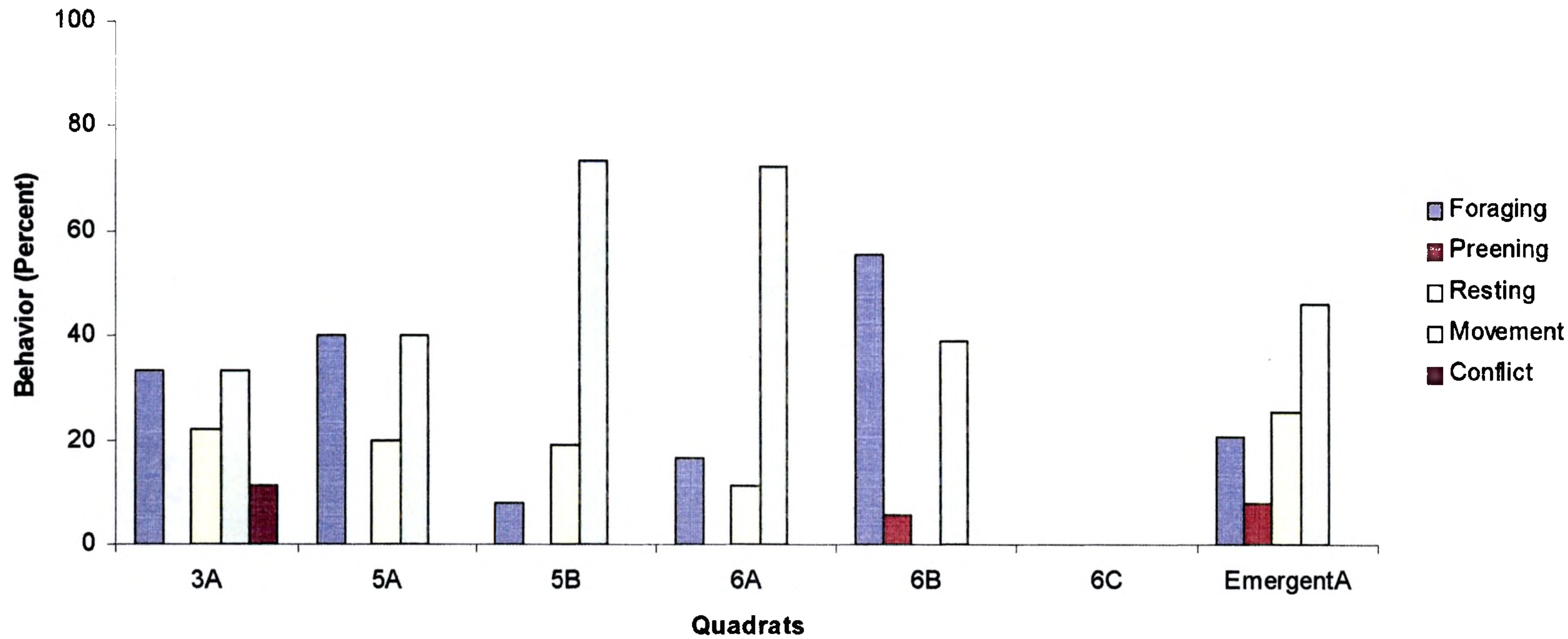

Figure 19. Behaviors of grebe species by quadrat expressed as a percentage of behaviors observed (n = 210). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

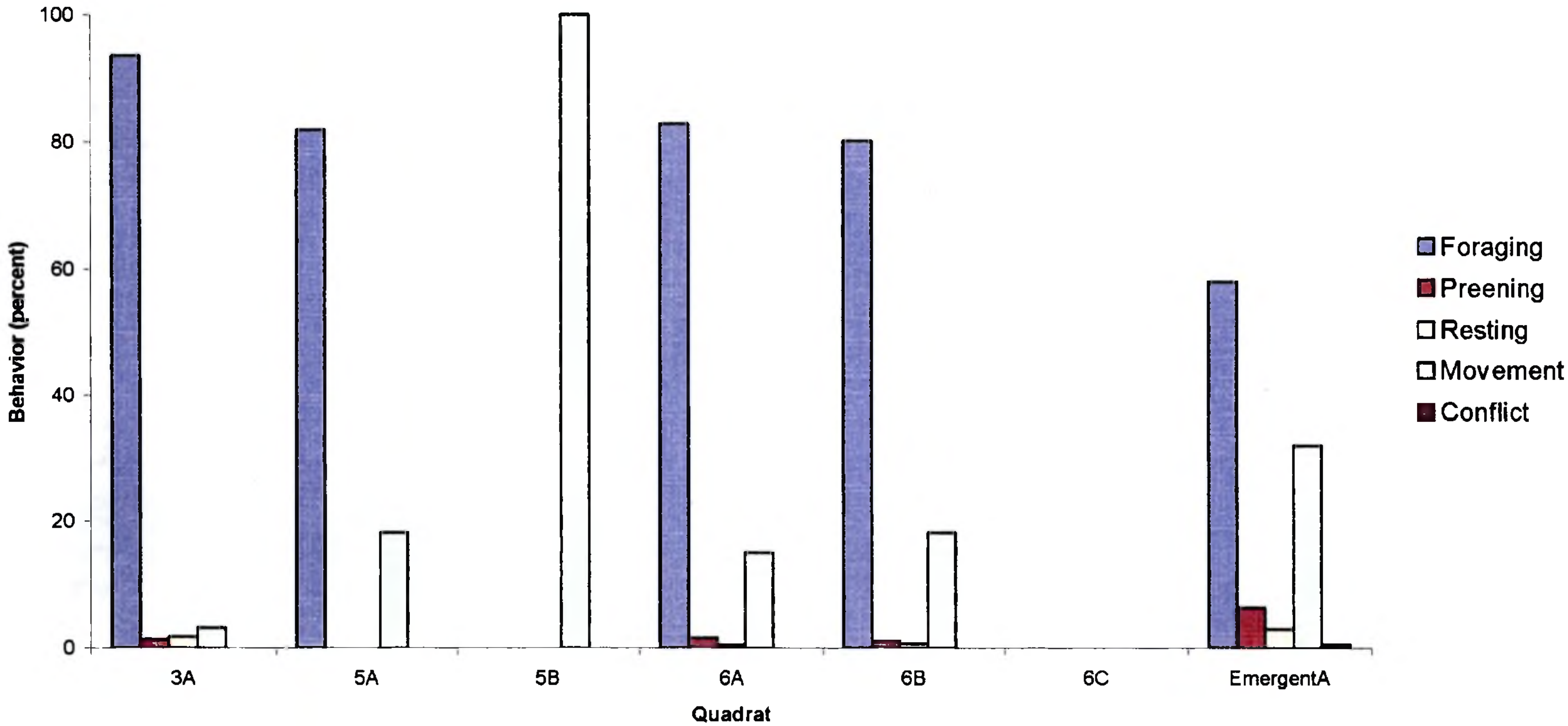

Figure 20. Behaviors of American coots by quadrat expressed as a percentage of behaviors observed (n = 2,298). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

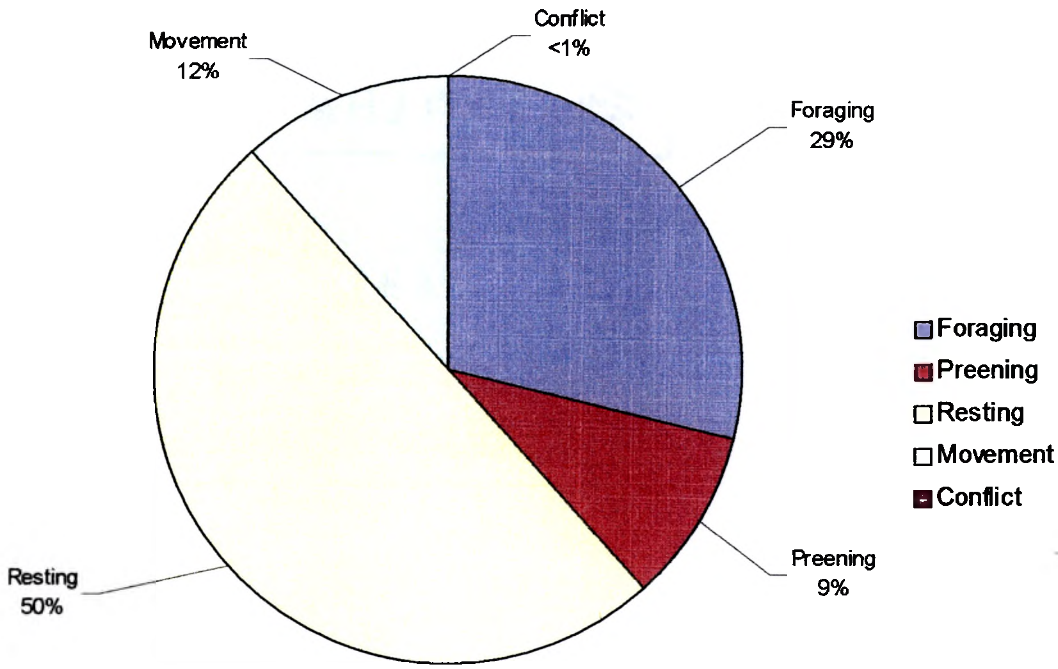

Figure 21. Overall frequency of behaviors for all species expressed as a percentage (n = 16,335). Behaviors of each bird were classified as foraging, preening, resting, movement, or conflict from 21 December 1999 through 20 February 2000. Behaviors were observed during 10-minute scan samples conducted every 30 minutes. Quadrats were located in constructed wetlands near La Ward, Texas in Jackson County.

Table 5. Chi-square values showing the effect of quadrats on behavior of waterfowl and waterbird in newly constructed wetlands in the Gulf Coast region along Highway 172 south of La Ward, Texas in Jackson County. A Fisher's Exact Test using a Monte Carlo simulation was used to corroborate the results. Behaviors were classified as foraging, preening, resting, movement, or conflict.

Species	DF	X^2	p
American Coot	15	249.379	< 0.0001
American Wigeon	2	2.222	1.0000
Blue-winged Teal	15	64.248	0.0000
Bufflehead	NA	NA	NA
Canada Geese	6	61.858	< 0.0001
Cinnamon Teal	9	27.448	0.0031
Gadwalls	6	53.821	< 0.0001
Grebes	15	48.976	< 0.0001
Green-winged Teal	6	347.913	0.0000
Lesser Scaup	NA	NA	NA
Mallard	12	87.433	< 0.0001
Mottled Duck	NA	NA	NA
Northern Pintail	12	96.277	< 0.0001
Northern Shoveler	18	178.785	< 0.0001
Redhead	4	3.600	0.7685
Ruddy Duck	NA	NA	NA
Snow Geese	12	1109.877	0.0000
White-fronted Geese	6	18.626	0.0513
All Species	18	1974.405	< 0.0001

Table 6. Waterfowl species richness (S), diversity (H'), and evenness (J') values for quadrats in newly constructed wetlands in the Gulf Coast region along Highway 172 south of La Ward, Texas in Jackson County.

Quadrats	S	H'	J'
3A	11	1.802	1.730
5A	6	0.165	0.212
5B	8	0.192	0.213
6A	17	1.733	1.439
6B	13	0.735	0.660
6C	1	0.008	N/A
Emergent A	9	0.414	0.434
All Quadrats	19	1.834	1.491

DISCUSSION

Waterfowl and waterbirds used all ponds with unequal frequency and appeared to discriminate in pond selection. For example, geese used quadrats 3A, 3B, and 6A with greater frequency. Northern shovelers used all quadrats except 6C with unequal frequency. Only two birds were observed using quadrat 6C during the study, making it the least used quadrat. Birds came to quadrat 6A in greater numbers and in larger flocks. Large flocks of geese tended to use quadrat 6A in the afternoon, but left in the late afternoon to forage. The emergent pond had moderate use. American coots used Emergent A quadrat more frequently than any other species and primarily foraged while on the pond (Fig. 5). The northern shoveler was the second species in importance of use of quadrat Emergent A and primarily foraged while on the pond.

Waterfowl and waterbird use correlated with several different abiotic factors. Factors such as humidity and cloud cover had minimal effect on pond use by waterfowl and waterbirds, and quadrat use was unequal. Time of day was a significant factor; some species used particular quadrats only at certain times of the day. Time of day and temperature were highly correlated with one another ($p < 0.0001$) and both had independent effects on use (Table 2). Wind direction also had a significant effect on use. Humidity alone had little effect on use. It correlated with other factors and may in combination with these factors synergistically affect use. Cloud cover was not a factor either, possibly due in part to the inconsistency in which data were collected.

Frequencies of behaviors exhibited by waterfowl and waterbirds were different among quadrats. Because quadrats did affect behavior, I rejected the hypothesis that quadrats do not affect waterfowl and waterbird behavior. The most common behavior observed was resting (Fig. 2). Generally, geese exhibited resting more than foraging, while American coots displayed foraging or moving. Interspecific and intraspecific conflicts were rare. A secondary priority for most species was foraging. All duck species observed during this study have a diet of aquatic invertebrates, mollusks, or aquatic vegetation (Ehrlich et al. 1988). Ducks primarily foraged on ponds. Therefore, one would expect foraging behavior to be exhibited often. Foraging was the second most common behavior (Fig. 21). Ducks foraged in the open water of quadrats, while geese used ponds for resting.

Preening is an important behavior for maintenance and oiling of feathers. I observed preening by all species except American wigeons and redheads. Movement was important to avoid conflict by leaving the space of another bird or to occupy a better location for foraging.

Species diversity was not equal across quadrats; therefore, I rejected the hypothesis that species diversity would be equal across all quadrats. Species diversity varied greatly from quadrat 6C, which had the lowest diversity, to quadrat 3A, which had the highest diversity (Table 6). The large number of geese on pond 6A affected species diversity, evenness, and use (Table 1). Geese tended to enter quadrats in mid-afternoon and left to forage in adjacent fields between 1500 and 1600 h. This large number of geese greatly increased the mean number of observations for quadrat 6A. Diversity for 6A was higher than all quadrats except 3A. Quadrat 3A also had an abundance of geese but was not it statistically dissimilar to all other quadrats. Overall, the ponds attracted 17 of 25 species of geese and ducks that generally winter along the Texas coast (Dickinson 1999).

Two physical differences appear to exist between quadrats used most often by waterfowl and waterbirds: cover and space. Space was defined as the amount of open water available for resting and foraging. Quadrats 3A, 6A, 6B, and Emergent A had more open water than quadrats 5A, 5B, and 6C. Open water may have been the factor that attracted more waterfowl because of greater areas for individual movement. Quadrat 6C only had a narrow strip of water in a ditch along its northern border. This fulfilled the criteria for using it as a sample site, but the pond did not attract waterfowl. The two northern shovelers spotted within the quadrat used the open water for foraging. Quadrats 5A and 5B appeared to have greater water surface areas than 6C but not as much as 3A and 6A. The open water in both of these ponds was also concentrated along the edges in ditches created when the levees were constructed.

Snow geese and Canada geese rarely foraged on the ponds. Geese left the ponds in late afternoon to forage in unplowed agricultural fields south of pond 6 and west of pond 3. Pond 5 was also near agricultural fields that were either primarily fallow or plowed at the time of the study. Quadrat 6B may have had a greater abundance of birds because of its proximity to external foraging sites and quadrat 6A, which had the greatest number of birds. This could have created a "spill over" effect that caused birds to use a different area because quadrat 6A already had a high abundance of birds using it.

The residual effect of large numbers of geese on ponds with a greater surface area of open water may have initiated the innate flocking instinct that waterfowl and other species of birds experience. A large flock of geese, or any other waterfowl species, could cause other birds to select that location, even if foraging or other behaviors might be better expressed at another location. This overwhelming impulse caused these birds to select a less suitable area with crowded conditions.

Aggression or conflict was extremely limited throughout the study. It is possible that the amount of space, size of foraging areas, and the reduced importance of maintaining territories in wintering populations accounted for this lack of conflict. The availability of space and foraging areas would be paramount to the success of wintering waterfowl and worth the risk of becoming aggressive in defense of available resources. However, when basic biological requirements are met, wintering waterfowl should be less likely to expend energy and encounter the risk of engaging in conflicts. This suggests that the newly constructed wetland provided at least the basic habitat requirements for wintering waterfowl.

There are some probable explanations for the correlation of abiotic factors. The most likely reason that air temperature correlated with time of day was that air temperature generally increases during the day unless a cold front moves into an area. Wind direction could be an important factor determining when and if individuals or flocks of birds change locations. Flying into or during heavy winds would not be the most efficient use of energy and might deter birds from moving in a certain direction.

Overall, it appeared that the ponds were useful resting and foraging sites for migrating waterfowl. Ponds were used often by several species. It is my assessment that building water impoundments is a good start in restoring habitat specifically for use by waterfowl. These ponds were not large enough to act as water purifiers for industry or commercial water projects, but they were large enough to expand the scope of future projects to begin experimenting with emergent vegetation and creation of actual food sources that could be useful to waterfowl and other species of animals.

MANAGEMENT IMPLICATIONS

Waterfowl responded very well to the minimal improvements that were made on this property. Having clay based soils, creating levees, and filling impoundments with water was enough to create wintering habitat for several thousand birds. This model creates both positive and negative implications for the future of waterfowl and wetlands management. A positive implication is that just creating impoundments for waterfowl will cause a response from migrating birds. Waterfowl will use these ponds to rest and possibly forage, depending on the species and their needs. This means that wildlife managers could encourage low-cost wetland production, which would be an incentive for landowners to become active in waterfowl management. The downside to this type of minimalist wetlands creation is that a lack of understanding of waterfowl food requirements may lead to wetlands that are being used by waterfowl, but lack the types of plants that provide the most beneficial diet for waterfowl diets. Research on wintering food habits of waterfowl and other wildlife should be incorporated into planning and creating wetlands in order to ensure that waterfowl will be provided with adequate nutrients while using newly created wetlands. By taking into account the nutrient needs of ducks and geese, wildlife managers can provide the basic dietary needs of waterfowl wintering in Texas.

An additional negative implication to minimalist wetlands management is the effect of these new impoundments on other species of wildlife. By incorporating data on shorebirds, mammals, and other groups of species, wildlife managers stand a better chance of creating diverse, beneficial habitats that are sustained indefinitely. Sustainable management is what is needed in wetlands management for both waterfowl and other indigenous, coastal wildlife species.

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