SUMMER HABITAT USE BY WATERBIRDS AND WATERFOWL

AT A BIOSOLIDS FACILITY

THESIS

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Stephanie Rosson-Singleton, B. S.

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In loving memory of my grandfather Joseph J. Chesson (1919-2005).

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ABSTRACT

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Stephanie A. Rosson-Singleton, B. S.

Texas State University-San Marcos

August 2006

SUPERVISING PROFESSOR: JOHN BACCUS

Wetlands are disappearing at an alarming rate because of agricultural practices and urban and suburban sprawl. Constructed wetlands may counter this loss and are an important resource for the conservation of birds. My study addressed waterbird use of constructed wetlands at a biosolids facility during the summer. I conducted 10-minute observations of foraging, resting, conflict and movement behavior that occurred in 3 different ponds consisting of 1) marsh, 2) shallow mudflat, and 3) open deep water (without vegetation) to determine behavior and habitat use by waterbirds. The null hypothesis for the study was equal use of pond habitat. Waterbirds and waterfowl used pond habitats disproportionately and the null hypothesis was therefore rejected. The marsh pond habitat had the greatest occupancy with 1769 birds seen during the study, highest Simpson's Index (2.12) and species richness (27 species). Waterbirds and waterfowl used the marsh pond mostly for foraging. Waterbirds and waterfowl used the deep water pond water habitat mostly for movement, and the mudflat pond mostly for resting. Different guild of birds used habitats differently. Atmospheric conditions did not influence waterbird activities. Biosolid facilities provide important habitat for the conservation of waterbirds and waterfowl. Future studies should examine habitat variability within and between seasons for a more comprehensive look at species and habitat use for the entire year. Future studies should also examine the effect of water fluctuations on waterbirds, size requirements, and site fidelity for constructed wetlands.

INTRODUCTION

Since the settlement of North America, many species of waterbirds have declined. Fifty-three percent of wetlands in the U.S. have been lost since the late 1700s (Mitsch 2000). The net loss of wetlands from the 1950s to the 1970s was 3.7 million ha with an average annual loss of 185,000 ha (Mitsch 2000). Major factors contributing to the continual loss of these habitats were drainage of wetlands and marshlands, urban and suburban sprawl and agricultural use (Gibbs 2000). Wetland losses have continued to the present at a reduced rate, but remain a problem (Mitsch 2000). Wetlands and marshes are important to waterbirds and waterfowl by providing sources of food, shelter and resting areas during migration and summer residence. Conservation and management of waterbirds and waterfowl in North America have relied on wildlife refuges and artificial wetlands situated along migratory flyways (Post et al. 1998). Long-distance migratory birds often cannot complete migration without replenishing their reserves of fat. It is critical to maintain stopover sites for the survival of these species (Myers 1983).

As a group, waterbirds and waterfowl have diverse habitat-use patterns, habitat size and shape, and foraging behaviors (Skagen and Knopf 1993). Species morphology often determines habitat use (Colwell and Oring 1988). For example, waterbirds and waterfowl as a group use a wide variety of habitats including deep water, shallow water, unvegetated mud flats, wet meadows and grassy uplands (Colwell and Oring 1988).

Wetland loss is being alleviated by conservation of natural wetlands and construction of artificial wetlands on public and private land. Golf course constructed ponds are a surrogate wetland used by waterbirds, waterfowl, and a large number of terrestrial birds (Jones et al. 2005; White and Main 2005). These constructed ponds can also support riparian bird communities (Merola-Zwartjes and DeLong 2005). Waterbirds used constructed salt marshes and a larger number of shorebirds used constructed, unvegetated habitats (Darnell and Smith 2004). Flooded rice fields provided positive surrogate wetlands for waterbird communities (Elphick and Oring 2003). Wastewater and sewage ponds supported large numbers of waterfowl (Hamilton and Taylor 2003). Wastewater treatment wetlands, because of their stable water levels, had higher bird densities than natural wetlands (Frederick and McGehee 1994). At a sewage facility, the greatest bird numbers occupied a pond with a sewage inlet. This pond received the greatest quantities of nutrients and suspended materials, which resulted in an increase in phytoplankton productivity (Waweru et al. 2005).

However, there is conflicting research on whether sewage lagoons have lower diversity and are not ideal substitutes for natural wetlands (Maxson 1981). Habitat size is important when constructing wetlands for waterbirds and waterfowl with emergent vegetation being a very important aspect during spring-summer periods (Paracuellos and Telleria 2004). There is paucity of research on waterbird and waterfowl use of wetland ponds at biosolids facilities. The objective of my study was to investigate and quantify waterbird and waterfowl use of constructed wetlands at a biosolids facility.

I examined the central question of whether or not migrating and resident waterbirds and waterfowl use all habitats associated with ponds at the biosolids facility equally. The alternative hypothesis was that waterbirds and waterfowl demonstrate disproportionate use of different habitats. Additionally, I assessed waterbird and waterfowl species diversity and behavior across all habitats.

MATERIALS AND METHODS

Study Area

Hornsby Bend is located on about 282 ha in a bend of the Colorado River 10 km southeast of Austin, Texas (N 30.21773° W 097.63908°). It is operated as a biosolids treatment facility by the City of Austin. Hornsby Bend offers prime habitat for many migratory birds. From the 1950s, the design of ponds at the facility has changed from a chain of lagoons used for wastewater treatment and sludge storage to a modern biosolids facility. A biosolids facility is a recycling center for sewage and yard trimming waste.

Three ponds were constructed in the late 1950s (Figure 1), which provided different habitats for waterbirds (Fergus 1999). Before the late 1950s, few waterbirds and waterfowl migrating in the Central Flyway stopped at the facility because of a lack of permanent ponds (Fergus 1999). Most birds temporally used stretches of the nearby Colorado River.

Each pond provides a different type of habitat. Until 1987, Pond 1 East and Pond 1 West (26 ha) formed a single lagoon with depths varying from 305 to 366 cm (Fergus 1999). When the pond was divided in 1987, Pond 1 West accumulated sludge and formed a marshy area and mudflat (Fergus 1999); while, Pond 1 East has mostly deep open (unvegetated) water.

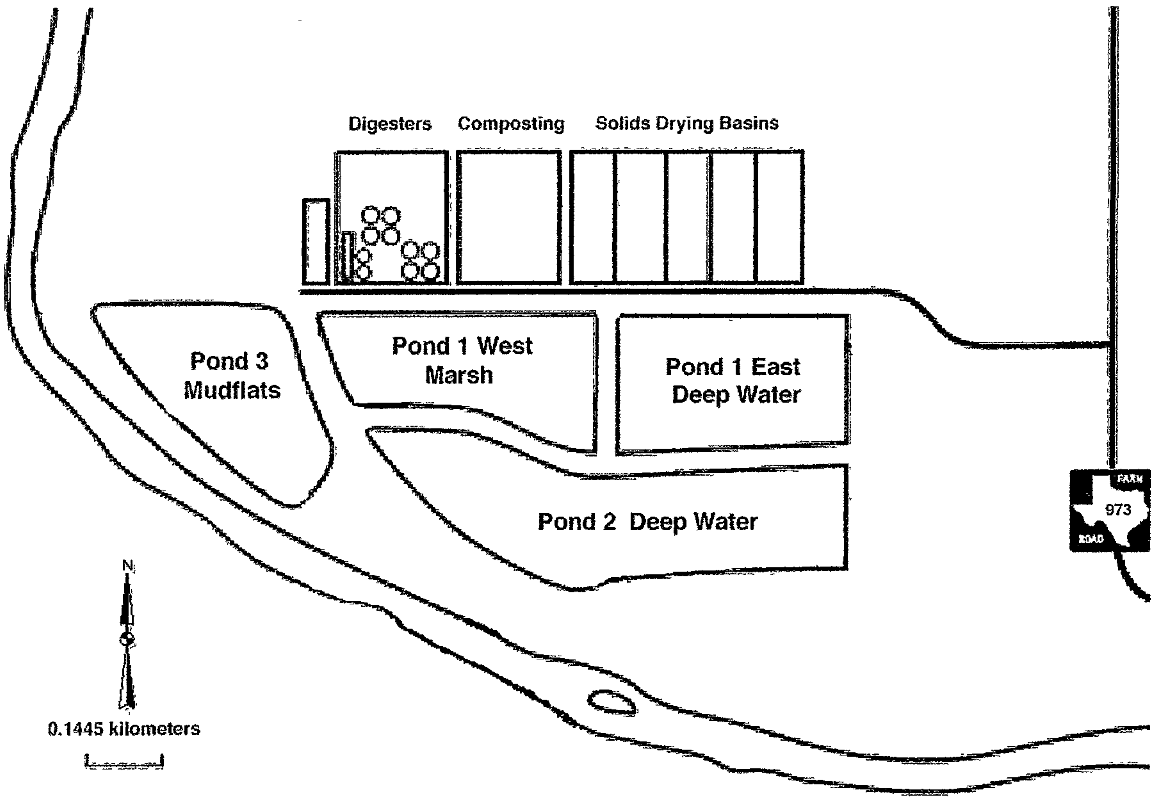

Figure 1. Map showing the location of ponds at Hornsby Bend Biosolid Treatment Plant, Austin, Texas, 2004.

Pond 2, the largest pond (34 ha), consists mostly of open deep water (Fergus 1999). Pond 3, the smallest pond (17 ha), mainly contains shallow water and mudflats (Fergus 1999). Hereafter the ponds will be referred to as their habitat type.

Methods

The study was conducted from 11 May–25 August 2004. I observed waterbirds and waterfowl twice weekly from 0830 h–1130 h and 1230 h–1530 h CDT in 3 habitat types 1) marsh, 2) shallow mudflat, and 3) open deep water (without vegetation). For clarification waterbirds and waterfowl are defined as follows: waterbirds consist of shorebirds, wading birds, rails and waterfowl consists of ducks in the family Anatidae.

Marsh was defined as a constantly or recurrently inundated wetland characterized by emergent, herbaceous vegetation adapted to saturated soil types (Mitsch 2000). Mudflat was defined as a flat, or low-lying plain made of muddy sediments with few plants. Open deep water was defined as water deeper than 152.5 cm containing no emergent vegetation.

Waterbirds and waterfowl were observed in two 50 m X 50 m quadrats in each habitat type per pond. Quadrats were spaced in habitats at a minimum distance of 50 m to prevent overlapping observations and double counts. The 6 quadrats had a total area of 2,500 m^2. I marked corners of quadrats using survey flags of different colors. I recorded boundaries using a GPS unit (GPS V, Garmin Internation, Olathe, KS). I randomly chose a quadrat for each day's observation by staggering quadrats numerically, so as to sample quadrats differently temporally. The same quadrat observed in the morning was then repeated for the afternoon.

To avoid bias in observer skill, I was the only data collector. I scanned quadrats visually counting birds by species and recorded types of behavior. After an initial 5-min period to allow birds to settle down, I visually scanned a quadrat for a 10-min period at 30-min intervals over 3 h in the morning and 3 h in the afternoon using a Guardforce Spotting Scope (GT-1000) with a 20x – 60x (zoom) x 80 mm lens. Waterbirds or waterfowl entering or leaving the quadrat after the 10-min. observation began were not included in the sample.

I recorded behaviors exhibited by waterbirds during sampling periods and categorized them as 1) moving, 2) preening, 3) foraging, 4) conflict, and 5) resting. Moving was defined as change in position from 1 point to another but no engagement in foraging. Preening was fluffing feathers and combing them with the bill (Sibley 2001). Foraging for food was defined as obtaining materials from marsh or looking at the ground, probing and pecking in the water by wading birds or dabbling or diving in water by ducks (Elphick 2000). Conflict behavior was considered biting and pecking at another bird in an aggressive manner thereby coming into physical contact and also rapid flapping of wings with beak agape in a threat display (Welty and Baptista 1988). Resting behavior was considered as eyes closed or open without movement or in some species with the bill tucked under feathers or resting on the chest in a sedentary position (Bender 2002).

Atmospheric conditions were recorded during observations using a Kestrel 3000 (Nielson-Kellerman Company, Chester, PA). These included wind speed, temperature, wind chill, relative humidity, heat index, and dew point.

To compare habitat use by waterbirds and waterfowl, I ran a MANOVA on all 6 quadrats. To determine whether habitats were used equally by species, I used an ANOVA with a post–hoc Tukey's test. For Tukey's test, habitats were labeled A (marsh habitat), B (deep water habitat) and C (mudflat/shallow pond habitat) for chart simplicity.

A Chi-square value was calculated to determine whether quadrats influenced certain behaviors in birds. To determine if there were significant differences between quantities of birds per pond, I used an ANOVA test on each pond followed by a post-hoc Tukey test to determine significant differences between ponds. I used multiple regression to determine whether atmospheric conditions affected the use of habitats. In addition I calculated Shannon and Simpson's diversity indices (H) and evenness (J') and species richness values for each pond. These tests determined abundance similarities among species by pond. The Shannon diversity index (H') is commonly used to characterize species diversity in a community. Like Simpson's index, Shannon's index accounts for both abundance and evenness of species present. These particular indices were used because of the assumptions of an open system and population size.

RESULTS

I made 312 scans of the 3 ponds with each pond scanned 104 times for a total time of 1,040 minutes. Different guilds of birds used the habitats differently (Table 1). Waterfowl mostly used the deep water habitat pond. During May-August, Northern Shovelers (*Anas clypeata*) visited the deep water pond 50 times (53%) during my observations, Blue-winged Teals (*Anas discors*) 23 times (24%) and Green-winged Teals (*Anas crecca*) 8 times (8%). The marsh habitat and mudflat habitat were mostly used by wading birds. The marsh habitat was visited by Snowy Egrets (*Egretta thula*) 755 times (43%) during my observations, Little Blue Herons (*Egretta caerulea*) 345 times (20%), and Black-necked Stilts (*Himantopus mexicanus*) 165 times (9%). The mudflat pond was visited by Snowy Egrets 153 times (64%), Green Herons (*Butorides virescens*) 20 times (8%), Wood ducks (*Aix sponsa*) 22 times (9%), and Great Blue Herons (*Ardea herodias*) 15 times (6%).

Habitats were not used equally ($F_2 = 114.676$, $P < 0.001$). A post-hoc Tukey's test on habitat use indicated significant differences in the mean habitat use between marsh and deep water habitats (Estimate 6.48, SE = 0.449, Lower Bound = 5.42, Upper Bound = 7.540), between marsh and mudflat pond habitats (Estimate 5.02, SE = 0.449, Lower Bound = 3.96, Upper Bound = 6.080), and between deep water and mudflat pond habitats (Estimate –1.46, SE = 0.449, Lower Bound = –2.52, Upper Bound = –0.399).

Tukey's test results on an ANOVA of bird abundance per pond indicated significant differences between marsh and deep water habitats (Estimate 33.30, SE = 2.99, Upper Bound = 26.20, Lower Bound = 40.30) and between marsh and mudflat habitat (Estimate 30.30, SE = 2.99, Upper Bound = 23.30, Lower Bound = 37.40), but no significant difference between deep water and mudflat habitat (Estimate –2.92, SE = 2.99, Lower Bound = –9.99, Upper Bound = 4.15). The marsh habitat had the greatest absolute bird abundance (1,769). The mudflat habitat had 239 birds and the deep water habitat 95.

Habitat type influenced behaviors among waterbirds and waterfowl. Behaviors of waterbirds and waterfowl varied by habitat type and quadrat ($\chi^2 = 565.6153$, df = 20, $p < 0.001$) (Table 2). The marsh habitat was mostly used for foraging, the deep water habitat for movement, and the mudflat for both resting and foraging.

A MANOVA on behaviors observed (presence or absence) by waterbirds and waterfowl by quadrat were significant (Pillai Trace F = 4.7382, P = < 0.001; Wilks L F = 6.515, P = < 0.001), indicating different behaviors primarily occurred in different habitat types (Table 3). Waterbirds and waterfowl exhibited an unequal use of ponds and appeared to discriminate in pond selection. Waterbirds and waterfowl used the marsh pond mostly for foraging. Waterbirds and waterfowl used the deep water pond mostly for movement and the mudflat pond mostly for both resting and foraging. An ANOVA indicated ponds had significant differences in the quantity of birds ($F_2 = 76.08457$, P = < 0.001). The marsh pond had the highest quantity of birds (1,769). When evaluating use by quadrats, Quadrat 1 (marsh habitat) had the most use by waterbirds and waterfowl with Quadrat 4 (deep water habitat) the least.

Atmospheric conditions such as temperature, humidity, and wind speed, did not affect waterbird or waterfowl use of ponds or habitats ($F_{236} = 0.04926$, $P = 0.9855$). Waterbirds and waterfowl used ponds for certain activities regardless of weather conditions.

Species diversity was not equal across pond habitats (Table 4). The deep water pond had the highest species evenness (J' 0.77). The marsh pond had the highest species diversity (H' = 2.12) and highest species richness (n = 27). The deep water pond had the lowest species richness and the mudflat pond had the lowest diversity. A total of 31 species visited all ponds.

DISCUSSION

The results of my study support the hypothesis that waterbirds and waterfowl demonstrated disproportionate use of habitats. Migrating and resident waterbirds and waterfowl did not use all ponds equally. Diversity indices indicated that the pond used for foraging, marsh habitat, had the highest species richness and diversity.

Waterbirds and waterfowl used the biosolids facility constructed-pond habitats disproportionately. This study confirmed that as a group waterbirds and waterfowl used a wide variety of habitats that include mudflats, deep water and marsh areas (Colwell and Oring 1988). The large number of species (n = 31) using the constructed wetlands indicated that sewage treatment ponds were used by a diversity of waterbirds and use was relative to habitat (Skagen and Knopf 1994). The results of my study agreed with Maxson's study (1981), that sewage lagoons were potential waterfowl refuges. My study agreed with Bender (2002), that waterbirds and waterfowl use habitats with unequal frequency and discriminated in habitat selection. Additionally, my study also confirmed that frequencies of behaviors such as foraging, resting, conflict and movement, differed among habitats (Bender 2002). Habitat type affected waterbird and waterfowl behavior in that different ponds resulted in different behaviors observed, with the most common behavior observed was foraging in the marsh habitat.

My study shows that marsh habitat available at a Biosolids facility provides important foraging opportunities to birds. Similar to Paraculeeos and Telleria (2004), my study identified emergent vegetation as an important habitat factor in spring-summer. Additionally, species diversity was not equal across habitats, also confirming the results of Bender (2002). My study showed that constructed wetlands have a positive effect on waterfowl and waterbirds and building wetlands will attract waterbirds and waterfowl to certain habitats (Frederick and McGehee 1994; Bender 2002; Hamilton and Taylor 2003; White and Main 2005). Waterfowl and waterbirds use ponds mostly for foraging and for movement and resting. Therefore, vegetation and standing water are important characteristic of created wetlands (Long and Ralph 2001).

Biosolids facilities fulfill an important ecological function in the conservation of waterbirds and waterfowl in their use as refuges for migrating birds in the midst of human urban and suburban settlements. In a similar study at a waste stabilization pond, ducks used the site as a summer molting refuge (Hamilton and Taylor 2003). In another study at a wastewater wetland, habitats were attractive habitat for breeding Ciconiiformes (Frederick and McGehee 1994). At sewage works (Biosolids Facility) in Kenya, waterfowl and waterbird preference of habitat use was based on food availability and quality, and the site served as important alternative habitat for waterfowl and waterbirds (Waweru et al. 2005). In a similar study investigating activity budgets of Anatidae, the Western Treatment Plant was an important site for waterfowl feeding, resting, comfort and locomotion (Hamilton et al. 2002). Additionally, sewage works in New Guinea and Britain demonstrated that waterbird abundance was related to season, local conditions and food source and were an important refuge for migrating waterbirds (Fuller and Glue 1978; Bell 1985).

In conclusion, sewage lagoons (Biosolids Facility) are a constructed habitat used by waterbirds and waterfowl. Sewage sludge attracts a wide variety of birds that concentrate to feed at sewer outlets and habitats consisting of more emergent vegetation and sludge, thereby, providing an important food source and refuge for birds (Leck and Hawkins 1978). Land managers wanting to conserve waterbirds and waterfowl and desiring a habitat with highest numbers, diversity and species richness should consider construction of a marsh type habitat. Waterbirds responded to such habitats at a small geographic scale (Skagen and Knopf 1994). Therefore, wildlife managers with constructed wetlands meeting these criteria should not have a problem attracting waterbirds and waterfowl to their land. Moreover, future studies could examine habitat variability within and between seasons for a more comprehensive look at species and habitat use for the entire year (Skagen and Knopf 1994). Future studies could also compare natural versus constructed wetlands habitat quality and their effects on energetic needs of birds. Additionally, future studies could examine water fluctuations and their affects on waterbirds and waterfowl, size requirements and site fidelity for created wetlands.

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APPENDIX I

Table 1. Habitat type and species present at Hornsby Bend Biosolid Treatment Plant, Austin, Texas, 2004

	HABITAT TYPE		
Species	Marsh	Deep Water	Mudflat
Waterbirds			
American Coot (*Fulica americana*)	x		
Baird's Sandpiper (*Calidris bairdii*)	x		
Black-necked Stilt (*Himantopus mexicanus*)	x		x
Cattle Egret (*Bubulcus ibis*)	x		x
Double-crested Cormorant (*Phalacrocorax auritus*)	x		
Great-blue Heron (*Ardea herodias*)	x	x	x
Great Egret (*Ardea alba*)	x		x
Greater Yellowlegs (*Tringa melanoleuca*)	x		
Green Heron (*Butorides virescens*)	x		x
Killdeer (*Charadrius vociferus*)	x		x
Least Sandpiper (*Calidris minutilla*)	x		
Lesser Yellowlegs (*Tringa flavipes*)	x		

Table 1. Continued.

Species	HABITAT TYPE Marsh	Deep Water	Mudflat
Waterbirds			
Little Blue Heron (*Egretta caerulea*)	x		x
Pectoral Sandpiper (*Calidris melanotos*)	x		
Semipalmated Sandpiper (*Calidris pusilla*)	x		
Snowy Egret (*Egretta thula*)	x		x
Solitary Sandpiper (*Tringa solitaria*)	x		x
Spotted Sandpiper (*Actitis macularius*)	x		
Stilt Sandpiper (*Calidris himantopus*)	x		
Western Sandpiper (*Calidris mauri*)	x		
White-faced Ibis (*Plegadis chihi*)	x		
Wilson's Phalarope (*Phalaropus tricolor*)	x		x

Table 1. Continued.

Species	HABITAT TYPE		
	Marsh	Deep Water	Mudflat
Waterfowl			
Black-bellied Whistling Duck (*Dendrocygna autumnalis*)	x		x
Blue-winged Teal (*Anas discors*)	x	x	
Gadwall (*Anas strepera*)	x		
Green-winged Teal (*Anas crecca*)	x	x	
Mallard (*Anas platyrhynchos*)		x	
Northern Shoveler (*Anas clypeata*)	x	x	
Redhead (*Aythya americana*)	x	x	
Ruddy Duck (*Oxyura jamaicensis*)		x	
Wood Duck (*Aix sponsa*)		x	
Total	**27**	**9**	**12**

Table 2. Behavior of waterbirds and waterfowl by category, habitat type and quadrat at Hornsby Bend Biosolid Treatment Plant, Austin, Texas, 2004.

	HABITAT					
	Marsh		Deep Water		Mudflat	
Behavior	1	2	1	2	1	2
Moving	101	70	66	9	15	27
Preening	35	27	2	1	4	1
Foraging	771	508	13	1	45	48
Conflict	38	17	0	0	0	0
Resting	111	91	0	3	54	45
Total	1056	713	81	14	118	121

Table 3. MANOVA results by behavioral response of waterbirds per quadrat at Hornsby Bend Biosolid Treatment Plant, Austin, Texas, 2004.

BEHAVIOR	F VALUE	DF	PR (F)
Moving	3.662149	5	0.003725714
Preening	6.040516	5	0.00004006221
Foraging	30.04249	5	< 0.001
Conflict	7.952765	5	1.133377e-006
Resting	7.798259	5	1.505727e-006

Table 4. Diversity indices by pond at Hornsby Bend Biosolid Treatment Plant, Austin, Texas, 2004.

	PONDS		
Diversity Values	MARSH	DEEP WATER	MUDFLAT
J' Evenness	0.64	0.77	0.56
Shannon Weiner	2.12	1.70	1.39
Simpson's Index	0.78	0.76	0.57
Species Richness	27	9	12

VITA

In 1999 Stephanie entered Texas State University- San Marcos and graduated in 2001 *Summa Cum Laude* with a degree in Psychology and a Minor in Biology. She also was a member of Psy Chi Psychology, Golden Key National and Tri Beta Biological Honor Society. In 2003 she entered the Wildlife Ecology Program at Texas State University-San Marcos. In 2005 she was certified in Geographic Information Systems. She is also certified as a Master Naturalist with the Capital Area Master Naturalist Chapter. During her graduate studies she taught labs for Modern Biology.

Permanent Address: 120 Elmer CV

Kyle, Texas 78640

This thesis was typed by Stephanie Rosson-Singleton.