HOME RANGE AND MOVEMENT OF NUTRIA (*MYOCASTOR COYPUS*) ALONG A SELECTED STRETCH OF THE RIO GRANDE RIVER, BIG BEND NATIONAL PARK, TEXAS

THESIS

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SUPERVISING PROFESSOR: THOMAS R. SIMPSON

I investigated the home range and movement patterns of nutria (*Myocastor coypus)* along a section of the Rio Grande River in Big Bend National Park (BBNP). Nutria, an exotic semi-aquatic South American rodent, currently are found mainly in the south-central, southeastern and Atlantic coastal areas of the United States where they are known to damage wetland ecosystems. This introduced species continues to expand its range in the United States. Nutria first appeared in BBNP in the mid 1990s. Since that time, they have continued to move upriver and into adjacent wetland habitats. The study site was centered at the beaver pond near the Rio Grande Village campground and includes the areas between the pond and the river as well as a ~4.5 km corridor along the river from Daniel's Ranch to the Boquillas Crossing area. The beaver pond and surrounding spring ponds are home to populations of the federally endangered Big Bend Mosquitofish (*Gambusia gaigei*). Seven adult nutria were captured, sedated, measured, marked, collared, and released during seven data collecting trips during the summers from May 2004 to June 2005. Collared nutria were tracked by radio telemetry techniques, and GPS coordinates were taken of their locations. An average of 27 locations per animal was used to calculate minimum convex polygon (MCP) home ranges and daily movement distances for five nutria (3 male and 2 female) using ArcMap software. The average home-range sizes were 10.05 ha (14.81 ha for males, 2.91 for females), and the mean maximum daily distance moved was 637.4 m (738.3 m for males, 486 m for females). Poor trap success and low sample size resulted in limited data. Data resulted in larger home ranges for males than females. This was comparable to other studies. Home range sizes for males were larger than other documented estimates. Mean daily movement distances of nutria in BBNP were similar to nutria in other locations.

INTRODUCTION

The nutria (*Myocastor coypus*), a large semi-aquatic rodent native to South America, was introduced into North America in California in 1899 as a potential resource for the fur trade (Ashbrook 1948, Evans 1970). Nutria were introduced in large numbers in Louisiana in the 1930s. Soon after, with the onset of World War II, nutria fur farming failed (Marx et al. 2003). In Louisiana, many nutria raisers then released their stock into the wild (Bounds and Carowan 2000). In other areas of the state nutria escaped enclosures due to flooding caused by hurricanes (Ashbrook 1957, Simpson 1980). Nutria were introduced or migrated into 30 states (Carter and Leonard 2002). Bounds (2000) lists the nutria's current North American distribution to include only 15 of these states. Highest densities are found in the south-central, southeastern, and Atlantic coastal areas of the United States with largest populations occurring in Louisiana and Maryland (Carter and Leonard 2002). The nutria continues to expand its range in some areas of the United States and elsewhere (Bounds et al. 2001).

Evans (1983) reported that nutria entered Texas in 1941. By 1946, Dallas fur buyers reported nutria trapped near Port Arthur, Texas (Swank and Petrides 1954). During 1947 and 1948, nutria were introduced throughout east Texas as a fur resource and aquatic vegetation control (Dozier 1952, Swank and Petrides 1954). Since that time, they have moved westward to the Rio Grande Valley and into the Trans-Pecos ecological region. Hollander et al. (1992) documented one specimen from Independence Creek in

Terrell County in 1979 and captured another from the banks of the Pecos River in Val Verde County in 1990. Schmidly (2004) describes the distribution of nutria as extending along the Rio Grande River through Big Bend National Park (BBNP). The first sightings of nutria in BBNP were reported in 1993 (J. R. Skiles, National Park Service, personal communication 2004)

Most research on nutria in the United States has focused on habitat impact. Nutria are destructive to wetlands and detrimental to native flora and fauna. Nutria have a voracious appetite and can consume approximately 25% of their body weight daily (LeBlanc 1994). Many studies have documented damage to marshes caused by nutria (Swank and Petrides 1954, Evans 1970, Johnson and Foote 1997, Carter et al. 1999, Bounds and Carowan 2000, Marx et al. 2003). Connor and Toliver (1987) reported the presence of nutria inhibits replanting of baldcypress (*Taxodium distichum*) in flooded logging areas. Nutria also damage agricultural crops (Bounds 2000, Marx et al. 2003). Nutria directly impact waterfowl and muskrat (*Ondatra zibethicus*) through competition for food (Atwood 1950, Swank and Petrides 1954, Simpson 1980, Bounds 2000, Schmidly 2004). In addition to competition for food resources, the consumption of vegetation by nutria removes cover, fragments habitat, and promotes soil erosion (Bounds and Carowan 2000).

Due to the destructive nature of this exotic pest, as nutria began moving into BBNP the National Park Service (NPS) wanted to determine the extent of their activity within the park. The Rio Grande River and a series of adjacent natural springs are small sensitive areas of wetland habitat in BBNP. One such area is near Rio Grande Village (RGV) campground in the southeastern part of the park. Ponds in this area are the only known refuge of the Big Bend mosquitofish (*Gambusia gaigae*), a federally endangered species. Based on known problems caused by nutria in other locations, these ponds are at risk of damage by nutria activities. To assess this risk, two projects were proposed to study nutria in BBNP. The first of these (Milholland 2005), studied nutria habitat use and food habits in the RGV area. My study is the second project, and I calculated home range sizes and analyzed movement of nutria in the RGV area.

Radio-telemetry (Cochran and Lord 1963) is a field-proved method of monitoring populations, determining home ranges, assessing habitat use, and determining movement patterns of animals. Radio telemetry allows frequent records of animal locations and allows researchers to locate an animal at a given time (Coreil 1984). This is impossible with other techniques used to monitor habitat use such as mark-recapture. Radio tracking increases the efficiency of collecting information and gives a more complete and accurate information on how an animal uses its habitat. Home range sizes and shapes and movements of an animal within its home range are important in understanding how an animal is utilizing its habitat. Food, cover, competition with conspecifics, and territoriality influence movements and home range placement (Litvaitis et al. 1996).

Few radio telemetry studies of nutria have been conducted in North America (Lohmeier 1981, Coreil 1984, Ras 1999, Denena et al. 2003). None of these studies addressed nutria ecology in a large river, nor nutria inhabiting a desert environment. In my study, I used radio telemetry to calculate home ranges and analyze movements of nutria living in the limited wetland habitat of the Chihuahuan Desert, near the RGV area of BBNP.

MATERIALS AND METHODS

Study Area

Big Bend National Park is 324,219 ha located in the Trans-Pecos ecological region of Texas. This represents the largest area of protected Chihuahuan Desert habitat in the United States. The Rio Grande River makes up the 190 km southern border of the park and creates a productive riparian corridor that is refuge to numerous species of concern including the Big Bend mosquitofish and the Mexican beaver (*Castor canadensis mexicanus*).

My study area is located along a stretch of the Rio Grande River in the southeastern part of the park, approximately 30 km from park headquarters. This site is centered near the RGV campground and encompassed the beaver pond wetland area, and 4.5 km of the Rio Grande River adjacent to RGV (Fig. 1). The Beaver Pond was created in the 1980s by Mexican beavers damming the runoff channel from the Spring 4 pond (Reeder 2001). This habitual alteration by beaver created a shallow (~1.5 m deep) approximately 0.25 ha pond. Cane marsh areas, also created by beavers, surround the pond. The pond is roughly 100 m from the Rio Grande River and adjacent to Spring 4 pond. The Beaver Pond is bisected by a boardwalk, which connects the campground to a nature trail.

The habitat surrounding the pond is a tall (~ 2-3 m) cane marsh consisting of two cane species. Native common cane (*Phragmites australis*) is found on the southern and

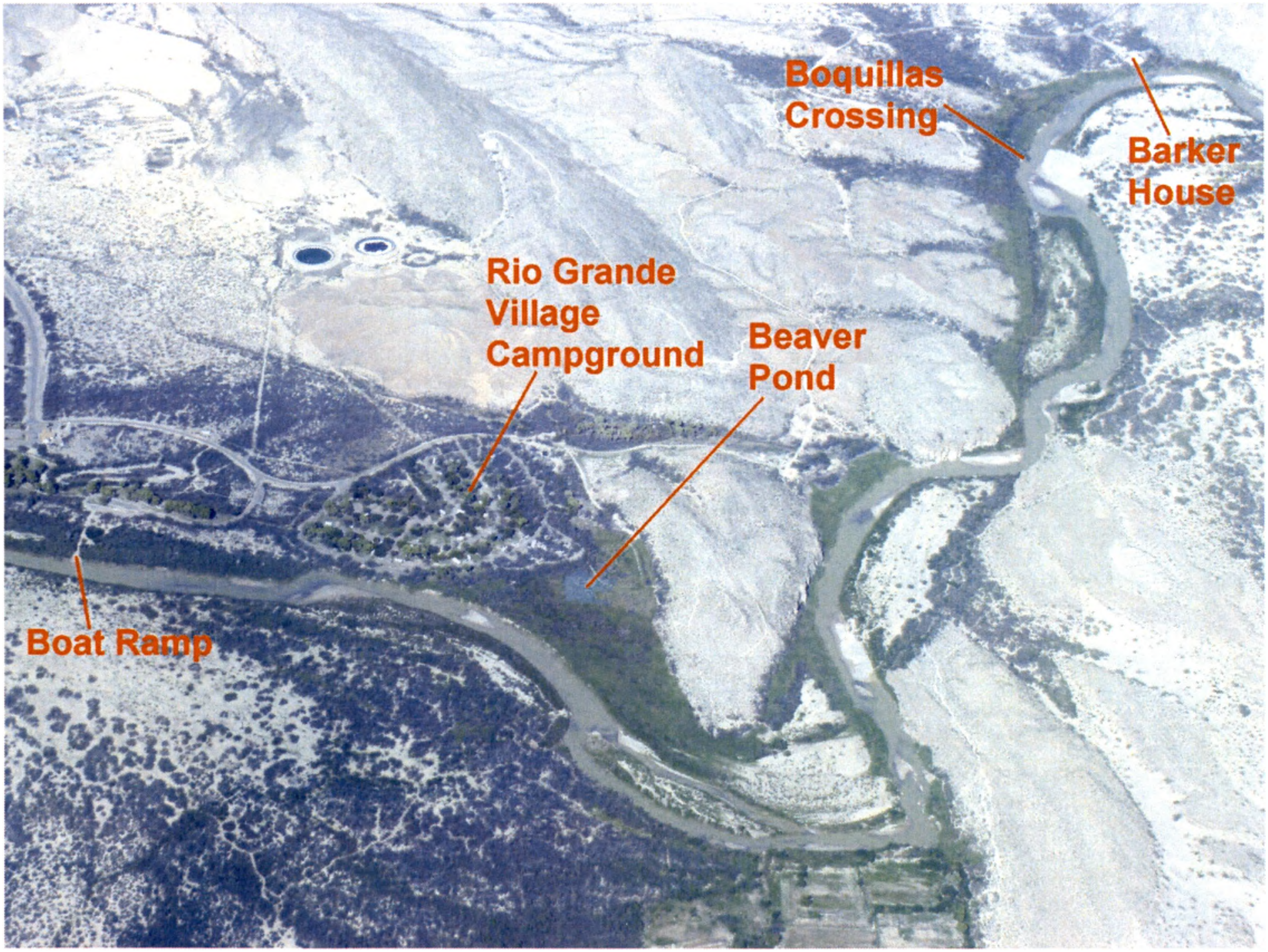

Figure 1. Aerial photograph of the Rio Grande Village area, Big Bend National Park, Texas

western portions of the pond in deeper water and along all banks of the pond except for the northwest corner. This corner of the pond is bordered by a huisache (*Acacia smallii*) thicket on the north and the beaver dam to the west. The exotic giant reed (*Arundo donax*) grows in areas of shallower water and dry land to the south and west of the wetland extending to the river, with small patches scattered on the edges of the pond.

Other plant species found in the beaver pond are water hyssop (*Bacopa monnieri*), spikerush (*Eleocharis caribaea*), water pennywort (*Hydroctyle umbellata*), flatsedge (*Cyperus sp.*), foxtail (*Alopecurus sp.*), and cattail (*Typha latifolia*) (Milholland 2005). In addition to these aquatic plants, woody species such as cottonwood (*Populus acuminata*) and huisache are scattered around the perimeter of the pond.

Riparian vegetation differs between the American and Mexican banks of the river. Milholland (2005) reported that the vegetation on the American side consisted primarily of *Phragmites* and *Arundo*. Much of the river bank was a closed stand of cane with scattered openings containing baccharis (*Baccharis glutinosa*), salt cedar (*Tamarix sp.*), and bermudagrass (*Cynodon dactylon*). Based on visual estimates, the two cane species are found on the American bank in a ratio of approximately 85% *Aroundo* to 15% *Phragmites.* However, the Mexican side of the river, within the study area, was more open with much less cane and higher diversity of species. The cane on the Mexican bank of the river was dispersed in equal concentration of *Arundo* and *Phragmites*. Within a short distance of the riparian area, the vegetation was typical Chihuahuan desert species (Milholland 2005).

Capture and Marking

Trapping of nutria took place during seven trips (13 May 2004 – 30 June 2005). Each trip lasted approximately seven days. Trips occurred in summer (May, June, July, and August) except for a short trip in December 2004. Medium sized (81x25x31 cm) Tomahawk live traps (Model #108, Tomahawk Live Trap Co., Tomahawk, WI) were set in the cane marsh along the water's edge of the beaver pond near tracks, at feeding signs, and other areas with nutria activity or suspected nutria presence. Along the river, traps were set at locations near nutria sign and possible resting or grooming sites or feeding platforms. Traps were set in late afternoon and checked the following morning. Traps initially were baited using sweet potatoes (Ragan 1960, Denena et al. 2003, Schmidly 2004, Milholland 2005). Later in the study, December 2004-June 2005, apples (Guichon et al. 2003), bananas, potatoes, and mangos (M. Forstner, Texas State University-San Marcos, personal communication 2003) were incorporated as bait in an attempt to increase trap success. Padded coil spring leg-hold traps (Oneida/Victor #1.5 Softcatch, Woodstream Corp., Lititz, PA) also were used later in the study to increase trap success.

Captured nutria were visually assessed for suitability for radio collar attachment. Those judged too small immediately were released. All others were taken to the Barker House research station to be measured, marked, and equipped with a radio collar. Nutria were weighed to determine sedative dosage. Animals were sedated with ketamine HCL (Ketaset) (via intramuscular injection) at a volume of 0.25 cc/kg (Van Foreest 1980, Bó et al. 1994, Milholland 2005).

Linear measurements of total length, tail length, right hind foot length, and right ear length were recorded for each nutria. Linear measurements were used to estimate age following Reggiani et al. (1995)

$$\ln A = -1.955 + 0.123(W) + 0.017(TTL) + 0.222(HFL)$$

where: A = age in months,

W = weight in kg,

TTL = total length in cm,

HFL = hind foot length in cm.

Gender was based on palpation for the presence or absence of a baculum. For each nutria a radio collar was placed around the neck and a numbered, self locking metal tag (Jiffy style 893, size 3, National Band & Tag Co., Newport, KY) was placed in the webbing of the hind foot for the identification of a recaptured animal should the radio collar be lost (Ras 1999, Milholland 2005). The pelage on the dorsum and back of the head and neck were bleached with hair bleach (Basic White extra strength powder lightener, Clairol Inc., Stamford, CT mixed 1:1 with Salon Care Professional 40 volume crème developer, Brentwood Beauty Labs International, Dallas, TX) to identify a "marked" nutria at a distance (Guichon et al. 2003). The nutria was placed back in the trap, and the bleach was allowed to dry and set for 30 minutes before it was rinsed clean. The trap was placed in a shaded garage in a shallow tray of water to allow the nutria time to recover from the sedation. The nutria was released at the capture location when completely recovered.

All field activity was conducted in compliance with the scientific collecting permit issued by the National Parks Service (BIBE-2004-SCI-0043), and the Texas State University Institutional Animal Care and Use Committee (permit # HOASJQ_02).

Radio Telemetry

Two models of radio collars (Wildlife Materials International, Murphysboro, IL) were used. The first collars (Model # HLPM-3180) malfunctioned, prompting a return of all collars to the manufacturer. The defective collars were replaced with a different design (Model # HLPM-3210). All collars transmitted a signal on the 151 MHz frequency and were similar to collars used in other nutria studies (Denena et al. 2003).

Animals were tracked and located from the time of release. Animal location data were gathered by foot or canoe using a portable receiver and Yagi antenna (Receiver: model TRX 100S, Wildlife Materials International, Murphysboro, IL; Antenna: Y-4FL 151-153 MHz Yagi antenna, Televilt TVP Positioning AB, Lindesberg, Sweden). Locations of collared nutria were determined by triangulation of the signal from known reference points. A Garmin GPS 12XL unit was used to record positions of tracked nutria. Location data were gathered on a standardized time scale. Locations of nutria were gathered as close to 300 h, 900 h, 1500 h, and 2100 h as possible each day of my field trips.

Tracking data were then transferred onto a digital orthophoto using GIS software (ArcMap 8.3 ESRI®, Redlands, CA). Minimum convex polygons (MCP) were transcribed around all locations of each animal to represent the home range (Mohr 1947). Adjustments were made to the MCP ranges to exclude unsuitable habitat. Home range area was determined using the GIS software's field calculations function (August et al. 1996, Ostro et al. 1999). Home ranges were only calculated for individuals with > 20 location fixes. Daily linear movement also was calculated for each nutria. Digital imagery was obtained from BBNP.

RESULTS

Capture and Marking

Trapping occurred on 47 nights for a total of 530 trap nights, 488 live trap nights and 42 leg-hold trap nights. More than 60% (323) of the trap nights were around the beaver pond. Of the total trap nights, three resulted in tripped empty traps, in eight the bait was removed and the traps were not tripped, and 23 resulted in the capture of nutria. Four non-target animals were captured over the course of trapping: one common raccoon (*Procyon lotor*), two bullfrogs (*Rana catesbeiana*), and one juvenile Mexican beaver (*Castor canadensis mexicanus*). Throughout the course of the study four Tomahawk traps were lost to theft along the river.

Of the 23 nutria captured, 10 juveniles were immediately released at the capture site, seven were adults (five males and two females), and six represented recaptures of collared nutria. Three captured nutria (one adult and two juveniles) died of causes beyond my control. Table 1 presents the sex, ketaset dosage, weight, total length, tail length, hind foot length, ear length, and age estimation of adult nutria captured in my study. Based on Adams (1956), one of my nutria may not represent an adult (≥ 5 months old), since the length of the hind foot did not exceed 127 mm. However, based on the equation presented by Reggiani et al. (1995), all nutria were over 12 months of age. The estimated ages of captured nutria ranged from 12.32 months to 37.12 months with an

Table 1. Identity, date of capture, measurements, and estimated age of radio collared nutria at Big Bend National Park, Texas, in 2004-2005.

Nutria	Collar Date	Sex	Weight (kg)	Ketaset Dosage (cc)	Total Length (mm)	Tail Length (mm)	Hind Foot Length (mm)	Ear Length (mm)	Estimated Age (months)
N1	15-May-04	M	3.9	1.00	903	361	133	30	20.3
	7-Jul-04	M	4.4	1.00	915	397	132	25	21.6
N2	15-May-04	M	3.9	1.00	844	365	132	32	18.0
N3	17-May-04	F	5.6	1.25	1030	444	141	21	37.1
	22-Jun-04	F	5.3	1.25	1015	440	140	25	35.2
N4	23-Jun-04	F	3.65	0.91	899	412	138	29	21.9
N5	7-Jul-04	M	4	1.00	906	395	131	25	19.8
N6	18-May-04	M	3	0.75	830	335	121	23	12.3
N7	21-May-05	M	3.4	0.80	758	358	129	26	13.7

average age of 22.2 months, and a Standard Error (SE) of 2.85 months. Average age of females was 31.39 ± 4.79 months and of males was 17.62 ± 1.54 months.

Weights varied from 3 kg to 5.6 kg. The average weight was 4.13 ± 0.28 kg, males averaged 3.77 ± 0.20 kg and females averaged 4.85 ± 0.61 kg. Total length varied from 1030 mm to 758 mm. The average total length was 900 ± 28.53 mm with males averaging 859 ± 24.87 mm and females averaging 981 ± 41.40 mm. Tail length varied from 335 mm to 444 mm. The average tail length was 390 ± 12.63 mm, males averaged 369 ± 9.69 mm and females averaged 432 ± 10.07 mm. Hind foot length varied from 121 mm to 141 mm. The average hind foot length was 133 ± 2.05 mm, males averaged 130 ± 1.82 mm and females averaged 140 ± 0.88 mm. Ear length varied from 21 mm to 32 mm. The average ear length was 26.2 ± 1.16 mm, males averaged 26.8 ± 1.40 mm and females averaged 25 ± 2.31 mm.

Home Range

Five of the nutria fitted with transmitters (three males and two females) were captured between 13 May 2004 and 24 August 2004. Table 2 presents the data on the time period each animal was tracked, number of fixes, MCP home ranges, and average and maximum daily linear movement distances. Two nutria captured and collared in May 2005 were not used in home range and movement analyses. One nutria was never relocated after only two tracking events, so thus excluded. Another died shortly after the marking process.

Home range was calculated for five animals using an average of 26.6 ± 2.73 locations per animal. Duration of tracking ranged from 14 to 53 days. Several collars

Table 2. Nutria home range size (MCP) and distance moved in Big Bend National Park, Texas, in 2004.

Nutria	Sex	Date Collared	Last Date Tracked	Days Tracked	# of Points	MCP Area (ha)	Avg Daily Linear Distance (m)	Max Daily Linear Distance (m)
N1	M	15-May-04	19-May-04					
		7-Jul-04	23-Aug-04	53	27	30.60	362.25	830
N2	M	15-May-04	25-Jun-04	42	23	1.01	116	244
N3	F	17-May-04	19-May-04					
		22-Jun-04	11-Jul-04	18	37	2.23	72.9	223
N4	F	23-Jun-04	11-Jul-04	14	22	3.58	285.8	749
N5	M	7-Jul-04	23-Aug-04	48	24	12.83	302.75	1141

malfunctioned after approximately 60 days and, therefore, tracking ceased until the animal was recaptured. Two nutria with faulty collars were recaptured. Collars were replaced and tracking resumed. All fixes for these nutria were combined in the calculation of home range. Tracking periods ended when no signal was detected from any point in the study area. Lack of signals might have occurred because of malfunctioning of collars or animals leaving the study site.

The size of nutria home ranges in BBNP averaged 10.05 ha (SE = 5.55 ha, minimum (min) = 1.01 ha, maximum (max) = 30.60 ha). The average home range of male nutria was 14.81 ha (SE = 8.60 ha, min = 1.01 ha, max = 30.06 ha) and the average home range of females was 2.91 ha (SE = 0.67 ha, min = 2.23 ha, max = 3.58 ha). Figure 2 presents home ranges of all nutria. Home range maps of all individuals are presented in Appendix I. Areas of non-habitat were removed from the MPC for N1 and N5.

Movement

The mean maximum distance traveled per day by nutria near RGV was 637.40 m (SE = 177.44 m, min = 223 m, max = 1141 m) (Table 2). The mean maximum distance traveled was 738.30 m (SE = 262.97 m, min = 244 m, max = 1141 m) for males, and 486 m (SE = 263.04 m, min = 223 m, max = 749 m) for females. The average distance traveled by males was 260.30 m (SE = 74.18 m, min = 116 m, max = 362.25 m) per day, while females traveled 179.35 m (SE = 106.46 m, min = 72.9 m, max = 285.8 m) per day. Two nutria, male N2 and female N3, rarely left the beaver pond. Their movement

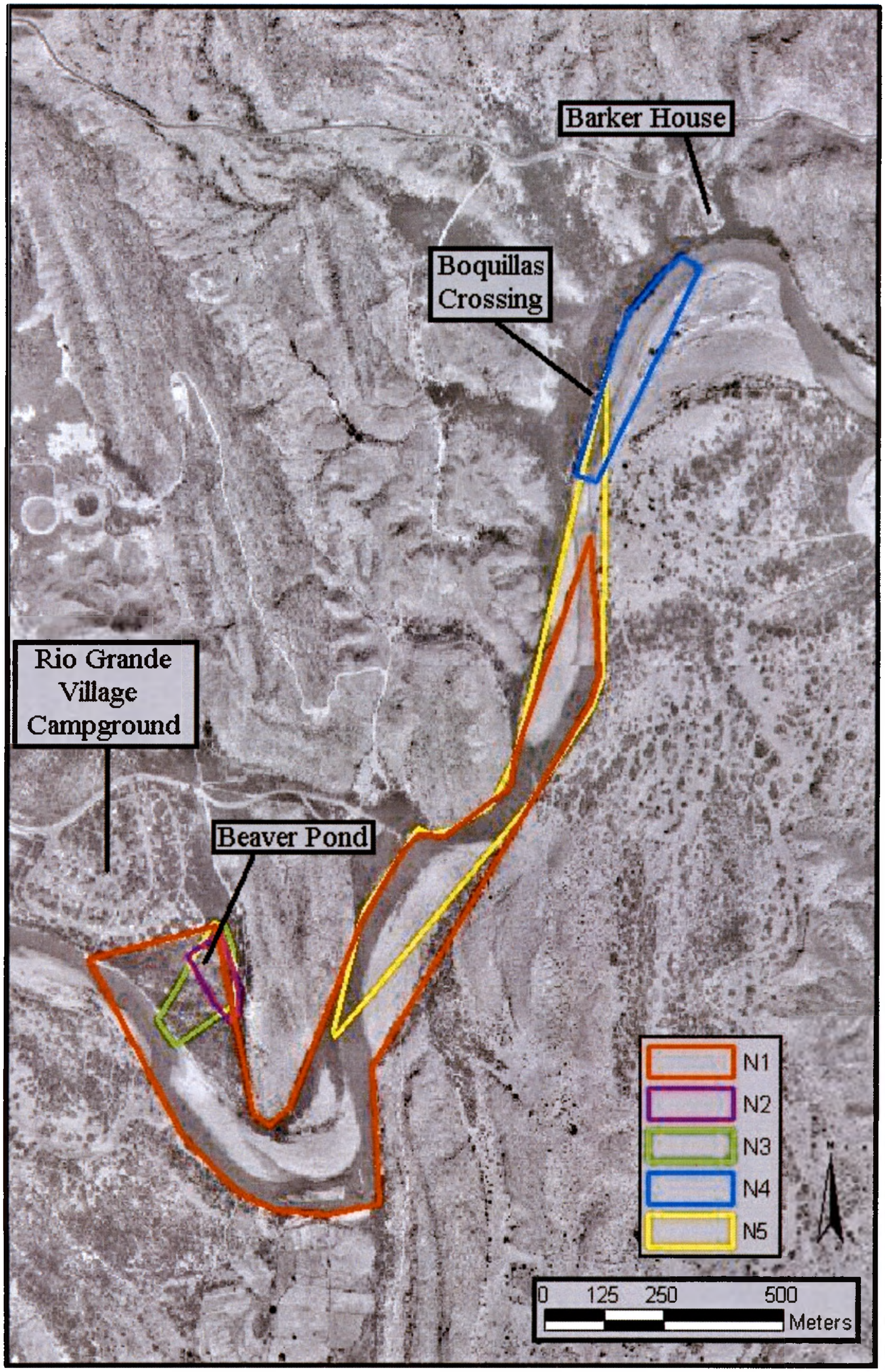

Figure 2. Home range for nutria near Rio Grande Village, Big Bend National Park, Texas, in 2004.

distances were less than nutria inhabiting riparian areas. The maximum distance traveled by nutria in the beaver pond was < 250 m.

No nutria burrow or den site was found. However nutria did use certain areas of their home range more extensively than others. Female N3 stayed near a small island in the beaver pond throughout most of my study. Male N2 most often was found near the western edge of the pond. Denena et al. (2003) postulated that nutria in their study did not stay within burrows during warmer months. All tracking fixes in my study were taken in summer, which may explain why definitive burrow sites were not located. During the study, numerous locations were found along the river that appeared to be used as "pull-outs" or feeding platforms. Some of these were closely associated with diurnal escape cover.

Activity

Radio-collared nutria had diurnal and nocturnal activities; however, movement patterns suggest increased activity during crepuscular and nocturnal periods compared to diurnal. One individual, male N2, moved longer distances during diurnal periods than nocturnal periods. His mean daily movement distance was 116 m (SE = 27.57 m, min = 39 m, max = 244 m), and on one day he moved 106 m between morning and an afternoon fixes and another 105 m to the nighttime fix. Another day he moved 145 m between the morning and nighttime fixes. On average this animal moved approximately 45 m between nighttime fixes and the morning fixes.

Behaviors associated with most fixes were feeding, hiding or resting in dense vegetation. One collared nutria was seen swimming in the beaver pond on 24 June 2004.

This was the only sighting of a collared nutria other than recapture events. One unmarked nutria was seen in the Rio Grande River just below the Barker House Research Station just after dawn. Nutria occasionally were seen swimming in the Beaver Pond at night (6 sightings).

DISCUSSION

Capture Success

The capture of adult nutria in the study area was somewhat of a problem. Milholland (2005) used the Schnabel estimate (Schnabel 1938) and the Chapman estimate (Schneider 1998) to approximate nutria population size in the Beaver Pond area. The Schnabel estimate suggested a population of 38 nutria within or near the beaver pond and the Chapman estimate suggested a population of 74 nutria. My trapping success at the beaver pond (4% success) does not support these estimates. Milholland (2005) captured 35 individuals with 10 recaptures in 234 trap nights (19% success). At the end of his study, Milholland removed 14 animals from the area for food habit analyses. This action, coupled with the tendency for adult nutria to become trap shy (Simpson and Swank 1979) may account for my decreased trapping success. No marked nutria from Milholland's study were captured during this study.

Poor success at the beaver pond led to increased trapping effort along the river, and this initially resulted in higher trapping success. However, eventually trapping success on the river was the same as the beaver pond: 4.8% compared to 4.0% in the beaver pond. Trapping on the river was more difficult and more time consuming. Dense stands of vegetation on the American bank of the river and my inability to trap on the Mexican side led to limited trap sites. Trapping along the river also increased human interactions along the border. Four Tomahawk traps were stolen from trap sites on the river. Traps were labeled with the NPS seal and signs in English and Spanish, advising the purpose of the traps. Vegetation was used as camouflage to protect traps from vandalism.

Trapping Adjustments

Modifications to the initial trapping protocol were incorporated in an attempt to increase trapping success. Tomahawk live traps were selected initially based on the success of other nutria studies (Coreil 1984, Ras 1999, Denena et al. 2003, Milholland 2005). Chapman et al. (1978) determined that the rate of survival of nutria captured in live traps was significantly different than that of leg-trapped animals. Conducting this study in a national park also results in public scrutiny, which often views leg trapping as inhumane (Andelt et al. 1999). When low trapping success threatened the validity of the study, we incorporated leg hold traps because of a greater documented capture success (Robicheaux and Linscombe 1978). I used discretion to avoid park visitors and to place traps in areas that would ensure the safety of any animal captured in the trap. Sites with beaver sign were avoided to reduce the chance of catching a beaver.

Oneida/Victor #1.5 Softcatch® traps were selected based on availability of traps and recent literature. Andelt et al. (1999) presented a comparison of eight different leg hold traps based on capture rate and injury levels. The #3 Softcatch® ranked low on injury score (4^{th} lowest) and had a 95% capture rate. The #1.5 Softcatch® is smaller and has a lower clamping force. Only one juvenile nutria was captured with a leg hold trap. It, however, sustained serious injuries (2 broken legs) and was euthanized. I continued to use the Softcatch® traps through the end of the study.

Different baits were also incorporated into trapping effort with no success. All animals (1 juvenile, N6, and N7) captured after using new bait were captured in Tomahawk traps baited with sweet potatoes.

Radio Collars

Difficulty with radio collaring nutria has been documented numerous times. Coreil and Perry (1977) discussed various types of collars based on the least negative impact on animals. The grooming habits of nutria have contributed to up to 50% of lost radio collars in the field (Denena et al. 2003). Bounds et al. (2001) reported nutria collars slipped off due to weight fluctuations.

In my study, transmitter failure was the greatest problem. Seven of the original collars were attached to nutria in the field. All signals were lost within two months of the date collared. Collars from two recaptured animals revealed that the waterproof potting around the battery and transmitter had cracked, shorting out the electronics. The manufacturer (Wildlife Materials Inc.) replaced the remainder of collars with a different model that reduced the stress on the waterproof potting.

Upon receipt of new collars, low trapping success resulted in the collaring of only two nutria, male N6 (died) and male N7. Male N7 was collared and released on 21 May 2005. Upon return to BBNP on 24 June 2005, the signal could not be located. It is not known whether the collar malfunctioned or the animal left the study area.

Home Range

Home range sizes varied greatly (1.01 ha to 30.06 ha) between individual nutria. Too few animals were captured to statistically test differences. However, males had larger home ranges than females (males: 14.81 ha, females: 2.91 ha). Also nutria living on or near the river had larger home ranges than those living in or near the pond (river: 15.67 ha, pond: 1.62 ha). The home range of two animals (male N1 and female N3) encompassed both the Beaver Pond area and areas of the river; thus, indicating there is some movement between these two areas. Male N1 was captured in the beaver pond; however, he was never tracked in the pond again. Female N3 was captured in the beaver pond and had four fixes on the river. These fixes directly follow this nutria's second capture event.

Other studies have shown varying home range sizes. Doncaster and Micol (1989) documented the home ranges of nutria as 5.68 ha for males and 2.47 ha for females in France, and the difference between genders was significant ($P = 0.019$). Denena et al. (2003) found home range size also varied by gender (3.82 ha for males and 1.61 ha for females), in Central Texas, but the differences were statistically non-significant ($t = 1.26$, $P > 0.05$). Lohmeier (1981) found smaller home ranges for males (2.26 ha) than females (2.35 ha) in Mississippi. These studies were located in pond settings, and when compared to my animals that spent most of their time in the beaver pond (male N1: 1.01 ha and female N3: 2.23 ha), they are similar.

Ras (1999) found the mean home ranges of 73 nutrias in Maryland was 9 ha for males and 11 ha for females. Coreil (1984) studied seven female nutrias in a southwestern Louisiana marsh and estimated their average minimum home range was 60 ha. These calculations are much larger than female minimum home range estimates at BBNP.

Variations in home range size might be directly associated with habitat. In limited habitats such as small ponds, home ranges are smaller, and in large marshes home ranges are larger. In BBNP, the habitat is a narrow riparian area around the Rio Grande River. This makes home ranges more linear along the river corridor. Food and adequate feeding and nesting platforms may be spread out over a greater distance causing increased movements. The cane marsh surrounding the beaver pond contains large amounts of food in a small area, thus producing smaller home ranges.

The home range data indicate there is free movement of nutria between the river and beaver pond. Nutria moved to the river and back to the pond (female N3). However, it seems nutria tend to stay within one habitat type or the other. This allows recruitment to the population at the beaver pond from river populations.

Movement

In this study, maximum daily movement ranged from 223 m to 1141 m, with a mean distance of 637.4 m. Nutria studied by Denena et al. (2003) moved on average 335.62 m. Ras (1999) documented movements spanning 30 m to 1500 m. Coreil (1984) reported average movements of 718 m. Mean linear distance traveled by nutria at Rockefeller State Wildlife Refuge in Louisiana was 226 m (Robicheaux 1978). Aliev (1965) documented a nutria traveling up to 80 km over a period of time in the USSR. Again variations probably arise due to differences in habitat type. In BBNP nutria move freely up and down the Rio Grande River. In other areas habitat might not be as suited for long distance traveling.

Activity

Few observations were made of nutria behavior. Nutria sightings occurred at night on the beaver pond and consisted mainly of nutria swimming in open water, probably traveling from one feeding site to another and feeding along the edges of the open water area. When nutrias were illuminated with a spotlight, they would swim for cover in vegetation. Most tracking fixes showed nutria in dense vegetation (cane). Presumably they use the vegetation as cover during the day and feeding plots at night. Milholland (2005) analyzed stomach contents of 14 nutrias from the beaver pond. His results show that nutria consumed primarily *Phragmites* (59.86%), water pennywort (12.71%), *Arundo* (6.3%), and spikerush (6.14%). These species make up the major vegetation around the beaver pond and river; *Arundo* and *Phragmites* more so than others. I never heard nutria vocalizations in the wild such as those documented by Denena et al. (2003) and Warkentin (1968). Caged nutria emitted grunting sounds, teeth grinding, and heavy breathing.

Management Implications

In 1999, Executive Order 13112 signed by President Clinton established the National Invasive Species Council, which oversees the control of invasive species by working with federal, state, and international agencies to implement the Invasive Species Management Plan (Clinton 1999). More recently, Congress passed the Nutria

Eradication and Control Act of 2003, which allowed federal funding for nutria eradication programs in Maryland, Louisiana, and other states. In these states, nutria populations are high and immediate action is needed to control the damage being caused (United States Congress 2003).

Under NPS policies (National Park Service United States Department of the Interior 2003), an appropriate program includes Integrated Pest Management (IPM) strategies for the nutria population and impact monitoring, establishment of thresholds for control, and a science-based control plan that accommodates local ecological conditions, best available methods, and social constraints as influenced by human use patterns.

The nutria could seriously damage wetland habitat in BBNP based on the selective foraging preference of native plant species, especially *Phragmites* (Milholland 2005). The Beaver Pond area is a high-risk area for nutria induced habitat damage, being the only natural habitat for the Big Bend mosquitofish. The Big Bend mosquitofish is a federally endangered species, which exists in the wild only in a few warm-water springs at RGV in BBNP. These fish populations have been decimated by road building, wetland drainage and irrigation practices of farmers, and by early actions and activities of the NPS (Reeder 2001). The NPS currently is involved in a project to restore wetland habitat around these ponds. Nutria have been viewed as a potential threat since their arrival in RGV. This invasion of nutria led to the construction of a "nutria-proof" fence around one pond (Spring 1) to serve as a refugium for Big Bend mosquitofish (J. R. Skiles, National Park Service, personal communication 2003). Milholland (2005) reported that nutria damaged up to 30% of the gambusia habitat by denuding aquatic and emergent vegetation.

A nutria management program is essential to preserving the limited riparian wetland habitats found along the Rio Grande River. The small size of the habitat may help to limit nutria densities in BBNP, however areas such as the Beaver Pond could serve as refugia for larger populations. Careful monitoring and management of nutria populations needs to be implemented before irreparable damage is made to this sensitive desert wetland area. Based on trapping effort at the Beaver Pond area, it appears that the nutria population is low enough that periodic trapping and removal may be all that is needed to limit or control impact of nutria. More data are needed for other locations along the Rio Grande River within the park.

Movement data suggest that nutria are capable of traveling long distances along the riparian corridor. Distance traveled in one day suggests that nutria can travel significant distance both up and down river. However, less suitable habitat (e.g., canyons) of several kilometers may be a significant barrier to movement. Additional research may indicate other areas of suitable nutria habitat along the river within traveling range of the nutria near RGV.

Conclusions

The home range data in this study were limited because of radio collar malfunction. This limited long-term tracking data. A longer duration of tracking data would have been useful in documenting shifts in home ranges over time or seasons. For example, male N1 originally was captured in the beaver pond on 15 May 2004 and was tracked to the river to the west and south of the pond area on the initial trip. The collar malfunctioned and all tracking data from the second collar (attached to N1 on 7 July 2004) were all downriver from previous locations. With limited data, no assumptions can be made on whether this was a shift in home range, or if the animal was using this area the entire time.

Limited trapping success also hindered data collection. General trends in home range sizes were indicated by data, but due to small sample size, no statistical tests could be performed. A larger sample size would have improved accuracy in determining whether differences occurred between home range sizes and gender and pond versus river inhabitants. An increased sample size would have also aided in analysis of movements as well.

Even with the problems that arose throughout this project, valuable data on the ecology of nutria in BBNP were gathered. This research, in conjunction with Milholland (2005) represents the first steps in developing an IPM plan for nutria in BBNP.

APPENDIX I

Figure 3. Home range for male N1 near Rio Grande Village, Big Bend National Park, Texas, in 2004.

Figure 4. Home range for male N2 near Rio Grande Village, Big Bend National Park, Texas, in 2004.

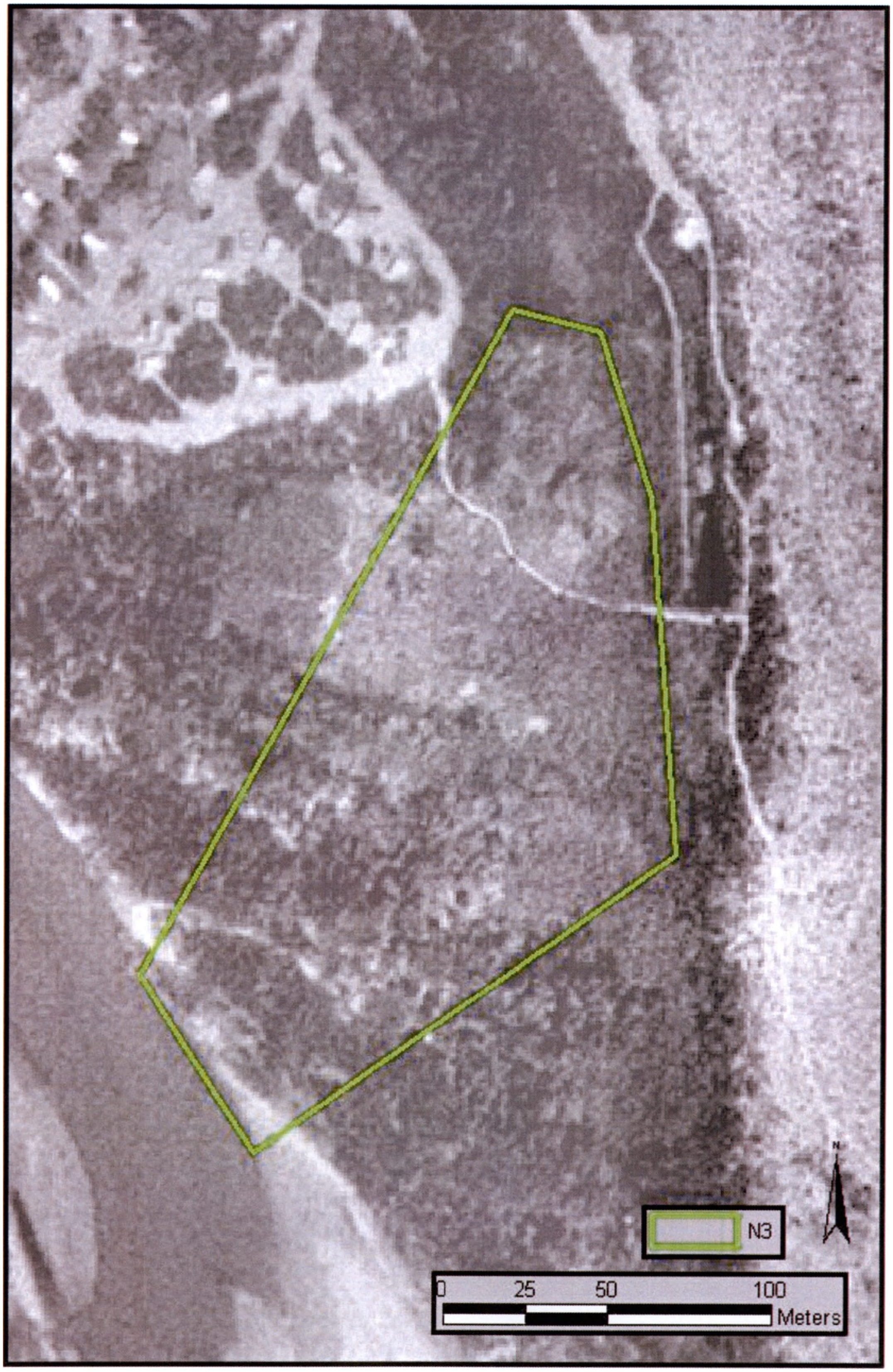

Figure 5. Home range for female N3 near Rio Grande Village, Big Bend National Park, Texas, in 2004.

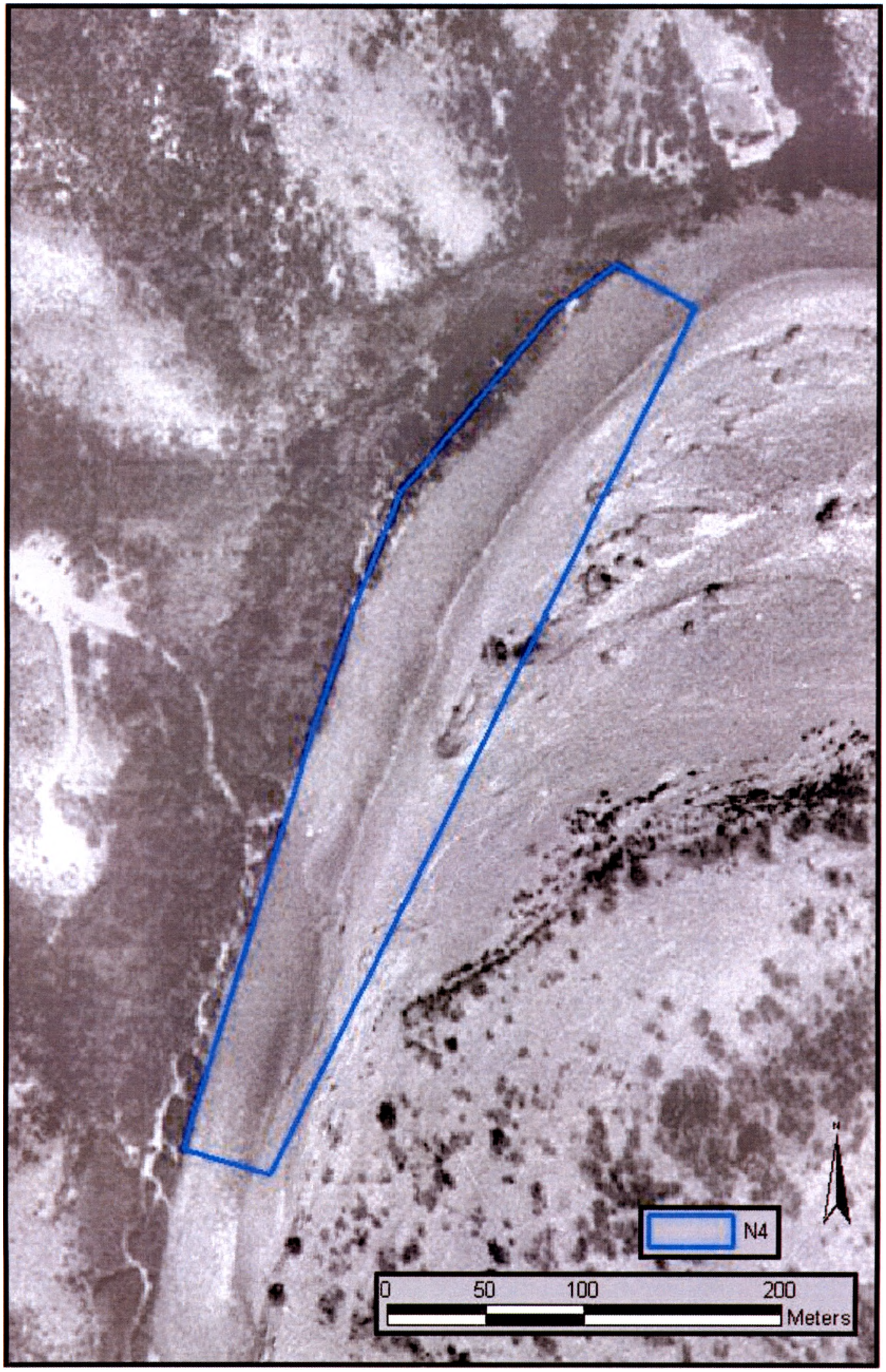

Figure 6. Home range for female N4 near Rio Grande Village, Big Bend National Park, Texas, in 2004.

Figure 7. Home range for male N5 near Rio Grande Village, Big Bend National Park, Texas, in 2004.

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VITA

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