MOVEMENTS AND HABITAT USE OF YELLOW RAILS WINTERING AT THE TEXAS MID-COAST NATIONAL WILDLIFE REFUGE COMPLEX IN SOUTHEAST TEXAS

by

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A THESIS

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THESIS ACCEPTANCE SHEET

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ABSTRACT

The yellow rail (*Coturnicops noveboracensis*) is a poorly studied migratory wetland bird that requires specialized habitats along the Gulf coast and southern Atlantic coast where it winters. Due to its secretive nature and tendency to occupy extremely dense habitat, yellow rail population numbers and trends are unknown. Wetland loss is a major factor affecting rallid populations, and much of their habitat has been substantially reduced.

Home range, daily movements, habitat use, wintering site fidelity, and the effects of prescribed fire were studied on yellow rails wintering at the Brazoria National Wildlife Complex in southeast Texas during the winters of 2003 and 2004. A weighted dragline was pulled through marsh habitat at night to flush the rails and a dip net was used to capture them, where morphological measurements were taken and a radio transmitter was attached. Radio-tagged rails were located using the homing method and habitat variables were measured within a 0.25 m^2 vegetation sampling plot.

Yellow rail had small home ranges, and home range overlap was common. Yellow rails selected sites that had lower water depths, higher dead vegetation depths, and denser dead vegetation coverage in salty prairies and high salt marsh habitats. Analysis of plant-species variables at yellow rail locations revealed that *Distichlis spicata* (saltgrass) had the highest frequency, *Spartina spartinae* (Gulf cordgrass) provided the highest % coverage, and *Scirpus robustus* (salt marsh bulrush) was the tallest plant species. Yellow rails and black rails (*Laterallus jamaicensis*) exhibited some wintering site fidelity within the same year and at the same site, while a Virginia rail (*Rallus limicola*)

was recaptured the following year at the same site. There was no evidence of direct mortality on rails during prescribed burns, but indirect mortality due to predation was noted.

Yellow rails have small home ranges and concentrated populations, which may indicate that their preferred habitat is limited or clumped; therefore, an increased importance on effective management strategies is crucial. Managers should consider burning at intervals > 2 years.

INTRODUCTION

The yellow rail (*Coturnicops noveboracensis*) is a poorly studied migratory wetland bird species that requires specialized breeding and wintering habitats. Some detailed studies have been conducted on the ecology and distribution of breeding yellow rails (Stalheim 1974, Stenzel 1982, Gibbs et al. 1991, Robert and Laporte 1997, Popper and Stern 2000, Robert et al. 2000), but only a single study has involved yellow rails in winter (Mizell 1998). The lack of research on yellow rail life history and ecological characteristics on wintering areas suggests that a priority be placed on obtaining such information necessary for effective management (Bookhout 1995).

A loss of wetlands due to human activity (dredging, filling, channelization, and draining) is a major factor affecting rallid populations (Eddleman et al. 1988). Texas has lost over 52% of its original wetlands, where over half of its wetlands occur along the Gulf Coast (Dahl 1990). In the United States, the yellow rail is listed as a Migratory Non-game Bird of Special Management Concern (USFWS 1995) and is considered a Species of Special Concern or Vulnerable in most states (North Dakota, Minnesota, Wisconsin, and Michigan) and in Canada where it breeds (COSEWIC 2003). Population numbers and trends are unknown because of the yellow rail's secretive nature and its tendency to occupy densely vegetated habitats. As a consequence, yellow rail numbers may be higher or lower than expected.

Studies of avian movement provide fundamental information pertaining to the life history, population dynamics, habitat use, and other ecological relationships (Sanzenbacher and Haig 2002). Despite a lack of research on home range and daily movements, they may be good indicators of the quality and size of habitat needed to sustain yellow rail populations. Through evaluation of these movements, important information about habitat requirements, assessment of landscape alterations, and other critical aspects of conservation planning can be obtained.

Previous studies of yellow rail habitat use have relied on locations of individuals responding to broadcast tapes (Bart et al. 1984, Gibbs et al. 1991, Kehoe et al. 2000, Prescott et al. 2002, Robert et al. 2004) and nest site searches (Popper and Stern 2000, Robert et al. 2000) during the breeding season. Because yellow rails are silent outside of their breeding grounds, gathering information on habitat requirements can be very difficult. A previous study used radio telemetry to determine habitat use in winter (Mizell 1998) which is a very effective way of gathering information on secretive animals.

Yellow rails migrate from their breeding grounds in the northern United States and Canada to their wintering grounds along the Gulf Coast in late fall, where they prefer drier portions of *Spartina spartinae* (Gulf cordgrass) and *S. patens* (marshhay cordgrass) marshes (Bookhout 1995; Figure 1). Prescribed fire is used to manage these habitats in the coastal region of Texas to control encroaching woody and exotic vegetation, and provide feeding areas for waterfowl, particularly snow geese (*Chen caerulescens*). Although the effects of prescribed fire on vegetation and seasonal abundance of avian species is well documented in these habitats (Van't Hul et al. 1997), immediate impacts on bird behavior and mortality are poorly understood. Because of water depth preferences, there may be a potential conflict between habitat requirements of

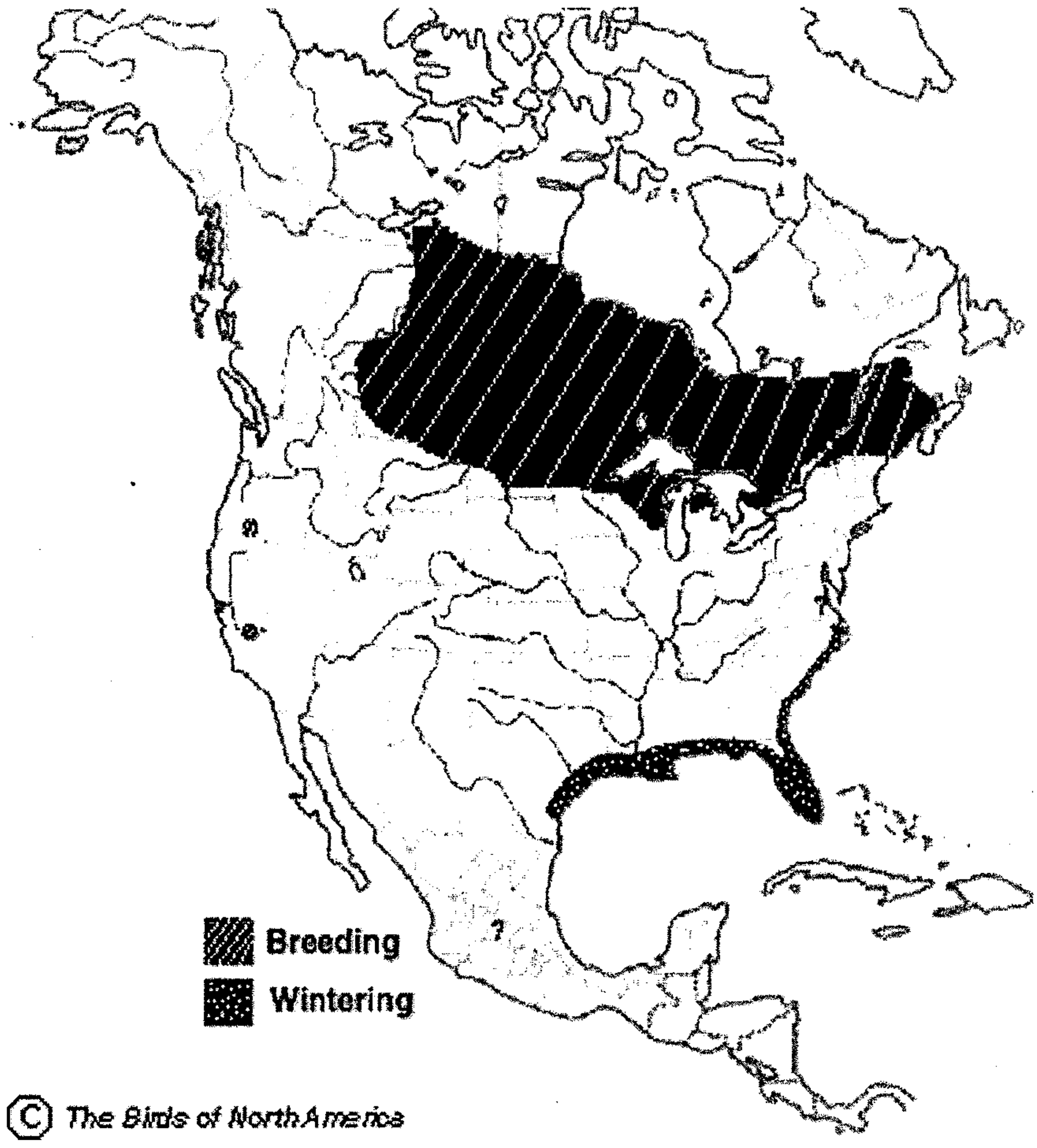

FIGURE 1. Breeding and wintering range of the yellow rail.

wintering yellow rails and the management goals of other species (Eddleman et al. 1988).

Nothing is known about the behavior of yellow rails during prescribed fire, but some preliminary evidence suggest that fire can cause mortality of some wintering rallids (W.R. Eddleman, pers. comm.). Study of the effects of prescribed fire on the mortality and movements of yellow rails can allow better design of prescribed burns needed to maintain coastal prairie habitat.

OBJECTIVES

1. Determine home range and daily movements of wintering yellow rails at the Texas Mid-Coast National Wildlife Refuge Complex in coastal Texas.
2. Determine habitat use of wintering yellow rails at the Texas Mid-Coast National Wildlife Refuge Complex in coastal Texas.
3. Determine wintering site fidelity of wintering rallids at the Texas Mid-Coast National Wildlife Refuge Complex in coastal Texas.
4. Describe the effects of prescribed fire on rallids at the Texas Mid-Coast National Wildlife Refuge Complex in coastal Texas.

STUDY AREA

Fieldwork was conducted at the Texas Mid-Coast National Wildlife Refuge Complex, which includes Brazoria National Wildlife Refuge, San Bernard National Wildlife Refuge, and Big Boggy National Wildlife Refuge in coastal Texas (Figure 2). Because of logistics, study sites were limited to Brazoria and San Bernard National Wildlife Refuges. The refuge is home to all 9 species of

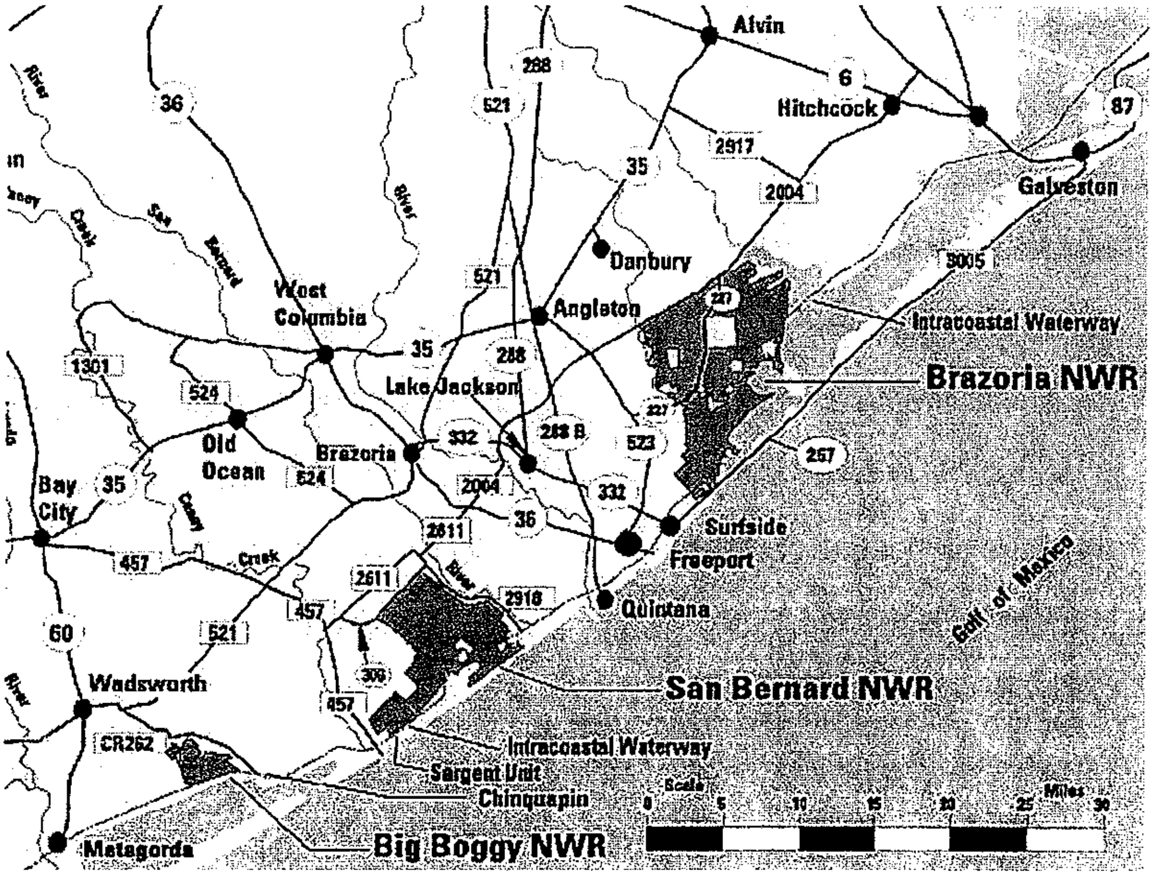

Figure 2. Map of Southeast Texas showing the location of the Brazoria National Wildlife Complex, including Brazoria National Wildlife Refuge, San Bernard National Wildlife Refuge, and Big Boggy National Wildlife Refuge.

North American rallids including yellow rails, black rails (*Laterallus jamaicensis*), soras (*Porzana carolina*), Virginia rails (*Rallus limicola*), clapper rails (*R. longirostris*), king rails (*R. elegans*), purple gallinules (*Porphyrio martinica*), common moorhens (*Gallinula chloropus*), and American coots (*Fulica americana*) during at least sometime of the year.

Established in 1966, Brazoria National Wildlife Refuge (29°02'N, 95°16'W) is located 79 km south of Houston in Brazoria County and includes 17,500-ha of coastal estuarine and coastal prairie habitat, and 2000-ha of native coastal bluestem-prairie. The 11,100-ha San Bernard National Wildlife Refuge (28°51'N, 95°34'W) was acquired in 1968 and is located 101 km south of Houston in Brazoria and Matagorda Counties. Refuge habitats consist of saline and non-saline prairie, salt/mud flats, fresh and salt marsh, numerous potholes, fresh and saltwater lakes, and wooded areas. Prior to federal acquisition, most of the land was used for cattle ranching. Throughout the 1970s and 1980s, the land was allowed to recover from years of heavy grazing. In late 1980s, refuge management began maintaining appropriate habitat through water level control by dikes and levees, and vegetation control by prescribed burning, limited cattle grazing, and some cultivation. Cattle are not allowed on refuge land today.

Trapping and subsequent tracking of yellow rails was conducted at 5 sites: Salt Lake (Brazoria), Hunt Road (San Bernard), McNeil (San Bernard), Road Pasture (San Bernard) and Sargent (San Bernard) (Figures 3, 4). Habitats at these sites are mostly salty prairie and high salt marsh intermixed with coastal prairie and low salt marsh. Dominant plant species typically include grasses, such as *Spartina spartinae* and *S. patens* in drier portions, and *Distichlis spicata*

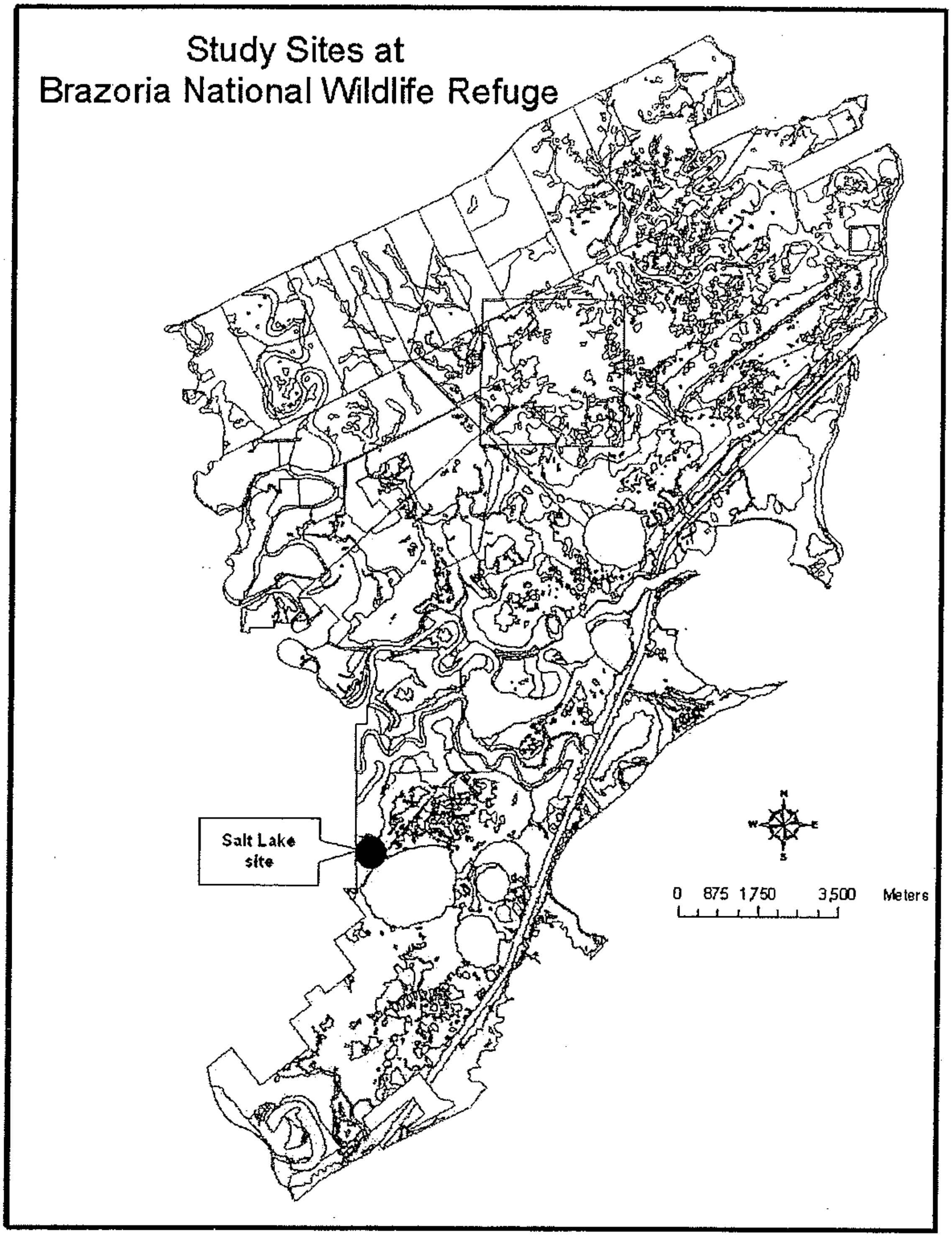

Figure 3. Study sites located at the Brazoria National Wildlife Refuge.

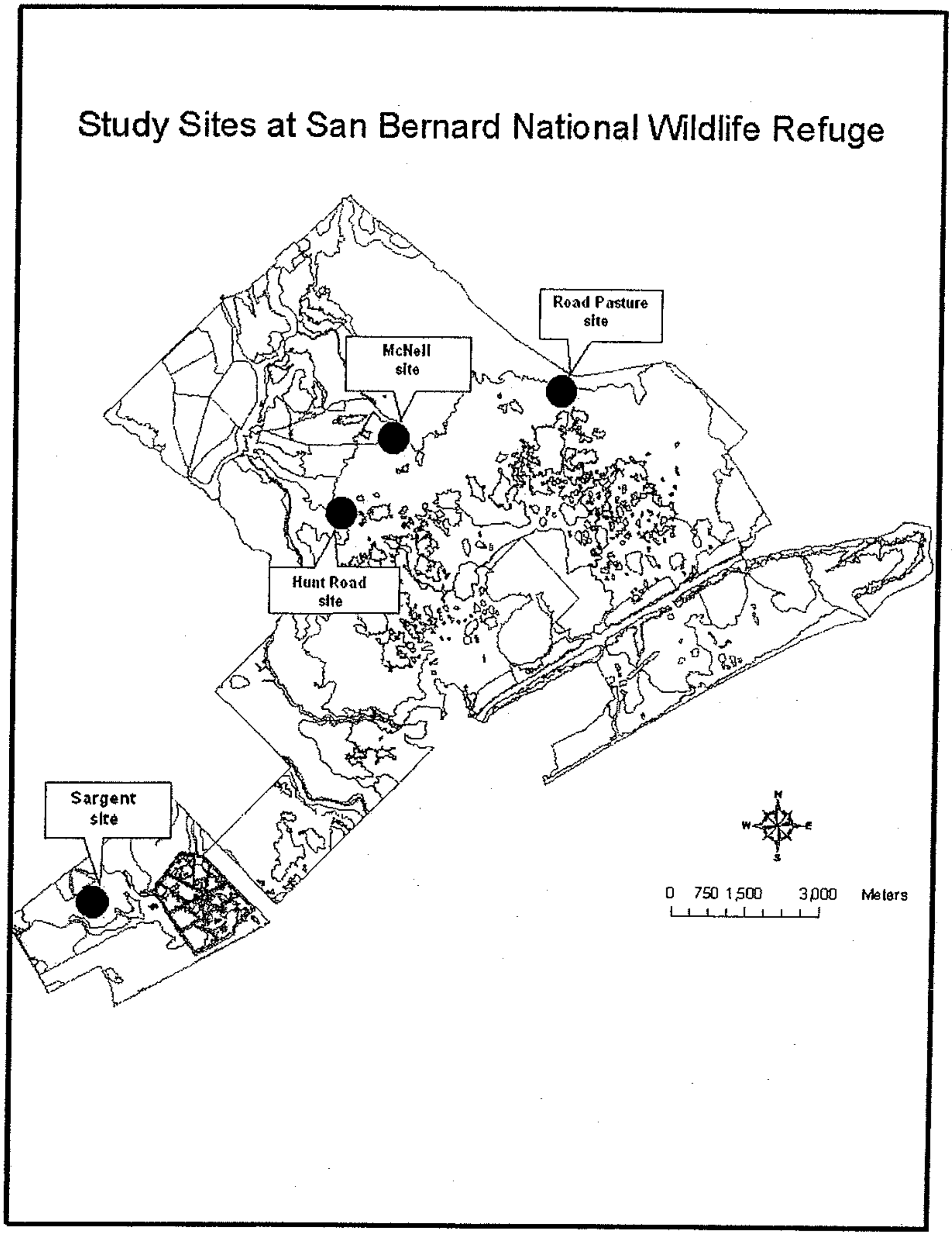

Figure 4. Study sites located at San Bernard National Wildlife Refuge.

(saltgrass), *Paspalum vaginatum* (jointgrass), *Scirpus robustus* (salt marsh bulrush), and *Scirpus americanus* (Olney bulrush) in the wetter depressions (Tiner 1993). Intermixed among the grasses are fleshy-leafed woody plants such as *Batis maritima* (saltwort) and *Salicornia* sp. (pickleweed). At the most upper edges of the high salt marsh, *Baccharis halimifolia* (sea-myrtle) is dominant.

METHODS

Capturing and radio telemetry

Yellow rails were captured from January to May 2003 and 2004, and from 13-18 March in 2005. Capturing was delayed until January to allow birds to complete migration and establish site fidelity before being disturbed. Areas with high yellow rail densities were assessed by participating in the Freeport (at Brazoria NWR) and San Bernard Christmas Bird Counts (CBC) in mid-December 2002. A marsh buggy was used in these counts to access rail habitat and flush individual birds.

Yellow rails were captured at night by pulling weighted drag-lines through marsh habitat (Mizell 1998). Drag-lines were constructed using a 15-m rope with 8 plastic milk jugs attached to the line by bailing wire. About 50 marbles were added to each milk jug. The marbles added enough weight to drag through the vegetation and created noise to aid in flushing rails. Beginning 30 minutes after sunset, a group of volunteers pulled these lines through the marsh in an attempt to flush yellow rails. One volunteer was needed to pull each end of the rope, while others walked behind and flanked the sides of the rope carrying dip-nets and shining flashlights. When an individual was flushed, a high-intensity hand-held spotlight was used to locate where the bird had landed. We found the birds had a tendency to fly farther when being chased in flight, so we did not pursue the bird until it had landed. After the individual had landed, volunteers equipped with high-intensity spotlights and flashlights rushed to the site of landing, put a net over the bird, and captured it.

Once a bird was captured, a United States Geological Survey (USGS) aluminum band was placed around the right tarsus of each yellow rail and morphological measurements were taken. Body weight (g) was measured using a hand-held Pesola metric scale. Measurements of wing chord, culmen, tarsus, and rectrices were taken using an Avinet wing rule.

A 1.7 g transmitter (Advanced Telemetry Systems, Isanti, Minnesota) was attached to individuals that weighed $\geq$ 45 g. Transmitters never exceeded 3% of an individual's body weight. Two types of transmitter attachment methods were used: glue-on and harness. The glue-on technique consisted of cutting a small patch of feathers on the interscapular region between the wings, exposing the skin and feather remnants. The transmitter was then attached directly to the back of yellow rail with cyanoacrylate glue (Duro® Quick Gel®) or epoxy (Robert and Laporte 1999, Johnson et al. 1991). The transmitter was placed to one side of the backbone, increasing adhesive surface area between the skin and the transmitter, and held in place for approximately 2 minutes. This process required one person holding the bird, while the other cut the feathers and applied the transmitter. Any surrounding feathers that adhered to the transmitter were removed.

The harness technique used a modified Rappole and Tipton (1991) synsacrum attachment designed for soras (Haramis and Kearns 2000). Each transmitter was equipped with attachment tubes made of heat shrink tubing; one tube was epoxied horizontally across the front of the transmitter and the second across the rear of the transmitter. Light elastic thread was wrapped around the abdomen of the bird, cross-threaded through the front tubes of the transmitter, and knotted. Then the remaining two ends of ligature were wrapped around both legs and cross-threaded through the rear tubes and double knotted, and glued. A drop of glue was placed at the tip of the antenna to prevent interference from contact with brackish water. Handling time was < 15 min for most individuals. Individuals were released in the area of capture and monitored for approximately 5 min to make sure the transmitter did not interfere with normal movements.

The glue-on technique was unsuccessful in adhering to most individuals for more than a few days. Transmitters attached using the harness technique were more successful and remained on the birds for up to 4 weeks until they were recaptured and the harness was removed. They were then reweighed and assessed for signs of abrasions where the harness laid against their body. Most birds showed no signs of body wear other than minor chaffing around the abdomen and legs. One bird was able to get out of its harness, and one harness loop got tangled in the bird's band. The bird's leg was swollen and infected where the thread had twisted around it. We removed the harness and treated the infected area with antibiotic ointment and released the bird.

Home Range and Daily Movement

After a 24-hour adjustment period, individuals were located using a receiver (Advanced Telemetry Systems, Inc. Isanti, Minnesota, model R4000) and a hand-held 3-element Yagi antenna. Individuals were located using the homing method (White and Garrott 1990, Mech 1983) which often allowed location of an individual to within 1 m. Tracking periods were conducted during 1 of 3 diurnal time periods of greatest yellow rail activity (Bookhout and Stenzel 1987); morning (0600 – 1000 hours), midday (1001 - 1400 hours), and afternoon (1401 - 1800 hours). Geographical location of fixes were taken with a Magellan (San Dimas, California), model GPS 320, Global Positioning System (GPS) unit and saved as Universal Transverse Mercator (UTM) coordinates.

Home range size was calculated using the 95% fixed kernel method (Worton 1989) with THE HOME RANGER version 1.5 radio-tracking program (Ursus Software, Revelstoke, British Columbia, Canada) with least squares cross validation (LSCV, h=1) to determine smoothing parameters for yellow rails with $\geq$ 5 locations. For ease of comparison with other studies, home ranges were also calculated using a 100% minimum convex polygon (MCP) (Mohr 1947) using Hawth's tools extension (Beyer 2004) for ArcGIS 8 (ESRI, Redlands, California). Previous studies have established that fixed kernel estimators provide reliable results with less bias than with other methods in estimating home range (Seamann and Powell 1996, Swihart and Slade 1997). The fixed kernel method is considered more accurate than other methods in estimating the home range size because the area is calculated based on a utilization distribution and takes into consideration density of points (Seaman et al. 1999). Because of the better accuracy, fixed kernel estimates of home ranges were used for statistical analyses. Core areas, areas of more intense activity, were calculated using a 50% fixed kernel with LSCV (h=1).

The "distance between points tool" in the Hawth's tools extension for ArcGIS was used to calculate the distance moved in successive days. This tool created a distance matrix in which the distance between any two rail locations could be determined. From the distance matrix, the distance moved between consecutive days was extrapolated and averaged for each bird.

Habitat Use

Once a yellow rail location was determined, a 0.25-m^2 vegetation-sampling plot was established in the immediate vicinity. Habitat characteristics measured within the quadrat included plant-species height and cover, percent coverage of total vegetation, percent coverage of dead vegetation, depth of dead vegetation, and depth of standing water. The tallest individual of each plant species was measured to calculate species height. Percent coverage was assessed using cover classes. Cover classes were assigned a value of 1 to 7, with 1 = 0-1%, 2 = 1-5%, 3 = 5- 10%, 4 = 10-25%, 5 = 25-50%, 6 = 50-75%, 7 = 75 –100%. When quantifying habitat data, the coverage classes (1 – 7) were assessed by using the midpoint of the range of each class.

In addition, 0.25-m^2 vegetation-sampling plots were used throughout the study site to compare yellow rail habitat use. In the 2002-03 season, sampling plots were created by generating random pairs of UTM coordinates using ArcView (ESRI, Redlands, California). An analysis of variance (ANOVA) was used to determine how many random plots would be needed. The random sampling plots were measured until the variance began to level off. In the 2003-04 season, each yellow rail location was used as the plot center and 4 habitat samples were taken in 4 compass directions 50 m from the plot center. The latter method of vegetation sampling was used to insure temporal consistency between yellow rail locations and random vegetation plots, however it did not represent a statistically reliable system of randomness.

Yellow rail locations, home ranges, and core areas were entered into the GIS and overlaid onto habitat cover maps provided by USFWS. THE HOME RANGER created an output file of the UTM coordinates that made up the 95% fixed kernel home range and 50% fix kernel core area contours. The output file was evaluated using "convert locations to path" feature under the animal movements tool in the Hawth's tools extension. This tool "connected the dots" of the fixed kernel home range and core area creating a line feature layer from a point feature layer.

From the habitat cover maps in ArcGIS, cover types were classified into the following categories: (1) coastal prairie, (2) salty prairie, (3) fresh marsh, (4) lower salt marsh, (5) high salt marsh, (6) moist soil, (7) open water, (8) gulf beaches, (9) mud flats, (10) salt flats, (11) old field, (12) spoil area, (13) industrial area, (14) developed area, and (15) Gulf Coast Intracoastal Waterway. Yellow rail macrohabitat was identified by observing where yellow rail home ranges were located in relation to the habitat cover types identified on the cover maps.

Wintering Site Fidelity

During the winter of 2004 and March of 2005, increased banding efforts were made in areas where rails were banded the previous years. Recaptured birds were classified using a system developed by Robert and Laporte (1999) as "repeats" (same site, same year), "returns" (same site, different year), "displacements" (same year, different sites), or "recoveries" (different site, different year).

Effects of Prescribed Fire

Yellow rails fitted with radio transmitters were monitored before and after prescribed burns and relocated each day after the burn until the bird either vacated the area or lost its transmitter. A PLGR (Precision Lightweight GPS Receiver, Rockwell Collins Avionics, Cedar Rapids, IA.) was used to save the UTM coordinates of the burned area boundary by either walking or driving an ATV along the interface of the burned and non-burned area. The boundary was then transferred to GIS and overlaid onto the habitat cover map where rail locations could be analyzed before and after the prescribed fire. Distance moved because of the prescribed fire was calculated from the rail location taken during the morning before the burn and the location taken the day following the burn using the "distance between two points" tool on the Hawth's Toool Extension for ArcGIS. The distance from the initial location after the burn to the closest burned edge was also calculated using the distance function in ArcGIS. During a prescribed fire, rail behavior was observed and noted by walking the edge of the fire line.

Statistical Analysis

Animal movements are rarely, if ever, normally distributed, so a nonparametric Mann-Whitney U-test (PROC NPAR1WAY: SAS Institute 1990) was used to examine differences in home range size, core area size, and average distance moved per day per individual versus habitat cover type. A paired t-test was used to examine the difference in the two home range methods: 100% MCP and 95% fixed kernel.

Habitat variables were analyzed by a multivariate test using stepwise discriminant functions (SDF) (PROC STEPDISC: SAS Institute 1990). The SDF was used to determine which habitat variables discriminate between yellow rail locations and available sites. The change in the habitat sampling method from 2003 to 2004 did not allow combination and comparison between the two years. Also, the habitats in 2004 were different between study sites, so each cover type (salty prairie and high salt marsh) was analyzed separately. A Mann-Whitney-U test (MWU) was use to compare plant-species differences between yellow rail locations and available plots. Because multiple Mann-Whitney U-tests were used on the same data set, the Bonferroni correction adjusted the significance level to $\alpha = 0.004$ for all plant-species comparisons.

RESULTS

Home range and daily movement

Eighteen yellow rails were radio marked during 2003 (n=10) and 2004 (n=8). During 2003, yellow rails were tracked at the Salt Lake study site between 13 February and 23 April. During 2004, yellow rails were tracked at the Salt Lake (n=2), Hunt Road (n=2), McNeil (n=1), and Road Pasture (n=3) sites between 26 January and 27 April. However, most locations in 2004 were determined in April just prior to migration. The average number of locations per individual was 15.6 ± 6.7 (range = 5 – 24, n = 18) for both years.

Home range estimates differed slightly, but not significantly, between the 95% fixed kernel method and the 100% MCP method (paired t-test, t = -1.88, P >

0.08). The minimum convex polygons were smaller because most locations within the home range tended to be in one clump (Figure 5). For individuals that moved considerable distances between locations or had multiple core areas, the minimum convex polygons were much larger because it included areas that were not used (Figure 6). This is why the kernel method is preferred over the MCP method in estimating home range size, and from this point on, the 95% kernel is used as the default home range method.

Home ranges varied considerably from 0.07 to 3.86 ha, but averaged 1.20 ha ± 0.92 (Table 1). The average size of core areas within the home range was 0.29 ha ± 0.21 (Table 1). Core areas represented, on average, 25% of the total home range size. Most individuals had very distinct core areas (cluster of points), but 4 individuals had multiple core areas. As the area of the home range increased, the core area also increased (Figure 7).

Home range overlap was very common in all study sites where home ranges of various individuals were in close proximity (Figures 8, 9); however, core areas seldom overlapped. Two birds within the same tracking period (6 March – 31 March 2003) had home ranges and core areas that overlapped completely.

The mean distance moved per individual in consecutive days was 36.7 m ± 33.6, and ranged from 1 to 320 m (Table 2). The mean longest and shortest distance moved per individual in consecutive days was 89.0 ± 66.8 m and 7.4 ± 4.8 m (Table 2), respectively. One individual moved 580 m in a two-day period, which was considerably longer than any other individual in the study.

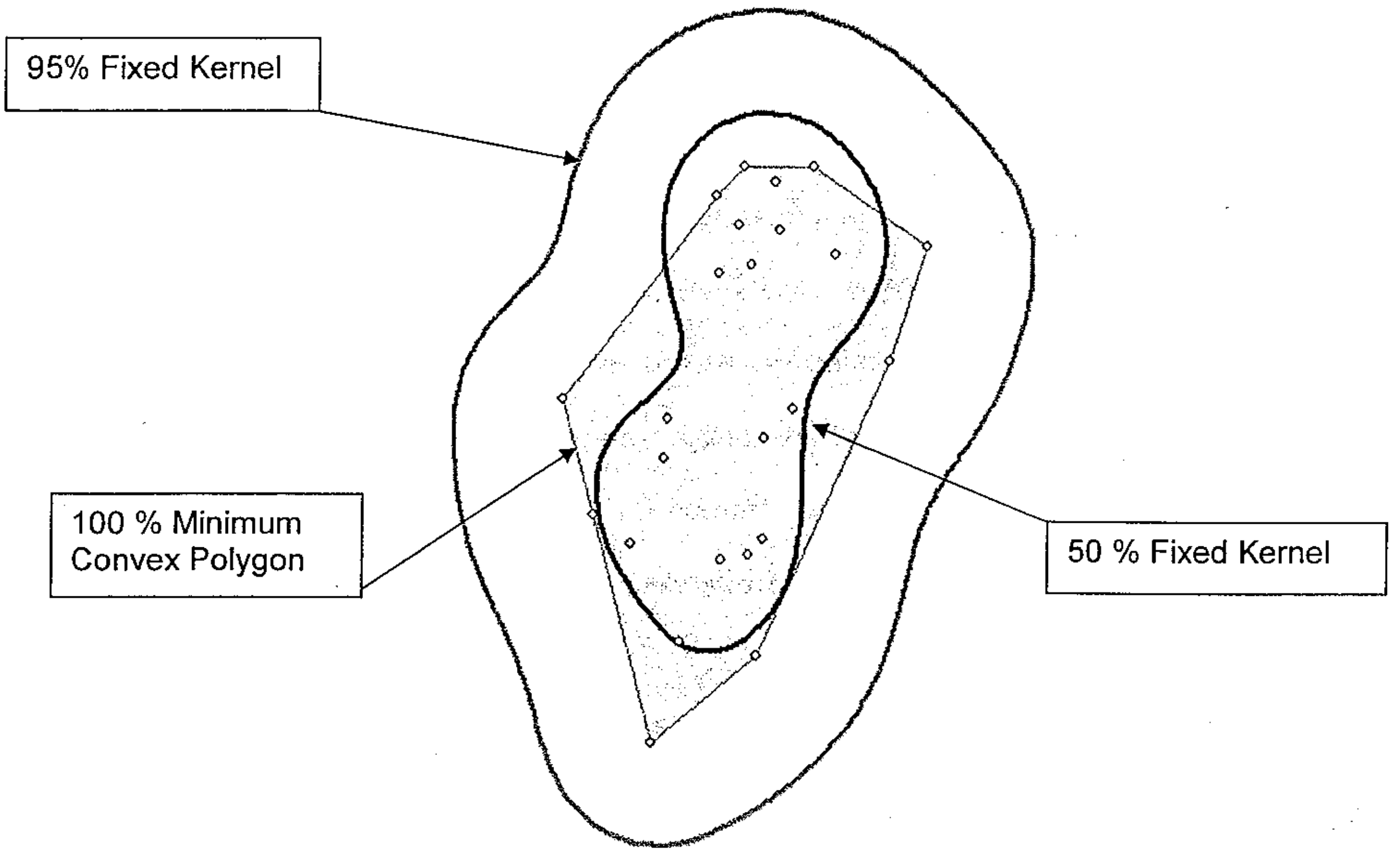

FIGURE 5. Underestimation of the minimum convex polygon (MCP) method in determining animal home ranges when locations (dots) are “clumped”.

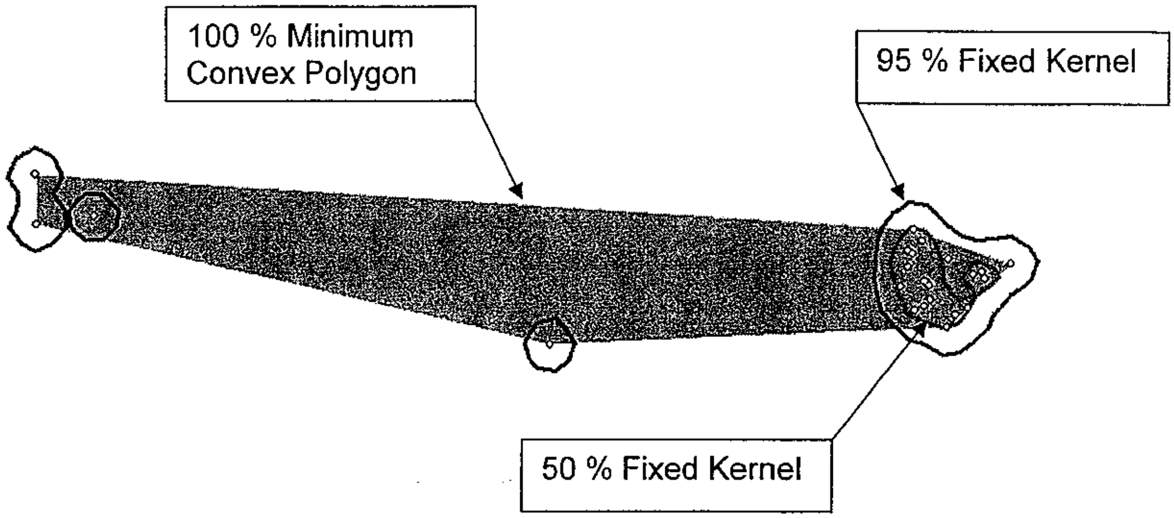

FIGURE 6. Overestimation of the minimum convex polygon (MCP) method in determining home ranges when the animal moved large distances or multiple core areas exist.

Table 1. Average home range and core area of 18 yellow rails wintering at the Texas Mid-Coast National Wildlife Refuge Complex during 2003 and 2004.

	Home range size		Core area size
Year	95% FK[a]	100% MCP[b]	50% FK[c]
2003			
Mean ± SD	0.98 ± 0.71	0.36 ± 0.32	0.25 ± 0.17
Range (min. – max.)	0.07 – 2.76	0.04 – 1.01	0.02 – 0.67
2004			
Mean ± SD	1.47 ± 1.12	1.03 ± 1.51	0.35 ± 0.25
Range (min. – max.)	0.46 – 3.86	0.06 – 4.48	0.11 – 0.82
Both years			
Mean ± SD	1.20 ± 0.92	0.65 ± 1.05	0.29 ± 0.21
Range (min. – max.)	0.07 – 3.86	0.04 – 4.48	0.02 – 0.82

[a] 95% Fixed Kernel method using THE HOMERANGER.

[b] 100% Minimum Convex Polygon method using Hawth's Tool Extension for ArcGIS 8.

[c] 50% Fixed Kernel method using THE HOMERANGER.

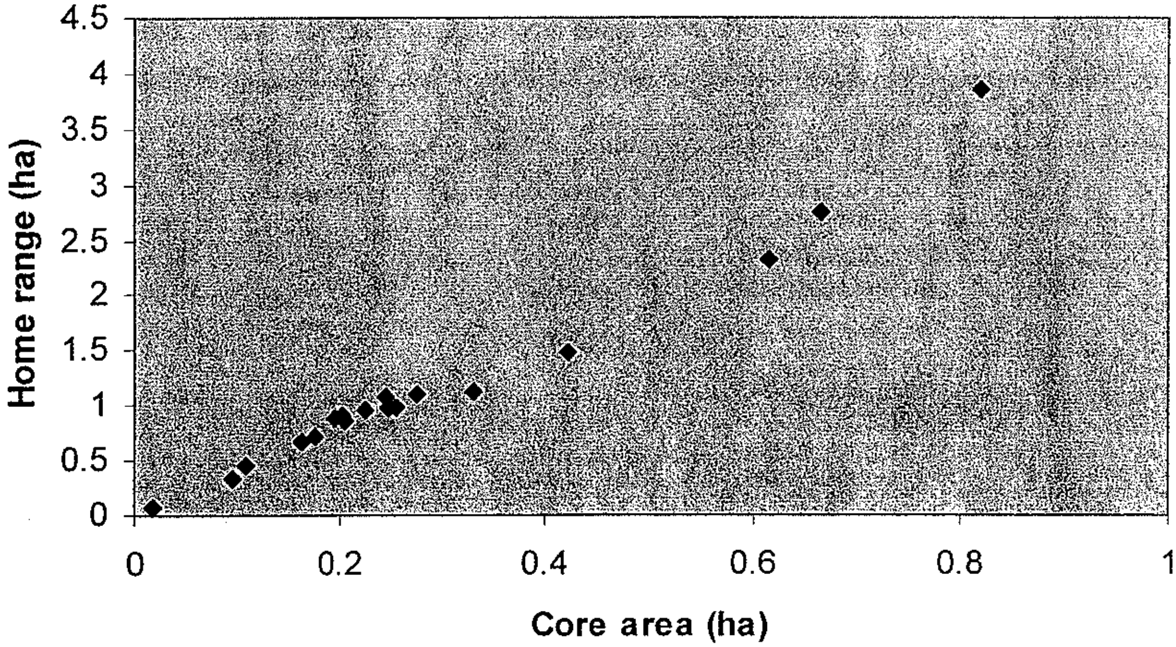

Figure 7. Home range size in relation to the core area for each yellow rail (n=18) at Texas Mid-Coast National Wildlife Refuge Complex in 2003 and 2004.

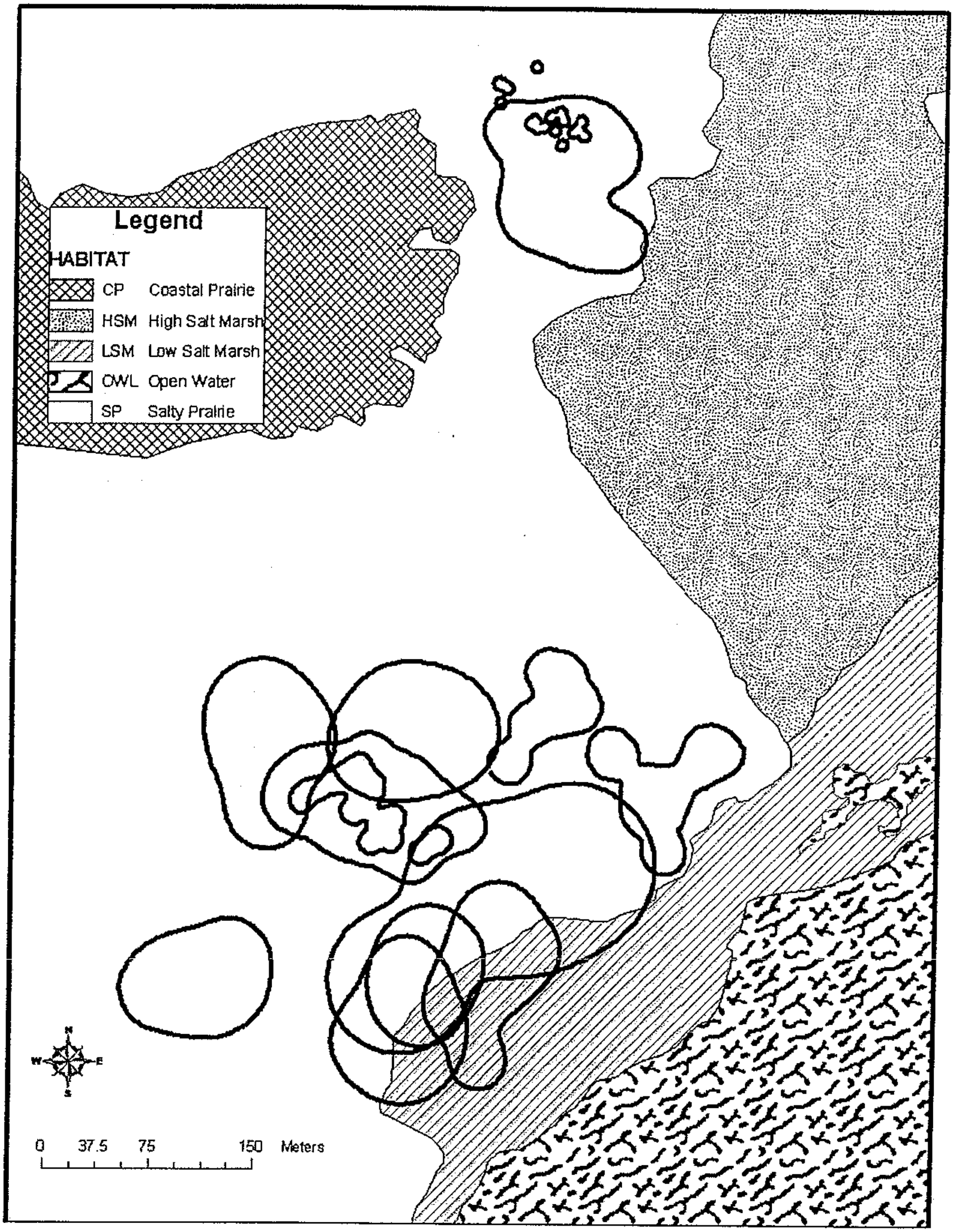

Figure 8. Home range overlap and macrohabitat use of yellow rails wintering at the Salt Lake site in Brazoria National Wildlife Refuge during 2003.

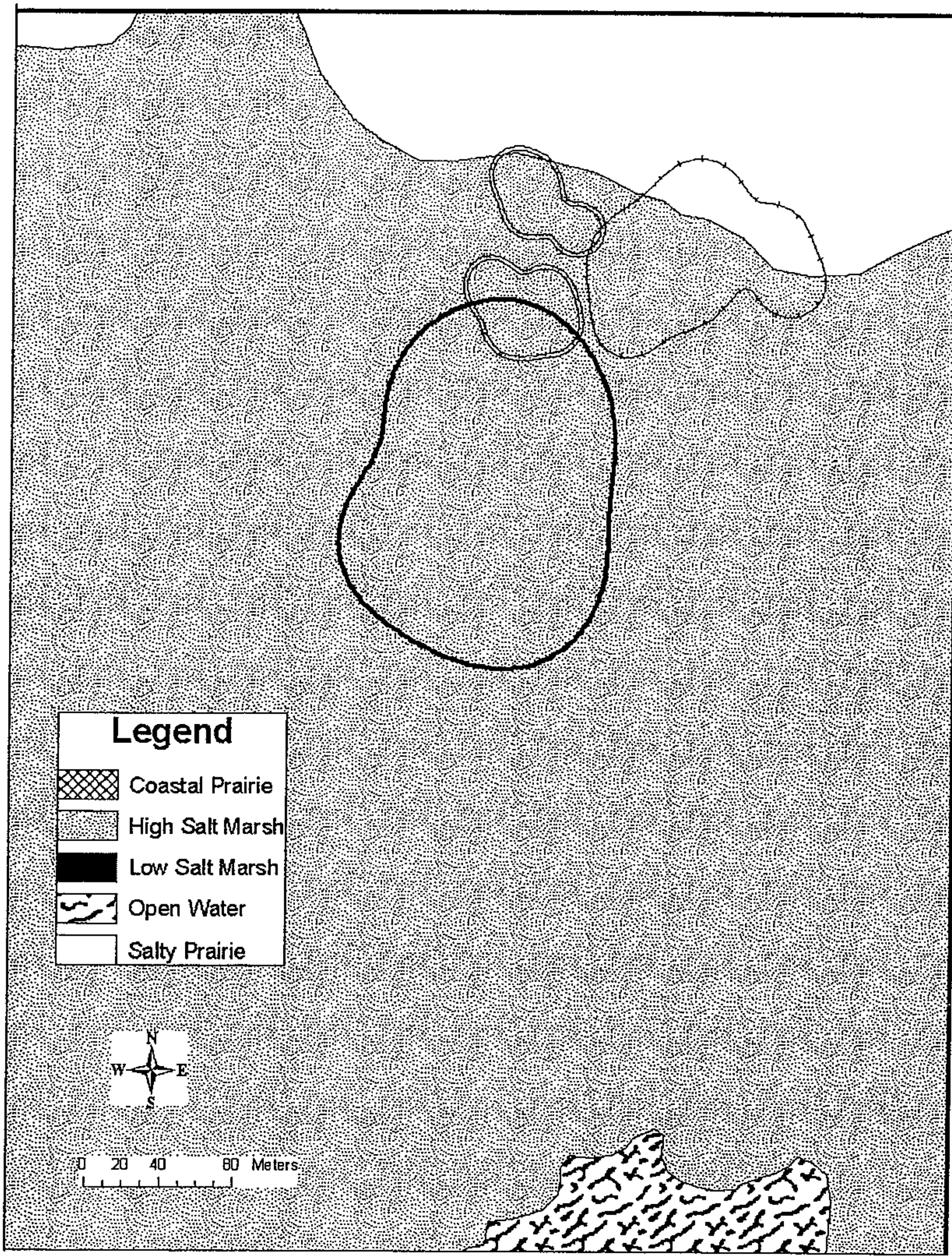

Figure 9. Home range overlap and macrohabitat use of yellow rails wintering at the Road Pasture site in Brazoria National Wildlife Refuge during 2004.

Table 2. Movements of yellow rails wintering at the Texas Mid-Coast National Wildlife Refuge Complex during 2003 and 2004.

Year	Distance moved in consecutive days (m)		
	Daily	Longest	Shortest
2003			
Mean ± SD	32.5 ± 22.4	65.9 ± 27.2	7.7 ± 5.4
Range (min. – max.)	1 – 107.6	21.0 – 107.6	1 – 16.1
2004			
Mean ± SD	41.6 ± 42.3	118.0 ± 90.3	6.9 ± 4.3
Range (min. – max.)	1.4 – 320.3	50.1 – 320.3	1.4 – 12.8
Both years			
Mean ± SD	36.7 ± 33.6	89.0 ± 66.8	7.4 ± 4.8

Habitat Use

GIS revealed that yellow rails use salty prairie, high salt marsh, low salt marsh, and coastal prairie cover types, although salty prairie and high salt marsh were used much more frequently (Figure 8,9,10,11). Very few yellow rail locations were observed in low salt marsh or coastal prairie, but the FK home range estimation included these covers types when transferred to habitat cover maps. At the Salt Lake site in 2003, yellow rails used the salty prairie cover type (mixed with some high salt marsh characteristics) dominated by *Spartina spartinae*, *Distichlis spicata*, and *Salicornia* sp., while in 2004 yellow rails were found using sites dominated by *Distichlis spicata, Paspalum vaginatum*, *Scirpus* sp., and *Spartina spartinae* associated with high salt marsh habitat cover type as well as salty prairie. Yellow rails probably did not switch their preference for a certain habitat cover type between years. The original study site was disturbed by prescribed fire and no longer available for yellow rails, so different sites were sampled in 2004.

Structural and plant-species habitat characteristics were measured at 271 locations taken on 17 yellow rails during 2003 (n=150) and 2004 (n=121). Structural habitat variables were averaged for 2003 and 2004, and combined for a total of both years (Table 3). Average water depth occurring at yellow rail locations was 1.3 cm ± 2.4. Mean dead vegetation depth was 1.2 cm ± 1.8, while dead vegetation % coverage averaged 50.4 % ± 39.4. Mean total vegetation height was 54.3 cm ± 21.2, and total vegetation % coverage averaged 83.2 ± 14.2.

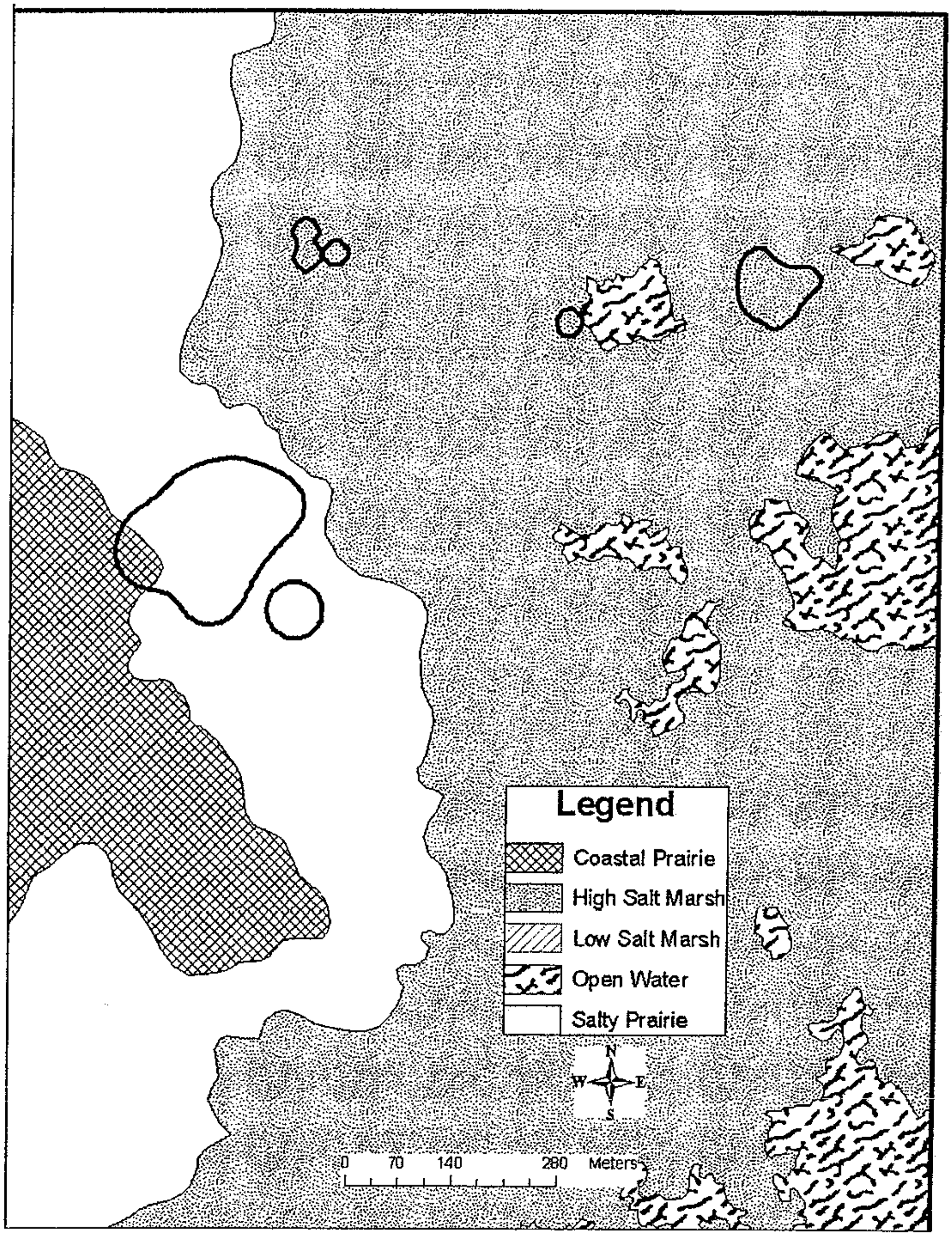

Figure 10. Macrohabitat use of yellow rails at the Hunt Road study site at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2004.

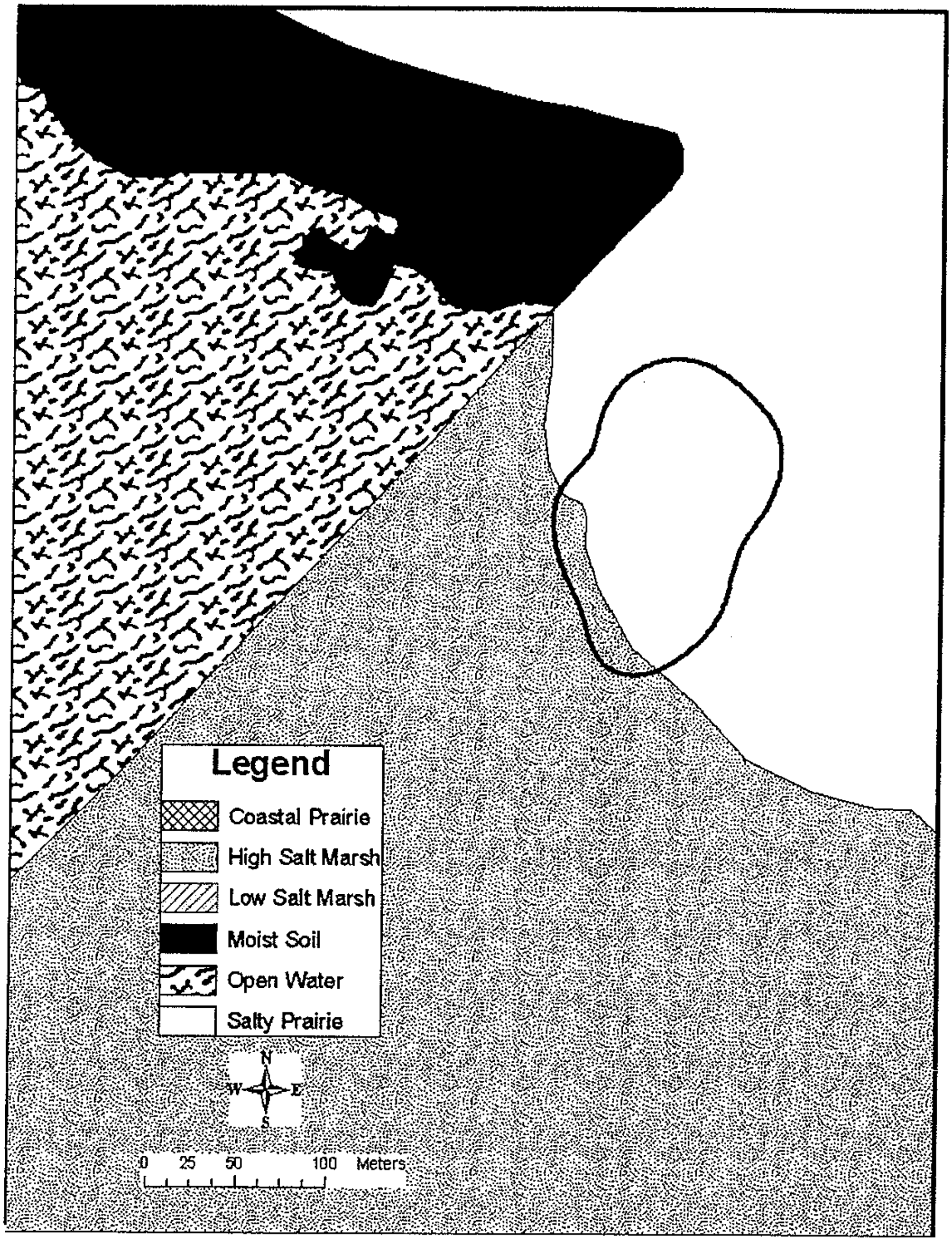

Figure 11. Macrohabitat use of yellow rails at the McNeil study site at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2004.

Table 3. Average habitat structural characteristics associated with 271 yellow rail radio-telemetry location on Texas Mid-Coast National Wildlife Refuge Complex during the winters of 2003 (n=150) and 2004 (n=121).

Habitat variables	2003	2004		Both years
		Salty Prairie	High Salt Marsh	
Total plant coverage (%)	79.8 ± 18.4	87.5 ± 0	87.5 ± 0	83.2 ± 14.2
Total plant height (cm)	46.4 ± 17.1	67.8 ± 12.0	68.2 ± 22.4	54.3 ± 21.2
Dead vegetation coverage (%)	41.2 ± 41.6	32.4 ± 29.1	79.6 ± 20.8	50.4 ± 39.4
Dead vegetation depth (cm)	1.0 ± 1.3	0.3 ± 0.1	2.4 ± 2.5	1.2 ± 1.8
Water depth (cm)	1.0 ± 1.5	0.1 ± 0.5	2.7 ± 3.7	1.3 ± 2.4

In 2003, yellow rails at the Salt Lake study site selected sites that had lower water depths (SDF, $F = 5.28$, $P < 0.0225$), higher dead vegetation depths (SDF, $F = 5.40$, $P < 0.0210$), and higher dead vegetation coverage (SDF, $F = 8.73$, $P < 0.0034$) (Table 4; Figures 12, 13, 14). Alternatively, in 2004, yellow rails did not select sites based on habitat structure in salty prairie, but did choose higher total vegetation % coverage in high salt marsh (SDF, $F = 4.48$, $P < 0.0350$) (Table 5; Figure 15). The habitat sampling method in 2004 was poor to explain variation in the data throughout the entire study site, and was probably responsible for the lack of significance in structural habitat characteristics in 2004.

Analysis of plant-species occurring in yellow rail habitat in 2003 revealed the species with the highest % frequency was *Distichlis spicata* (f = 72.0) (Table 6). In 2004, *Spartina spartinae* occurred most frequently in the salty prairie cover type (f = 97.8), while *Distichlis spicata* was the most frequently occurring plant-species in the high salt marsh cover type (f = 89.3) (Table 7). *Distichlis spicata*, *Batis maritime*, and *Salicornia* sp. were all present in much higher frequency in yellow rail locations than in the available plots in 2003 (Figure 16). In 2004, *Spartina patens* occurred more frequently in yellow rail locations than in the available plots in the high salt marsh cover type, while no plant-species occurred in greater % frequency in yellow rail location compared to the available plots in the salty prairie cover type (Figure 17, 18).

Spartina spartinae had the highest % coverage in 2003 ($\xi = 59.0\ \% \pm 33.8$) and in the salty prairie cover type in 2004 ($\xi = 86.9 \pm 3.7$), while the plant-species that had the highest % coverage in the high salt marsh cover type in

Table 4. Habitat use by yellow rails at the Salt Lake study site at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2003.

Habitat Variables	Yellow rail	Available	Stepwise Discriminant Function		
	$\xi \pm SD$	$\xi \pm SD$	R-square	F	P
SALT LAKE (2003)					
Water depth (cm)	1.0 ± 1.5	1.6 ± 2.0	0.0225	5.28	0.0225*
Dead vegetation depth (cm)	1.0 ± 1.3	0.6 ± 1.0	0.0230	5.40	0.0210*
Dead vegetation coverage (%)	41.2 ± 41.6	24.9 ± 37.0	0.0367	8.73	0.0034*
Total vegetation coverage (%)	79.8 ± 18.4	76.4 ± 23.0	0.0067	1.55	0.2145

* denotes significance (∀ = 0.05)

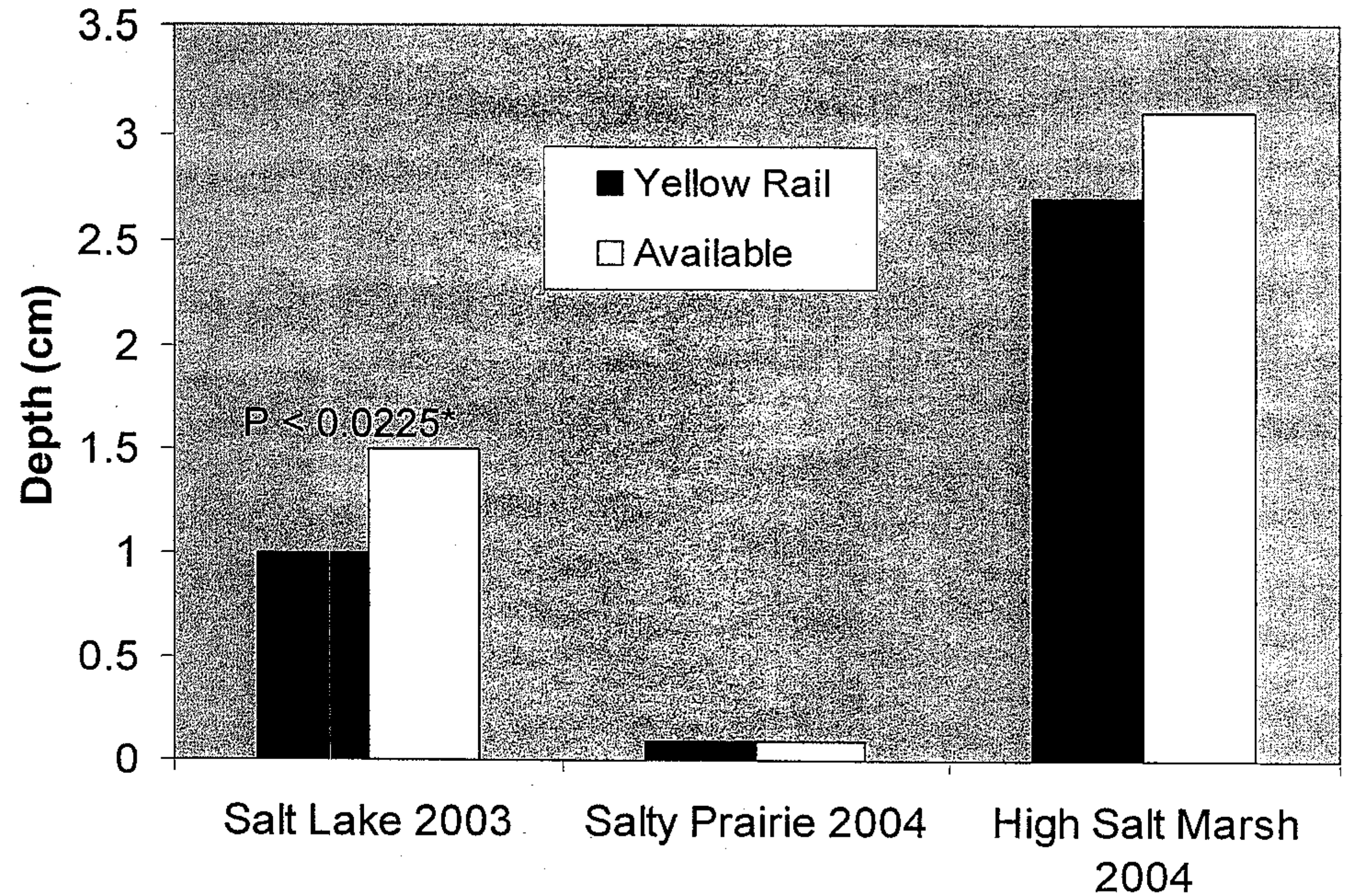

Figure 12. Average water depth (cm) between yellow rail locations and available plots at the Texas Mid-Coast National Wildlife Refuge Complex during the winters of 2003 and 2004. The * denotes significance at $\alpha = 0.05$ (Stepwise Discriminant Function).

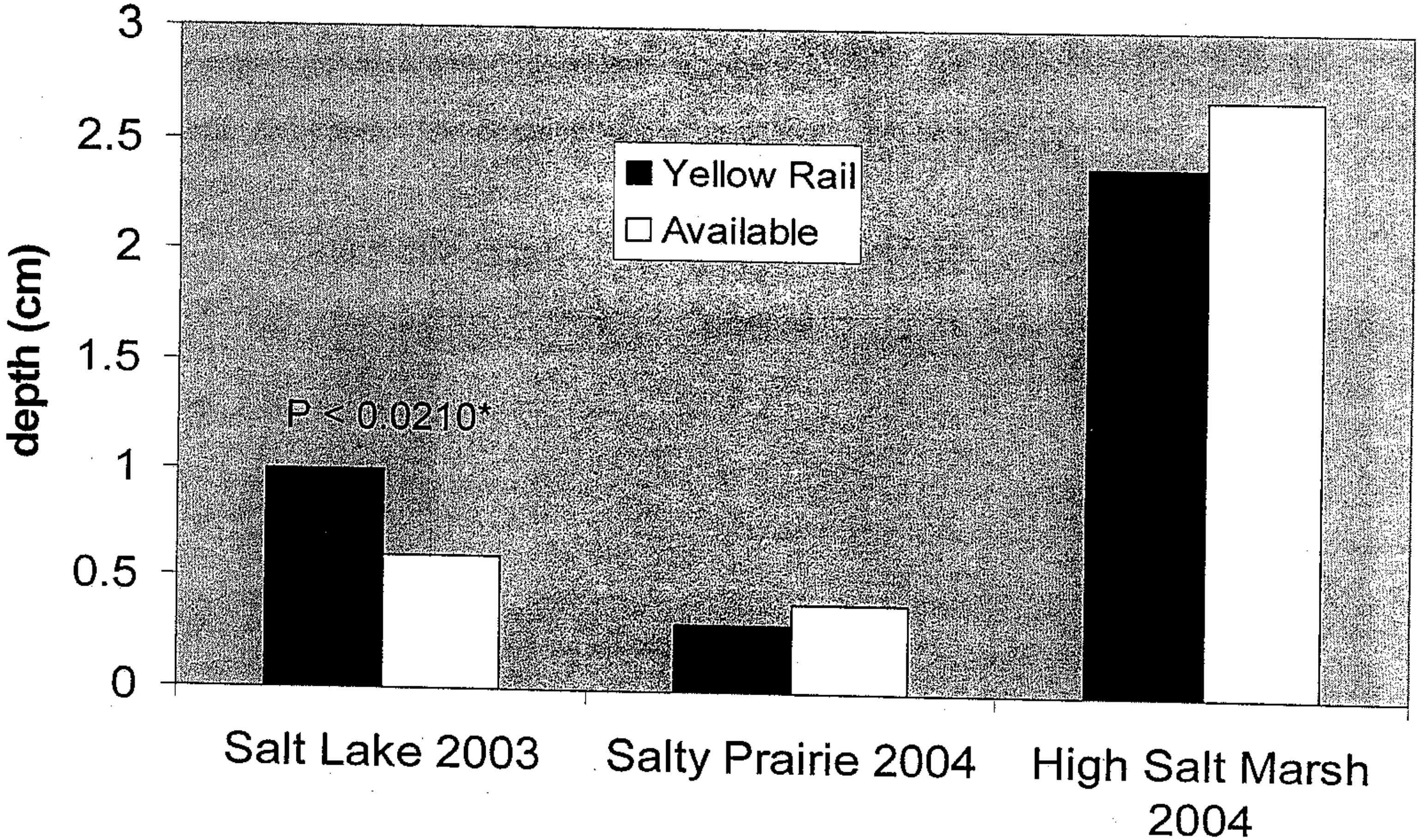

Figure 13. Average dead vegetation depth (cm) between yellow rail locations and available plots at the Texas Mid-Coast National Wildlife Refuge Complex during the winters of 2003 and 2004. The * denotes significance at $\alpha = 0.05$ (Stepwise Discriminant Function).

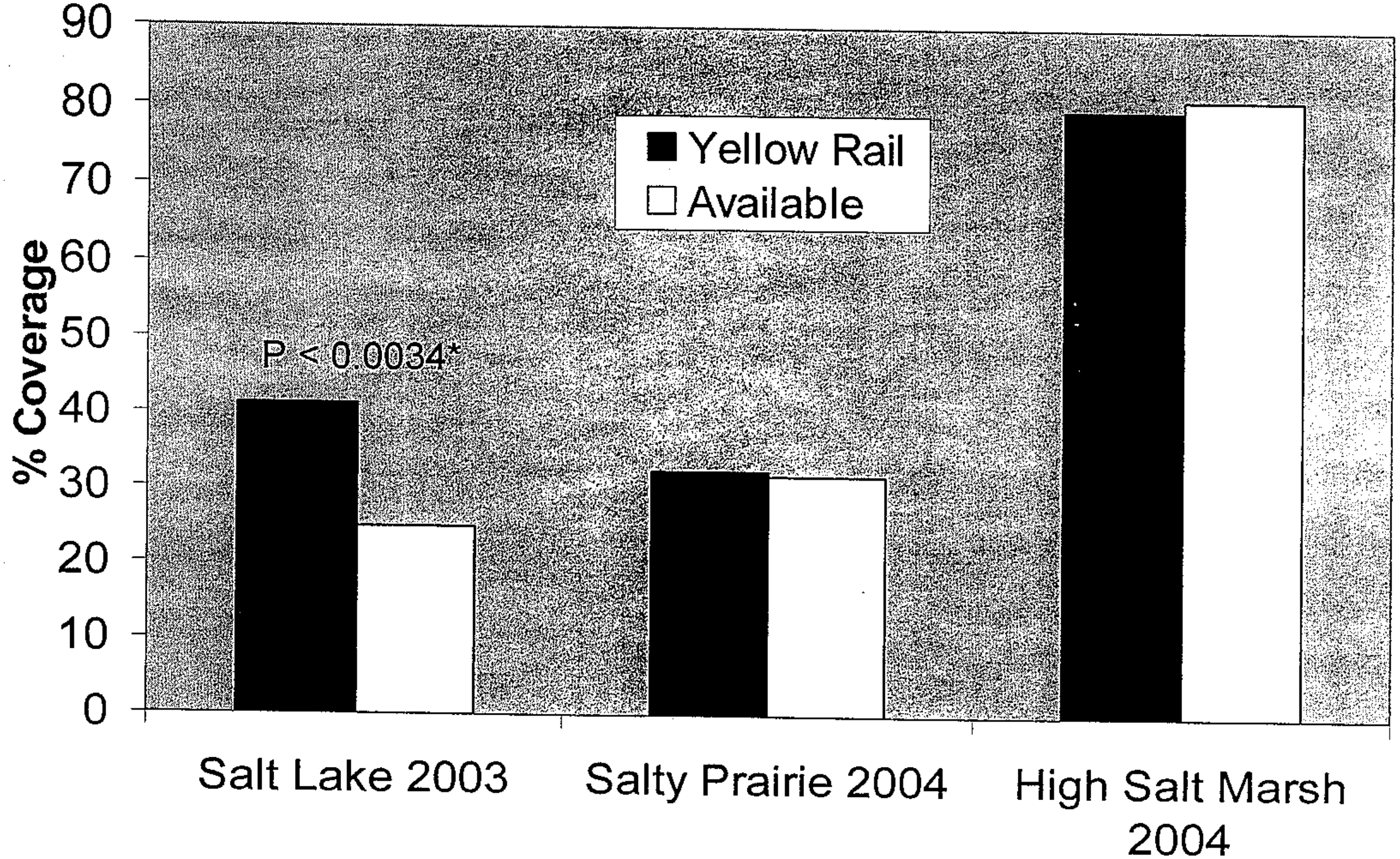

Figure 14. Average dead vegetation % coverage between yellow rail locations and available plots at the Texas Mid-Coast National Wildlife Refuge Complex during the winters of 2003 and 2004. The * denotes significance at $\alpha = 0.05$ (Stepwise Discriminant Function).

Table 5. Habitat use of yellow rails in salty prairie and high salt marsh cover types at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2004.

Habitat variables	Yellow Rail	Available	Stepwise Discriminant Function		
	ξ ± SD	ξ ± SD	R-square	F	P
SALTY PRAIRIE (2004)					
Water depth (cm)	0.1 ± 0.5	0.1 ± 0.5	0.0008	0.16	0.6883
Dead vegetation depth (cm)	0.3 ± 0.1	0.4 ± 0.5	0.0067	1.29	0.2566
Dead vegetation coverage (%)	32.4 ± 29.1	31.6 ± 31.8	0.0001	0.02	0.8830
Total vegetation coverage (%)	87.5 ± 0.0	87.0 ± 3.5	0.0049	0.94	0.3330
HIGH SALT MARSH (2004)					
Water depth (cm)	2.7 ± 3.7	3.1 ± 3.8	0.0023	0.70	0.4037
Dead vegetation depth (cm)	2.4 ± 2.5	2.7 ± 2.6	0.0027	0.82	0.3663
Dead vegetation coverage (%)	79.6 ± 20.8	80.8 ± 19.9	0.0006	0.18	0.6698
Total vegetation coverage (%)	87.5 ± 0.0	84.8 ± 11.0	0.0148	4.48	0.0350*

* denotes significance (∀ = 0.05)

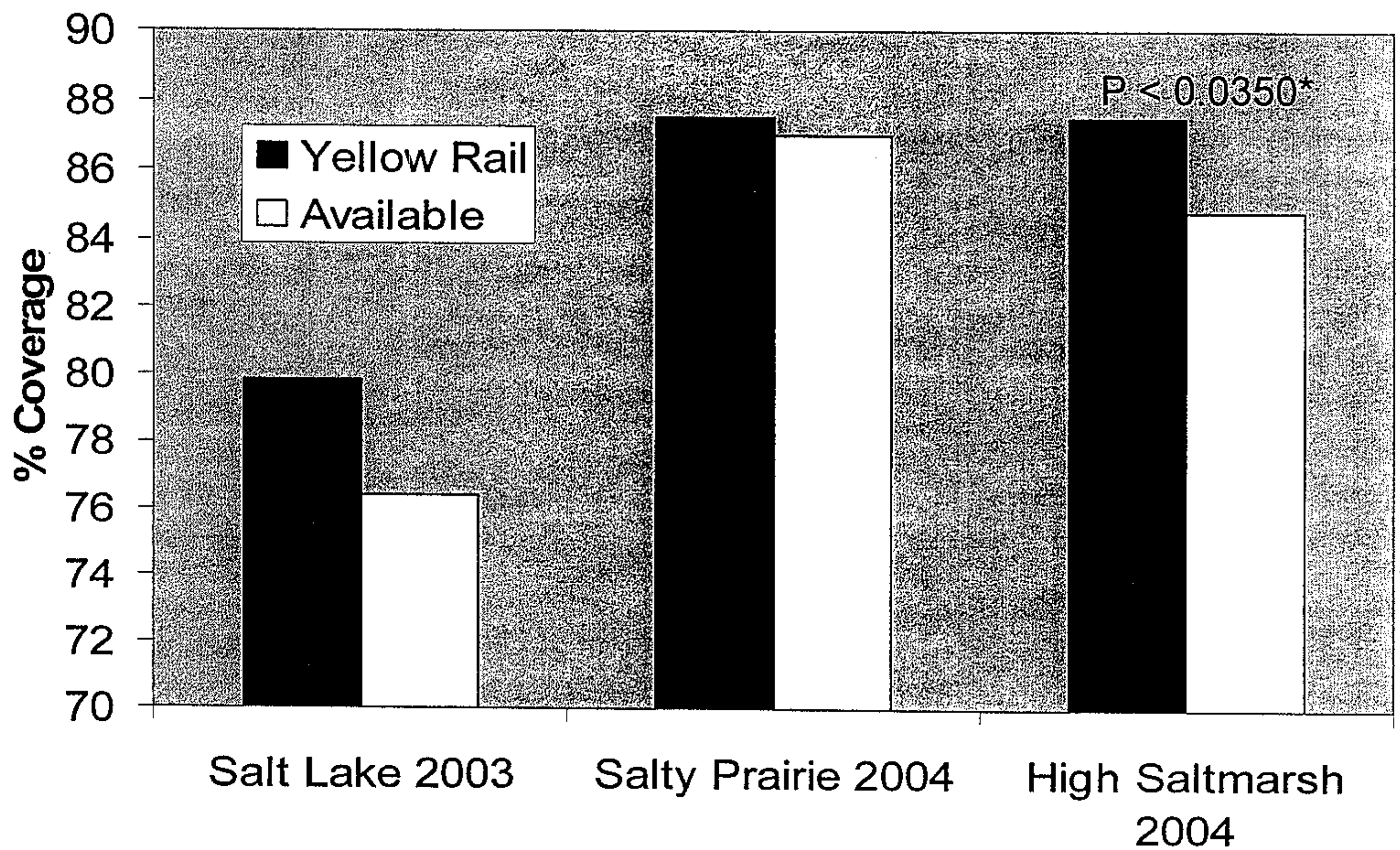

Figure 15. Average total vegetation % coverage between yellow rail locations and available plots at the Texas Mid-Coast National Wildlife Refuge Complex during the winters of 2003 and 2004. The * denotes significance at $\alpha = 0.05$ (Stepwise Discriminant Function)

Table 6. Plant-species % frequency associated with yellow rail locations and available plots at the Salt Lake study site at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2003, where % frequency = (# of plots species occur)/ *n*(# of total plot sampled) x 100.

Plant Species	% Frequency	
	Yellow rail	Available
Distichlis spicata	72.0	25.9
Spartina spartinae	69.3	70.3
Batis maritima	69.3	28.4
Salicornia spp.	67.3	33.3
Spartina patens	18.0	22.2
Borrichia frutescens	6.0	17.3
Scirpus robustus	1.3	-
Spartina alterniflora	0.7	-
Baccharis halimifolia	-	6.2
Monanthochloe littoralis	-	1.2
Briar sp.	-	1.2

Table 7. Plant-species % frequency associated with yellow rail locations and available plots for salty prairie and high salt marsh cover types at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2004, where % frequency = (# of plots species occur)/ *n*(# of total plot sampled) x 100.

Plant-species	% Frequency			
	Salty Prairie		High Salt Marsh	
	Yellow rail	Available	Yellow rail	Available
Spartina spartinae	97.8	93.2	6.7	10.1
Distichlis spicata	10.9	16.2	89.3	91.7
Spartina patens	2.2	5.4	66.7	39.5
Paspalum vaginatum	2.2	3.4	58.7	71.9
Scirpus americanus	-	-	33.3	15.8
Scirpus robustus	-	-	9.3	13.6
Batis maritima	-	-	6.7	7.9
Borrichia frutescens	2.2	4.7	-	3.5
Eleocharis sp.	-	6.1	-	-
Typha sp.	-	3.4	-	-
Juncus roemerianus	-	0.6	-	-
Lycium carolianianum	-	2.0	-	-
Aster subulatus	-	2.7	-	-
Baccharis halimifolia	-	0.6	-	-
Sesbania sp.	-	0.6	-	-
Ragweed	-	4.7	-	-
Unknown	2.2	8.8	-	-

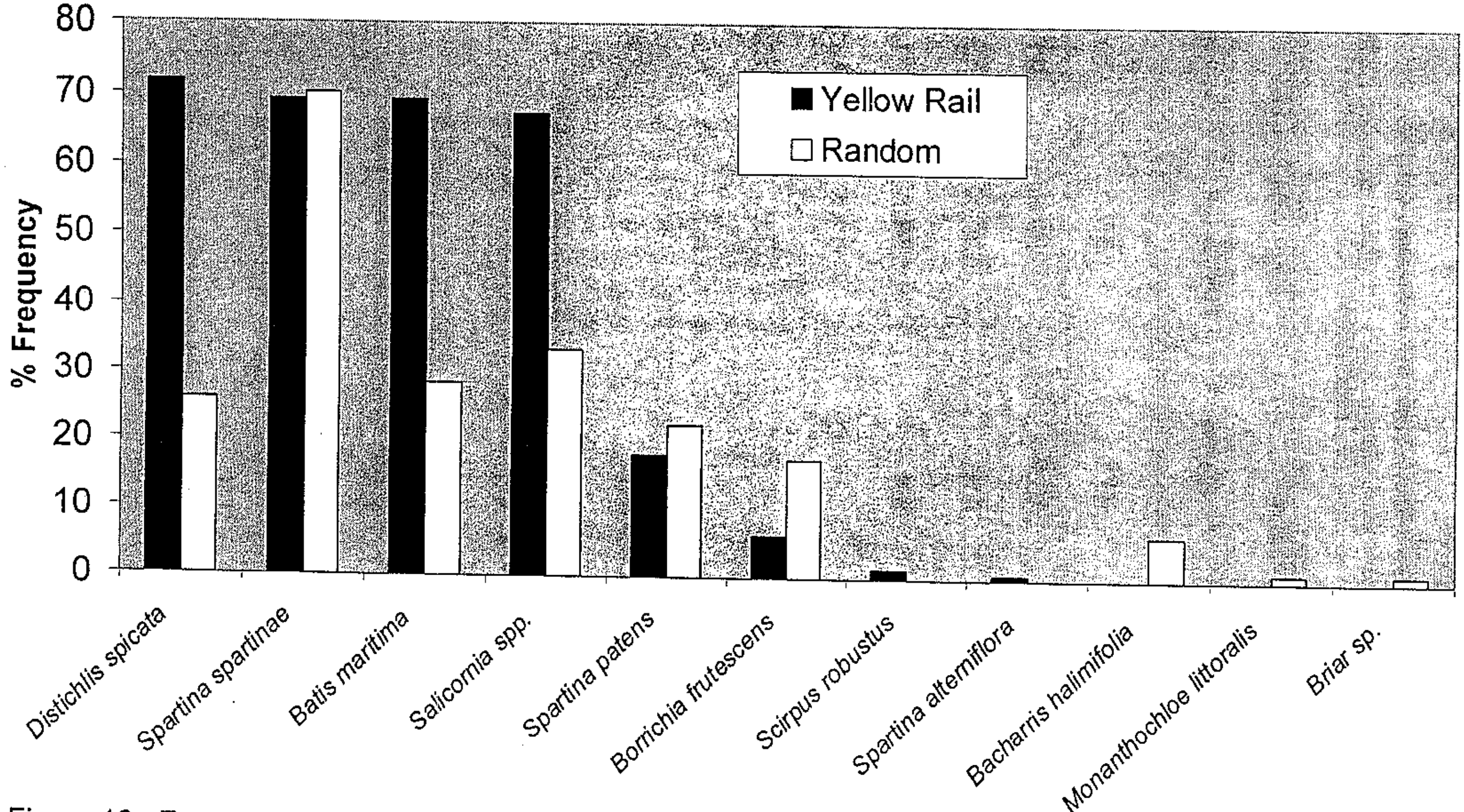

Figure 16. Frequency (%) of plant-species occurring at yellow rail locations and available plots at the Salt Lake study site at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2003.

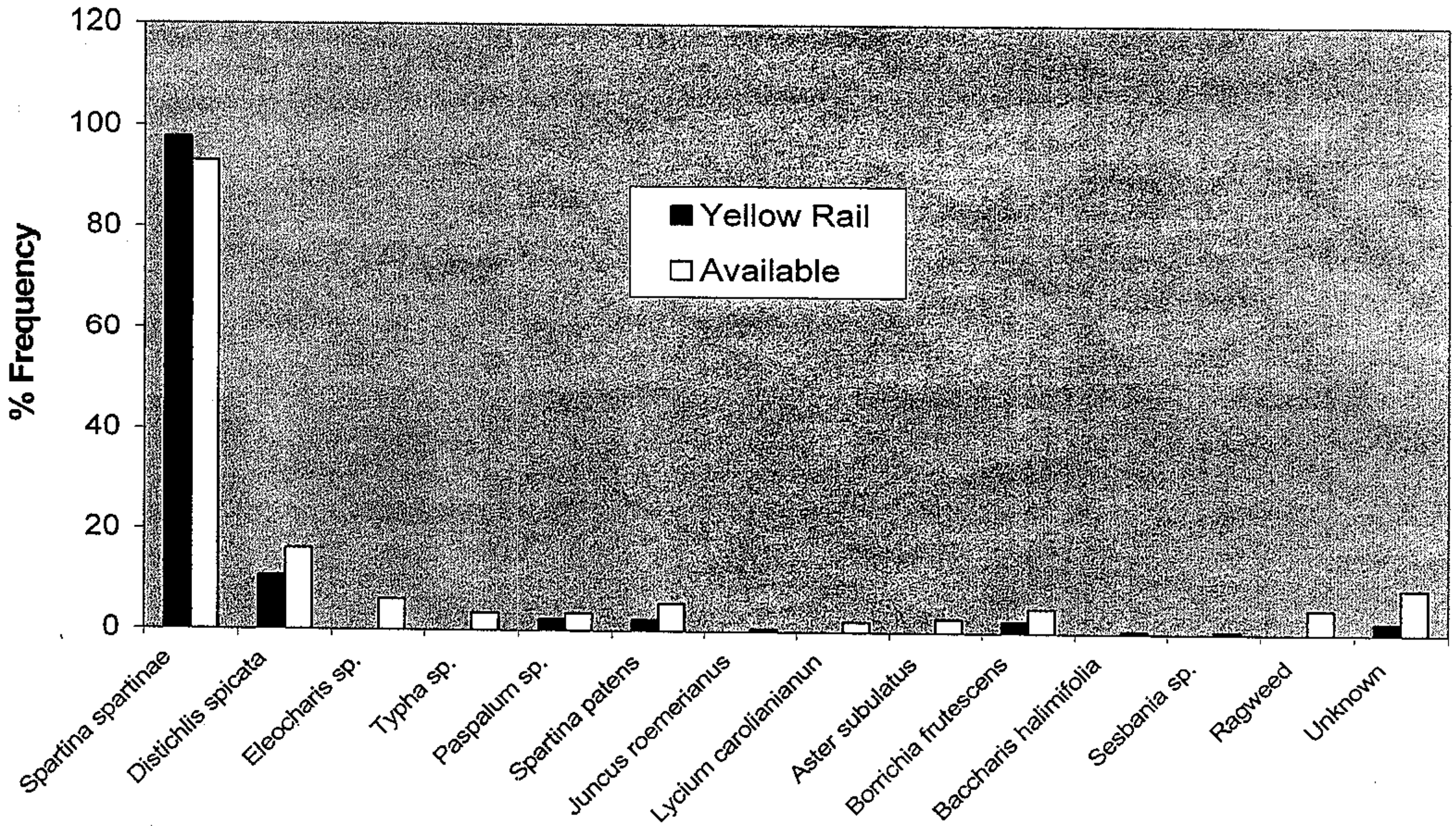

Figure 17. Frequency (%) of plant-species occurring at yellow rail locations and available plots in the salty prairie cover type at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2004.

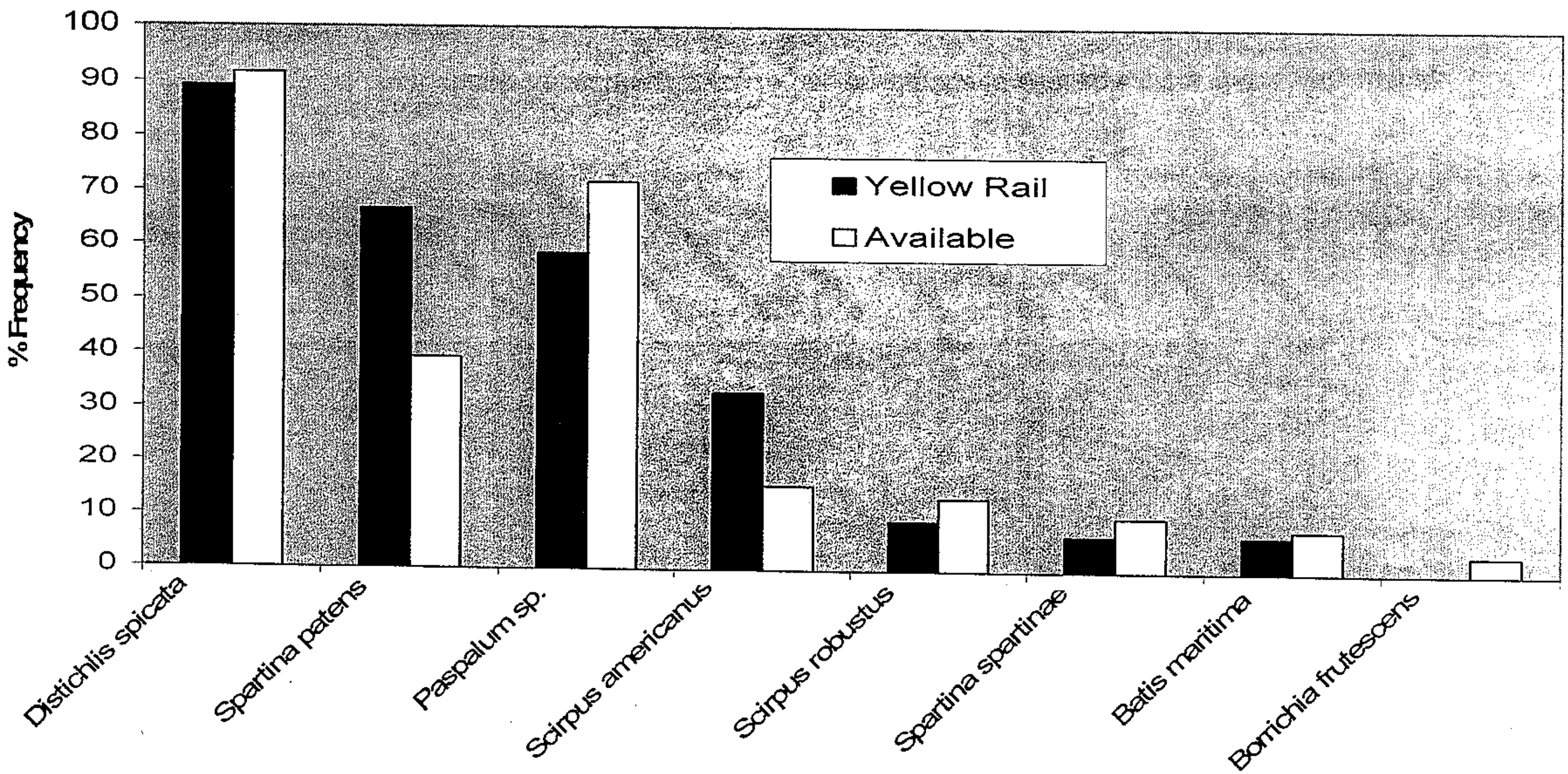

Figure 18. Frequency (%) of plant-species occurring at yellow rail locations and available plots in the high salt marsh cover type at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2004.

2004 was *Paspalum vaginatum* (ξ = 74.4 % ± 20.6) (Tables 8, 9). There were no significant differences between % coverage of any plant-species occurring at yellow rails locations compared to sites available to them.

Scirpus robustus was the tallest plant species in 2003 (ξ = 95.8 cm ± 4.9) and in the high salt marsh cover type in 2004 (ξ = 113.9 ± 28.0), where *Spartina spartinae* was the tallest (ξ = 69.7 cm ± 11.0) in the salty prairie cover type in 2004 (Tables 10,11). *Spartina patens* was used by yellow rails at shorter heights (MWU; $Z = 3.3595$, $P < 0.0005$) than what was available to them in 2003. No other plant-species height differences were identified between yellow rail and available sites in either the salty prairie or the high salt marsh cover type in 2004.

Wintering Site Fidelity

Banding efforts and radio telemetry have revealed that some rails exhibit wintering site fidelity (Table 12). From 110 yellow rails banded, 15 were recaptured within the same year and at the same site. The mean interval between date banded and date captured was 27.0 ± 12.5 d, but 1 yellow rail was recaptured 70 days later. Two black rails were recaptured within the same year and at the same site, although only 5 days separated the banding and recapturing date. Remarkably, a Virginia rail was recaptured the following year at the same site, despite only 6 Virginia rails being banded throughout the entire study.

Table 8. Plant-species % coverage using the midpoints of the cover class associated with yellow rail locations and available plots at the Salt Lake study site at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2003, where 1=0 – 1%, 2=1 – 5%, 3=5 – 10%, 4=10 – 25%, 5=25 – 50%, 6=50-75%, 7=75-100% represent each cover class.

Plant species	Coverage (%) ± SD	
	Yellow rail	Available
Spartina spartinae	59.0 ± 33.8	69.3 ± 29.6
Spartina patens	30.8 ± 34.9	60.5 ± 37.6
Distichlis spicata	26.3 ± 30.3	22.3 ± 32.2
Borrichia frutescens	19.7 ± 26.9	5.2 ± 9.7
Spartina altemiflora	17.5 ± 0	-
Salicornia spp.	17.3 ± 25.3	10.3 ± 16.9
Scirpus robustus	12.5 ± 7.1	-
Batis maritima	5.1 ± 11.9	3.2 ± 8.5
Baccharis halimifolia	-	2.9 ± 3.3
Monanthochloe littoralis	-	3.0 ± 0.0
Briar sp.	-	0.5 ± 0.0

Table 9. Plant-species % coverage associated with yellow rail locations and available plots for salty prairie and high salt marsh cover types at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2004, where % frequency = (# of plots species occur)/ *n*(# of total plot sampled) x 100.

Plant-species	Coverage (%) ± SD			
	Salty Prairie		High Salt Marsh	
	Yellow rail	Available	Yellow rail	Available
Spartina spartinae	86.9 ± 3.7	85.0 ± 9.9	54.6 ± 45.1	68.0 ± 26.1
Distichlis spicata	50.5 ± 40.6	41.6 ± 37.5	60.8 ± 26.5	55.0 ± 30.0
Spartina patens	87.5 ± 0.0	63.8 ± 37.8	65.6 ± 26.9	60.7 ± 32.0
Paspalum vaginatum	7.5 ± 0.0	63.5 ± 28.6	74.4 ± 20.6	65.3 ± 30.2
Scirpus americanus	-	-	19.2 ± 20.9	26.4 ± 27.1
Scirpus robustus	-	-	16.7 ± 31.8	26.2 ± 24.7
Batis maritima	-	-	5.7 ± 2.5	10.1 ± 17.4
Borrichia frutescens	62.5 ± 0.0	32.7 ± 36.7	-	17.4 ± 29.2
Eleocharis sp.	-	27.9 ± 29.5	-	-
Typha sp.	-	3.4 ± 2.5	-	-
Juncus roemerianus	-	7.5 ± 0.0	-	-
Lycium carolianianum	-	2.8 ± 4.0	-	-
Aster subulatus	-	4.6 ± 3.5	-	-
Baccharis halimifolia	-	3.0 ± 0.0	-	-
Sesbania sp.	-	0.5 ± 0.0	-	-
Ragweed	-	3.6 ± 2.9	-	-
Unknown	0.5 ± 0.0	-	-	

Table 10. Plant species height associated with yellow rail locations and available sites at the Salt Lake study site at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2003.

Plant species	Height (cm) ± SD	
	Yellow rail	Available
Scirpus robustus	95.8 ± 4.9	-
Spartina alterniflora	88.1 ± 0.0	-
Spartina patens	59.5 ± 13.1	74.8 ± 14.4
Spartina spartinae	57.1 ± 10.7	63.9 ± 17.3
Borrichia frutescens	55.7 ± 16.0	66.4 ± 11.0
Distichlis spicata	45.3 ± 10.3	43.9 ± 8.3
Salicornia spp.	39.8 ± 7.8	35.6 ± 13.2
Batis maritima	37.5 ± 25.4	35.7 ± 10.8
Baccharis halimifolia	-	91.8 ± 46.4
Monanthochloe littoralis	-	39.5 ± 0.0
Briar sp.	-	58.7 ± 0.0

Table 11. Plant-species height associated with yellow rail locations and available plots for salty prairie and high salt marsh cover types at the Texas Mid-Coast National Wildlife Refuge Complex during the winter of 2004, where % frequency = (# of plots species occur)/ *n*(# of total plot sampled) x 100.

Plant-species	Height (cm) ± SD			
	Salty Prairie		High Salt Marsh	
	Yellow rail	Available	Yellow rail	Available
Spartina spartinae	69.7 ± 11.0	70.4 ± 10.4	74.4 ± 19.0	79.2 ± 11.2
Distichlis spicata	60.8 ± 10.7	60.0 ± 9.4	58.1 ± 7.8	56.8 ± 10.1
Spartina patens	69.8 ± 0.0	76.6 ± 12.8	82.1 ±12.3	81.8 ± 13.6
Paspalum vaginatum	53.2 ± 0.0	42.3 ± 5.9	47.3 ± 6.6	43.6 ± 8.9
Scirpus americanus	-	-	93.8 ± 21.1	99.8 ± 14.5
Scirpus robustus	-	-	113.9 ± 28.0	101.8 ± 19.5
Batis maritima	-	-	43.9 ± 6.6	45.4 ± 9.6
Borrichia frutescens	64.5 ± 0.0	63.8 ± 9.6	-	65.2 ± 13.0
Eleocharis sp.	-	68.5 ± 11.7	-	-
Typha sp.	-	101.5 ± 22.3	-	-
Juncus roemerianus	-	98.2 ± 0.0	-	-
Lycium carolianianum	-	70.7 ± 8.2	-	-
Aster subulatus	-	65.6 ± 34.3	-	-
Baccharis halimifolia	-	55.5 ± 0.0	-	-
Sesbania sp.	-	21.2 ± 0.0	-	-
Ragweed	-	28.6 ± 10.7	-	-
Unknown	34.0 ± 0.0	26.2 ± 12.9	-	-

Table 12. Wintering site fidelity of rails at the Texas Mid-Coast National Wildlife Refuge Complex during the winters of 2003 and 2004 using a system of classification by Robert and LaPorte (1999), where "repeats" = same site, same year, "returns" = same site, different year, "displacements" = same year, different site, and "recoveries" = different year, different site.

Species	Date banded	Date recaptured	Classification system
Virginia rail	01/28/03	02/15/04	Return
Yellow rail	01/25/03	02/12/03	Repeat
Yellow rail	01/25/03	04/05/03	Repeat
Yellow rail	02/12/03	03/04/03	Repeat
Yellow rail	03/04/03	03/31/03	Repeat
Yellow rail	03/04/03	03/31/03	Repeat
Yellow rail	03/09/03	03/31/03	Repeat
Yellow rail	03/09/03	03/31/03	Repeat
Yellow rail	03/09/03	03/31/03	Repeat
Yellow rail	03/22/04	04/14/04	Repeat
Yellow rail	03/31/04	04/25/04	Repeat
Yellow rail	04/02/04	04/28/04	Repeat
Yellow rail	04/07/04	04/26/04	Repeat
Yellow rail	03/15/05	04/13/05	Repeat
Yellow rail	03/15/05	04/13/05	Repeat
Yellow rail	03/15/05	04/13/05	Repeat
Black rail	03/13/05	03/18/05	Repeat
Black rail	03/13/05	03/18/05	Repeat

Effects of Prescribed Fire

There was no evidence of direct mortality on rails during prescribed burns (Table 13). Radio transmitters were glued to the backs of 5 rails (3 yellow rails, 1 Virginia rail, and 1 sora) and tracked before and after a prescribed burn at Brazoria National Wildlife Refuge on 17 February 2004. One yellow rail was not found the day after the burn and was assumed to have left the area. Another yellow rail was found the day after the fire in unburned fringe habitat, but the signal was lost on the 2^{nd} day. The third yellow rail was tracked for 4 days after the burn until the transmitter fell off. The Virginia rail was tracked for three days after the burn until its transmitter fell off. Finally, the sora was tracked for 4 days after the burn until the signal was lost. The sora was located in the middle of the burned area the day after the fire under a clump of burned *Spartina spartinae*.

Seven rails (4 yellow rail, 2 black rails, 1 sora) were radio-tagged and tracked after a prescribed burn at San Bernard National Wildlife Refuge on 6 March 2004. Unfortunately, all but one (sora) of the transmitters fell off the birds during or shortly after the fire and were recovered the next day. The sora was tracked for 6 days after the fire in wetter habitat that did not burn adjacent to the burned area until its transmitter fell off.

Rail Morphology

Morphological measurements were taken from 111 yellow rails, 22 black rails, 15 soras, 7 Virginia rails, and 1 clapper rail in 2003, 2004, and 2005. Wing chord, culmen length, tarsus length, rectrices length, and body weight were averaged for each species (Table 14).

Table 13. Movements of rails after a prescribed fire at Brazoria National Wildlife Refuge on 17 February 2004.

Species ID	Recovery location	Distance to burned edge (m)	No. of days after burn
Yellow rail 1	?	?	?
Yellow rail 2	Unburned fringe	43.4	1
Yellow rail 3	Unburned fringe	46.1	$\geq$ 4*
Virginia rail 1	Unburned adjacent	225.3	$\geq$ 3*
Sora 1	Burned area	0	4

* transmitter fell off

Table 14. Morphological measurements of wintering rallids captured at the Texas Mid-Coast National Wildlife Refuge Complex during 2003, 2004, and 2005.

Morphological measurements	Yellow rail (n=111)	Black rail (n=22)	Sora (n=15)	Virginia rail (n=7)	Clapper rail (n=1)
Wing (mm)	84.0 ± 3.7	73.9 ± 2.8	102.3 ± 3.7	99.1 ± 4.3	159
Culmen (mm)	12.9 ± 1.0	13.8 ± 1.1	19.1 ± 0.9	35.3 ± 2.6	61
Tarsus (mm)	24.0 ± 1.5	23.2 ± 1.3	32.1 ± 2.3	33.0 ± 2.5	53
Rectrices (mm)	33.1 ± 2.4	34.3 ± 2.0	48.2 ± 3.1	41.9 ± 4.6	68
Weight (g)	50.7 ± 7.5	37.7 ± 4.6	72.5 ± 14.0	76.9 ± 14.3	295

DISCUSSION

Home Range and Daily Movements

Very little research has been done on yellow rail home ranges. Home ranges of yellow rails breeding at Seney National Wildlife Refuge in Michigan averaged 7.8 ha (n=4) for males and 1.3 ha (n=3) for females (Bookhout and Stenzel 1987). Home ranges of yellow rails wintering at Texas Mid-Coast National Wildlife Refuge Complex in southeast Texas averaged 0.6 ha (n=18, 100% MCP method). In contrast, yellow rails wintering at Anahuac National Wildlife Refuge, approximately 100 km up the coast from Brazoria NWR, had home ranges averaging 1.8 ha (n=28, 100% MCP method) (Mizell 1998). The amount and quality of available habitat could be a factor influencing yellow rail home ranges and could explain the difference in home range sizes between Brazoria and Anahuac; but this information is not available for the Anahuac study.

Yellow rails are gregarious on breeding grounds (Terrill 1943, Bart et al. 1984) and wintering grounds (Mizell 1998). This behavior was also exhibited by wintering yellow rails at Brazoria NWR. Concentrated populations of yellow rails were encountered during trapping sessions and evidence from radio telemetry data revealed that home ranges for many individuals overlapped. Whether yellow rails are sociable in winter or these concentrations are a function of habitat is still debatable and further research is required. Unlike other species of rails, yellow rails are silent during winter and their habitat is very dense, so I hypothesize the latter is probably the case.

Habitat Use

Yellow rails appeared to be associated with varying habitat characteristics in winter. Based on radio telemetry data, dense vegetative cover and relatively low plant height were the most constant factors encountered at all yellow rail locations. Other factors, such as water depth, dead vegetation coverage, and food availability, may be supporting factors in yellow rail habitat. Yellow rails have small home ranges and concentrated populations, which may indicate that their preferred habitat is limited or clumped.

Mizell (1998) reported that yellow rails are associated with a narrow range of standing water depths, which was the most important determinant of yellow rail habitat. However, in this study, standing water was only found in 41% of yellow rail locations, but at locations where standing water was absent, the soil was still moist. Radio-telemetry data revealed that after an area has dried up, yellow rails do not move to a new location. Therefore, I hypothesize that other factors, possibly food availability, are more important than water depth in describing yellow rail habitat. Yellow rails consume a wide variety of food items (Robert et al. 1997), so they may have the ability to switch food sources when water levels dry up.

Vegetative habitat characteristics associated with yellow rail habitat use were consistent between years. *Distichlis spicata* was the most frequently encountered species. *Spartina spartinae* provided the most cover, while leafy 3-square was the tallest. Additionally, *Paspalum vaginatum* was discovered in 2004 as a plant-species that provided dense cover and heavy use by yellow rails.

Three plant-species including *Distichlis spicata*, *Batis maritima*, and *Salicornia* sp. were found at yellow rail location at much higher frequencies than in available plots at the Salt Lake study site in 2003. The disproportional frequencies of these plants could indicate rails are honing in on specific plant-species. Although no data was taken on the diet on yellow rails, the relatively high association with *Distichlis spicata*, *Batis maritima*, and *Salicornia* sp. may indicate that they are feeding on the seeds or fruits produced by these plants. Although *Batis maritima* and *Salicornia* sp. offer very little wildlife value, *Distichlis spicata* is considered a very good source of seeds that are available to wildlife (Stutzenbaker 1999).

Yellow rails used salty prairie and high salt marsh habitats during winter. Although these two habitat types are distinct, there is much overlap in defining the boundary between the two. The high salt marsh often times grades into the salty prairie as elevation increases, and yellow rails were observed using the high salt marsh, salty prairie, and the transition between the two. Similarly, yellow rails wintering at Anahuac NWR used salty prairies and high salt marshes (Mizell 1998). During the breeding season, high salt marshes were most widely used in Canada (Robert and LaPorte 1999, Robert et al. 2000), while wet sedge meadows were preferred in Michigan (Stenzel 1982). Despite geographic variation in habitat types used by yellow rails, habitat structure is similar throughout. Low growing plants (often monocultures of one species) in a wet environment that offer dense coverage is the constant factor for all yellow rail habitats.

Home ranges and core areas did not differ between salty prairies and high salt marshes, but daily movements were greater in salty prairies. Salty prairies, dominated by *Spartina spartinae*, are drier and offer more overhead cover than high salt marshes. *Spartina spartinae* grows in clumps and forms a tunnel system underneath where rails can move without being detected from above. The overhead cover may give yellow rails more security to move greater distances without the risk of predation. Also, the drier nature of the salty prairie may require yellow rails to travel further distances to find food. Wetter areas have higher densities of invertebrates, which comprise a large part of the yellow rail's diet (Robert et al. 1997).

Wintering Site Fidelity

Preliminary results from band recoveries show some yellow rails exhibit wintering site fidelity within the same year. A more intensive banding program is needed to determine if site fidelity exists between years. A Virginia rail was recaptured the following year at the same site, validating that winter site fidelity does occur in that species.

Effects of Prescribed Fire

Transmitter attachment problems prevented me from obtaining rail mortality data during prescribed burns. The transmitters were glued to the backs of rails a few days before a prescribed burn. Many transmitters fell off the rails sometime during or immediately following the fire. There was no evidence of mortality (feathers, carcass, hard-body parts) near the area of the fallen transmitter, so it was assumed that the rail was still alive when the transmitter fell off. Additionally, most of the fallen transmitters were found in burned habitat. I have two speculations as to why the transmitters did not stay attached to the birds: 1) the transmitters got snagged on the vegetation as the rails were fleeing from the fire or 2) the heat of the fire broke the bond of the glue. I recommend using a harness attachment for radio transmitters in future studies with rails and prescribed fire.

The immediate effects of prescribed fire on wildlife are not well known. A few studies have evaluated mortality and movements due to prescribed fire with a variety of wildlife with varying results. Smith et al. (2001) found that eight rattlesnakes (*Crotalus* spp.) exposed to low-intensity fire survived, whereas one rattlesnake exposed to intense fire died. Harper et al. (2000) concluded that many arthropod species are substantially reduced by prescribed fire and proposed that land managers should allow sufficient intervals between burns to allow recolonization of burned areas by native arthropods. Alternatively, Fischer et al. (1997) and Seaman and Krementz (2001) found no evidence of mortality of sage grouse (*Centrocercus urophasianus*) and Bachman's sparrows (*Aimophila aestivalis*) as a result of prescribed fire. There was no difference in daily movements of sage grouse in burned areas (Fischer et al. 1997), but Seaman and Krementz (2001) found that Bachman's sparrows had longer daily movements in burned stands than in unburned stands.

Evidence of rail survival of prescribed burns was documented by radio-telemetry data. One sora was found alive under a clump of burned *Spartina spartinae* and several yellow rails were relocated in unburned habitat near the site of the prescribed burn the day after the burn. These rails abandoned the area between 1-4 days later, apparently because of unsuitable habitat conditions. A Virginia rail was observed by a Refuge firefighter popping out of the ashes just after the fire moved over the area. The rail was captured, inspected, and released with no apparent injuries. I believe the rails that are unable to escape the fire may survive by burying themselves underneath the layer of dead, damp vegetation under clumps of *Spartina spartinae*. The presence of standing water could aid in the survival of rails during prescribed burns. Managers conducting winter prescribed burns in rail habitat should burn early in the winter when water is still present. Waiting until late winter, when the growing season has already started, and after the water levels have dried up, could result in higher rail mortality.

Although no direct mortality from prescribed fire was discovered with rails, evidence of indirect mortality from predation was found. Raptors were attracted to the fires and were observed pursuing prey fleeing from the fire. Fresh remains of a yellow rail and Virginia rail were found on a levee adjacent to one burn. Prescribed fire temporarily reduces cover and exposes rails to increased predation. Many species of rails were observed using the tall strips of unburned vegetation along a ditch between the levee and the burn. I suspect these areas are vital to the short-term survival of rails. It provides cover from predators and refuge from the fire.

This study attempted to fill an information need on the mortality and behavior of yellow rails in response to prescribed fire. Many factors contributed to the lack of obtaining this information. No prescribed burns were conducted in my potential study sites during the winter of 2002-03, and only 2 in 2003-04. The lack of fire-related data in 2002-03 was a result of a lack of communication from the fire management team on their burning intentions. A few prescribed burns in yellow rail habitat were conducted without my knowledge. Many of the project's design problems (transmitter attachment) in 2003-04 could have been prevented if I was able to acquire more cooperation and communication from the fire management team during 2002-03.

However, this study did contribute to the missing ecological information that is necessary for determining acceptable wintering habitat of yellow rails. In addition, movement and home range information was obtained, and some insight was discovered on how rails survive prescribed fires.

Rail Morphology

Differences in some morphological traits were discovered between yellow rails at Texas Mid-Coast National Wildlife Refuge Complex and those reported by Bookhout (1995). The average weight reported by Bookhout was greater than at Texas Mid-Coast National Wildlife Refuge Complex. A majority of the yellow rails reported by Bookhout (1995) were males, which could explain the difference between average weights because Bookhout (1995) reported that males are 12% heavier than females. Sex is indistinguishable on wintering grounds because of similarities in plumage, but a few yellow rails were sexed at the end of April by the presence of a cloacal protuberance (CP). A CP was not present on any other birds earlier in the winter.

CONCLUSION AND MANAGEMENT IMPLICATIONS

With ever-increasing losses of wetland habitat along the Gulf Coast where yellow rails winter, it is very important that the remaining habitat be effectively managed. Some yellow rail habitat is managed by prescribed burning on federal (National Wildlife Refuge System) and state (Texas Parks and Wildlife) lands in Texas. Knowledge of home range and habitat use can be important information when considering prescribed burning management schemes. Yellow rails have small home ranges and concentrated populations, which may indicate that their preferred habitat is limited or clumped; therefore, an increased importance on effective management strategies is crucial. However, results from this study found that yellow rails heavily occupy both salty prairie and high salt marsh cover types. Some high salt marsh habitats (i.e. *Distichlis spicata* marshes) do not readily burn, therefore prescribed fire is not performed there. The Texas Mid-Coast National Wildlife Refuge Complex has many of these marshes available to yellow rails, so prescribed fire probably is not a major concern for yellow rail populations in these areas.

Prescribed fire performed in the salty prairie cover type should be carried out more cautiously. Managers should consider burning intervals of > 2 years because fire virtually eliminates all available cover, which is an important component of yellow rail habitat needs. Capturing sessions conducted about 2 months after a prescribed burn revealed very little rail use. Even 1 year following a prescribed fire yellow rail numbers were low, mainly because the cover component had not yet been restored to preburn conditions.

In drier and less tidally influenced areas, *Spartina* sp. stands can become extremely dense when not managed by prescribed fire. Despite low numbers of yellow rails flushed during capturing sessions in highly dense *Spartina* sp. stands, I believe yellow rails are using these areas from evidence acquired during marsh buggy rides, and were either unable or chose not to flush at the approaching drag-line. A better flushing technique is needed in situations like this to determine if yellow rails are using the highly dense stands of *Spartina* sp.

Leaving a strip of unburned vegetation around the perimeter of the burn will aid in the short term survival of rails. Rails use these areas for temporary refuge from the fire, smoke, and predators during and shortly after prescribed fires.

To reduce possible mortality of rails, burning should be conducted early in the winter before conditions begin to dry-up. Rails probably have the ability to survive prescribed fires, when they are unable to escape the flames and the smoke, by burying themselves beneath the layer wet dead vegetation that covers the soil and allow the flames to carry over the top of them. In addition, rails can be protected by hunkering down in the shallow water and allow the fire to pass.

Although pertinent information was gained about home range, movements, and habitat use by yellow rail during winter, more research is needed. Most home range measurements were obtained late in winter. Trapping efforts revealed that an influx of yellow rails occurs on the Upper Gulf Coast in April, possibly as a result of staging prior to spring migration which could possibly affect normal wintering home range estimates. It is unknown whether or not the rails tracked in April were new arrivals or winter residents, but banding efforts revealed that some yellow rails do have high fidelity to local habitats. More emphasis should be placed on home range and movements throughout the winter from early October when the birds arrive to late April when the birds leave.

Results of this study filled an important information need on the movements, habitat use, and effects of prescribed fire on wintering yellow rails, and supported the suggested hypothesis that small home ranges and concentrated populations increase the importance of effective management strategies and intensify the potential effects of stochastic environmental events (Mizell 1998, Bookhout 1995). There is a still serious lack of information about yellow rails in winter. Recognizing home ranges and identifying habitats used by them will allow better management of what few coastal wetlands are left, where yellow rails spend more than half of their lives each year.

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Appendix A. Home range and core area estimations using 100% minimum convex polygons (MCP), 95% fixed kernels, and 50% fixed kernels for 18 yellow rails wintering at the Texas Mid-Coast National Wildlife Refuge Complex during 2003 and 2004.

Appendix A. Home range (HR) and core area (CA) estimations using the 100% minimum convex polygon (MCP), 95% fixed kernel (FK), and 50% FK for 18 yellow rails wintering at the Texas Mid-Coast National Wildlife Refuge Complex during 2003 and 2004.

Bird ID	100% MCP HR (ha)	95% FK HR (ha)	50% FK CA (ha)	# of locations
SL03	0.08	0.99	0.25	8
SL04	0.72	0.33	0.09	22
SL05	0.23	2.76	0.67	5
SL06	0.46	1.14	0.33	23
SL07	0.44	1.11	0.28	19
SL08	0.18	0.07	0.02	19
SL09	1.05	0.97	0.25	19
SL10	0.04	0.66	0.16	7
SL12	0.26	0.91	0.20	16
SL13	0.11	0.87	0.20	8
SL21	0.11	0.96	0.23	7
SL22	0.06	0.72	0.17	7
CR22	0.26	0.46	0.11	15
CR25	0.55	2.31	0.62	18
CR6	0.35	0.88	0.19	18
MP24	0.53	1.48	0.42	24
HR23	1.87	3.86	0.82	22
HR27	4.46	1.07	0.25	24

Appendix B. Movements of 18 yellow rails wintering at the Texas Mid-Coast National Wildlife Refuge Complex during 2003 and 2004.

Bird ID	Mean distance moved between consecutive days (m)	Longest distance moved between consecutive days (m)	Shortest distance moved per individual (m)
SL03	34.2 ± 12.0	54.6	16.1
SL04	25.2 ± 16.0	64.2	2.0
SL05	43.4 ± 34.7	91.0	7.8
SL06	40.8 ± 24.3	87.0	8.6
SL07	40.8 ± 16.1	64.6	14.9
SL08	27.4 ± 18.7	65.4	6.3
SL09	44.7 ± 28.2	107.6	13.0
SL10	8.2 ± 7.3	21.0	1.0
SL12	27.9 ± 23.3	77.2	3.6
SL13	13.9 ± 8.5	26.0	4.1
SL21	32.4 ± 25.8	72.0	6.0
SL22	22.6 ± 14.0	50.1	12.4
CR22	29.1 ± 21.0	64.6	8.1
CR25	43.8 ± 34.1	110.7	1.4
CR26	27.8 ± 17.8	57.0	1.4
MP24	38.6 ± 28.1	101.6	7.3
HR23	57.5 ± 37.6	167.7	12.8
HR27	53.6 ± 76.6	320.3	6.1

Appendix B. Movements of 18 yellow rails wintering at the Texas Mid-Coast Wildlife Refuge Complex during 2003 and 2004.