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The Florida Burrowing Owl in a Rural Environment: Breeding Habitat, Dispersal, Post-Breeding Habitat, Behavior, and Diet.

By

Robert Mrykalo

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
Department of Environmental Science and Policy
College of Arts and Sciences
University of South Florida

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ABSTRACT

The first observations of Florida burrowing owls (*Athene cunicularia floridana*) occurred in the 19th century on historical dry prairie habitat in south central Florida. These early observations documented the ecology of burrowing owls in rural environments. Since then the vast majority of research on this subspecies has been undertaken in suburban and urban environments during the breeding period. The research undertaken on burrowing owls in suburban and urban environments includes determining natal dispersal distance, assessing female fecundity, mate fidelity, territory fidelity, date of juvenile and adult dispersal from breeding habitat, date of clutch initiation, nesting success, density of breeding pairs, causes of mortality, prey preference, and minimum annual survival of fledglings, juveniles, and adults. Very little research has been undertaken on burrowing owls in rural environments.

The purpose of this thesis was to elucidate the behavior and ecology of burrowing owls in a rural environment. The topics researched in this thesis include home range in breeding habitat, dispersal distance to post-breeding habitat, location of post-breeding habitat, behavior during the breeding period, diet of rural versus urban owls, and the evaluation of three methods to trap burrowing owls.

The results of this thesis indicate that, during the daytime, juvenile burrowing owls utilized habitat very close to the main and satellite burrows during the breeding period. At night juvenile owls foraged in an extensive saw palmetto patch surrounding the breeding habitat. The predominant prey of both rural and urban burrowing owls during the breeding period was insects. Dispersal of juvenile burrowing owls from breeding habitat coincided with the flooding of the breeding habitat during the rainy

season. During the post-breeding period, juvenile burrowing owls shifted from colonial to solitary activity and utilized habitat consisting of saw palmetto and scrub oak. The location of adult burrowing owls in the improved pasture and their behavior during the breeding period depended on an owl's sex and if it was or was not raising young.

Burrowing Owl Habitat: Breeding Habitat, Dispersal, and Post-Breeding Habitat.

Introduction

Early observations of burrowing owls (*Athene cunicularia floridana*) occurred on the dry prairie ecosystem occupying the south central portion of Florida (Cahoon 1885, Hoxie 1889, Rhoads, 1892, Scott 1892, Palmer 1896). The vegetative structure of dry prairie ecosystems varies from grassy areas of variable size interspersed within dense stands of saw palmetto (*Serenoa repens*) to expansive open areas containing a variety of grasses and sedges with scattered patches of trees and shrubs (Davis 1943). In northern Florida, dry prairie ecosystems contain cabbage palm flatwoods and also merge into wet flatwoods and pine flatwoods (Abrahamson and Hartnett 1990). Periodic natural fires due to lightning strikes and flooding may have maintained the dry prairie ecosystem (Platt and Huffman 2004). Most lightning strikes occur during June to September (Abrahamson 1984a) and roughly 1,000 fires are set each year by lightning (Tanner et al. 1991). Highly flammable plants found within dry prairies, such as wiregrass (*Aristida stricta*) and saw palmetto, helped fuel these natural fires (Abrahamson and Hartnett 1990). In turn, fire benefits native grass species of dry prairies by increasing the rate of flowering (Abrahamson 1984b) and creating open areas devoid of trees and shrubs thereby reducing the competition for resources such as water, light, and nutrients (Abrahamson and Hartnett 1990).

Periodic fires and flooding in dry prairies, coupled with natural firebreaks such as rivers and wetlands, may have created a continuously shifting mosaic of short grass habitat suitable for breeding burrowing owls. Millsap (1997) hypothesized that burrowing owls were nomadic and followed these short-term disturbances that created new breeding habitat.

Breeding Habitat

Observations of burrowing owls on dry prairies documented the unique ability of these owls to dig their own breeding and satellite burrows. Rhoads (1892) and Palmer (1896) located burrows excavated in moist sand on short grass slopes interspersed between saw palmetto patches and the waters edge of swamps. Burrows have also been excavated in dry soils at the highest elevated areas of pasture containing shrubs (Hoxie 1889, Scott 1892) and, in one instance, clumps of tall grass (Palmer 1896). The burrows, which can be 3-10 feet in length, contain an enlarged nest chamber at their terminus (Rhoads 1892, Scott 1892, Nicholson 1954, Sprunt 1954). A breeding pair of owls excavates one breeding burrow and one or more satellite burrows (Scott 1892, Neill 1954, Wesemann 1986, Mealey 1997). Both the inside and outside of the burrows are decorated with a variety of items including cow manure, horse manure, dog feces, grass, and refuse (Palmer 1896, Nicholson 1954, Mealey 1997).

Male and female Florida burrowing owls can breed at one year of age (Haug et al. 1993). Breeding occurs between October and July with the majority of females laying eggs in the spring (Nicholson 1954, Courser 1976, Millsap and Bear 1990). Roughly 2-10 eggs are layed per nest (Rhoads 1892, Scott 1892, Nicholson 1954, Owre 1978, Stevenson and Anderson 1994). Females do all brooding of the young. Males initially do all of the hunting and provisioning of females while they are incubating. Females begin hunting when chicks are about two weeks old (Haug et al. 1993). There is no available information on the number of days before Florida burrowing owls fledge, but the Western burrowing owl fledges 44 days after hatching (Landry 1979).

Rural breeding habitat varied in size from large expansive prairies to small open areas occupying only a few hectares (Bent 1938). Mr. N.B. Moore, in a correspondence to Ridgeway (1874), reports finding three communities of burrowing owls each separated by 1.2-1.6 kilometers. Each community contained 7-8 burrows. Rhoads (1892) located 2-3 owls in areas roughly 2.6 kilometers in size and one colony containing hundreds of pairs of burrowing owls stretching approximately 4.8 kilometers. On a large expanse of prairie approximately 32-48 kilometers wide and 80 kilometers long, Scott (1892) located

3-4 pairs of burrowing owls per 2.6 square kilometers. Several kilometers of prairie were traversed before he would locate another small colony. Palmer (1896) observed colonies containing 3-6 burrows and the burrows separated by 27-91 meters. The colonies he located were separated by many kilometers. Observations in the fall by Hoxie (1889) discovered small colonies containing 3-11 burrows.

Much of the area comprising dry prairies has been lost due to development or has been converted to grazing pasture, agricultural land, or timber production (Birnhak and Crowder 1974, Abrahamson and Hartnett 1990). Anthropogenic changes to breeding habitat were already evident to Palmer (1896) when he noted that much of the prairie had been converted to grazing land and fires were often set by ranchers to burn off dead and undesirable vegetation. There is also evidence of cattle trampling burrows (Rhoads 1892).

New prairie-like breeding habitat has been created due to the continuous clearing and draining of previously unsuitable habitat (Neill 1954, Owre 1978, Courser 1979). Some of the new areas on which burrowing owls currently breed include grazing pastures (Mealey 1997), college campuses (Courser 1976), private residences (Mealey 1997), airports (Owre 1978, Mealey 1997), vacant lots (Wesemann 1986, Millsap and Bear 1990), borders of interstates (Owre 1978) and industrial parks (Courser 1976). These open, short grass areas mimic the original breeding habitat (Owre 1978, Wesemann 1986, Millsap and Bear 1997). Land clearing has resulted in the expansion of breeding habitat north, northwest, south, and southeast of the original dry prairies in central and southern Florida (MacKenzie 1944, Neill 1954, Ligon 1963, Hennemann 1980).

Breeding habitat has been an important component of previous research on burrowing owls and has included determining natal dispersal distance (Millsap and Bear 1997), assessing female fecundity (Millsap and Bear 2000), mate fidelity (Millsap and Bear 1997), territory fidelity (Millsap and Bear 1997), date of juvenile and adult dispersal from breeding habitat (Courser 1976), date of clutch initiation (Courser 1976), nesting success (Mealey 1997, Millsap and Bear 2000), density of breeding pairs (Millsap and Bear 1988), causes of mortality (Mealey 1997), prey preference (Lewis 1973, Hennemann 1980, Wesemann 1986), and minimum annual survival of fledglings, juveniles, and adults (Millsap and Bear 1997). The majority of previous research has been conducted in suburban or industrial areas.

Few studies have been undertaken in agricultural areas, such as grazing land for cattle, and areas managed as natural habitat. The lack of research in these areas may be due to the lack of available data regarding the distribution and abundance of burrowing owls in these areas throughout the state. There have been recommendations to expand the monitoring of populations and also conduct a statewide inventory of the breeding populations in Florida (Owre 1978, Millsap 1997). It wasn't until 1999 that a commendable statewide census was conducted on burrowing owls using data from historic and current owl sites. The lack of previous data on agricultural sites, coupled with reduced access to agricultural areas (Bowen 2000) plus the majority of ranchland surveys conducted from roads (Bowen 2004, personal communication) may have hindered the statewide census. Some state owned lands managed as natural areas have not been surveyed for burrowing owls further hindering the statewide census.

Dispersal and Post-Breeding Habitat

There is very little information on why some burrowing owls disperse from breeding habitat while others remain. Early observations indicated that burrowing owls disappeared at the end of the breeding season (Hoxie 1889, Bendire 1892). Nicholson (1954) noted that few owls were located on breeding habitat in winter. Burrows flood during the breeding period (Nicholson 1954, Millsap and Bear 1988) and Mealey (1997) hypothesized that burrow flooding during the rainy season may be a proximate dispersal mechanism for burrowing owls.

Subsequent observations of dispersal indicate that a small number of individuals in a metapopulation may disperse (Courser 1976) or all individuals of a metapopulation may disperse (Stevenson and Anderson 1994, personal observation 2003, 2004). Stevenson and Anderson (1994) reported that of 11 relocated burrowing owls, five did not disperse, five dispersed 18 kilometers south, and one dispersed 74 kilometers north. Their results indicate that burrowing owls may undergo frequent post-breeding dispersal.

Sightings of burrowing owls have occurred in unusual areas such as 16 kilometers (Castenholz 1954) and 40 kilometers off the Florida coast (Ogden 1972). Florida Burrowing Owls have even been located outside of Florida including three occasions in New York (Davis 1977), and once in North Carolina (Sykes 1974) and Alabama (Howell 1928).

The sightings of burrowing owls outside of Florida and the continued expansion of breeding range within the state (Ligon 1963, Courser 1979) suggest that dispersal distance can be noteworthy. The evidence of post-breeding dispersal indicates that post-breeding habitat may be an unknown but important component of burrowing owl ecology.

The lack of information on post-breeding habitat may be due to the difficulty in locating this species after breeding. There have been several hypotheses proposed to explain why burrowing owls may be difficult to locate during the post-breeding period. First, their cryptic coloration and ability to blend in with the surrounding habit (Millsap 1997) may make it difficult to locate during post-breeding periods. Second, burrowing owls may shift activity patterns and become more crepuscular, nocturnal (Hoxie 1889, Mealey 2004, personal communication), and arboreal (Hoxie 1889) during the post-breeding period. Third, burrowing owls may disperse long distances to habitat that differs from breeding habitat. Any of these hypotheses or combination of hypotheses could explain the disappearance of burrowing owls during the post-breeding period.

Objectives

The objectives of this study were to 1) determine the home range of adult and juvenile burrowing owls in breeding habitat, 2) measure juvenile and adult dispersal distance from breeding habitat to post-breeding habitat, 3) locate post-breeding habitat, and 4) determine the home range of adult and juvenile burrowing owls in post-breeding habitat. Post-breeding habitat was defined as any habitat occupied by burrowing owls when main and satellite burrows were no longer utilized. The following hypotheses were to be tested:

Home range comparison:

H_O: Post-breeding home range for adult burrowing owls will not be significantly different in size from breeding home range.

H_1: Post-breeding home range will be smaller because adults are only foraging for themselves and not for juvenile burrowing owls.

Post-breeding habitat:

H_O: The vegetative structure of the post-breeding habitat will not be comparatively different from the breeding habitat.

H_1: Post-breeding habitat will be comparatively different from breeding habitat because adults are no longer reliant on short grass for excavating burrows, using these burrows to raise and protect juvenile owls, and detect predators.

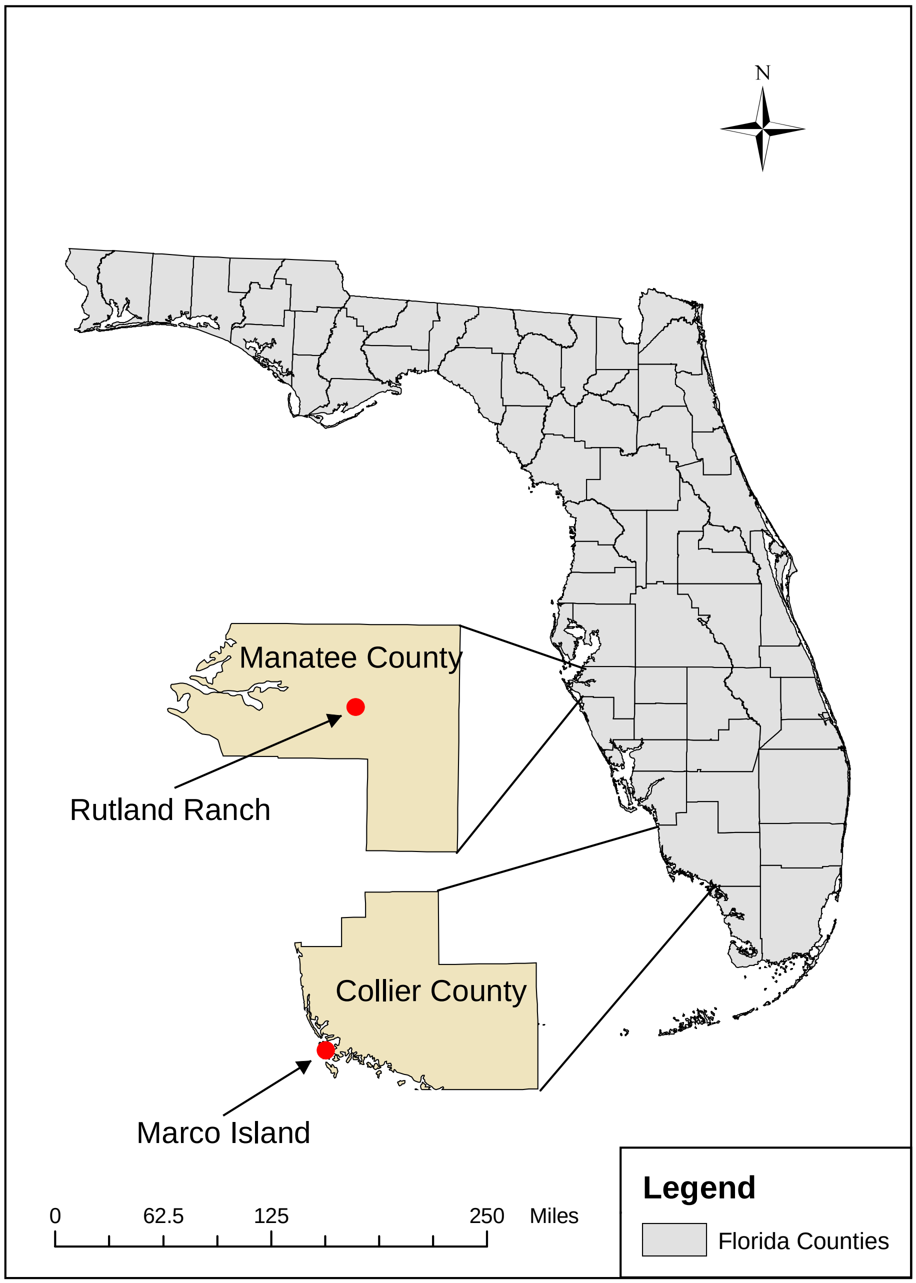
Methods

The study site was Rutland Ranch, in Bradenton, FL (Figure 1). Rutland Ranch encompasses approximately 2,372 hectares and is managed by the Southwest Florida Water Management District (Barnwell et al. 2003). The ranch contains a mixture of habitats including oak scrub, herbaceous marshes, riparian hardwoods, pine flatwoods, and non-native pastures. The dominant soil types include Cassia, Duette, Myakka, Pomello, St. Johns, and Waveland fine sands (Barnwell et al. 2003). Vegetation associated with these soil types include sand pine (*Pinus clausa*), live oak (*Quercus virginiana*), and saw palmetto (Barnwell et al. 2003). Florida Burrowing Owls excavate burrows on an 81-hectare rectangular piece of improved pasture (Barnwell et al. 2003). The pasture is located at the following UTM coordinates: Zone 17 0375665E and 3044342N.

Locating Burrows

The improved pasture was surveyed twice for active burrows: 3/26/04 and 7/10/04. The pasture was surveyed twice because, over time, burrows may be abandoned, destroyed by predators, and new burrows excavated by resident and immigrating burrowing owls. The survey began at the east side of the pasture. Three surveyors separated by 20 meters walked from the north end to the south end of the pasture scanning the ground for burrows. A burrow was identified as being excavated by burrowing owls if any one or more of the following conditions were met: insect remains were found at the burrow mound or entrance, owl feathers were found at the burrow mound or entrance, regurgitated pellets were found at the burrow mound or entrance, or owls were sighted at or near the burrow. When the south end of the pasture was reached the three surveyors shifted 60 meters west and walked to the north end of the pasture. This process was repeated until the entire pasture was surveyed.

Figure 1: Location of Research Areas: Rutland Ranch and Marco Island

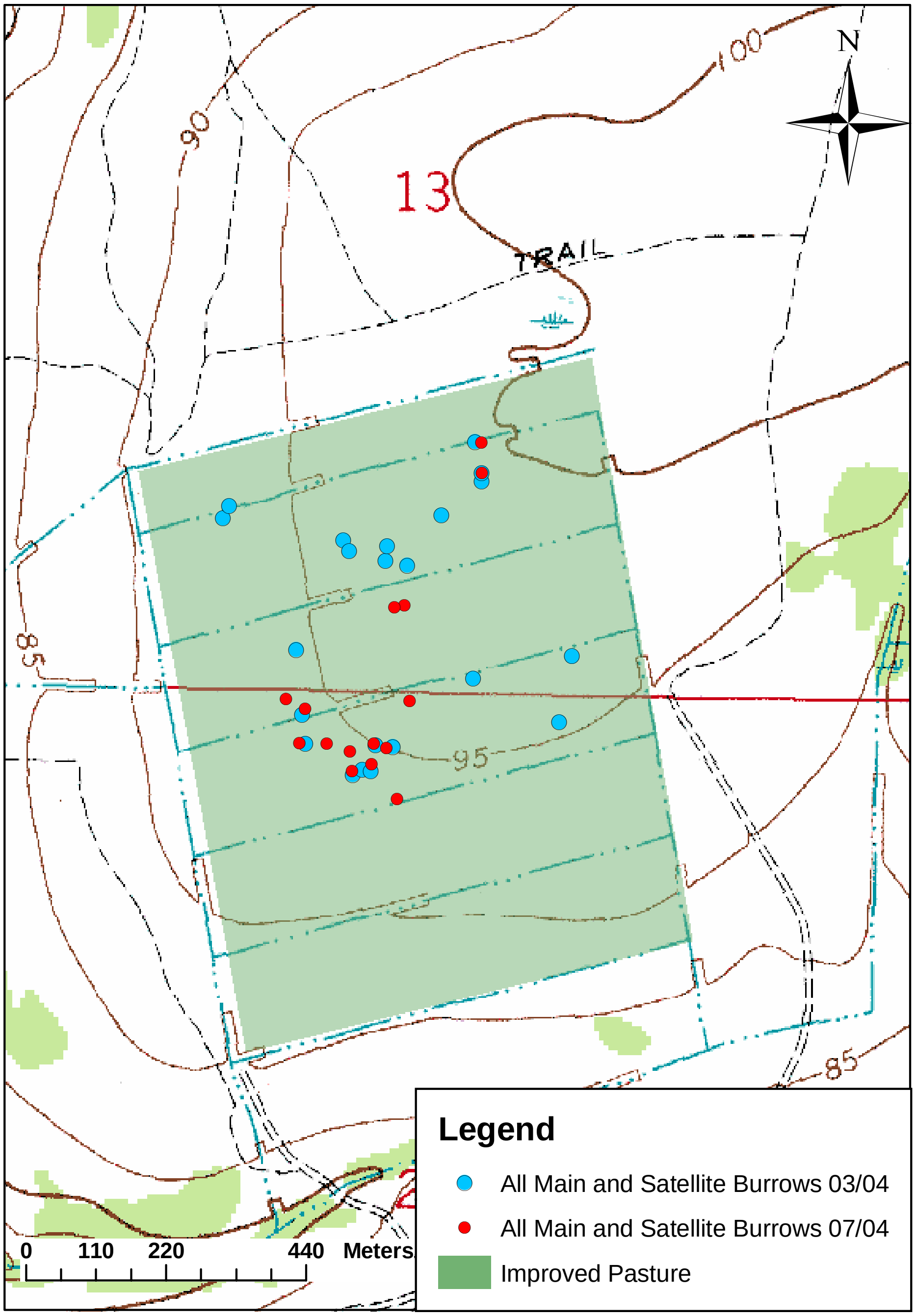


A Garmin GPS model 12 CX was used to determine the location of main and satellite burrows, for each pair of owls, and the four corners of the improved pasture. The main burrow was distinguished from the satellite burrows by the male burrowing owl delivering food to the burrow occupied by the female, the female spending the majority of time in one burrow, and/or the presence of recently hatched chicks at the burrow entrance. Each GPS location was recorded using the UTM coordinate system and NAD27 datum. The location of each burrow was later stored in a Microsoft Excel table. The tables were converted into dBASE IV format and imported into ArcMap 8.3. Each imported table was then converted into X, Y data, added to a layer in ArcMap 8.3, and then saved as a shape file. The location of the four corners of the pasture were also stored as a Microsoft Excel table, converted into the dBASE IV format, and imported into an ArcMap 8.3 layer using the same procedures for the burrows. The four corners of the improved pasture were converted into a polygon shape file using XTools. A digital raster graphic (DRG) containing Rutland Ranch, scanned from a 7.5 minute topographic map of the Rye quadrate, was imported into ArcMap 8.3 as a layer. The improved pasture shape file, burrow shape files, and DRG were used to create a map indicating the position of each burrow, for each of the two time periods that we conducted surveys (Figure 2).

Radio Telemetry

Adult and juvenile burrowing owls were captured using noose carpet traps (Mealey 1997, Millsap and Bear 1997, Mehl et al. 2003) placed on the burrow mound and in the entrance of the burrows. Owls were captured on the burrow mound and also inside the entrance when exiting or entering the burrow. The dependence of juvenile and adult burrowing owls on their main and satellite burrows (Mealey 1997) allowed us to occasionally herd owls toward their burrows at which noose carpet traps were set. This was accomplished by walking around burrows until individual owls were located between research personal and a burrow and then slowly walking toward the owl. We stopped walking toward an owl when it flew at or near the trapped burrow.

Figure 2: Location of all Active Burrows on Rutland Ranch



Captured owls were weighed to the nearest gram by placing the owl in a cloth or plastic bag suspended from a 300 gram Pesola® LightLine Spring Scale. The sexes of adult owls were identified by the presence or absence of a brood patch and feather coloration. Females had darker feathers and a conspicuous brood patch on their lower chest area (Martin 1973). The brood patch was distinguished by de-feathering and thickening of the skin surface (Lea and Klandorf 2002). Male burrowing owls were identified by the lack of a brood patch and sun bleached lightening of feather coloration. The difference in feather color is due to males spending more time outside of the burrows searching for food in order to provision females during incubation (Martin 1973). Three to five chest feathers were removed from captured juvenile burrowing owls in order to sex individuals. The feathers were sent to a laboratory for DNA PCR analysis (Avian Biotech 2004).

Captured adult and juvenile burrowing owls were fitted with necklace radio transmitters. The transmitters, non-scanning receiver, and Yagi antenna, were made by AVM Instrument Company Limited. The frequency coverage for the receiver and transmitters was 151.000 – 151.999 MHz. The maximum range of the receiver and transmitters during field tests was 1.61 kilometers. Five transmitters were randomly selected to determine the precision of directional bearings. Five bearings were recorded for each transmitter, which had been placed in habitat similar to the improved pasture. The mean and standard deviation for the precision of directional bearings was 1.64 ± 4.13 degrees (White and Garrot 1990).

The average weight of the transmitters was 4.9 grams. With an adult average weight of 150 grams (Millsap 1997) each transmitter weighed 3.3% of adult body weight. Each transmitter had an elastic collar covered with shrink wrap to reduce the possibility of abrasion. The elastic collar was spliced with a small piece of cotton string that would disintegrate over time and allow the transmitter to detach from the owl after the study was completed. When handling captured owls a cloth covering was temporarily placed over the owls head when it exhibited signs of stress such as tongue-snapping (Mealy 1997). An aba, a rectangular piece of cloth that holds the raptors wrists, was used to restrain owls (Maechtle 1998) when only one individual was handling owls and attaching transmitters. After attaching a transmitter we observed an individual for several days in order to determine an owl's affinity for wearing a transmitter.

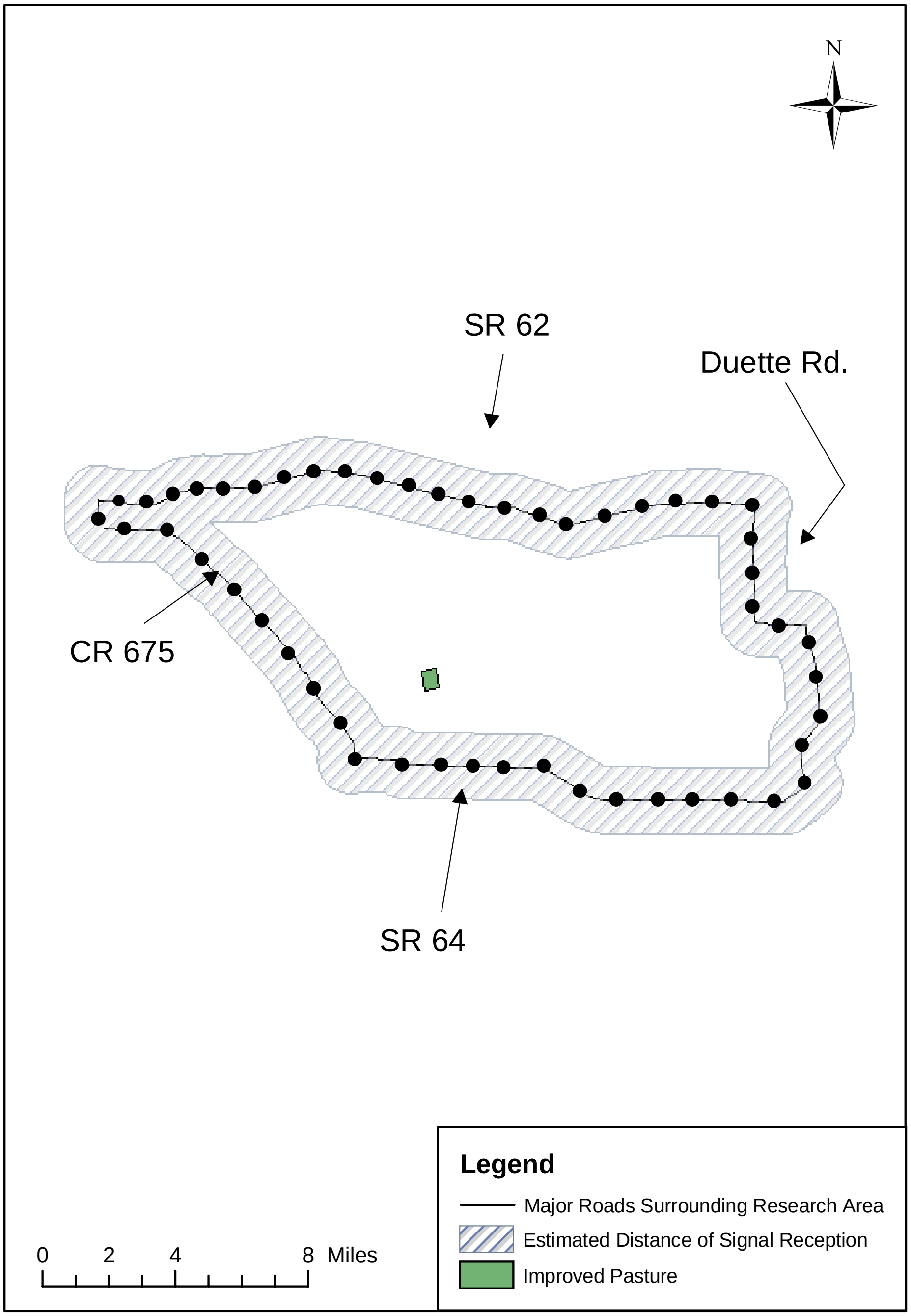
After a transmitter was attached an attempt was made to relocate an owl once each day in the improved pasture using a non-scanning receiver and a four-element Yagi antenna. Relocation attempts took place between 10 am and 8 pm. Two relocations were used to triangulate the location of each owl during the breeding and post-breeding periods. During the evening of 8/01/04, hourly relocations were attempted between 9 pm and 5 am to document activity and location of each owl during the evening in the improved pasture. The date, time, transmitter frequency, UTM X and Y coordinates, signal bearing, and habitat type (urban, suburban, rural, or pasture) were recorded for both the day and evening relocations (White and Garrot 1990). Broad habitat types were utilized because there was no idea how far burrowing owls were capable of dispersing. Urban areas were characterized as city or industrial areas, suburban areas were characterized as residential outskirts of a city, rural areas were characterized as open areas with little or no development, and pasture was characterized as land used to graze cattle. The relocation data for each owl was saved in separate Excel tables and later converted into a dBASE IV table.

All the available road and trails within Rutland Ranch were searched by ATV when any radio collared owl was not relocated during the day and evening telemetry sessions. I would stop approximately every 100 meters and scan with the receiver and antenna for the missing frequency. If an owl was not located after several such attempts I then searched along the road network surrounding Rutland Ranch as displayed in Figure 3. I stopped every half mile and scanned with the receiver and antenna. Finally, if an owl was still not located, aerial telemetry was attempted to locate the missing owls.

Calculating Home Range and Dispersal Distance

The computer program Location of a Signal 3.0.1 (LOAS) was used to calculate each owl's location from the relocation data. The dBASE IV tables containing the relocations for each owl were imported into LOAS, the location for each owl calculated,

Figure 3: Roads Surveyed for Missing Burrowing Owls



and the location data for each owl was exported as a dBASE IV table. These tables were then imported into ArcMap 8.3, converted into X, Y data, added to a layer in ArcMap 8.3, and then saved as a shapefile. The ArcView extension Animal Movement V.2 Beta was used to calculate the home range for each owl.

In Animal Movement V.2 Beta the fixed kernel home range estimate, with least squares cross validation as the smoothing parameter, was used to calculate the home range in the breeding and post-breeding periods. The kernel home range is a nonparametric method that calculates a probability density estimate for the distribution of data points on a two dimensional plane. A probability density estimate, the kernel, is placed over each data point. The density estimate for the distribution of data points is calculated by the proximity (overlap of kernels) of data points to themselves or a grid placed over the data set (Worton 1989, Seaman et al. 1998). The program calculated three separate home range estimates for each owl based on predetermined probabilities (95, 75, and 50%) of the estimated utilization distribution.

The minimum convex polygon method to estimate home range was not utilized in this study because relocations in the peripherary of main activity can drastically affect the home range estimate. Also, this method does not indicate the intensity of habitat use (Harris et al. 1990).

I defined dispersal as an owl moving from its breeding habitat in the improved pasture to any habitat outside of the improved pasture. Dispersal distance was calculated by measuring the distance, to the nearest meter, from each owl's location outside of the improved pasture to its respective breeding burrow. Two shapefiles, one containing the location of each breeding burrow and one containing the locations of each owl outside of the improved pasture, were added to a layer in ArcMap 8.3. The measure tool in ArcMap 8.3 was then used to determine the dispersal distance.

Results

Attaching Transmitters

Between 4/17/04 and 4/18/04 a total of three adult female owls were captured and fitted with necklace transmitters. Behavioral observations over a three day period (4/18/04 – 4/20/04) showed that the three adult female owls constantly attempted to remove the transmitters. The adult owls never acclimated to wearing necklace radio transmitters and a decision was made to remove the transmitters from adults and only attach transmitters to juvenile burrowing owls. On 4/26/04 two of the adult burrowing owls had stretched the elastic necklace and bit through the spliced cotton string. One transmitter was located approximately 60 meters from the owl's main burrow. The other transmitter was located on the burrow mound of the pair's main burrow. The third owl was captured using noose carpet traps on 4/30/04 and the transmitter was removed.

Table 1 describes the seven juvenile burrowing owls captured and fitted with necklace radio transmitters. Owl number one was captured and fitted with a second radio transmitter due to a transmitter malfunction.

Table 1. Juvenile burrowing owls fitted with necklace radio transmitters.

Owl	Frequency (MHz)	Date Attached	Sex	Weight (G)
1	151.755 (1st) 151.690 (2nd)	6/6/2004 6/22/2004	Female	131 (1st) 111 (2nd)
2	151.735	6/6/2004	Unknown	117
3	151.570	6/10/2004	Male	127
4	151.665	6/21/2004	Unknown	129
5	151.530	7/3/2004	Unknown	119
6	151.470	7/12/2004	Unknown	110
7	151.610	7/22/2004	Unknown	139

Home Range in Breeding Habitat

Hawks possibly killed three juvenile burrowing owls wearing transmitters. The remains of two juvenile owls, a pile of feathers and the transmitter, were located in the improved pasture on 6/21/04 and 7/22/04. The remains of the third juvenile owl, a pile of feathers and the transmitter, were located on 6/20/2004 outside of the improved pasture. The remains were found 366 meters from the owl's main burrow in a small clearing within a patch of saw palmetto. One juvenile owl, not wearing a transmitter, was found dead and covered with fire ants (*Solenopsis invicta*) in the entrance of a burrow. The cause of death was unknown.

The remaining four juvenile burrowing owls were successfully relocated for 41 out of the 56 days radio telemetry was attempted. Radio telemetry ceased for two days due to lightening and for 13 days because two stream crossings were flooded. Table 2 describes the kernel home range estimate for the four remaining juvenile burrowing owls in breeding habitat. A graphic of the kernel home range estimate for each owl is displayed in the following figures: Freq. 151.470 MHz (Figure 4), Freq. 151.530 MHz (Figure 5), Freq. 151.665 MHz (Figure 6), and Freq. 151.690 MHz (Figure 7).

Table 2. Kernel home range estimates in breeding habitat.

Frequency (MHz)	Relocations	95% Kernel Home Range (M^2)	75% Kernel Home Range (M^2)	50% Kernel Home Range (M^2)
151.470	8	176.93	122.57	79.24
151.530	13	185.50	110.10	70.26
151.665	22	104.60	64.44	44.83
151.690	22	97.65	59.86	37.82
		Average =141.17	Average = 89.24	Average = 58.04

Figure 4: Kernel home range estimate for frequency 151.470 MHz

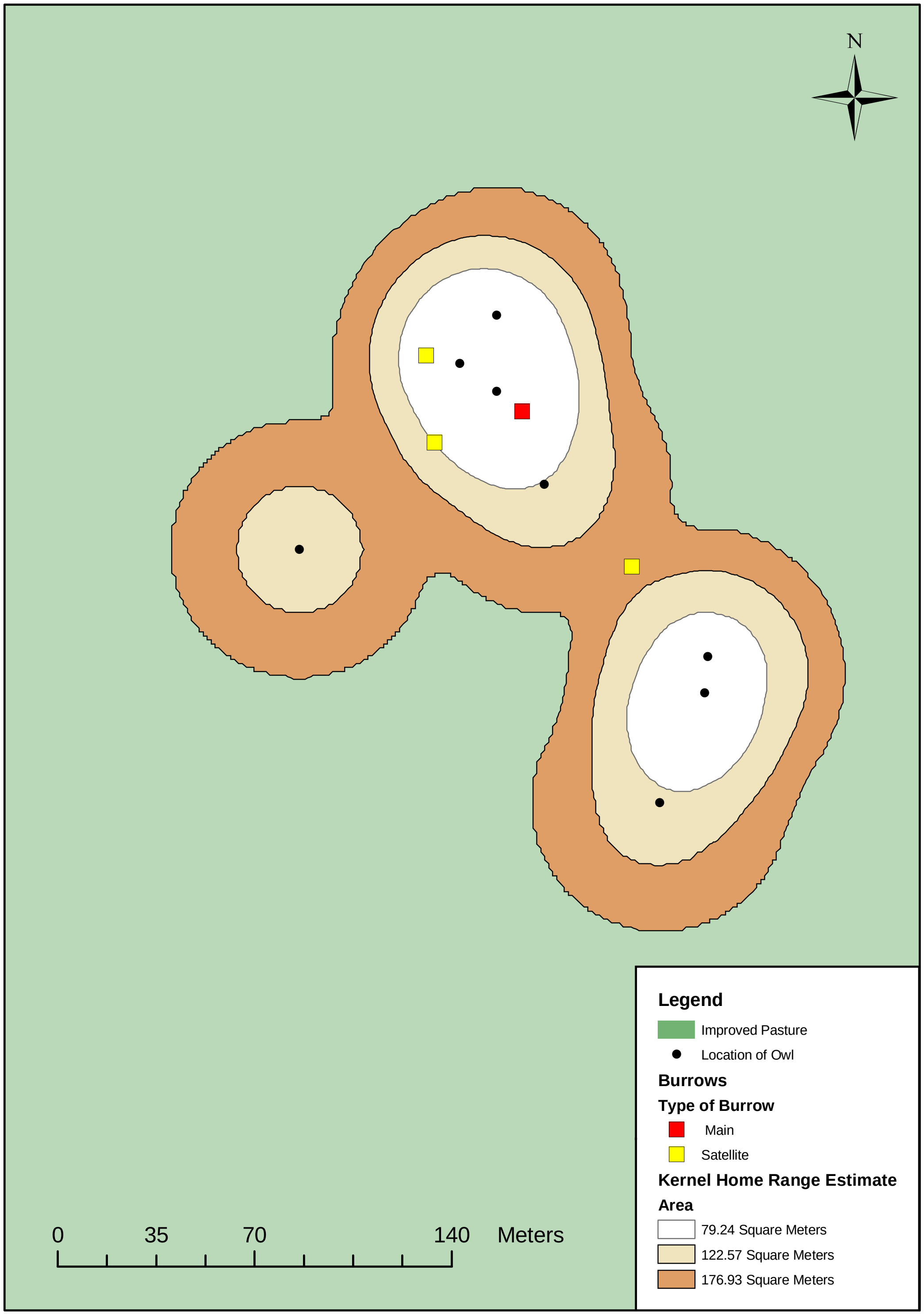


Figure 5: Kernel home range estimate for frequency 151.530 MHz

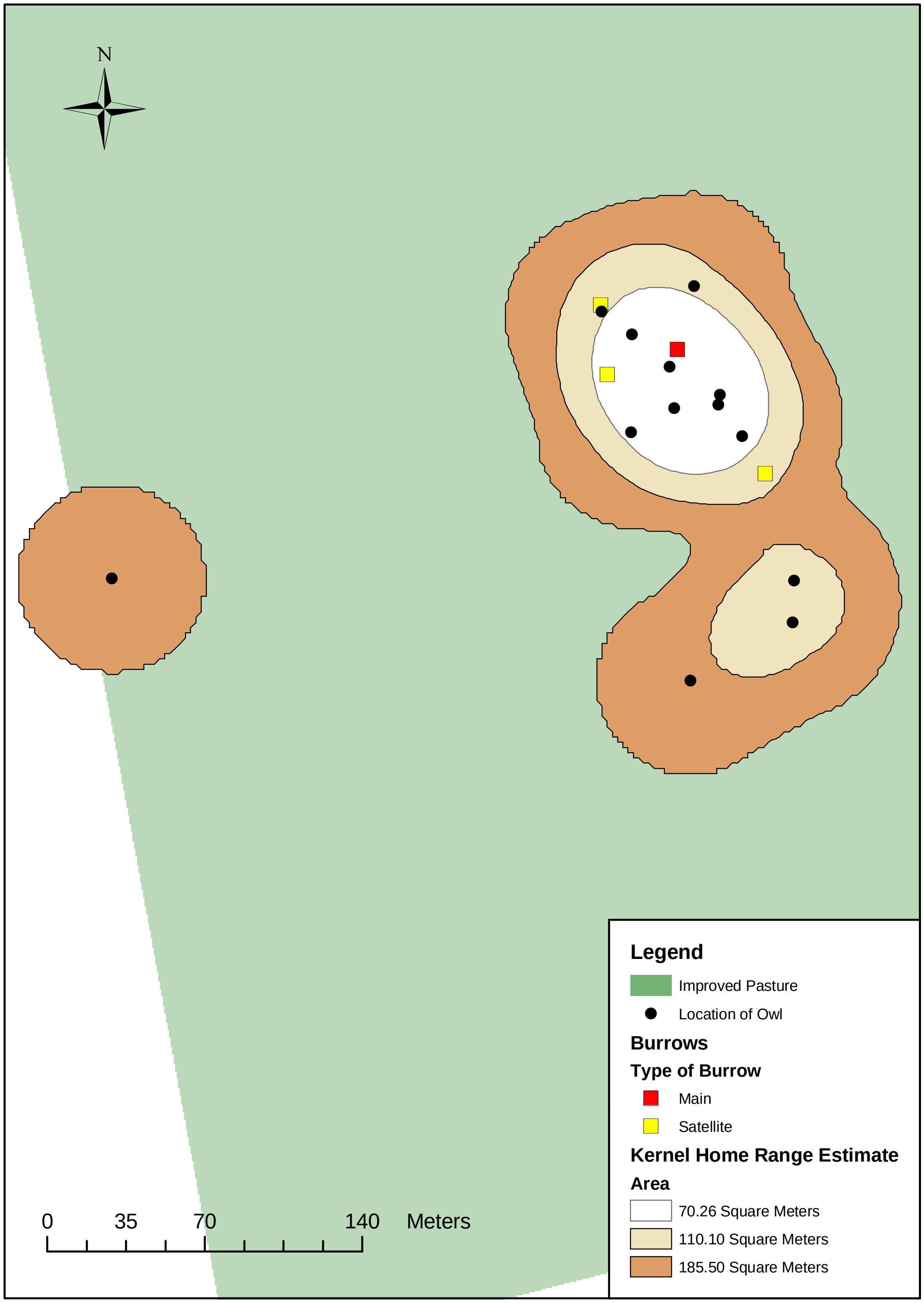


Figure 6: Kernel home range estimate for frequency 151.665 MHz

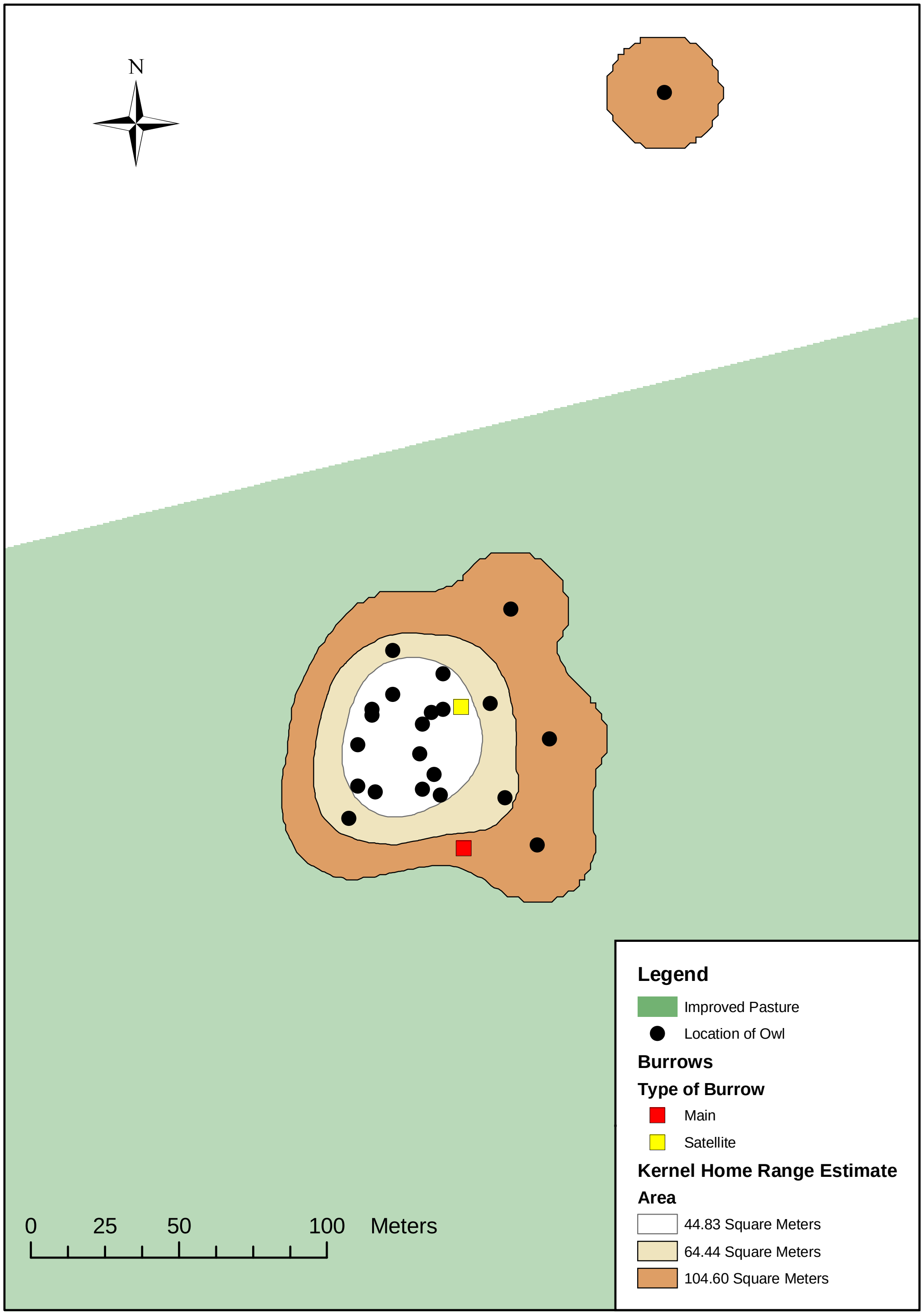
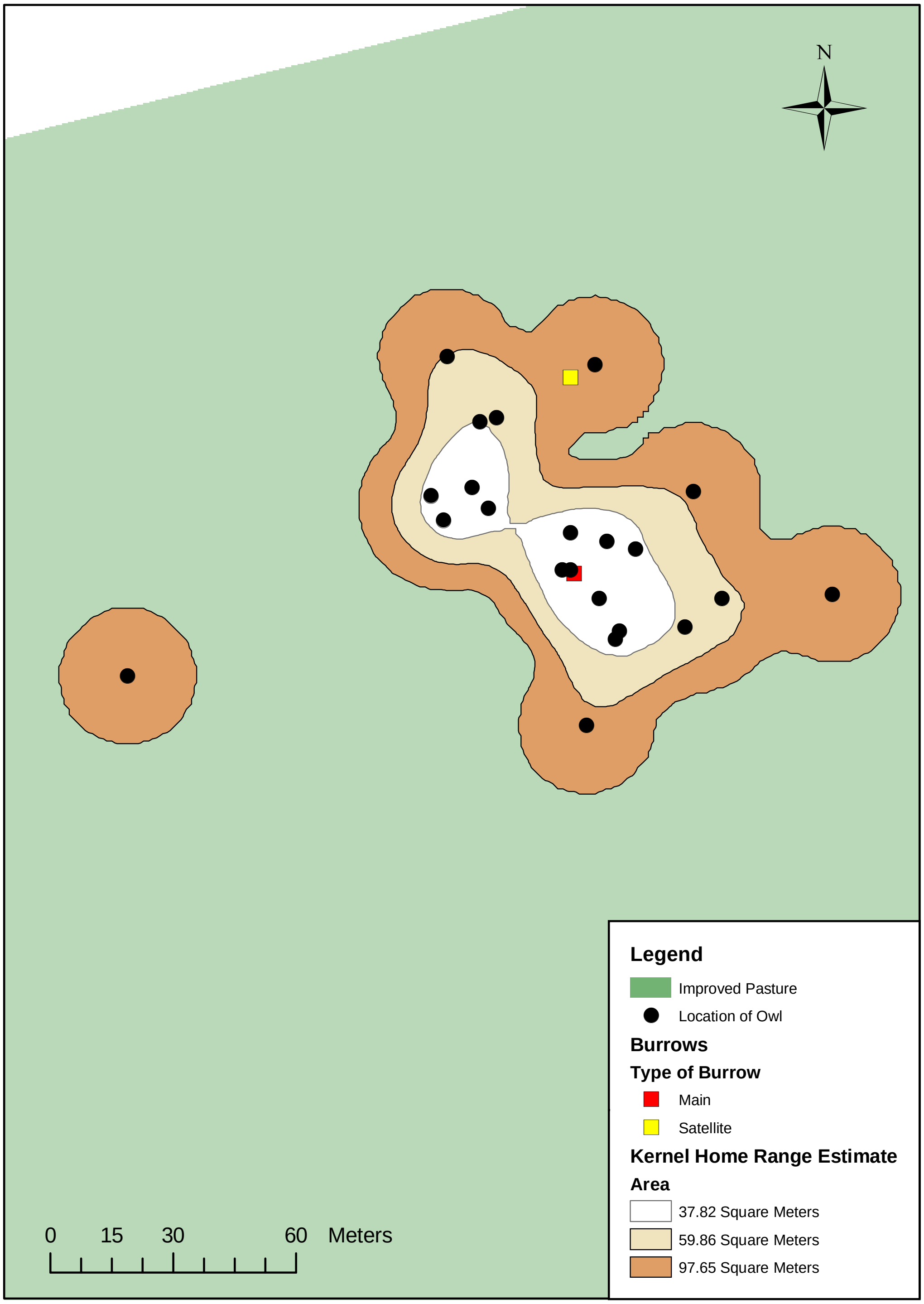


Figure 7: Kernel home range estimate for frequency 151.690 MHz



From 8/1/02 to 8/2/02 hourly relocations were conducted on the four juvenile burrowing owls from 9pm – 5am. Table 3 describes the results of the evening telemetry session. Each juvenile burrowing owl was extremely active in the evening. No signals were located in the pasture after 10 pm. Signals, when located outside of the improved pasture, were faint and brief making it difficult to triangulate the position of any owl. After midnight, no signals were located in the improved pasture or from the trails surrounding the improved pasture.

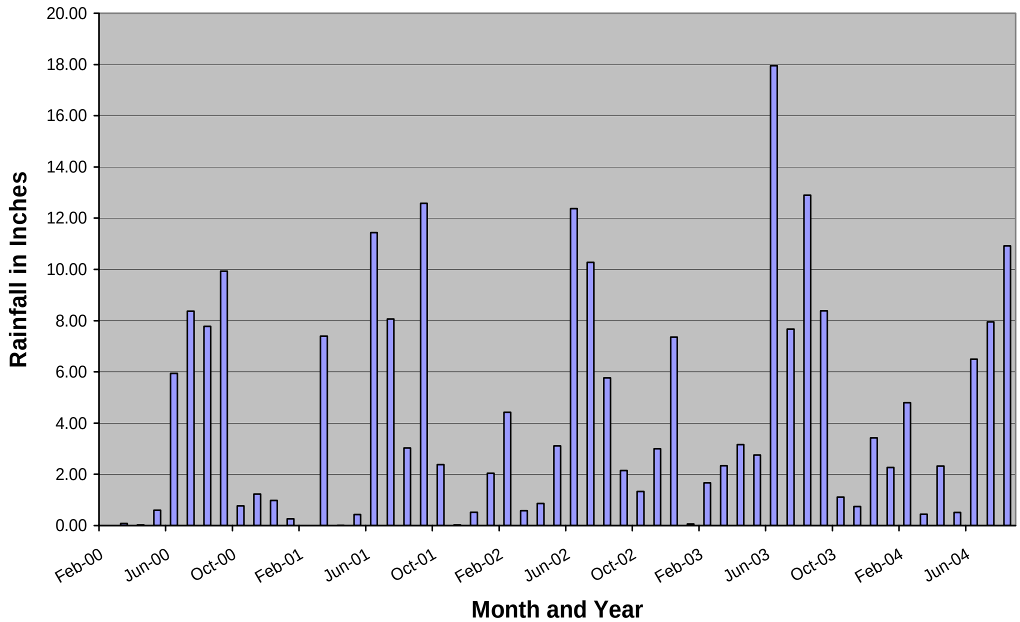
Table 3. Evening relocations of juvenile burrowing owls.

Time	Frequency Relocated (MHz)	Notes
9 pm	151.665, 151.690	Both located near their main burrow in pasture
10 pm		No owls relocated
11 pm	151.665	Located outside of pasture 264 meters from main burrow
12 pm		No owls relocated
1 am		No owls relocated
2 am		No owls relocated
3 am		No owls relocated
4 am		No owls relocated
5am		No owls relocated

Flooding of Breeding Habitat

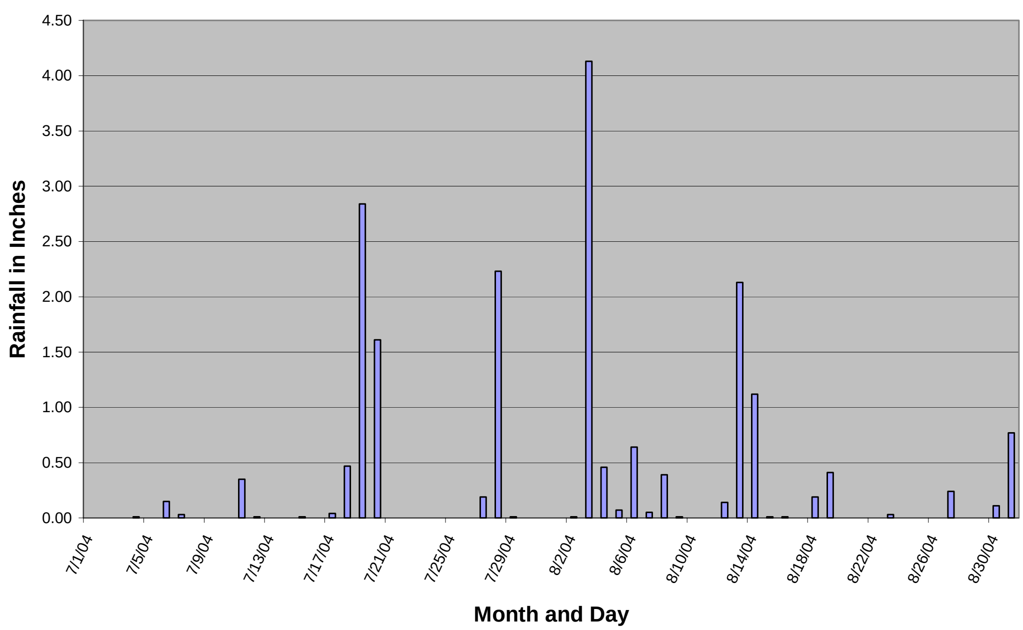
Daily rainfall data was collected from a Southwest Florida Water Management District rainfall station, site number 528, located approximately 5.8 kilometers from Rutland Ranch. Monthly rainfall data recorded at site number 528 from 2000-2004, as shown in Figure 8, displays the June to October rainy season in Florida.

Figure 8: Monthly rainfall amounts for station 528 from 2000-2004



The daily rainfall, during July and August, recorded at site number 528 in 2004 is displayed in Figure 9. On 8/6/04 all burrows, except for a main and satellite burrow located in the highest elevated area of the pasture, were flooded.

Figure 9: Daily rainfall at station 528 for July and August of 2004



Dispersal and Post-Breeding Home Range

Burrowing owls began dispersing from the improved pasture on 8/6/04. Three out of four juveniles were relocated outside of the pasture on this date. The only juvenile owl relocated in the pasture on this date, frequency 151.665 MHz, was found near one of the non-flooded burrows from which it was born. This juvenile owl finally dispersed from the pasture on 8/17/04. On this date, surface water was found on all areas of the improved pasture.

By 9/30/04 all four juvenile owls could not be located within Rutland Ranch nor from the road network surrounding the property. Aerial telemetry was conducted on 10/5/04 to locate the missing owls. The only owl located during aerial telemetry was frequency 151.470 MHz. The pulse rate of the transmitter had slowed from 50 beats per minute to roughly 10 beats per minute. The owl was located 10.83 kilometers southeast of Rutland Ranch.

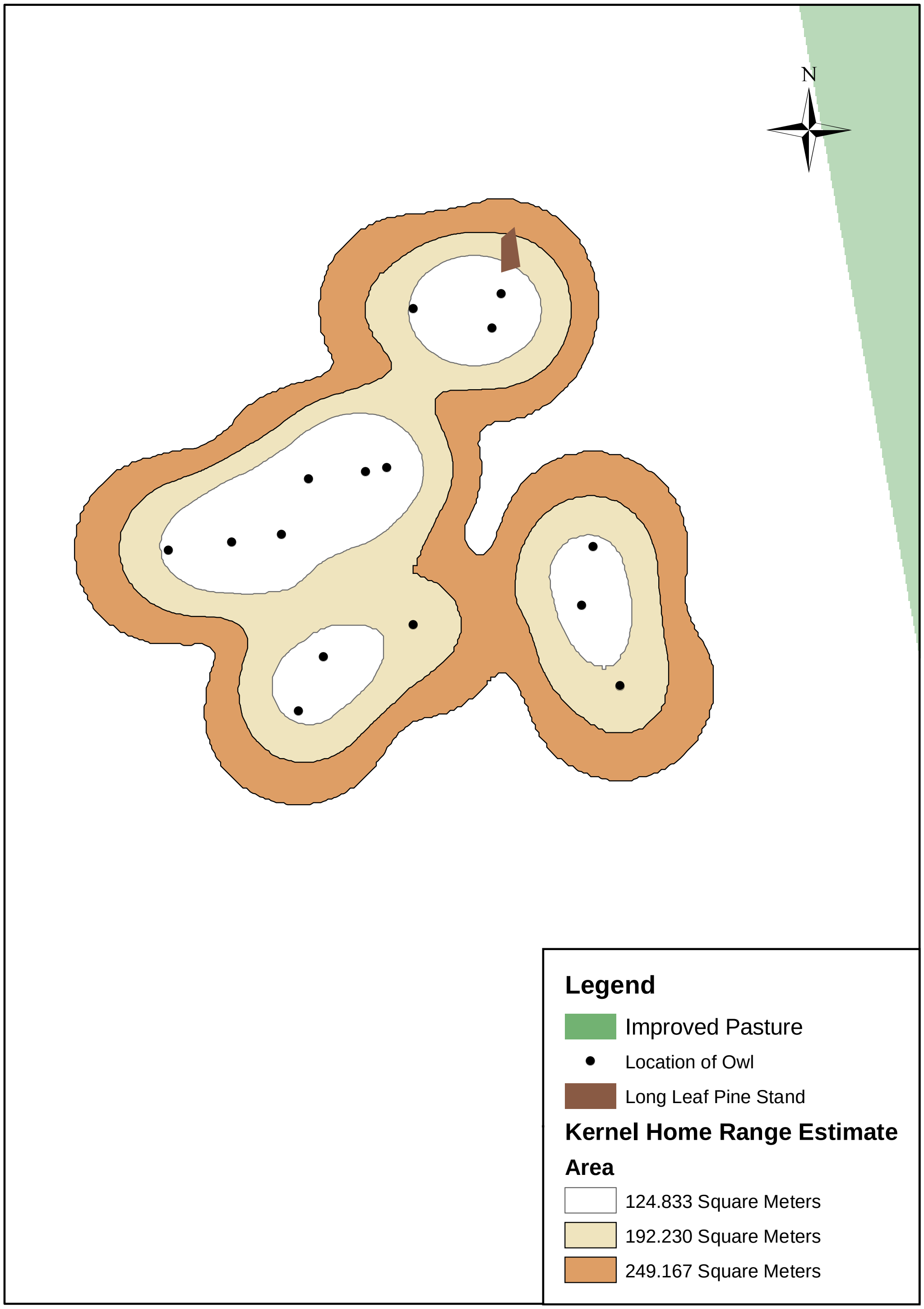
The area where the owl was located is composed of predominantly scrub oak (Gordon 2004, personal communication). Dispersal distance for each juvenile owl is shown in Table 4.

Table 4. Dispersal distance of juvenile burrowing owls.

Frequency (MHz)	Dates Located	Relocations	Min. Distance from Main Burrow (M)	Max. Distance from Main Burrow (M)
151.665	8/17/04	1	366	366
151.470	8/6/04 – 8/9/04	3	407	10,083
151.690	8/6/04 – 8/17/04	7	236	337
151.530	8/6/04 – 9/24/04	15	466	679

Due to the small number of post-breeding relocations for each burrowing owl the kernel home range estimate during the post-breeding period was only calculated for the owl wearing frequency 151.530 MHz. The 95% kernel home range estimate equaled 249.17 m^2, the 75% kernel home range estimate equaled 192.230 m^2, and the 50% kernel home range estimate equaled 124.83 m^2. A graphic of the kernel home range estimate for this owl is displayed in Figure 10.

Figure 10: Kernel home range estimate for frequency 151.530



Discussion

The early observations of burrowing owls in breeding habitat during the late 1800's indicate that small nomadic colonies may have been common. Post-breeding dispersal may have allowed burrowing owls to colonize breeding habitat created each year by fire and flooding. These small colonies may have persisted due to immigration and emigration. A previous population viability analysis indicating high probabilities of extirpation for small populations was modeled after the available data collected on burrowing owls from Cape Coral, Florida (Bowen 2000). This population viability analysis did not include immigration and emigration (Bowen 2004, personal communication), thus possibly elevating extinction rates.

The improved pasture at Rutland Ranch is burned yearly in January to create suitable breeding habitat for burrowing owls (VanGelder 2003, personal communication). Ten pairs of adult burrowing owls were located within the improved pasture in 2001 (Barnwell et al. 2003) and in the spring and summer of 2003 ten pairs of adult burrowing owls were located at Rutland Ranch (personal observation). In 2004, five pairs of adult burrowing owls were located in the pasture and only three of these pairs fledged young. It is unknown if the smaller adult population in 2004 is due to low immigration, high predation, or low territory fidelity.

The location of burrows in the pasture as shown in Figure 2 suggests that adult owls may have selectively excavated burrows in the higher elevated areas of the pasture. During the first survey for burrows on 3/26/04 the areas of lowest elevation within the pasture did not contain surface water. These findings concur with Hoxie (1889), Scott (1892) and Palmer (1896) who located burrows in the highest elevated areas of pasture. Unfortunately, neither water table data nor potentiometric surface maps for the Floridan Aquifer, Intermediate Aquifer, and Tamiami - Upper Hawthorne Aquifer were available for the improved pasture during the first survey in March of 2004. A high water table, evenly distributed under the improved pasture, could further support the hypothesis that burrowing owls were selectively excavating burrows in the higher areas of the improved pastures. Alternatively, the distribution of burrows during the 2004 breeding season may be due to the colonial nature of burrowing owls. More research needs to be conducted to understand the distribution of burrows in rural breeding habitat.

Vegetation, especially dog fennel (*Eupatorium capillifolium*), grew quickly after the January burn in 2003. By the time the majority of burrows had been excavated in March of 2004, large patches of dog fennel surrounded the main and satellite burrows of two pairs of adult burrowing owls. Both of these pairs successfully fledged young.

The areas of thick vegetation may make the burrowing owls susceptible to predation by hawks. On two occasions, an unidentified hawk was flushed from the ground within a large patch of dog fennel that grew roughly within 50 meters of the main burrows for two burrowing owl pairs. During the second of these sighting, 7/29/04, a hawk flew up from within the patch of dog fennel, caught an owl in the air with its talons, and both owl and hawk tumbled to the ground. The owl escaped and survived the encounter with the hawk. On 5/21/04 an adult and juvenile red-tailed hawk (*Buteo jamaicensis*) were seen hunting along the fence line surrounding the improved pasture.

Other unknown predators also preyed upon burrowing owls in the improved pasture. On 4/18/2004, the main burrow for one pair of adult burrowing owls was completely excavated. There was no sign of the adults and no burrowing owl remains were located. The satellite burrow for another pair of adult burrowing owls was completely excavated on 6/2/04. The banded adult female and the male were located two weeks later at a new burrow approximately 100 meters from their previously excavated burrow.

In an attempt to document potential predators of burrowing owls during breeding season, a CamTrakker® infrared camera was setup approximately 25 meters from the main burrow of one burrowing owl pair. After three days of monitoring, the only animal documented by the infrared camera was a raccoon (*Procyon lotor*). Other wildlife seen in the pasture include whitetail deer (*Odocoileus virginianus*), feral hogs (*Sus scrofa*), armadillo (*Dasypus novemcinctus*), coachwip snake (*Masticophis flagellum*), eastern diamondback rattlesnake (*Crotalus adamanteus*), and black racer (*Coluber constrictor*). Wildlife seen outside of the pasture includes coyote (*Canis latrans*), bobcat (*Lynx rufus*), and American alligator (*Alligator mississippiensis*).

In the daytime relocated juvenile burrowing owls were consistently located within the vicinity of the main or satellite burrow during the breeding period. After the young are able to fly they are dependent upon the main or satellite burrows for up to 60 days (Mealey 1997). The home range estimates of juvenile burrowing owls in the breeding habitat indicates that the juvenile owls were extremely dependent on the main and satellite burrows.

The null hypothesis that post-breeding home range for adult burrowing owls would not be significantly different in size from breeding home range could not be tested in this study. Adult burrowing owls never acclimated to wearing necklace radio transmitters. In a personal communication after completion of my fieldwork it was noted that adult Western burrowing owls also never acclimated to wearing necklace radio transmitters (Gervais 2004).

After two to three days juvenile burrowing owls acclimated to wearing the necklace radio transmitters. The home range estimates for juvenile burrowing owls may be overestimated due to the small number of relocations per owl. Seaman et al. (1999) recommend that a minimum of 30 locations are required to get an accurate home range estimate using the kernel method. The inaccessibility of the improved pasture due to stream flooding during the rainy season reduced the number of opportunities in which to relocate juvenile owls. In hindsight, more than one relocation per day for each burrowing owl would have increased the sample size.

The difficulty in locating burrowing owls in breeding habitat during the evening telemetry session suggests that the juvenile owls avoided the improved pasture at night. During the evening, there were several brief and faint relocations of juvenile owls outside of the pasture, but a location could only be estimated for one juvenile owl.

Dispersal from breeding habitat coincided with the flooding of the pasture and burrows beginning on 8/6/04. Once an owl dispersed it was never again relocated in the improved pasture, even after the pasture had dried due to evapotranspiration, infiltration, and surface runoff. During the daytime juvenile burrowing owls utilized dissimilar habitat from the improved pasture. Three out of four juvenile owls were found utilizing the extensive saw palmetto patch surrounding the pasture for 3-11 days before dispersing beyond the range of the receiver. One of these juvenile owls also utilized several live oak trees growing near the improved pasture. A Florida scrub jay (*Aphelocoma coerulescens*) also utilized these live oak trees. The fourth juvenile owl spent 18 days in the extensive saw palmetto patch before dispersing beyond the range of the receiver. There was no noticeable change in pulse rate (beats per minute) for any transmitters before the owls dispersed beyond the range of the receiver. A decrease in pulse rate would infer that the transmitter battery would soon fail. The different habitat preference for juvenile burrowing owls during the breeding and post-breeding period refutes the null hypothesis that breeding habitat would not be comparatively different from post-breeding habitat.

The large areas of private land surrounding Rutland Ranch coupled with the limited access to these properties made it difficult to locate burrowing owls from the surrounding road network. Aerial telemetry assisted in locating only one out of four juvenile burrowing owls. This may have been due to possible battery failure for the other three radio transmitters. The burrowing owl successfully located was the last bird on which a transmitter was attached. The drastic reduction in beats per minute for this transmitter indicated that the battery would soon fail.

The use of feathers for DNA PCR analysis was not successful in determining the sex of juvenile burrowing owls. This may have due to an inadequate amount of tissue within the calamus, the portion of the feather in the skin after the feather was pulled from the chest area.

The wearing of radio transmitters may have had an effect on burrowing owls in this study. Only one owl wearing a transmitter was recaptured and weighed a second time. This owl lost 20 grams in sixteen days. More research is needed in order to determine if weight loss was due to the effect of wearing a transmitter, the juveniles beginning to forage on their own, less food being given to juveniles from adults, or other unknown factors.

This research was the first documentation of burrowing owl ecology in a rural environment. The small sample size in this study only provides a partial clue to the ecology of burrowing owls in rural areas. There is still much to learn about this subspecies, especially habitat requirements after burrowing owls have dispersed from breeding habitat. For example, it is not known if burrowing owls utilize specific habitats or a variety of habitats during dispersal and the post-breeding period. Determining habitat requirements is particularly important because of the past and current loss of habitat in Florida due to development and agriculture. Florida's population is the third fastest growing in the nation (U.S. Census Bureau 2004) and a variety of habitats are being lost such as upland forests (Sprott and Mazzotti 2001), scrub oak (Myers 1990), and prairie habitat (Abrahamson and Hartnett 1990).

The burrowing owl has been listed as a Species of Special Concern since 1979 by the Florida Fish and Wildlife Conservation Commission (Millsap 1997) and also as a Bird of Conservation Concern by the U.S. Fish and Wildlife Service (Klute et al. 2003). Without conservation and management it may be listed as a threatened species because of vulnerability to habitat modification, environmental alteration, human disturbance, or human exploitation (Florida Fish and Wildlife Conservation Commission 2004). A greater understanding of burrowing owl ecology in rural environments is required in order to determine management and conservation strategies for this subspecies in Florida.

Comparison of Diet and Potential Prey for Rural and Urban Burrowing Owls During the Breeding Period

Introduction

Management and conservation of a species requires understanding its habitat and food requirements, which can vary over space and time (Litvaitis et al. 1996). For example demographic information, prey preference, and habitat requirements of a species collected from research on a small spatial scale may not extrapolate to a larger spatial scale (DeSante and Rosenberg 1998). Further, a shift in the geographic distribution of a species over time, such as from historically rural to urban areas, can affect a species food use, size of territory, exposure to predators, social structure, and basic demographic factors (McGowan 2001). Therefore, research from a variety of disciplines, geographic areas, and temporal scales may be required in order to understand the ecology of a species (Marzluff and Salabanks 1998).

Previous detailed studies have documented the prey preference of burrowing owls such as Lewis's (1973) analysis of tabulated records of stomach contents from 1907-1929, Hennemann's (1980) research at an industrial park, and Wesemann's (1986) analysis in an urban area. These studies have shown that the most frequent prey of burrowing owls is insects (Lewis 1973, Wesemann 1986). Documentation of prey preference for burrowing owls in rural areas has been mostly observational (Ridgeway 1874, Cahoon 1885, Hoxie 1889, Rhoades 1892, Palmer 1896, Bent 1938, Sprunt 1954), but also suggests that insects are a major prey item.

Prey of burrowing owls, other than insects, found in urban and industrial areas includes crayfish (*Procambarus alleni*), least tern (*Sterna antillarum*), cotton rats (*Sigmodon hispidus*), rosy wolf snail (*Euglandia rosea*), marsh crab (*Sesarma reticulatum*), Cuban tree frog (*Osteopilus septentrionalis*), southern toad (*Bufo terrestris*), eastern spadefoot toad (*Scaphiopus holbrooki*), and mammals from the Genus Peromyscus and Sylvilagus (Owre 1978, Hennemann 1980, Wesemann 1986). Prey remains other than insects found in rural environments include savannah sparrow (*Passerculus sandwichensis*), bobolink (*Dolichonyx oryzivorus*), and unknown species of rodents, crayfish, snakes, frogs, and minnows (Rhoads 1892, Bent 1938, Nicholson 1954).

Various methods have been used to document the diet of burrowing owls in Florida including: analysis of stomach contents (Palmer 1896, Bent 1938, Lewis 1973), regurgitated pellets (Hoxie 1889, Palmer 1896, Neill 1954, Hennemann 1980, Wesemann 1986), and uneaten prey remains found near burrows (Bent 1938, Neill 1954, Nicholson 1954, Owre 1978, Hennemann 1980, Wesemann 1986).

Each method on its own may not accurately represent the prey preference of burrowing owls. Prey remains found in regurgitated owl pellets have been used to identify individual prey (Errington 1930, Neill 1954, Hennemann 1980, Wesemann 1986). This method may not accurately represent an owl's diet because skeletal material of large prey may not be consumed (Thompson 1971). Other methods, such as visual observation of predation (Grant 1965), should be used to gain further information on a species diet.

The purpose of this study was to compare the diet and potential prey of burrowing owls in a rural environment and an urban environment. Due to lack of information on post-breeding habitat requirements of burrowing owls in Florida, the study area was limited solely to breeding habitat. In both rural and urban environments, I compared prey remains found in regurgitated pellets, richness of small mammals in breeding habitat, and richness of insects in breeding habitat.

Methods

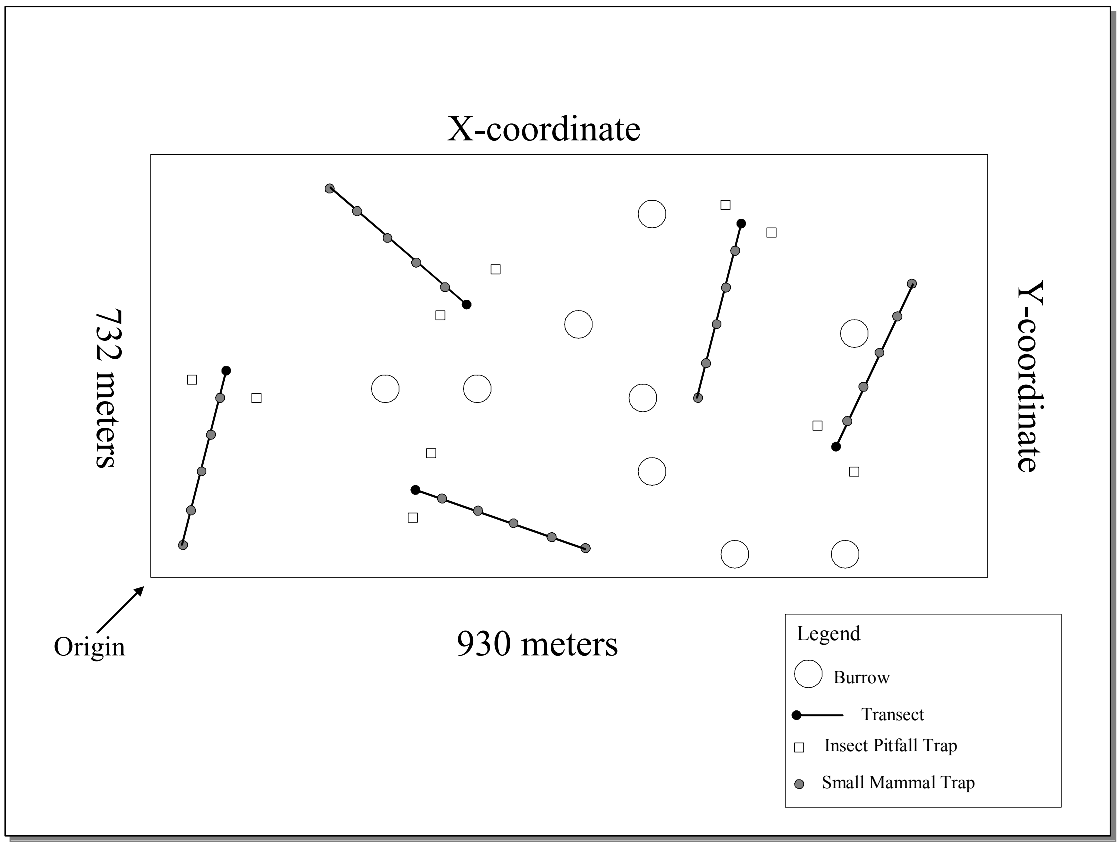
The study occurred on Marco Island and Rutland Ranch from October 2003 to October 2004. Marco Island is a large barrier island, 36.25 square kilometers in size, located off the southwest coast of Florida as shown in Figure 1. It has a permanent population of 15,000 residents and the winter population peaks at roughly 35,000 people (Marco Island City Hall 2003).

On Marco Island the vast majority of burrowing owls are found breeding on vacant housing lots. In 2004 there were approximately 1,080 vacant housing lots and 113 of these lots were occupied by a total of 171 adult burrowing owls. Only three pairs of owls were found breeding on property other than vacant housing lots. In 2005 burrowing owls occupied 83 vacant housing lots. Based on the rate of new home construction there will be no vacant housing lots on Marco Island by 2011 (Nancy Ritchie 2005, personal communication).

Sherman small mammal traps were utilized to compare the richness of small mammal species on Rutland Ranch and Marco Island. Five species of small rodents found in Florida may be potential prey of burrowing owls (Schmidly et al. 1999). One Sherman small mammal trap was placed every ten meters along each of the five transects fifty meters long. The baits for traps consisted of either a rolled oats/shelled peanuts or shelled peanuts (Patric 1970). An insecticide was sprayed on the ground in a two-meter circumference around each trap to deter loss of bait due to ants (Mitchell et al. 1996). Small mammal trapping was conducted every other month for a two-day period in both research areas. Traps were set at sunset and checked each morning. Each small mammal trapping session consisted of 50 trap nights: 25 traps x 2 trapping nights.

The five transects at Rutland Ranch were 50 meters in length and randomly placed in the rectangular improved pasture containing burrowing owls as shown in Figure 11. The placement of each transect was determined by the following procedure: One corner of the rectangular pasture, the southeast corner, was designated the origin. The two perpendicular sides of the rectangle emanating from the origin were designated X and Y. The X and Y sides were measured to the nearest meter and the starting point for each measurement was the southeast corner. The starting point for each transect was determined by using a random number table to generate two distances in meters, X and Y, from the southeast corner.

Figure11: Location of transects, pitfall traps, and small mammal traps within improved pasture at Rutland Ranch



The random number generated for the X distance represented the starting points distance north of the southeast origin. The random number generated for the Y distance represented the starting points distance west of the southeast origin. A random number table was then used to select a number from 1-360, which determined the compass bearing for the direction of each transects endpoint.

One transect was placed on one of five vacant lots on Marco Island containing burrowing owls. Every vacant lot containing burrowing owls was assigned a random number and a random number table was used to determine which lots would contain transects. Vacant lots on Marco Island are 80 X 100 feet or 80 X 110 feet in size (Nancy Ritchie 2005, personal communication). Due to small lot size, each fifty meter transect was divided into two perpendicular transects forming the shape of the letter "T". One transect was thirty meters in length and the other twenty meters.

Insect pitfall traps were placed in both research areas to compare the richness of insect species over time (Wesemann 1986). Two pitfall traps were placed 5 meters away from the starting point of each transect. A random number table was used to select the compass bearing for the direction of each pitfall trap. The pitfall traps were made of #10 size cans buried in the ground and level with the soil surface (Wesemann 1986). A few inches of water was placed in the bottom of the cans to stop insects from climbing out (Wesemann 1986). Pitfall traps were baited with either spoiled meat or fruit (Wesemann 1986). A covering made of Plexiglas and wire mesh was placed a few inches above each trap to deter rain and predators. Insect trapping was conducted every other month for a two-day period. Traps were checked each morning and captured insects were removed. Each insect trapping session consisted of 20 trap nights: 10 traps x 2 trapping nights. Insects were identified to the Family level.

Regurgitated pellets were collected every other month in both the rural and urban breeding habitat. I searched for pellets within a radius of several meters of five randomly selected burrows on both Marco Island and Rutland Ranch. Each pellet was stored in a paper envelope labeled with the date and location. A dissecting microscope was used to identify insects based on the remains of body parts found in pellets. The mandibles, heads, elytra, legs, and forceps were examined to identify and count insects and arthropods to the level Family in each pellet (Gleason and Craig 1979, Wesemann 1986). Researchers from the Florida State Collection of Arthropods assisted in classifying insect and arachnid remains within pellets (Paul Skelley 2004, personal communication). Bones and or bone fragments in pellets were classified with the assistance of the Florida Museum of Natural History (Candace McCaffery 2004, personal communication).

Results

No small mammals were captured in the small mammal traps during the 300 trap nights at either research area. Insect pitfall traps were set in both research areas for a total of 120 trap nights.

The prey captured in the Marco Island pitfall traps consisted of five orders of insects and one order of spiders (Table 5). The largest numbers of insects caught were from the family Gryllidae. Eighteen organisms were captured in the insect pitfall traps.

The prey captured in the Rutland Ranch pitfall traps consisted of four families of insects and one family of spiders (Table 6). The largest numbers of insects caught were from the family Gryllidae. Sixty-six organisms were captured in the insect pitfall traps.

Table 5. Organisms captured in pitfall traps at Marco Island.

Class	Order	Family	Quantity
Insecta	Orthoptera	Gryllidae	6
Insecta	Coleoptera	Carabidae	5
Insecta	Diptera		4
Insecta	Hemiptera	Cicadellidae	1
Insecta	Hemiptera	Gelastocoridae	1
Arachnida	Araneae	Clubionidae	1

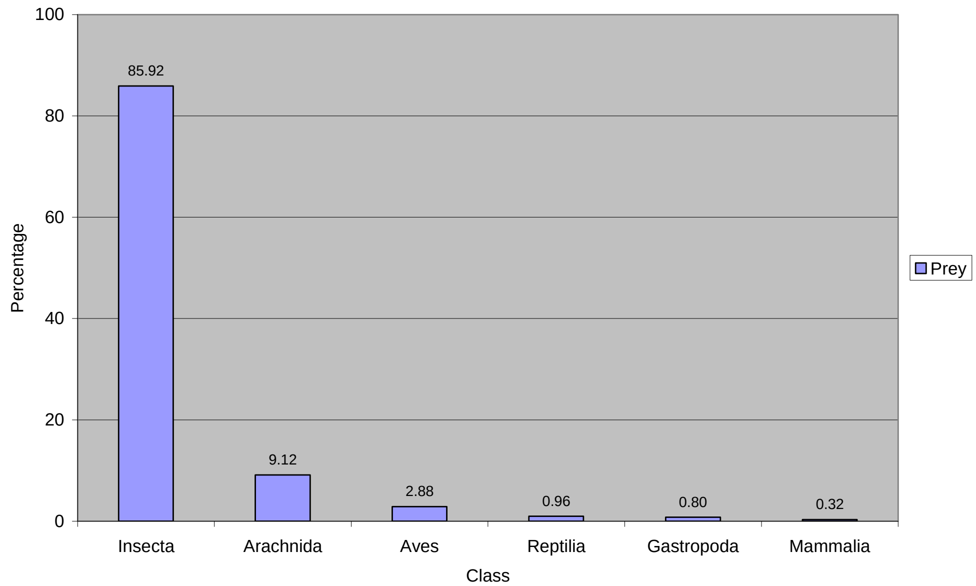
Table 6. Organisms captured in pitfall traps at Rutland Ranch.

Class	Order	Family	Quantity
Insecta	Orthoptera	Gryllidae	29
Arachnida	Araneae	Clubionidae	24
Insecta	Coleoptera	Carabidae	7
Insecta	Orthoptera	Acrididae	4
Insecta	Orthoptera	Tettigoniidae	2

The analysis of the 55 pellets collected on Marco Island is displayed in Table 7 while Table 8 displays the analysis of 31 pellets collected at Rutland Ranch. A graph of the percentage of prey found within all the pellets, organized by class for each research area, is shown in Figure 12.

Figure 12: Prey remains in pellets from Marco Island and Rutland Ranch

Prey remains in pellets from Marco Island



Prey remains in pellets from Rutland Ranch

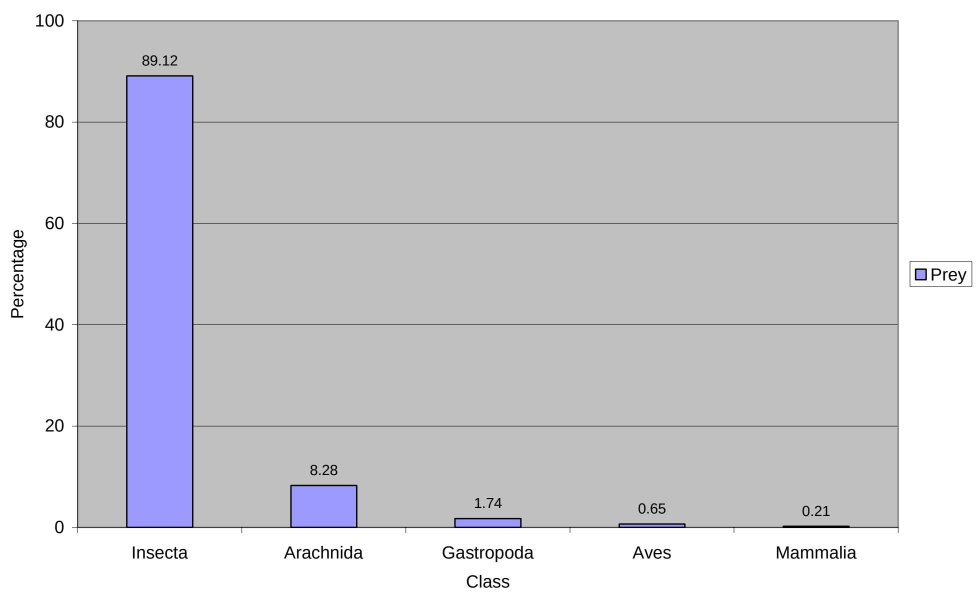


Table 7. Marco Island: Analysis of pellets and remains found on burrows.

Prey Remains in Pellets

Class	Order	Family	Total	Percentage
Insecta	Coleoptera	Scarabaeidae	250	40.00
Insecta	Orthoptera	Gryllidae	196	31.36
Insecta	Dermaptera		58	9.28
Insecta	Orthoptera	Acrididae	23	3.68
Insecta	Coleoptera	Carabidae	5	0.80
Insecta	Coleoptera	Curculionidae	5	0.80
Arachnida	Araneae	Clubionidae	57	9.12
Aves			18	2.88
Reptilia	Squamata	Polychrotidae	6	0.96
Gastropoda	Stylommatophora	Spiraxidae	5	0.80
Mammalia	Rodentia	Muridae	2	0.32
			625	100

Prey Remains Found on Burrow Mound

Class	Order	Family	Total
Aves			2
Mammalia	Rodentia	Muridae	2
Reptilia	Squamata		1
Amphibia	Anura	Hylidae	1

Table 8. Rutland Ranch: Analysis of pellets and remains found on burrows.

Prey Remains in Pellets

Class	Order	Family	Total	Percentage
Insecta	Coleoptera	Scarabaeidae	146	31.81
Insecta	Dermaptera		127	27.67
Insecta	Orthoptera	Acrididae	48	10.46
Insecta	Orthoptera	Gryllidae	47	10.24
Insecta	Coleoptera	Carabidae	19	4.14
Insecta	Coleoptera	Curculionidae	11	2.40
Insecta	Hemiptera	Reduviidae	7	1.53
Insecta	Coleoptera	Cerambycidae	4	0.87
Arachnida	Araneae	Clubionidae	38	8.28
Gastropoda	Stylommatophora	Spiraxidae	8	1.74
Aves			3	0.65
Mammalia	Rodentia		1	0.21
			459	100

Prey Remains Found on Burrow Mound

Class	Order	Family	Total
Insecta	Coleoptera	Scarabaeidae	4
Insecta	Orthoptera	Acrididae	3
Insecta	Coleoptera	Carabidae	1
Insecta	Lepidoptera		1
Reptilia	Squamata	Polychrotidae	1

Discussion

Insect Pitfall Traps

The insect pitfall traps on Marco Island captured very few insects. This may be due to the short trapping period (2 nights every other month), small number of insect pitfall traps, the short life cycle of some insect species (Arnett 2000), and or possibly low number of insects species found within the vacant lots. A far greater number of insects were seen on breeding habitat at Rutland Ranch than at Marco Island, but this may be due to more field time spent at Rutland Ranch.

A greater number of insects were caught in pitfall traps on Rutland Ranch than Marco Island, but pitfall trapping did not give an accurate representation of the potential prey of burrowing owls. For example, no insects from the family Scarabaeidae were caught in pitfall traps, but insects from this family were the most frequent prey found in regurgitated pellets. Pitfall traps have previously proven successful in capturing insects from this family (Goehring et al. 2002). The poor representation of prey items captured in pitfall traps may be due to burrowing owls feeding outside of the improved pasture in the evening. A greater variety of insects may have been captured if pitfall traps had been placed in any of the habitats surrounding the improved pasture.

Small Mammal Traps

There are a number of possible reasons why no small mammals were caught in the small mammal traps. First, a longer trapping period might have given small mammals a greater opportunity to discover the baited traps. Second, the bait of shelled peanuts and or shelled peanuts and rolled oats combination may have been ineffective. Peanut butter, used in previous small mammal trapping studies (Patric 1970, Woodman et al. 1996), may be more aromatic than peanuts and thus a better attractant. Third, small mammals may not be commonly located on either the vacant lots or improved pasture.

Burrow Mound

The collection of prey remains found on burrow mounds further elucidated the diet of burrowing owls on Marco Island. Prey remains included Cuban Tree Frog (*Osteopilus septentrionalis*), Cotton Rat (*Sigmodon hispidus*), bird bones, and the remains of a snake, rodent, and frog, which were too decomposed to classify. The prey remains found on burrows mounds at Rutland Ranch consisted of insects and in one instance the bones of an Anole.

Pellet Analysis

The analysis of pellets from Marco Island indicates that insects were the most frequent prey item. Interestingly, arachnids and birds were two other frequent prey items of burrowing owls. Hennemann (1980) and Wesemann (1986) reported finding birds as prey, but not as frequently as in this study.

Only six pellets on Marco Island contained the remains of Anolis (genus). Previous pellet analysis on Cape Coral, Florida found a higher percentage of Anolis remains within pellets (Wesemann 1986). The differing results between the two studies may be due to different sample sizes and sampling periods. In the Cape Coral study 70 pellets were collected in December of 2004 and May of 1985 (Wesemann 1986) versus 55 pellets collected on Marco Island from October 2003 – October 2004.

The pellet analysis results from Rutland Ranch indicate that insects were the most frequent prey item. Another frequent prey item were arachnids, which were commonly seen in the pasture (personal observation). One insect family, Cerambycidae, provides a clue to the foraging patterns of burrowing owls in rural environments. Insects from this family are woodborers and are not commonly located in pastures (Paul Skelley 2004, personal communication).

At Rutland Ranch adult male and female burrowing owls were seen hunting in the improved pasture in the daytime. The most frequent prey items were insects. On 5/6/04, an adult male burrowing owl brought a rodent (species not known) to an adult female. Burrowing owls were never seen preying on birds although several bird species were commonly seen in the pasture such as Mourning Dove (*Zenaida macroura*) and Eastern Meadowlark (*Sturnella magna*).

Although there was not a large difference in the percentage of insects found in pellets at both research areas, 85 % on Marco Island versus 89 % at Rutland Ranch, a greater variety of insects was discovered in the pellets from Rutland Ranch. The pellets from Rutland Ranch contained insects from one Order and seven Families while the pellets from Marco Island contained insects from one Order and five Families. Burrowing owls in homogeneous urban environments may be supplementing their diet with anoles (Wesemann 1986) or birds because of the reduced availability of insects.

These results suggest that a heterogeneous rural environment may present a greater opportunity for burrowing owls to feed on insect prey than a homogeneous urban environment. The improved pasture at Rutland Ranch is composed of various grasses and herbaceous vegetation. Rutland Ranch also contains pine flatwoods, oak scrub, riparian hardwoods, and herbaceous marshes (Barnwell et al. 2003). The urban environment of Marco Island is composed of either vacant housing lots that are routinely mowed, developed lots containing office buildings or homes, and open areas such as small parks, athletic fields, and playgrounds. Developed lots and open areas are commonly composed of monoculture lawns and small areas of trees and or shrubs, which are commonly sprayed with insecticides to control insects.

Due to the small number of pellets collected (55 pellets from Marco Island versus 31 pellets from Rutland Ranch) a note of caution should be taken when comparing the results of pellet analysis. A larger sample size from both research areas may provide a different interpretation when comparing the diet of burrowing owls from rural and urban areas.

Research has been used to determine factors which may limit burrowing owl populations in urban areas. Some of these limiting factors include loss of nest burrows and nesting habitat to construction, human harassment of burrowing owls, nest abandonment due to extensive vegetative growth around burrows, and predation by feral and domestic cats and dogs (Millsap and Bear 1988). The majority of information on burrowing owls in rural areas is observational. There are no detailed studies documenting productivity, survival, prey preference, and habitat requirements (breeding and post-breeding) of burrowing owls in rural areas. It's not known if factors other than habitat loss contributed to the decline of burrowing owls on the dry prairies of south central Florida.

Proactive research, research which determines factors limiting populations, could be an important tool in the conservation of burrowing owls throughout the state. This may require research from a variety of disciplines over various spatial and temporal scales (Marzluff and Sallabanks 1998). The results of proactive research could allow focused conservation efforts instead of possibly expensive future burrowing owl restoration projects.

Behavioral Observations of Adult and Juvenile Burrowing Owls during the Breeding Period

Introduction

Wildlife management and conservation plans are often designed to reduce the effects of anthropogenic disturbances to animal populations and their habitats. By understanding the interaction between an animal's ecology and behavior, we can help predict the consequences of specific wildlife management or conservation actions (Macdonald et al. 2000). Current conservation and management strategies for burrowing owls in Florida focus on urban/suburban populations (Millsap and Bear 1988, Haug et al. 1993, Mealey 1997, Bowen 2000, Millsap and Bear 2000), because the majority of previous research on this subspecies has been conducted on suburban and urban populations in south Florida; specifically Lee, Dade, and Broward counties (Wesemann 1986, Millsap and Bear 1988, Mealey 1997, Millsap and Bear 1997, Millsap and Bear 2000).

The change in the geographic distribution of a species over time, from a rural to urban environment, can affect basic demographic factors, food use, size of territory, exposure to predators, and social structure (McGowan 2001). Therefore, management and conservation strategies designed for burrowing owls in urban environments may not be suitable for burrowing owls in rural environments. Behavioral observations of burrowing owls in rural environments can be one tool to predict the consequences of future management and conservation strategies in rural areas.

Some forms of behavior that have important implications for wildlife management and conservation include juvenile dispersal, habitat selection, courtship behavior, daily and seasonal activities, territorial defense, flocking, renesting, migration, and response to predators (Bolen and Robinson 1999). Observations of burrowing owls from the early nineteenth century to present have described the behavior of this subspecies. Bowen (2000) was the first to quantify specific behaviors of adult and juvenile burrowing owls during a demographic, distribution, and metapopulation analysis of the species throughout Florida. The behaviors recorded include roosting, hunting, feather maintenance, practicing flying, burrow maintenance, feeding young, and territory defense (Bowen 2000).

The purpose of this study was to document the behavior of adult and juvenile burrowing owls in rural habitats, specifically during the breeding period. This information could aid in predicting the effect of management and conservation strategies for burrowing owls in rural environments.

Methods

We observed burrowing owls located at Rutland Ranch as shown in Figure 1. Behavioral observations were conducted from 5/4/04 – 6/2/04 in the improved pasture on all ten adult burrowing owls and nine juvenile burrowing owls. Observations occurred between 10am and 8pm. Radio transmitters were not attached during the observation periods because trapping, handling, and attaching transmitters can alter an animal's behavior (White and Garrott 1990).

I created an ethogram that described the behaviors that were observed (MacDonald et al. 2000) for adult burrowing owls (Table 9) and juvenile burrowing owls (Table 10). The choice of which behaviors to document was based on personal observations and previous documentation of burrowing owl activity (Bowen 2000).

Table 9. Ethogram of adult burrowing owl behaviors.

Behavior	Definition
Preening	Cleaning feathers with beak
Scanning	Quickly glancing at surrounding ground or sky
Hunting	Jumping on prey from ground or diving at prey from air
Dozing	Closing eyes for five or more seconds while perching
Vocalizing	Making calls or sounds
Digging	Owl in burrow and sand erupting from burrow entrance
Feeding Self	Eating prey captured by self or another adult
Thermoregulation	Sitting or perching with wings extended and/or performing gular flutter.
Feeding Young	Female taking food from male and feeding young

Table 10. Ethogram of juvenile burrowing owl behaviors.

Behavior	Definition
Scanning	Quickly glancing at surrounding ground or sky
Dozing	Closing eyes for five or more seconds while on burrow mound
Being fed by Adult	Receiving food captured by adult male or female
Vocalizing	Making calls or sounds
Digging	Owl in burrow and sand erupting from burrow entrance
Practice Flying	Flapping wings and jumping up from ground
Stretch Wings	Quickly opening wings from body. No attempt at flight.
Running into Burrow	Owl running into burrow

The behavior of one pair of adult burrowing owls and/or young was documented during each observation period by instantaneous scan sampling at five minute intervals (Altmann 1974, MacDonald et al. 2000). Two pairs of adult burrowing owls and/or young were simultaneously observed when two researchers were present. Behavioral observations, which ranged from one to four hours, were recorded by observing owls through a spotting scope from a distance of roughly 100 meters. During each observation period an attempt was made to locate each adult burrowing owl and/or young and record the behavior observed at five minute intervals.

I assigned each adult owl to one of four categories based on the presence or absence of young: males without young, males raising young, females without young, females raising young. The results for all adult owls within each category were combined to document the behaviors observed for each category.

During every observation the location of each adult owl in the improved pasture was recorded (Table 11). Each instantaneous scan was considered a point event and the transition probabilities, the probability of an adult burrowing owl going from one location in the improved pasture to another location, was calculated for each category of adult

Table 11. Description of adult burrowing owl locations at Rutland Ranch.

Location of owl	Definition
Burrow	Owl on burrow mound, in burrow entrance, or inside burrow
Not at Burrow	Owl located anywhere in pasture except at burrow
Missing	Location of owl unknown

burrowing owls (Haccou and Meelis 1992). For example, the transition probability of adult male burrowing owls without young going from the burrow (B) to missing (M) was calculated using the following formula:

$$P_{b/m} = \frac{N_{b,m}}{N_m}$$

$N_{b,m}$ equals the total number of times all burrowing owls in this category were documented as going from the burrow to missing. N_m equals the total number of times all burrowing owls in this category were documented as missing.

The G-test of independence for 2 X 3 contingency tables was used to test two hypotheses regarding the location of adult burrowing owls in the improved pasture (Table 11). H_O: The location of adult burrowing owls raising young is independent of sex. H_O: The location of adult burrowing owls not raising young is independent of sex.

The G-test of independence for 2 X 8 and 2 X 9 contingency tables was used to test two hypotheses regarding the behavior of adult burrowing owls in the improved pasture. H_O: The behavior of adult burrowing owls raising young is independent of sex. H_O: The behavior of adult burrowing owls not raising young is independent of sex.

Results

Adults with Young

Approximately 31 hours were spent observing burrowing owl behavior at Rutland Ranch. A graph of female (Figure 13) and male (Figure 14) burrowing owls with young indicates the behaviors observed during the breeding period.

Figure 13: Behavior of adult female burrowing owls raising young

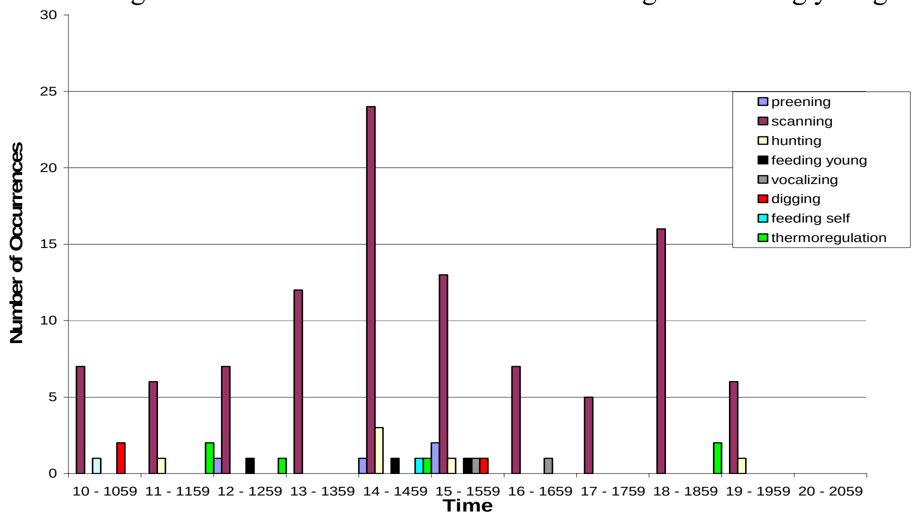
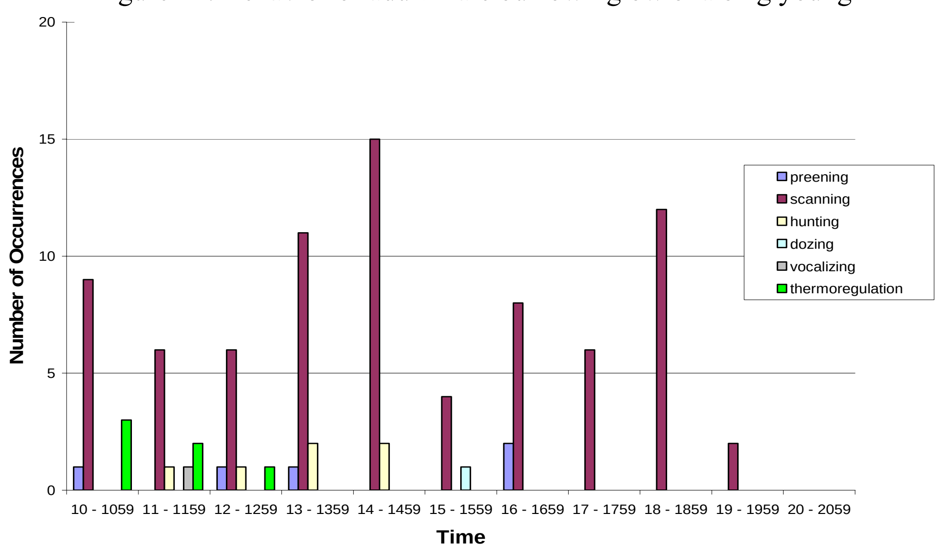


Figure 14: Behavior of adult male burrowing owls raising young



Scanning was the most frequently observed behavior for both male and female owls with young during any observation period. Thermoregulation and hunting were the second and third most frequent behaviors for both sexes. Both male and female adult burrowing owls raising young were observed hunting during the daytime on six occasions. The results of the G-test of independence support the null hypothesis of no association between sex and behavior $G = 10.721 < X^2_{(0.05,8)} = 15.507$.

The locations of adult burrowing owls within each of the four categories (males without young, males raising young, females without young, females raising young) were combined and displayed in Table 12. The locations of male and female burrowing owls raising young within the improved pasture were different. The results of the G-test of independence do not support the null hypothesis of no association between sex and location $G = 35.157 > X^2_{(0.05, 2)} = 5.991$.

Table 12: Sum of locations for adult owls during five minute observation periods

Young Present Yes/No	Sex	Main Burrow	Satellite Burrow	Sum Sightings at Burrows	Not at Burrow	Missing	Total Number Observations
Yes	F	80	26	106	50	24	180
Yes	M	65	9	74	33	73	180
No	F	52	3	55	32	68	155
No	M	45	12	57	36	62	155

The transition probabilities, the probability of an owl going from one location in the improved pasture to another are shown in Table 13. The most frequent transition for males was from the burrow to somewhere within the improved pasture (0.66). This was very similar to the probability of a male transitioning from somewhere within the pasture to missing (0.62). The lowest transition probability calculated was an adult male moving from the burrow to missing (0.33).

Table 13. Transition probabilities for adult burrowing owls raising young versus adults not raising young

Males without Young

		To		
		Burrow	Not at Burrow	Missing
From	Burrow	0.00	0.54	0.46
	Not at Burrow	0.63	0.00	0.37
	Missing	0.71	0.29	0.00

Females without Young

		To		
		Burrow	Not at Burrow	Missing
From	Burrow	0.00	0.44	0.56
	Not at Burrow	0.62	0.00	0.38
	Missing	0.80	0.20	0.00

Males with Young

		To		
		Burrow	Not at Burrow	Missing
From	Burrow	0.00	0.66	0.33
	Not at Burrow	0.38	0.00	0.62
	Missing	0.50	0.50	0.00

Females with Young

		To		
		Burrow	Not at Burrow	Missing
From	Burrow	0.00	0.80	0.20
	Not at Burrow	0.85	0.00	0.15
	Missing	0.86	0.14	0.00

The most frequent transition for females was from missing to a female located at the burrow (0.86). This transition was very similar to the probability of an adult female going from somewhere within the pasture to the burrow (0.85). The lowest transition probability calculated was from missing to a female located somewhere within the pasture (0.14). This was very similar to the probability of an adult female transitioning from somewhere within the pasture to missing (0.15).

Adults without Young

The graph of female (Figure 15) and male (Figure 16) burrowing owls without young indicates the behaviors observed during the breeding period. Scanning was the most frequently observed behavior of both adult male and female owls. The second most frequently observed behavior was thermoregulation, which was documented nine times for females and eight times for males. The third most frequently observed behavior for male burrowing owls was hunting (four times). Preening was the third most frequently observed behavior for female burrowing owls (eight times). The results of the G-test of independence do not support the null hypothesis of no association between sex and behavior $G = 20.619 > X^2_{(0.05,7)} = 14.067$. Figure 17 indicates the observation periods for all adult burrowing owls in the improved pasture.

Figure 15: Behavior of adult female burrowing owls without young

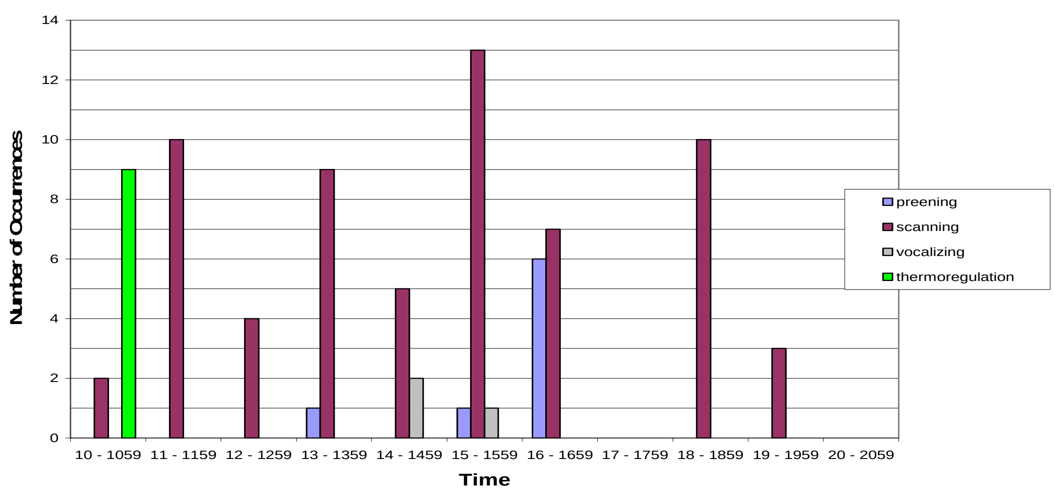
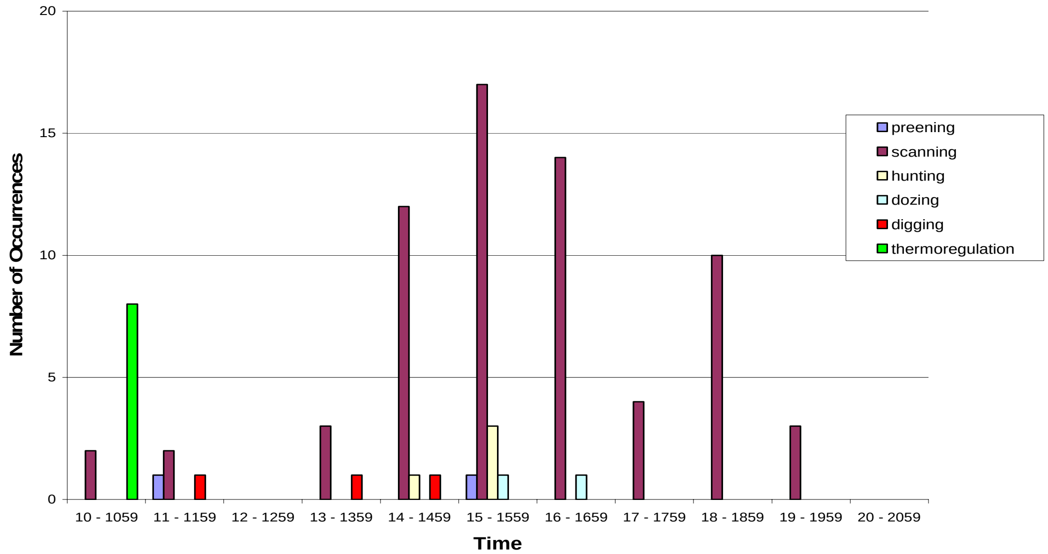


Figure 16: Behavior of adult male burrowing owls without young



During behavioral observations the locations of male and female burrowing owls within the improved pasture were similar (Table 12). The results of the G-test of independence supported the null hypothesis of no association between sex and location of adult burrowing owls without young $G = 0.548 < X^2_{(0.05, 2)} = 5.991$.

The transition probabilities for adults without young were similar (Table 13). The most frequent transition for males without young was from missing to a male located at the burrow (0.71). The least frequent transition was from missing to a male located somewhere within the improved pasture (0.29).

For females without young the most frequent transition was from missing to a female located at the burrow (0.80). The least frequent transition was from missing to a female being located somewhere within the improved pasture (0.20).

Figure 17: Observation periods (X) for adult burrowing owls

	Time																				
Date	10	10:30	11	11:30	12	12:30	13	13:30	14	14:30	15	15:30	16	16:30	17	17:30	18	18:30	19	19:30	20
5/4/04										X	X	X	X	X	X						
5/6/04									X	X	X	X		X	X	X					
5/9/04									X	X	X	X	X	X							
5/12/04					X	X	X	X	X	X	X	X	X	X							
5/14/04	X	X	X	X	X	X	X	X	X												
5/21/04	X	X	X	X	X	X	X	X	X	X											
5/25/04	X	X	X																		
5/26/04	X	X	X	X	X	X															
5/31/04																	X	X	X	X	X
6/2/04																	X	X	X	X	X

Juvenile Burrowing Owls

A graph of juvenile burrowing owl behavior is displayed in Figure 18. The observation periods for all juvenile burrowing owls is shown in Figure 19.

The most frequently observed behavior for juvenile burrowing owls was scanning. The second most frequent behavior, observed ten times, was practicing flying. Running into the burrow was the third most frequently observed behavior and was documented eight times.

Figure 18: Behavior of juvenile burrowing owls

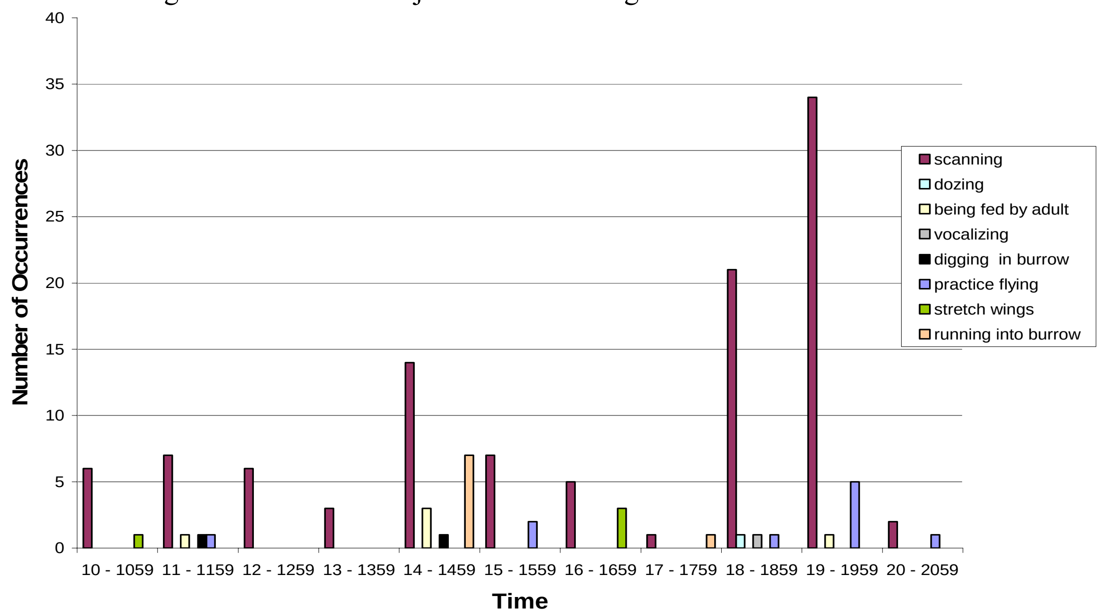


Figure 19: Observation periods (X) for juvenile burrowing owls

Date	10	10:30	11	11:30	12	12:30	13	13:30	14	14:30	15	15:30	16	16:30	17	17:30	18	18:30	19	19:30	20
5/6/04														X	X	X					
5/9/04									X	X	X										
5/12/04					X	X	X	X	X	X	X	X	X	X							
5/14/04								X	X	X											
5/26/04	X	X	X	X	X	X															
5/31/04																	X	X	X	X	X
6/2/04																	X	X	X	X	X

Discussion

Behavior

The most frequently observed behavior for adult burrowing owls with and without young was scanning. This was expected considering the burrowing owls exposed position in the improved pasture, the need to capture prey, and the numerous potential predators of burrowing owls in the rural habitat.

Interestingly, for adult burrowing owls without young, only males were observed digging burrows. Alternatively, for adults raising young, only females were observed digging burrows. Both adults are known to excavate and maintain burrows (Haug et al. 1993). It is unknown if prior to breeding adult males do the majority of burrow excavation and, after brooding young, adult females do the majority of digging in order to maintain burrow structure. The disappearance of males for extended periods of time may account for the observations of only females excavating burrows after brooding. During field observations male burrowing owls with young were documented as “missing” for up to one hour at a time.

For adult burrowing owls without young only males were observed hunting during the daytime. Both male and female burrowing owls raising young were observed hunting. The need to feed young probably explains the observations of both sexes hunting during the daytime. Initially the adult male does all of the hunting while the female is brooding (Haug et al. 1993). In this study, females with young began hunting close to the main burrows when downy-feathered young were observed in the burrow entrances. As the young grew older, female hunting trips proceeded to get farther and farther from the main burrows.

The behavior of juvenile burrowing owls was dependent upon their stage of growth. At all stages of growth the young were observed scanning the surrounding area. Recently hatched young, covered with downy feathers, spent the majority of time at the entrance of the main burrow. As the young grew older, they made excursions farther away from the main burrow. When juvenile plumage began to resemble that of adults, juveniles were observed stretching their wings. As the feathering became more fully developed, the young were seen attempting to fly.

Juvenile burrowing owls appeared to mimic the behavior of nearby adult burrowing owls. Juvenile burrowing owls attempted to perch on wooden stakes next to burrow mounds and dog fennel (*Eupatorium capillifolium*) growing in the pasture when an adult was perched on these structures and/or recently flew from the structure. Also, juvenile burrowing owls were twice observed digging in a burrow immediately after an adult was observed digging in the same burrow.

Before the young fledged, they began flying with the adult females from the main burrows to satellite burrows. Juvenile burrowing owls were also observed flying toward adult females that had just captured prey.

Interestingly, on 5/14/2004, one juvenile burrowing owl emerged from the main burrow carrying part of a moth's wing (species unknown) in its mouth. The chick walked roughly 10 meters from the burrow, dropped the wing into the grass, and then ran back into the main burrow. Adult burrowing owls were never observed removing prey remains from the inside of burrows.

Location of Adult Burrowing Owls and Transition Probability

The locations of male and female burrowing owls without young in the improved pasture were very similar (Table 12). There was no association between the sex of an adult and the adult's location within the improved pasture. Alternatively, the locations of male and female burrowing owls with young in the improved pasture were not similar (Table 12). Where a male or female might be located was dependent on the sex of the owl. The majority of time adult male burrowing owls would be found at either the main or satellite burrow or missing. Adult female burrowing owls would be located at either the main or satellite burrow or somewhere in the improved pasture.

The transition probabilities calculated for male and female burrowing owls with young concurs with field observations during the breeding season. Male burrowing owls raising young had a high probability of transitioning from the burrow to somewhere in the improved pasture (0.66). The males also had a high probability of transitioning from somewhere in the improved pasture to missing (0.62). During the breeding season at Rutland Ranch male burrowing owls could be seen flying from the main or satellite burrows and perching on a dog fennel plant, wooden post, or other object in the improved pasture. The adult males would then fly to another perch farther away and this process was repeated until the owl could no longer be located in the improved pasture.

Females with young had a high probability of transitioning from missing to the burrow (0.86). This may be explained by adult females being in the burrow during one observation period and then emerging from the burrow at the following observation period. The second and third highest transition probabilities, moving from somewhere in the improved pasture to the burrow and transitioning from the burrow to somewhere in the improved pasture, agree with field observations. After hatching, the young were commonly seen in the entrance of the burrow or on the burrow mound. During this time it was not uncommon to find females perched on a dog fennel plant or wooden post within roughly 30 meters of the main or satellite burrows. Adult females were also observed perched on the ground in the shade created by dog fennel plants. Females transitioned back and forth from the burrows to either perches in the pasture or the shade created by the perches.

For adult burrowing owls raising young there was an association between the sex of an adult and its location in the pasture, but there was no association between the sex of an adult and its behavior during the breeding period. The similarity in behavior between the sexes may be due to the need to feed young during the breeding period.

Alternatively, for adult burrowing owls without young there was no association between the sex of an owl and its location in the improved pasture during the breeding period, but there was an association between the sex of an owl and its behavior. Females without young were observed vocalizing while males without young were never observed vocalizing. Also, males without young were observed hunting, dozing, and thermoregulating, while females were never observed exhibiting these behaviors. Male and female burrowing owls may exhibit different behaviors outside of the breeding season and these behaviors may persist until the female begins brooding young during the breeding period. For example, burrowing owls are thought to shift activity patterns during the post-breeding period and become more arboreal (Hoxie 1889), crepuscular, and nocturnal (Hoxie 1889, Mealey 2004 personal communication). Also, during this study, juvenile burrowing owls were not observed with other juvenile or adult burrowing owls during the dispersal and post-breeding period. Therefore, the colonial behavior of burrowing owls may only occur during the breeding period.

What effect anthropogenic changes to the improved pasture, such as the introduction of cattle, would have on habitat use of adult burrowing owls during the breeding period is unknown. The observations in this study indicate that adult burrowing owls with young, especially adult males, utilized extensive areas of the improved pasture during the daytime. Adult males were observed flying hundreds of meters from main and satellite burrows before being lost from view. Previous observations of burrowing owls breeding in cattle pastures suggest that grazing may create suitable breeding habitat for burrowing owls.

The use of grazing, prescribed burning, and mowing has been recommended to maintain prairie habitat (Vickery et al. 1999). These land management practices could benefit burrowing owls by creating a heterogeneous breeding habitat containing a mixture of short grass areas and non-grazed areas. The short grass areas would be suitable for the excavation of burrows. Areas that haven't undergone grazing, burning, or mowing would contain vegetation that could be use by burrowing owls for both perches and shade. More research needs to be done to determine the benefits and hazards of each of these land management strategies for burrowing owls. For example, what stocking rate (animals per acre) is optimal to allow both cattle and burrowing owls to coexist in pastures? Would a heavily grazed pasture result in burrow trampling, reduced nesting success, decreased prey availability, or reduced burrow density? When should prescribed burning or mowing be initiated in order to maintain suitable breeding habitat for burrowing owls on public land while not negatively affecting reproductive success? Could the time period of prescribed burning (winter versus spring) deter or encourage the immigration burrowing owls?

Much more research is required to understand the behavior and habitat use of burrowing owls in rural areas. Other avenues of research include elucidating the behavior and habitat use of burrowing owls in the evening during the breeding period. Of particular interest is the behavior and habitat use of burrowing owls during the post-breeding period. The successful conservation and management of burrowing owls will require understanding the year round habitat requirements of this subspecies.

Evaluation of Three Methods to Capture Burrowing Owls in Florida

Introduction

Anthropogenic changes to the Florida landscape has resulted in both the loss and creation of burrowing owl breeding habitat (Millsap 1997). The expansion of burrowing owls from rural breeding habitat in southwestern and south-central Florida to new breeding habitat created in suburban and industrial areas throughout the state has resulted in numerous research activities. These endeavors have been undertaken to elucidate the demography and ecology of burrowing owls in these new environments.

The various management and research activities on burrowing owls in suburban and industrial areas have sometimes required the capture of this species. Florida burrowing owls have been captured in order to attach leg bands for individual identification (Courser 1976, Millsap and Bear 1988, Millsap and Bear 1990, Mealey 1997, Millsap and Bear 1997), weighing (Courser 1976, Millsap 1997), measuring (Courser 1976, Mealey 1997), inspection for parasites (Courser 1976), and evaluation of feather condition (Courser 1976). Determining which trapping technique to use depends on the effectiveness of previously tested methods and the location of the study. For example, in urban areas the public perception of wildlife management and their participation in creating wildlife management plans may influence the methods used to capture wildlife (Peterson et al. 2003). Therefore, individuals interested in capturing a species need to determine which trapping method may be the most effective for their particular research (Schemnitz 1996).

Various trapping techniques have been used in an attempt to capture the western subspecies of burrowing owl (*Athene cunicularia hypugaea*). Some of the methods used include the PVC tube trap (Botelho and Arrowood 1995), padded leg-hold traps (Haug and Oliphant 1990), push-door trap (Winchell 1999), noose rod (Winchell and Turman

1992), mist nets (Ferguson and Jorgensen 1981), and noose carpet traps (Barrentine and Ewing1988). Burrowing owls have also been captured within artificial nest boxes (Todd 2001).

Florida burrowing owls have been captured using variations of leg hold traps such as bal-chatri traps (Mealey 1997) and noose carpet traps (Millsap and Bear 1988, Millsap and Bear 1990, Mealey 1997, Millsap and Bear 1997). Juvenile owls have also been secured by reaching into burrows and capturing them by hand (Mealey 1997). There has been no previous research to evaluate different methods to capture burrowing owls in Florida.

The purpose of this study was to compare one variation of a leg hold trap, the noose carpet, versus two box type traps (PVC tube trap and push-door trap) that have never been used to capture Florida burrowing owls. Determining which type of trap is most effective may aid future studies on burrowing owls in rural areas of Florida.

Methods

Juvenile burrowing owls were captured in order to attach necklace radio transmitters. All trapping of burrowing owls took place in the improved pasture at Rutland Ranch in Bradenton, Florida. Trapping was conducted from 6/6/04 – 7/12/04 between the hours of 7:30am and 7pm.

Two PVC tube traps were constructed following the methods of Botelho and Arrowood (1995). The traps consisted of PVC tubing that was 16cm in diameter and 61cm long. One end of the PVC tube was covered with wire mesh to prevent an owl from escaping. The end of the PVC tube extending into the burrow had a one way door made of Plexiglass strips which only swung one way (into the trap). A hinged door, which would be used to remove captured owls, was cut into the center of the trap and attached with Velcro tape. The traps were placed into the entrance of the burrows according to the methods of Botelho and Arrowood (1995).

Two push-door traps were constructed following the methods detailed by Winchell (1999). The traps were constructed of wire mesh fencing and were 46cm long X 15cm wide X 15cm high. One end of the trap was closed to prevent escape. A hinged Plexiglas door was placed at the entrance of the trap. It hung at roughly a 45 degree angle into the trap allowing owls to enter, but not escape (Winchell 1999).

Eight noose carpet traps were created using wire mesh. The three trap sizes were 15cm X 10cm, 15cm X 15cm, and 20cm X 10cm. Ten pound monofilament line was used to create the nooses. Drags, made of 57-85 gram lead weights and attached to the traps with monofilament line, allowed captured owls to only fly a short distance before returning to the ground (Barrentine and Ewing 1988, Mealey 2004, personal communication).

The PVC tube traps and push-door traps were set in place when it was known that juvenile burrowing owls were inside the burrows. The PVC tube traps were placed as far as possible into the burrow. The push-door traps were placed against the entrance of the burrow. The structure of the burrow entrance and burrow mound were not modified when the traps were set in place. Any open areas created because the trap did not sit flush within the burrow or against the burrow entrance were covered with brown burlap cloth. The cloth prevented an owl from escaping the burrow.

Three to five noose carpet traps per burrow were usually placed inside the burrow and on the burrow mound. The traps were easily bent to contour the inside of the burrow. Traps were pressed into the sand so only the nooses were exposed. Noose carpet traps were set when juvenile burrowing owls were either inside or outside of the burrow.

Before trapping began we placed small unpainted wooden stakes within three meters of the burrow mound for each main burrow (Thomsen 1971). Each stake protruded approximately 30 centimeters from the ground. The stakes were used as perches by the owls and also allowed us to determine if adults were present at burrows when vegetative growth began to obstruct viewing.

During behavioral observations we noted that juvenile burrowing owls would quickly emerge from burrows once either adult returned to the burrow and stood on the burrow mound, perched dog fennel (*Eupatorium capillifolium*) growing near the burrow, or perched on the small wooden stake near the burrow mound. We attempted to encourage juvenile burrowing owls to exit the burrows by herding adult male or female burrowing owls towards their burrows in which traps were set. This was accomplished by walking around burrows until individual owls were located between research personnel and a burrow and then slowly walking toward the owl. We stopped walking toward an owl when it flew at or near the burrow. This same technique was used to herd any juvenile owls that were outside the burrows toward burrows set with noose carpets.

In 2004 only three out of the five burrowing owl pairs were observed raising young. Due to the short trapping period and small number of juvenile burrowing owls a trapping method was discontinued if it deterred adult burrowing owls from returning to the burrow therefore reducing the possibility of capturing juvenile burrowing owls.

Results

One PVC tube trap was set in the main burrow of a burrowing owl pair with young on 6/11/04 at 1pm. A second PVC tube trap was set in the main burrow of another burrowing owl pair with young on 6/20/04 at 9am. Each trap was in place for one hour. No juvenile owls were captured during either trapping session. During both trapping sessions the adult male and female burrowing owls would not approach the burrow while the trap was in place.

On 6/6/04, at 9:30 am, one push-door trap was set against the main burrow entrance of a burrowing owl pair with young. A second push-door trap was set in the main burrow of another pair with young on 6/7/04 at 2:45 pm. Each trap was set in place for one hour. No juvenile owls were captured in either trapping session. During both trapping sessions the adult male and female burrowing owls would not approach the burrow while the trap was in place.

I decided to discontinue trapping with PVC tube traps and push-door traps because no juveniles were caught and adults avoided burrows in which traps were set. Only noose carpet traps were used to trap juvenile burrowing owls for the remainder of the breeding season.

Noose carpet traps were used from 6/8/04 – 7/12/04. During each trapping session between three and five traps were set at main, satellite burrows or both. Adult male and female burrowing owls did not avoid burrows in which traps had been set. Noose carpet traps were set for a total of 30 hours and 35 minutes resulting in the capture/recapture of eleven juvenile owls. Table 14 indicates the number of burrowing owls captured during three time periods.

Table 14. Number of owls captured/recaptured during three time periods.

Time Period	Duration of Trapping	Number of Juvenile Owls Captured/Recaptured
7am - Noon	10 hours and 35 minutes	4
Noon – 5pm	15 hours and 30 minutes	7
5pm – 9pm	4 hours and 30 minutes	0

Discussion

The PVC tube traps and push-door traps were ineffective in capturing juvenile burrowing owls. When in place the PVC tube trap and push-door trap protruded from the burrow entrance. During trapping sessions the adult male and female burrowing owls would fly over to the burrows that were trapped, but fly away once the traps were seen. The adults would not perch on nearby dog fennel plants or the stake next to the burrow mound. This was opposite of the behavior observed when traps were not set at burrows and juveniles would readily emerge from burrows upon the return of either adult.

Another reason to discontinue using PVC tube traps and push-door traps was their bulkiness. Due to stream flooding it was sometimes impossible to drive a four wheel drive pickup truck or ATV all the way to the improved pasture. It was difficult for one individual to carry a trap, plus other research equipment to the improved pasture.

Noose carpet traps were the most effective method in capturing juvenile burrowing owls. Adult male and female burrowing owls would readily return to burrows in which traps were set. The majority of the time noose carpet traps resulted in the capture of one juvenile burrowing owl per trapping session. Only during one trapping session were two juvenile burrowing owls captured at the same time while running into the burrow.

Another benefit of using noose carpet traps was the ease of transporting traps to the research area. Each trap and lead drag was place in a separate plastic bag to stop nooses from different traps entangling each other. The traps were quickly set and captured burrowing owls were easily observed struggling to free themselves.

Further research of burrowing owls rural environment may require the capture of individual owls. Herding adult burrowing owls toward burrows was an effective inducement for juvenile burrowing owls to exit the burrows. Noose carpet traps are recommended for capturing burrowing owls because of their ease of transport and efficiency.

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