EVALUATION OF POPULATION DENSITY AND CHARACTERIZATION OF SUITABLE HABITAT FOR THE GULF-COAST KANGAROO RAT (*DIPODOMYS COMPACTUS*)

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EVALUATION OF POPULATION DENSITY AND CHARACTERIZATION OF SUITABLE HABITAT FOR THE GULF-COAST KANGAROO RAT (*DIPODOMYS COMPACTUS*)

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ABSTRACT

Evaluation of Population Density and Characterization of Suitable Habitat for the Gulf-Coast Kangaroo Rat (*Dipodomys compactus*)

by

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May 2011

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The Gulf-coast kangaroo rat (*Dipodomys compactus*) is characteristic of the arid ecosystems of South Texas and the barrier islands. It is listed by Texas Parks and Wildlife Department as a species of concern and is the only member of the family Heteromyidae found on Mustang Island, North and South Padre islands, Texas, and the barrier islands of Tamaulipas, Mexico. I conducted my study at Padre Island National Seashore, to investigate this poorly understood species. I estimated population density and distribution, characterized burrow microhabitat, and used Geographic Information Systems (GIS) to compare transects with different kangaroo rat densities. Live-trapping using mark-recapture methodology was conducted for two periods between April 2010 and October 2010 along 12 transects. A variety of microhabitat characteristics of burrows were measured on active burrows. Trap success for the entire sampling period was 5 %, but more individuals were caught during the spring sampling period than the fall sampling period. Using the Lincoln-Peterson index, I estimated a population density of 3.6 individuals per hectare. Active burrows differed significantly in slope, type of vegetative cover, and percent vegetative cover compared to paired random locations. Burrows were found in areas with a higher slope and less vegetative cover. Low trap success and coarse scale ecogeographical layers made development of a habitat suitability model difficult. A more intensive study over a longer time frame will be essential to effectively delineate habitat and predict population sizes.

CHAPTER I

INTRODUCTION

The Gulf-coast kangaroo rat (*Dipodomys compactus*) is one of a few mammals, and the only rodent, classified by the Texas Parks and Wildlife Department as a species of high concern (Texas Wildlife Action Plan 2005). The Gulf-coast kangaroo rat, hereafter kangaroo rat, inhabits sandy soils of southern Texas as well as the barrier islands (Mustang, North and South Padre) of Texas (Setzer 1949), and Tamaulipas, Mexico (Hall 1951). They are also found on the eastern two-thirds of the southern Texas mainland (Baumgardner and Schmidly 1981, Figure 1).

Little research into habitat characteristics, abundance, or behavior has been done on *D. compactus*. There has been extensive research on physiological and behavioral characteristics comparing many species of kangaroo rats (Johnson and Selander 1971; Baumgardner and Kennedy 1993; Carrasco 2000). Yet there have been very few studies focusing specifically on *D. compactus* (McCoig 1983; Baumgardner and Schmidly 1985). Because of this gap in knowledge, Texas Parks and Wildlife Department (TPWD) classifies *D. compactus* as a species of concern and has given "high priority status" to research on this species (Texas Wildlife Action Plan 2005). Texas Parks and Wildlife Department also recognizes that this species may be threatened by habitat destruction and changing land use practices within its limited geographic range.

The taxonomic classification and phylogeny of this species has been debated over the past decades (Davis 1942). It was first described as two subspecies: *Dipodomys compactus compactus* (barrier island population) by True in 1889 and *Dipodomys compactus sennetti* (mainland populations) by Allen in 1891. Davis (1942) reclassified these as different subspecies of *Dipodomys ordii* with overlapping ranges. Karyotyping has since placed *D. compactus* as its own species and re-elevated the two subspecies' status (Schmidly and Hendricks 1976, Schnell et al. 1978). *Dipodomys compactus* has a diploid number of 74 while *D. ordii* has a diploid number of 72. Because of their overlapping ranges in southern Texas, previous researchers may have examined specimens for both species, leading to false conclusions that kangaroo rats from the mainland of southern Texas were intermediate between island *D. compactus* and western Texas *D. ordii* (Baumgardner 1991).

Other species of kangaroo rats have been identified as keystone species capable of maintain the physical structure of arid grasslands (Brown and Heske 1990b), but to date no one has conducted similar studies on *D. compactus*. One trait found throughout the genus *Dipodomys* is the behavior of constructing burrows for food storage and cover, usually in loose soils (Waser and Jones 1991). Often, kangaroo rats will build multiple burrows in a given area and some burrows will have multiple entrances (Cross and Waser 2000). This activity is so widespread that the creation of the burrows can be thought of as microhabitat disturbance that can affect patterns in plant community structure (Heske et al. 1993).

Dipodomys compactus is the only member of the family Heteromyidae currently found on the barrier islands. Like other species of kangaroo rats, *D. compactus* is highly active during the night, a result of open habitat of sand dunes and sparse vegetation (Kennedy et al. 1973). Given that they occupy open and arid habitats, nocturnality in kangaroo rats is presumable an adaptation that decreases the risk of predation and water loss.

A study conducted by Baumgardner and Schmidly (1985) compared microhabitat features of *D. compactus* with *D. ordii* on the mainland of southern Texas. Contrary to other studies showing similar habitat affinites, *D. compactus* was found exclusively in disturbed fields while *D. ordii* was found only in undisturbed areas. These habitat differences may have existed because disturbed fields were less dense in vegetation and were composed of loose and broken soil, habitat features that may be more important to *D. compactus* than *D. ordii*.

To date, only McCoig (1983) has attempted to estimate population sizes of *D. compactus* on Padre Island. McCoig's goal was to assess monthly changes in capture rate in relation to sex, reproductive status, and amount of cover. His estimate of population densities in his trapping area fluctuated throughout his study, ranging from 3.02 to 6.18 kangaroo rats per ha. *Dipodomys compactus* was found to exhibit two distinct periods of seasonal activity, early spring and early fall, and found to prefer medium cover (McCoig 1983). The species also had a dispersal period in mid-winter and both sexes were found to have extremely small home ranges.

Given the limited ecological knowledge currently available, biologists need to obtain a better understanding of the habitat and population ecology of *D. compactus.* Extensive studies into other *Dipodomys* species have led to some well-founded generalizations about their ecology. Kangaroo rats often numerically dominate local rodent assemblages in a microhabitat setting (Thompson 1982, Brown and Heske 1990a, Valone et al. 1995). Vegetative microhabitat features may be influenced by kangaroo rat activity that in turn further influences the population dynamics of rodent species found in a particular area (Price 1978, Fields at al. 1999, Murray et al. 2006). The hoarding of seeds directly facilitates seed dispersion and direct competition with other species seeking the same resources. While general characteristics such as nocturnal activity and granivory have been documented for *D. compactus*, this species of concern has had very little research estimating population size or evaluating habitat preference.

The overall objectives of my study were to estimate population density, characterize burrow microhabitat and develop a more detailed habitat description for *D. compactus* using a geographic information system (GIS). Building upon this baseline research, future studies can focus on the dynamic changes in population size in relation to a variety of other environmental parameters such as changing land use practices or climate change. Living in a world of increasing coastal development and continuing habitat loss, it is essential that we accumulate as much information as possible on the natural flora and fauna of Texas in order to understand how best to maintain the unique biodiversity of Texas.

CHAPTER II

MATERIALS AND METHODS

STUDY AREA

I conducted this study within the boundaries of Padre Island National Seashore (PINS), located on North Padre Island, Texas from April 2010 until October 2010. Padre Island National Seashore is the largest protected undeveloped barrier island in the world, roughly 112 km long and consisting of sand dunes and coastal flats stretching from just below Corpus Christi to the channel of Port Mansfield. Width of North Padre Island varies from 450 m to approximately 4.8 km at the widest point. North Padre Island has been artificially separated from South Padre Island by the Port Mansfield Pass since 1964. This island contains extensive grasslands between its foredune ridges on the eastern gulf side and tidal flats bordering the western Laguna Madre (Nelson et al. 2000). The McCoig (1983) study focused on an area of beach near the park entrance bounded on both sides by creosote posts that prevented access by vehicular traffic. The beach access roads allowed traffic to move north or south along the beach away from these posts. I utilized approximately the same 3.2 km stretch of beach for my study (Figure 2). Baccus et al. (1977) found this particular area to have higher plant and animal diversity than other parts of the beach. I documented the following prominent species of plants: gulf croton (*Croton puncatatus),* partridge pea *(Chamaechrista fasiculata),* camphorweed *(Heterotheca subaxillaris),* common sunflower *(Helianthus annuus),* and shore little bluestem *(Schizachynum littorale).* Other plant species previously identified include sea oats (*Uniola paniculata),* beach evening primrose *(Oenothera drummondii*), gulfdune paspalum *(Paspalum monostachyum,* and coastal indigo *(Indigofera miniata).* Mammal species observed on the island include white-tailed deer (*Odocoileus virginiana*), coyotes (*Canis latrans*), cotton rats (*Sigmodon hispidus*), spotted ground squirrels (*Spermophilus mexicanus*), northern pygmy mice (*Baomys taylori*), deer mice (*Peromyscus maniculatus*), and Texas pocket gophers (*Geomys personatus*). Other mammals reported on the island include American badgers (*Taxidea taxus*), American opossums (*Didelphus virginiana*), and black-tailed jackrabbits (*Lepus californicus*). The island has dozens of reptile and amphibian species while also supporting hundreds of species of birds using the Central Flyway during migration.

POPULATION ESTIMATES

To estimate the population density of *D. compactus* in my study area, I modified the area trapped by McCoig (1983) and increased the number of traps per transect. I divided the study area into halves. I measured microhabitat characteristics (discussed in the next section) in the northern half. In the southern half of the study area, I delineated twelve 200 m trapping transects every 0.5 km for 5.5 km (Figure 3). I positioned each transect perpendicular to the beach towards the interior of the island in order to test for a gradient in *D. compactus* distribution from the foredune region to the interior of the island. This allowed me to evaluate whether dune succession influenced kangaroo rat distribution. Due to campgrounds on the island, some of the spacing and placement of transects had to be modified (Figure 4). Starting with transect 9, I shifted the remaining transects an additional 0.5 km southwards. Along each transect I established 20 trap stations spaced at 10 m intervals. At each trap station, 2 Sherman live traps (9 cm x 7.5 cm x 23 cm, H.B. Sherman Traps, Inc., Tallahassee, FL) were placed in close proximity to the flagging, yielding a total of 40 traps per transect. I baited traps with rolled oats, set nightly just prior to sunset, and checked the following morning at sunrise. Trapping occurred for two consecutive nights on each transect, and I conducted two seasonal trapping (sampling) periods. The first period of trapping was conducted from April to May of 2010 (termed "spring"); the second period of trapping was conducted from September to October of 2010 (termed "fall"). I selected these specific times based upon the results of McCoig's (1983) study which concluded that peak activity of adult *D. compactus* was observed during these time periods. Like other studies (Brown and Heske 1990a), I avoided trapping four days around a full moon. I identified and recorded all species of rodents trapped and determined sex for *D. compactus*. Also, kangaroo rats were marked in the left ear using numbered self-piercing tags (.91 g, model 1005-1 Monel, National Band & Tag Company, Newport, KY). After tagging, I released animals at the point of capture. Animal handling was approved under Texas State University-San Marcos Institutional Animal Care and Use Committee approval code 0904_0204_04.

I estimated population density for the spring trapping session using the Lincoln-Peterson index. This value is obtained from the equation $N = M * n / R$, where N is population estimate, M is number of animals marked and released from the first night, n is the total number of animals caught the second night, and R is the number of marked animals recaptured on the second night. This simple and basic estimator has a long history of use in population studies. The study design and limited amount of data collected did not allow for the use of more elaborate estimation methods. Because capture success was so low in the fall, I used the Minimum Number Known Alive (MNKA) estimator instead of the Lincoln-Peterson index.

CHARACTERIZING MICROHABITAT

I used the northern half of the study site to characterize kangaroo rat habitat. It is important to note that not all burrows found on the island belong to kangaroo rats and that not all kangaroo rat burrows are active. Many species of animals on the island dig burrows, chiefly the Ghost Crab (*Ocypode quadrata*). While differentiating burrows can be difficult, characteristics such as foot prints and distinctive tail drags around the entrance helped identify kangaroo rat burrows. It was easier to decide whether a burrow was active or not. Inactive burrows often had spider webs or vegetation blocking the entrance. For all habitat measurements, only active *D. compactus* burrows were used.

Beginning at the line separating my two study sections, I placed numbered flagging at burrow locations. Burrow entrances within 0.5m of each other were considered multiple entrances to the same burrow and were flagged once. Using a grid search pattern, I identified burrows in all dune areas while moving north towards the study area boundary. Based on accounts in the literature, information attained from my transect trapping, and personal observation, I did not monitor flat areas in the interior of the island with complete vegetative cover because kangaroo rats are not known to use those locations. Three hundred burrows were identified with numbered flagging. Of these, 40 were randomly selected for microhabitat analysis.

At each site, the following characteristics were recorded, burrow aspect, slope, ground cover type, distance to next nearest active burrow, and whether or not the burrow had visible multiple entrances. Percent ground cover was estimated using a 1 x 1 m quadrat. Estimating slope proved to be difficult since a given dune can have multiple slopes. I assumed the most relevant slope would be the one immediately surrounding the burrow and constructed a device to measure that slope. The device consisted of two wooden dowel rods, graduated in centimeters, and connected by 2 meters of twine. The rods were place equally above and below the burrow in the direction of the slope and the 2 m twine was slid up or down on the downslope rod until level. This device allowed me to determine the length of side A and B of a right triangle and therefore I was able to calculate the angle of slope (hypotenuse) around the burrow.

In order to evaluate whether *D. compactus* selected certain microhabitat features (listed previously) for burrow location, I collected data for the same parameters from randomly selected locations (1 x 1 m quadrats) paired with each burrow. I selected a random azimuth (from 1-360º) and a random distance (4 to 20 m) to locate each random point. A minimum distance of 4 m to minimizes any bias from spatial proximity to actual burrows and a maximum distance of 20 m represents the normal range of travel that a kangaroo rat might use in locating a new burrow. Because the random plots did not actually have burrows, the habitat characteristic of aspect was not recorded.

I used principle components analysis (PCA) to simultaneously tests for a difference in the microhabitat of active burrows and random plots. Principle components analysis decomposes complex patterns of variation into a hierarchical set of independent axes; each successive axis represents a combination of variables that account for progressively smaller proportions of the total variation (Brown and Heske 1990a).

USING GIS TO INVESTIGATE SUITABLE HABITAT

I further analyzed the mark-recapture data and micro-scale habitat data using ArcMap (ESRI, Redlands, CA). Using mark-recapture data, I determine the greatest distance between initial capture of an individual and its recapture. I then created a buffer around each transect using that value as a constant for all transects. Using this conservative measure, I extrapolated the population size along each transect by multiplying my estimated population size by buffer area along the transect. I then classified each transect as low density, medium density, and high density with regard to *D. compactus* density. I then examined whether the habitat characteristics within these bounded areas were different and related to kangaroo rat density.

CHAPTER III

RESULTS

POPULATION ESTIMATES

During 960 trap-nights in the spring period, I captured 55 unique and 18 recaptured kangaroo rats. During 960 trap-nights in the fall, I captured 20 unique and 3 recaptured kangaroo rats. Overall, kangaroo rats were captured on 96 trap nights yielded a 5 percent trap success (Table 1). While almost every transect had a higher success rate in the spring than during the fall period, transect 7 had relatively high numbers in both seasons while no captures were made on transects 11 and 12 during either season. Only one individual, marked during spring period, was recaptured during the fall period (transect 7). The sex ratio for my entire study area was 2.0 M:F (during both sampling periods) , considerably less male-biased than reported (4.8 M:F) from the previous study (McCoig 1983) of *D. compactus* on Padre Island.

Using the Lincoln Peterson Index, I estimated that there were 72 (sd = 7.7) individuals in the immediate area of the transects during the spring trapping period. The combined area for all 10 buffered transects was 20 ha, giving a density estimate of 3.6 individuals per ha. Transects 11 and 12 were removed from analysis because no sign of *D. compactus* was confirmed. Extrapolating to the 108 ha between the 10 transects, my estimate for the total study area was 461 individuals.

Because the trap success was so low for fall (2.19 %), I used the MNKA (Krebs 1966) as an estimate of the *D. compactus* population size during this sampling period. This estimate is described by the equation MNKA= $M + (n\text{-}R)$; where M equals the total number of individuals captured and initially marked during first trapping, n equals the total number (marked and unmarked) captured during the second trapping, and R equals the number of marked individuals recaptured. Based on MNKA, I estimated that there were at least 19 individuals in the immediate area of the transects during the fall trapping session. Thus, the density may have been as low as < 1 individual per ha.

MICROHABITAT ANALYSIS

I identified 300 burrows in the northern portion of my study area. I created a minimum convex polygon to approximate the area covered (Figure 5), which was found to be 8 ha. Based on this calculated area, I estimate that there are roughly 37.5 burrows per hectare of suitable habitat. Forty of the burrows were randomly selected for microhabitat analysis.

The majority of occupied burrows had bare ground dominant in plots (60 %), followed by grass dominant (22.50 %), and forbs dominant (17.50 %). The dominant cover type for unoccupied random plots was grass (75 %), followed by both bare ground (12.50 %) and forbs dominant (12.50 %). The average amount of vegetative cover for the occupied burrows was 49.85 % in comparison to 75.45 % for unoccupied random plots. Mean distance to nearest burrow and mean calculated slope for occupied burrows was 6.80 m and 23.58 %, respectively. In comparison, mean distance to nearest burrow and mean calculated slope for unoccupied random plots was 8.30 m and 18.45 %, respectively.

The majority of the burrows faced north, northwest, or northeast (52.5 %) with roughly a quarter (27.5 %) of the burrows facing south, southwest, or southeast.

The first two PCA axes accounted for 77 % of total variance in the microhabitat variables. The first PCA axis (42 %) included slope, percent vegetative cover, and dominant vegetation type as the factors with the highest loadings. The second PCA axis (35 %) included slope and distance to between burrows. Occupied burrows and unoccupied plots were significantly different for PCA axis 1 ($t_{39} = 1.99$; $P < 0.01$) primarily because occupied burrows had less cover and less vegetation than unoccupied plots. Also, occupied burrows were found in areas with higher slopes. No significant difference ($t_{39} = 0.99$; $P = 0.33$) was found for PCA axis 2 between burrows and unoccupied plots.

ANALYSIS OF HABITAT DIFFERENCES AMONG TRANSECTS

This analysis was intended to compare macro-scale habitat data (e.g. percent grassland cover, bare dune cover, soil type, distance to road) among transects with different kangaroo rat densities. The maximum distance between a capture and a recapture was 30 m. I used this as a conservative estimate for *D. compactus* movement and to create a buffer for each transect (Figure 7). I then classified each transect by trapping density (Figure 8) as either low (0-3 total individuals caught), medium (4-8 total individuals caught), or high (> 9 total individuals caught). Initial visual inspection of GIS map images indicated that the habitat of the overall study area (i.e. transects and buffers) was relatively homogeneous consisting of a mix of grassland and bare dunes that did not differ much among transects. In addition, soil maps revealed that all transects were in the same general soil type. Thus, I did not conduct any statistical tests of differences among the transects. Instead, the results here are simply visual comparisons. Figures 9 and 10, shown in color infrared, illustrate the similarities between transects with different capture rates. All transects fell mostly within the soil layer defined by the NRCS as "Greenhill fine sand, 2 to 12 % slope, rarely flooded." I also estimated the distance to the nearest road from the midpoint of each transect (Figure 11). Transects 1 and 7 were found to have the greatest distance from the road (861 and 779 m, respectively) and the greatest number of captures. Transect 6, classified as low capture, had the third longest distance (703 m). Figure 12 shows the study area with the transects and microhabitat MCP in place.

CHAPTER IV

DISCUSSION

My estimate of population density for *D. compactus* (3.6 individuals per ha) is within the range (3 – 6 individuals per ha) reported by McCoig (1983) at the same study site three decades earlier. This suggests that the population may be very stable, although relatively small. This estimate is realistic in that similar densities have been reported for kangaroo rats of similar size. Valone et al. (1995), while monitoring the impact of *D. spectabilis* removal on other rodent densities, reported a stable density for *D. merriami* around 11 individuals per ha. They also reported densities of *D. ordii* to be close to 3 individuals per ha, regardless of presence or absence of *D. spectabilis*. Kelt et al. (2005) reported changes densities of *D. simulans* in relation to extreme weather events. This change in density range from 10 - 25 individuals per ha to 2 individuals per ha. Moore (2003) estimated density of *D. simulans* to change from 5 – 10 individuals per ha to 2 – 3 individuals per ha. In a generalized description of *D. ordii*, Garrison and Best (1990) estimated densities of Texas populations to be 16 individuals per ha. However, based on the presence of many *D. compactus* burrows and positively identified tracks, I concluded that my trapping results may not be a true indicator of actual population density. Therefore, my Lincoln-Peterson estimate may also have underestimated the *D. compactus* population in my study area. Unfortunately, I could only estimate population density based upon the data I collected. By extrapolating my estimate for the spring session to the entire study area between transects, I obtained a preliminary estimate of population size in the immediate vicinity of the transects. While this can be informative, there are assumptions inherent with this approach. One major assumption is that all of the area between Transect 1 and Transect 10 is habitat suitable to *D. compactus.* Another is that the 95 % confidence intervals are not large enough to introduce a gross amount of error in the estimate. In addition, estimating population size inherently assumes that the area surveyed (or trapped) encompasses the entire population, particularly if such an estimate is to have some biological reality.

One question resulting from this study was why trapping was so poor in the fall period compared to spring. McCoig's (1983) trapping data of the same area indicated that these two periods were the best time to capture *D. compactus*. Also, McCoig (1983) found that populations in fall were more abundant than spring. My trapping data indicates the opposite. The differences may be a result of increased precipitation. During the summer months of 2010, there were relatively large amounts of rainfall across Padre Island. NOAA records indicate that from the months of May to August 2010, the area received 411 mm of precipitation. While specific precipitation data from McCoig's trapping period were not available, NOAA records indicate the average precipitation for those same months to total 318 mm. Directly, this would provide water to the flora on the island and increase productivity. Seed-producing grasses, which kangaroo rats rely on, would likewise become more productive and produce greater food stores. This abundance of food could make the oats used in trapping less appealing. Also, there was an abundance of ants in and around the traps in the fall session but very few in the spring. Indirectly, the excess water could allow these ant species to thrive. More than 50 % of all my traps during the fall trapping period were loaded with ants which might deter kangaroo rats from entering the trap.

Interestingly enough, a relationship between ants and kangaroo rats has been proposed (Davidson et al. 1984). In response to rodent-only removal plots, populations of the most common harvester ants first increased but later declined, as their small-seeded resource species were competitively replaced by large-seeded annuals (Davidson et al. 1984). Thus, even though the ants and rodents were competing for different resources, kangaroo rats were indirectly facilitating ant survival by keeping large seed numbers low. The rolled oats used as bait for the traps must have been appealing to other species, as there were numerous by-catches throughout my study. Other species captured include four mammals (*Baiomys taylori, Geomys personatus, Peromyscus maniculatus, Sigmodon hispidus*), one skink (*Scincella lateralis*), and numerous Ghost Crabs (*Ocypode quadrata*). Finally, this species could be trap-shy. A study of the mainland subspecies *D. compactus sennetti* is currently finding that this species has a propensity to avoid Sherman traps (D. Phillips, pers. comm.).

Transect 7 (Figure 13) bisected an interesting dune formation. This dune formation, although not unique, is infrequent across the island. Many dunes of similar size are completely covered by the vegetation while this one is incredibly steep and bare. The leeward side of the dune is a large, bowl-shaped formation void of vegetation or any type of cover. One would infer that this absence of cover would deter kangaroo rat movement as many predators would have a distinct advantage. This not only was one of the highest yielding transects overall, but I caught the most kangaroo rats here during the fall trapping period when trap success was low. This site was also the only location where an individual marked in the spring was recaptured in the fall. Visual observation showed multiple lanes of kangaroo rat movement, but no burrows were detected. Perhaps the lack of resources in this particular area regardless of precipitation and subsequent seed production made the oats in the Sherman Traps more appealing.

Microhabitat analysis confirmed that *D. compactus* burrows are found in places with relatively sparse vegetation and significant slopes. No connection was found between burrow placement and distance to nearest neighboring burrow, indicating burrow placement is independent of neighbor proximities. My estimate of burrow density, this supports my contention that population sizes are actually much larger than estimated. My estimate for the population density was 3.6 individuals per ha while my estimate of burrow density was 37 burrows per ha. While some burrow sharing in some species of kangaroo rats have been documented (Brock and Kelt 2004), most species are solitary and some individuals dig multiple burrows. But, based on these numbers, kangaroo rats would have to dig 10 burrows for a single individual. No study of burrow use has ever estimated any species of *Dipodomys* to do this. While some transects with greater catch rates were farthest from obvious human disturbance, this was not always the case. The effect of vehicular traffic and human presence on *D. compactus* is either very slight, or still unknown. The fact that no kangaroo rats were caught on the last two transects, both of which are extremely close to roads, would support presence of an effect by human presence. However, contrary to this, many kangaroo rats were captured near the Visitor Center parking lot (Table 1, Figure 4).

Many authors consider kangaroo rats a keystone species, helping to shape local flora and fauna (Brown and Heske 1990b, Heske et al. 1993). There are most likely interactions between kangaroo rats and local flora and fauna, but *D. compactus* is likely not a keystone species in this ecosystem. Unlike many places where kangaroo rats are found, Padre Island is a highly dynamic landscape composed of shifting dunes driven by gulf winds. Extreme disturbance events like hurricanes and even strong shifts in winds can shape and drive dune movement. Species on the island are likely adapted to these conditions to survive and occupy open niches when disturbance happens. The plant species found there help stabilize dunes and slow down dune movement (Nelson et al. 2000).

While the study has yielded valuable information, there are a variety of improvements that can be made to better understand *D. compactus*. Additional information might be gained by measuring microhabitat characteristics in the same areas where transect trapping is located. To increase chances of capturing all the individuals along a given transect, an increase in number of consecutive trap nights and sampling periods should be undertaken. Most small studies trap for more than 2 consecutive nights, usually 3 or 4 (Rosenzweig 1973, Slade and Blair 2000, Waser and Ayers 2003, Brock and Kelt 2004). Many studies increase trap success by only trapping during a new moon (Brown and Heske 1990a, Valone et al. 1995), adoption of this methodology could increase trap success. The transects were initially designed to extend further than 200 m, but ground-truthing revealed moist lowlands (deemed unsuitable habitat for *D. compactus)* beyond this distance that were frequently inundated with water. End of transects did cross into these lowlands, and with one exception only species other than the target species were caught there. Instead, additional transects extended along the island would provide more detail into spatial distribution of *D. compactus*. Development of a habitat suitability model that can be applied across the island will help to further delineate potential areas with high kangaroo rat densities. This will require higher catch rates combined with a set of fine-scale ecogeographical information.

The Gulf-coast kangaroo rat is an important member of the barrier island dune community. This species will no doubt respond to changing environmental pressures by an increase or decrease in populations. While human encroachment is limited within Padre Island National Seashore, suitable habitat is still threatened by global factors such as climate change and natural disaster. The data collected here will provide a baseline for future studies that should examine factors such as genetic variation and aid in development of a robust habitat suitability model. With so little information available on this particular species, collection of more data is essential to ensuring the on-going management towards population stability of *Dipodomys compactus*.

Table 1. Transect Captures of *Dipodomys compactus* at Padre Island National Seashore, Texas, USA, in 2010

Transect number	Number of captures first night (M), second night(n),recaptures(R) in spring	Number of captures first night (M), second night(n),recaptures(R) in fall
1	9, 9, 5	0, 2, 0
2	3, 3, 1	1, 1,0
3	5, 3, 3	0, 0, 0
4	2, 1, 0	2, 3, 2
5	4, 3, 3	1, 3, 0
6	0, 2, 0	0, 0, 0
7	1, 10, 1	4, 5, 1
8	4, 4, 3	1, 0, 0
9	0, 1, 0	0, 0, 0
10	3, 6, 2	0, 0, 0
11	0, 0, 0	0, 0, 0
12	0, 0, 0	0, 0, 0
Totals	31, 42, 18	9, 14, 3

Note: Due to low capture rates in the fall, fall data was not used in calculation of Lincoln-Peterson Index.

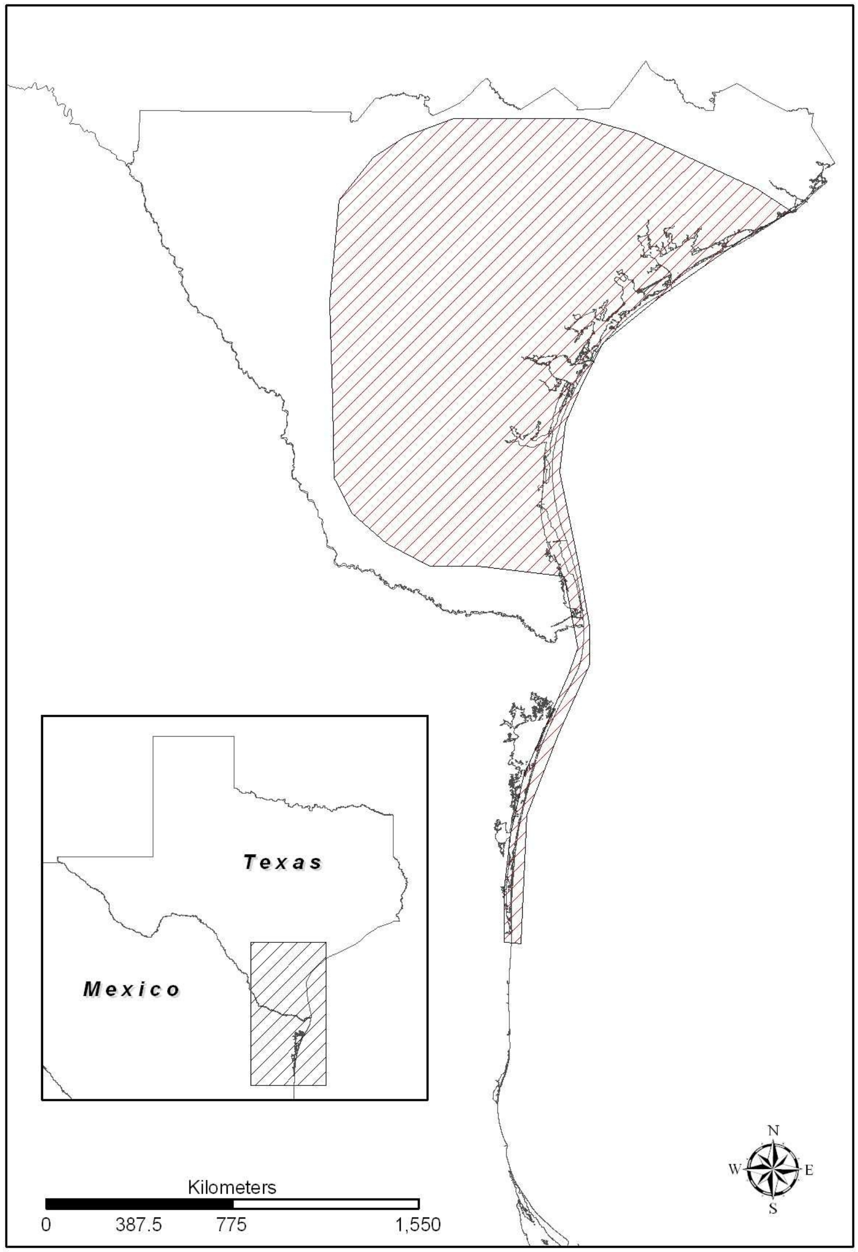

Figure 1. Distribution of Gulf coast kangaroo rat (*Dipodomys compactus*).

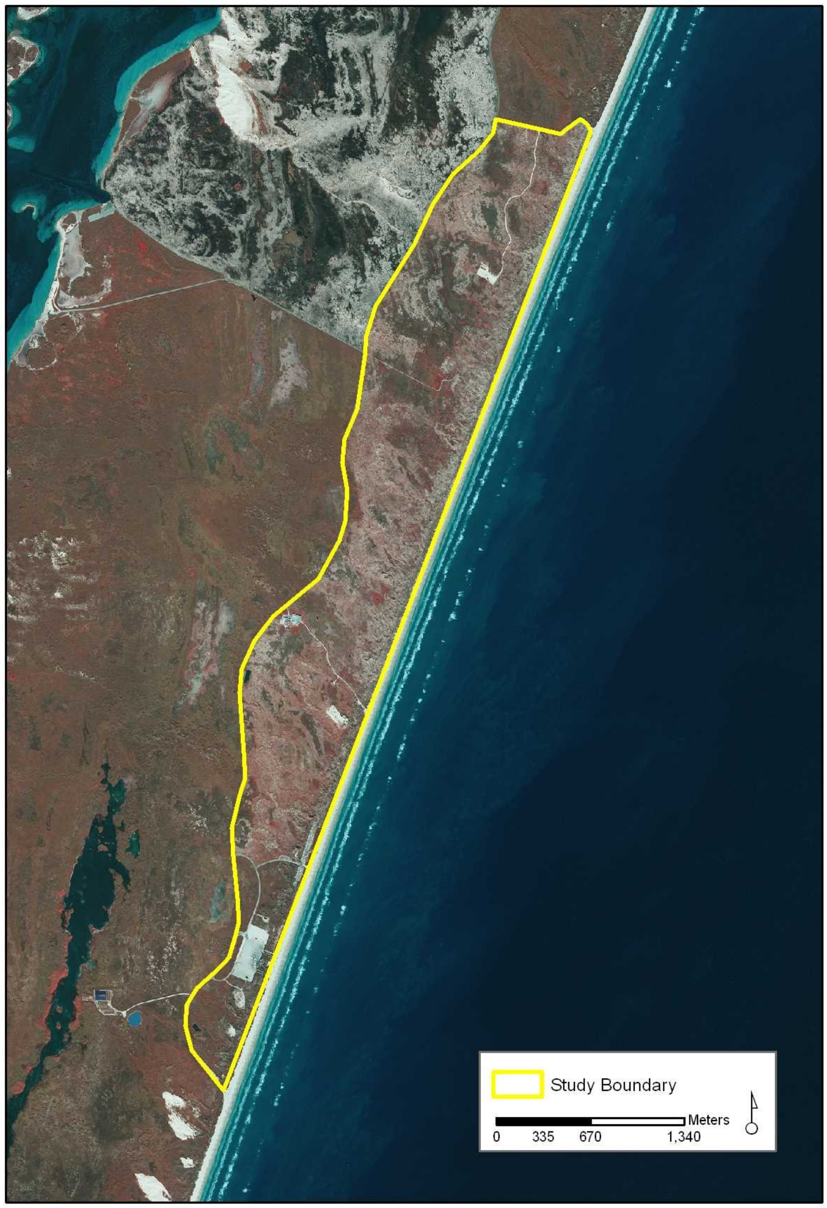

Figure 2. Study area in Padre Island National Seashore (PINS).

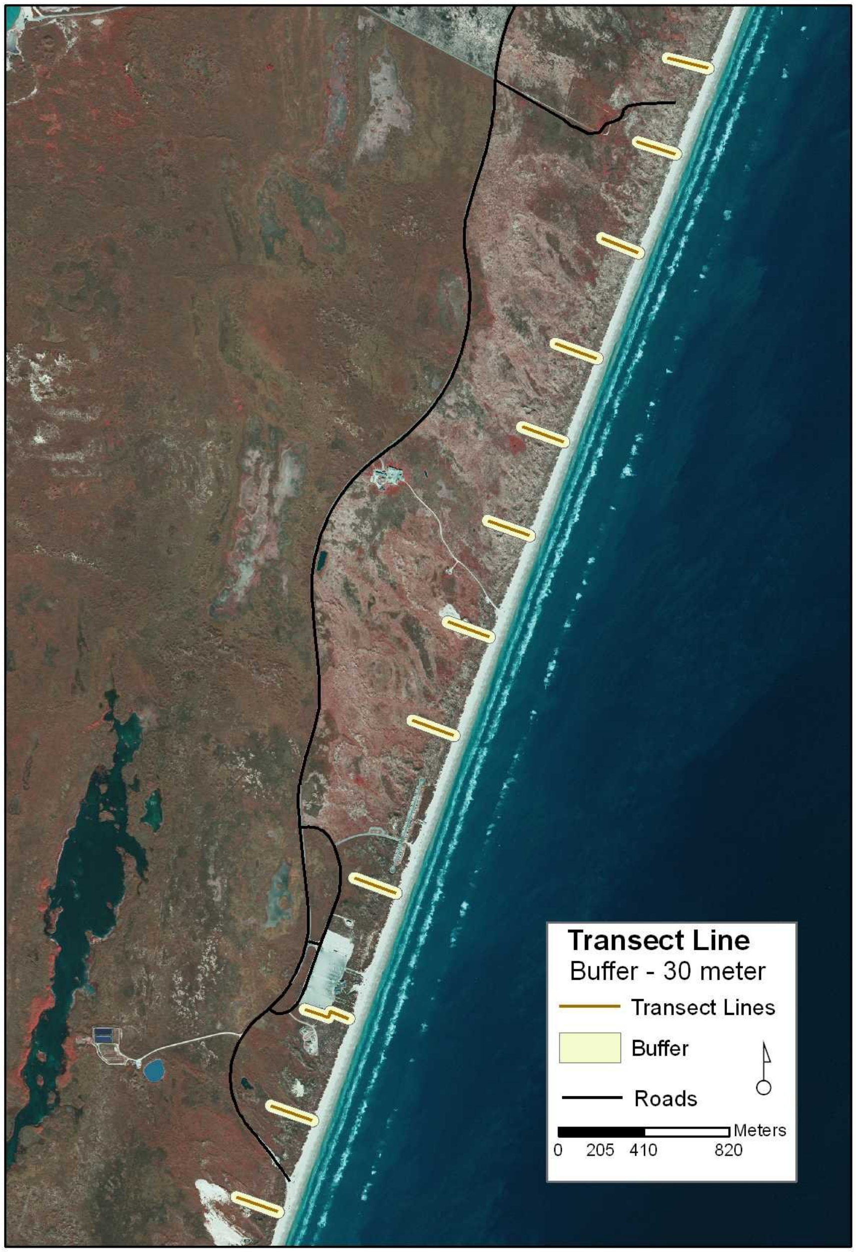

Figure 3. Twelve transect lines placed perpendicular to the beach and extending for 200 m.

Figure 4. Transect 10, modified to account for Visitor's Center parking lot.

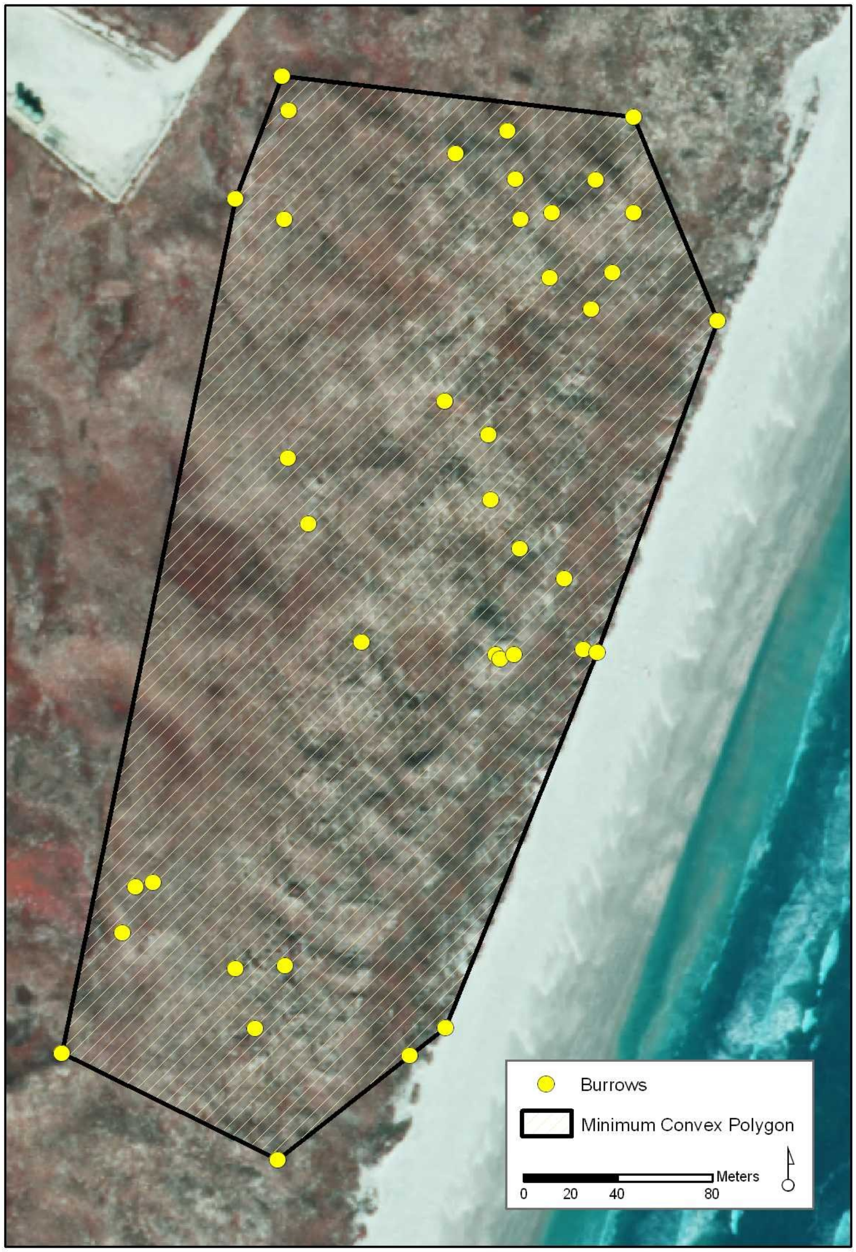

Figure 5. Minimum convex polygon (MCP) for burrows measured during microhabitat analysis.

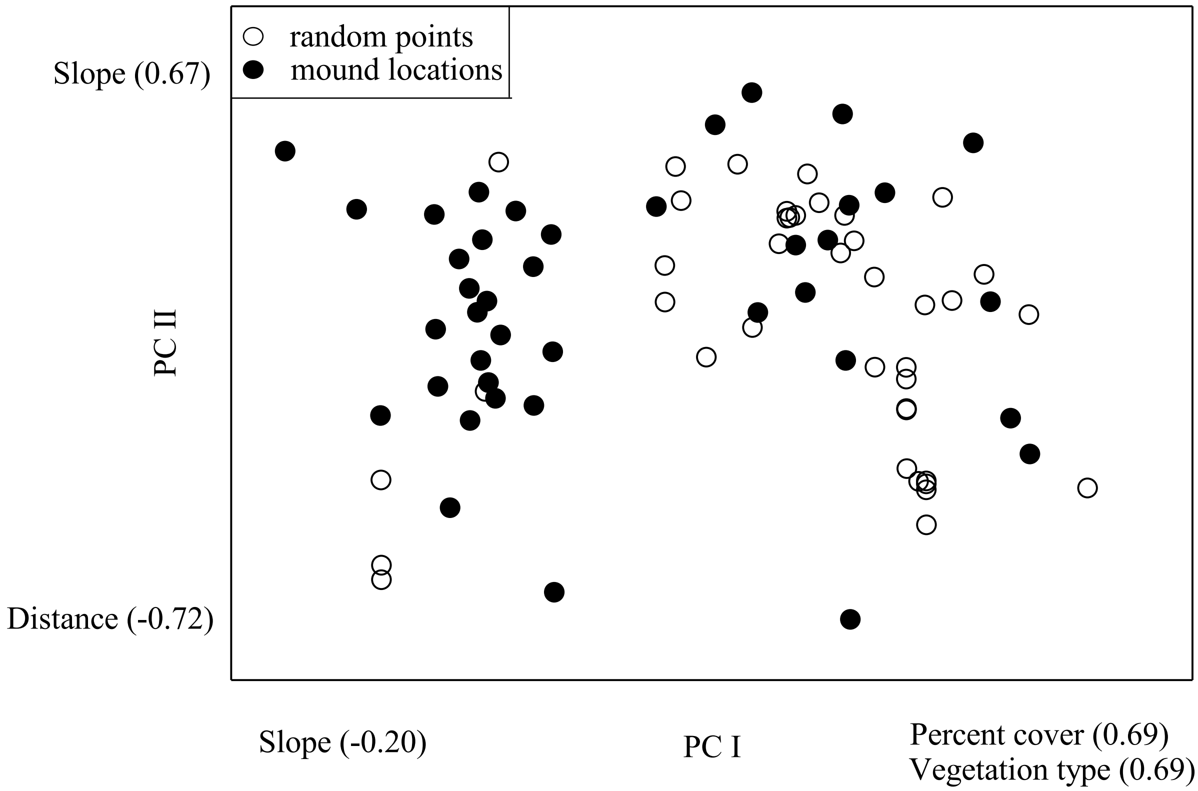

Figure 6. Principle components analysis (PCA) for variables measured during microhabitat analysis.

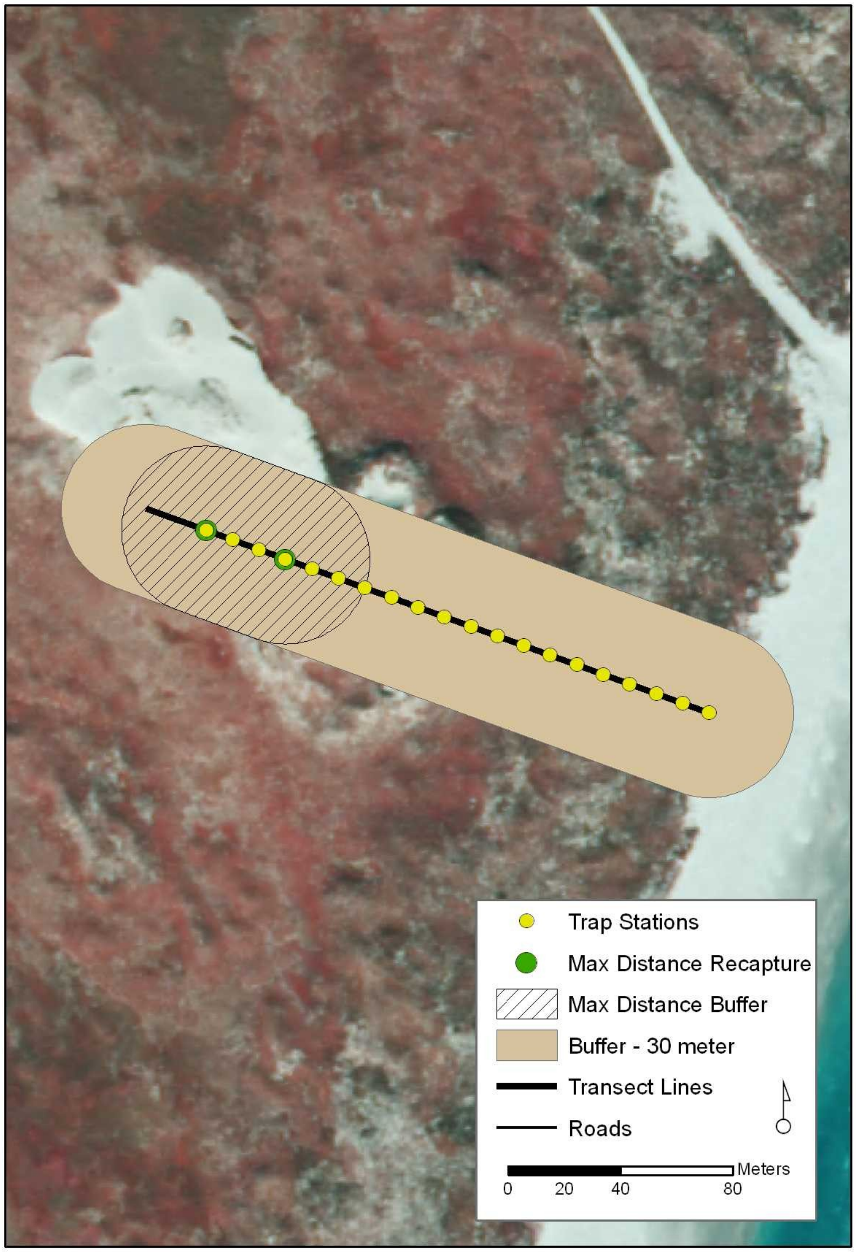

Figure 7. Creation of 30 m buffer due to capture and recapture distances.

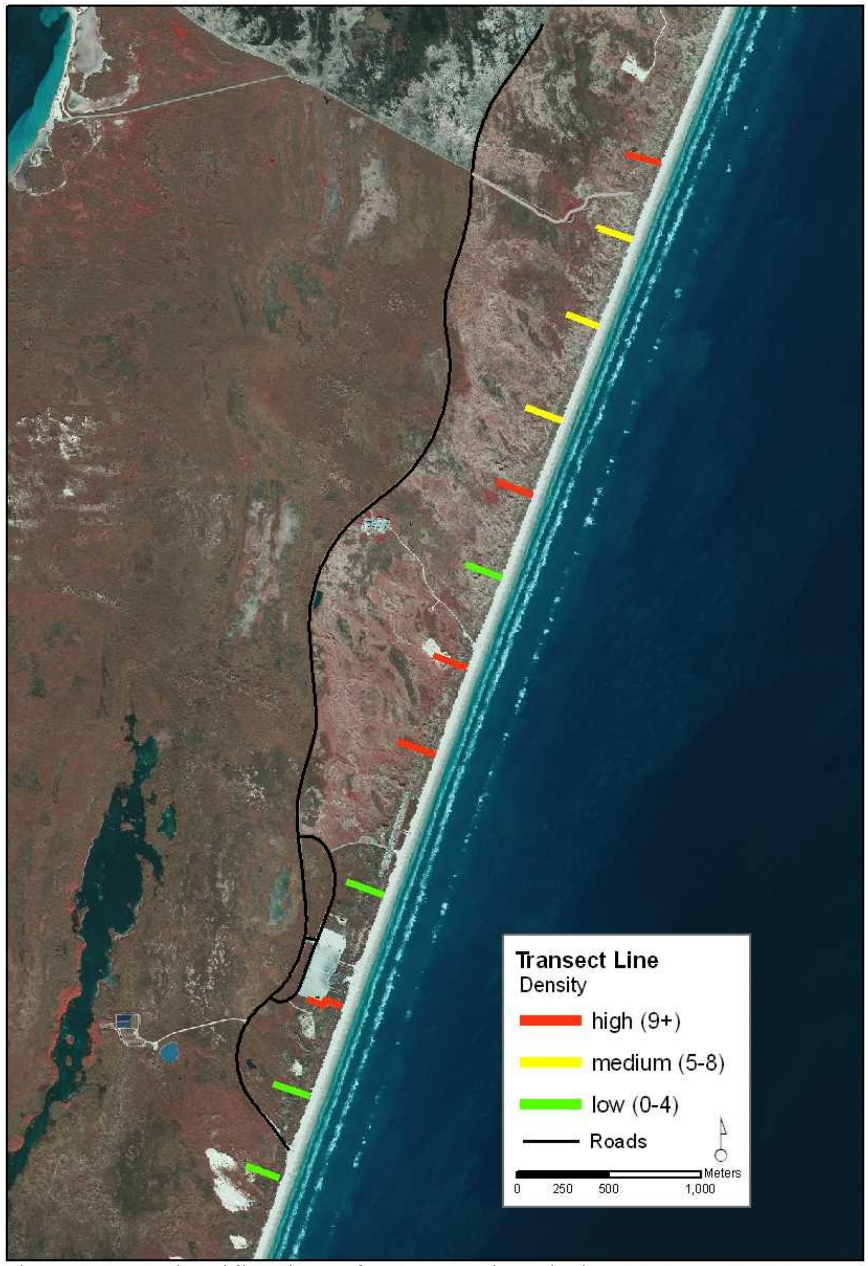

Figure 8. Reclassification of transects in relation to trap success.

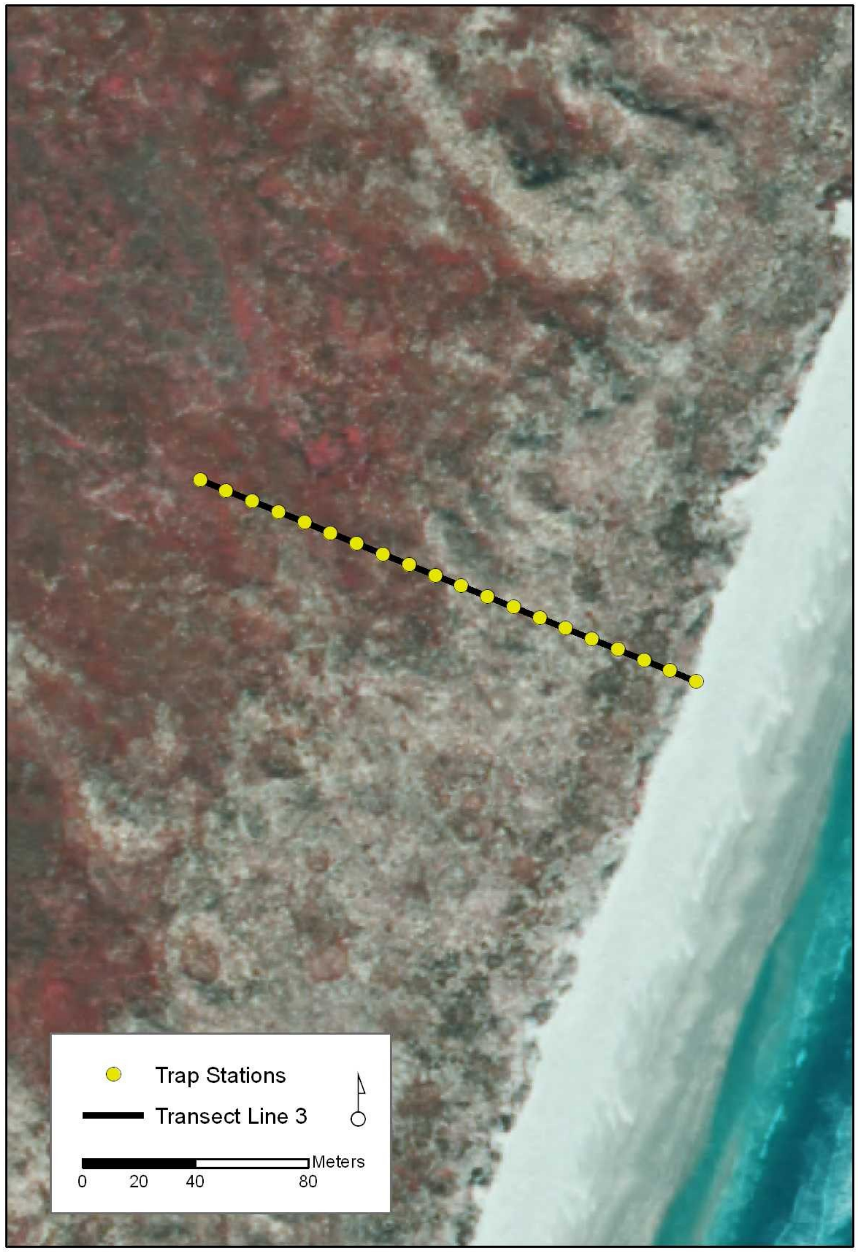

Figure 9. Transect 3, reclassified as “medium” density.

Figure 10. Transect 12, reclassified as “low” density.

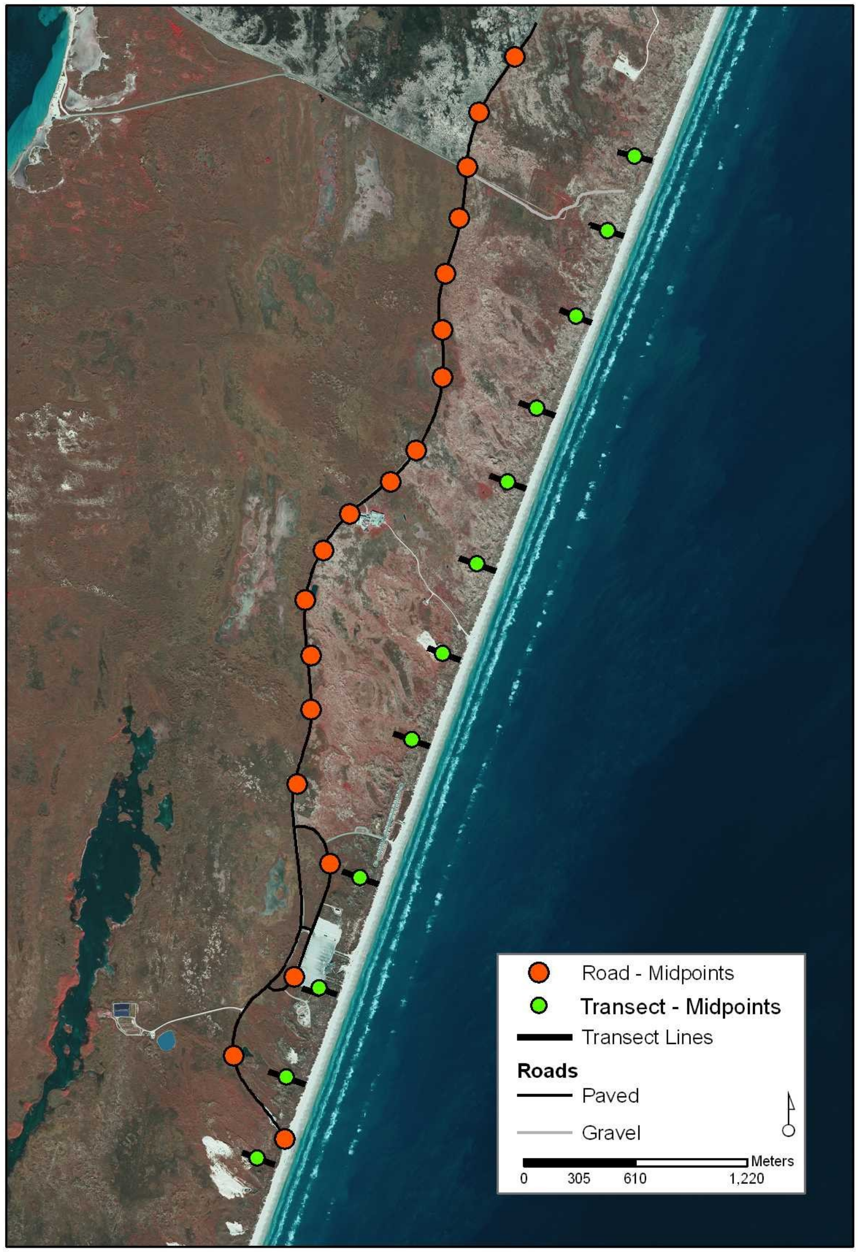

Figure 11. Distance to nearest road calculated from the midpoint of each transect.

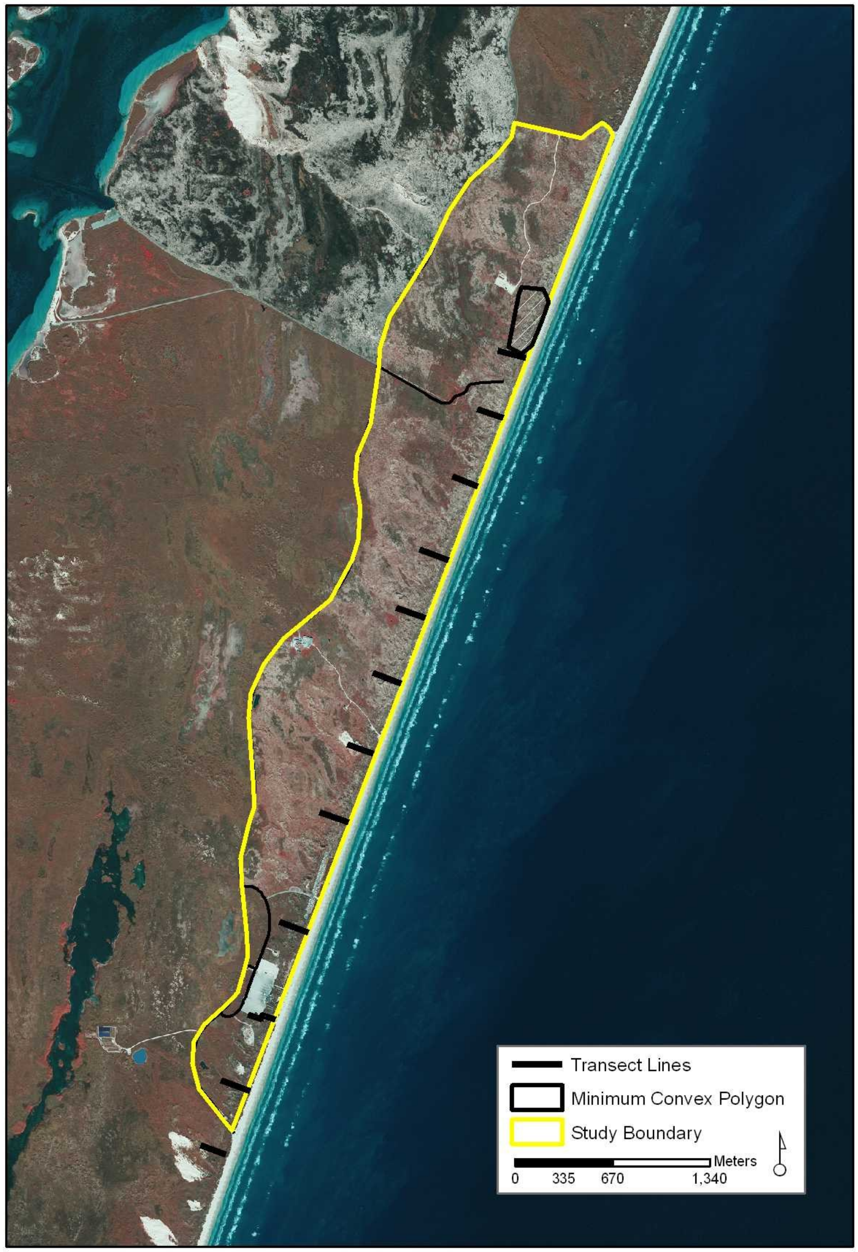

Figure 12. Study area with transects and microhabitat MCP in place.

Figure 13. Transect 7 intersecting dune formation.

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VITA

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While attending college, he received multiple scholarships and was recognized on the Dean's List 10 times. He has worked as a tutor at the Student Learning Assistance Center, an instructional assistant for the biology department, and for the Texas Forest Service as a wildland firefighter and fire research assistant.

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