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SURVIVAL AND DISPERSAL OF BOBCAT KITTENS IN A FRAGMENTED URBAN LANDSCAPE

Western National Parks Association final report
by
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ABSTRACT

Bobcats are found throughout most of North America but their existence is threatened in some areas due to increasing urban encroachment. Many studies have been conducted on adult bobcats, but reproductive behavior, and specifically kitten survival, behavior, and dispersal, is less well understood, and nothing is known about the potential effects of urban development on reproduction and kitten dispersal. I studied kitten survival and dispersal throughout the remaining habitat fragments of a southern California suburb. Adult female and kitten survival and movements were monitored through radio-telemetry. Survival, home range size and location, and movement patterns were analyzed with respect to land use, time of year, and developmental stage of the kittens. Kitten survival was low, and all of the mortality occurred within the first 5 months. Home range size varied with time of year and kitten development for both adult females and kittens. Kitten movement rate was highly correlated with developmental stage, with older kittens exhibiting more extensive movements. Understanding the way in which altered landscapes affect reproduction and kitten survival in bobcats will play an integral role in the conservation of this species along the urban edge.

INTRODUCTION

Recent studies conducted in urbanized regions have shown that carnivores, including bobcats, are particularly sensitive to the habitat fragmentation created along urban edges (e.g. Crooks 2002; Riley et al. 2003). These studies have shown impacts from factors such as habitat patch isolation, increased sources of mortality such as motorized vehicles, other carnivores, and toxins, and behavioral modification. Impacts such as these raise concerns about the viability of carnivore populations in urban interface areas. The wildlife communities of southern California's globally rare mediterranean environment are of particular concern. The mild climate and extraordinary landscape have made southern California a popular tourist destination and the preferred residence for millions of people. However, this popularity has also led to accelerated destruction of much of the remaining landscape throughout the biome. Along with neighboring wild areas, the Santa Monica Mountains National Recreation Area (SMMNRA) is being surrounded, fragmented, and engulfed by one of the largest metropolitan districts in the world.

Previous studies conducted in and around the SMMNRA have shown that while there may be some alterations in behavior and ecology, carnivores are present in many urban interface areas. In fact, previous adult survival rates for bobcats have been recorded as high, or higher than some populations in more rural areas (Riley et al. 2003). What is not known is whether the bobcat populations inhabiting these interface areas are able to successfully replenish themselves and contribute to the larger population, or whether they are simply a population sink into which bobcats from other source areas disperse. Very little is known about whether the behavioral modifications imposed on adults by urbanization disrupt successful reproductive behavior. Recent work by the National Park Service has determined that bobcats in the fragmented areas in and around the Santa Monica Mountains are producing kittens, but kitten longevity and the effects of urban encroachment on the survival and dispersal of these kittens remain open questions. Are the resources of this confined landscape able to even temporarily support nursing females or additional individuals? Are kittens able to navigate and forage in this landscape as they develop and disperse into new territories? Are they able to avoid human associated mortality such as vehicular collision and secondary poisoning? Are they able to locate suitable land available for a new home range? And finally are they able to successfully reproduce themselves?

The vitality of a bobcat population is dependent upon successful reproduction, and therefore management practices will only be successful if they integrate the developmental requirements of kittens as well as adults. To gain a better understanding of the bobcat population along the western edge of Los Angeles, I studied the development, behavior, and survival of bobcat kittens through dispersal age. I used implantable radio transmitters to track kittens alongside their mothers. The objectives were to acquire general information on kitten development, to learn about the possible effect of urbanization on reproductive behavior and success, and to gain an understanding of land requirements for females as their kittens develop throughout the year. I expected kitten survival to be low, especially in the early months and possibly again at dispersal time, and urban related mortality to play an important role. I also expected that females with kittens would have reduced home range sizes during periods in which kittens were kept in dens and when they were just beginning to move with the female, as well as low association with urban areas when young kittens were traveling with them.

METHODS

The National Park Service has been conducting an ongoing study of adult bobcat ecology and behavior throughout the fragmented habitat within and surrounding Santa Monica Mountains National Recreation Area. Adult bobcats are trapped, collared, and tracked through radio-telemetry. For this project kittens were located by tracking the adult females to their den sites. In the spring, monitoring of female bobcats was intensified and locations were taken five times a week to determine if she had a litter of kittens. When the female's movements became localized for several weeks, it was assumed she had inhabited a den and likely given birth. When kitten

were 4 to 6 weeks of age 3-4 researchers simultaneously radio-tracked and triangulated the female and gradually approach her den. This would eventually cause the female to temporarily retreat from the den and then the team would search the immediate area for kittens.

Once located, the kittens were hand captured, ear-tagged, and surgically implanted with intraperitoneal radio transmitters (Telonics® IMP/130/L). Each kitten was given a preliminary exam to assess age (tooth eruption), sex, weight, and general health. Only those kittens over 400 g and determined to be in good health were implanted. The kittens were anesthetized with an injectable combination of 0.08 mg/kg Medetomidine HCl and 5.0mg/kg Ketamine HCl. The surgical procedure was preformed in the field by Lynn Whited D.V.M., a wildlife veterinarian, and assisted by park biologists. After all of the kittens were fully recovered they were returned to the den together, and the team left as soon as possible. The transmitters are implanted for life to avoid the extra stress caused by removal surgery, but the battery expectancy was 6-8 months. At this point we attempted to recapture surviving juveniles and fit them with radiocollars to continue monitoring. The implants were also equipped with mortality sensors and would emit a pulse rate of 2x normal if the transmitter remained motionless for greater than eight hours.

Locations were achieved by ground triangulation, where observers recorded their own location and the azimuth to the animal from three different positions. Bearings were taken a minimum of 30° apart and all within 15 minutes. In the event of a death, the body was recovered as quickly as possible and a necropsy was performed to determine the cause of death. Home range use and survival was monitored through independent telemetry locations (>12 h apart) recorded a minimum of three times per week. The time of monitoring was varied and locations were taken throughout the circadian cycle. In addition to independent locations, intensive monitoring was also conducted on kittens and their mothers 3-4 times per month. This entailed recording locations every 30-60 minutes for 2-6 hours, and allowed for more detailed information on behavior and movement patterns in order to discern kitten developmental stages.

Kittens were initially aged by tooth eruption (Jackson et al. 1988) and weight, and timelines of development were based on these ages. Although kitten development was likely gradual, distinct behavioral milestones were evident. These milestones were used to divide kitten development into seven stages, beginning with denning. A den was considered any site in which the female kept kittens for two or more consecutive days. Natal dens were where parturition took place, and all subsequent dens are "auxiliary dens". The denning period was split into three stages: (1) in the natal den; (2) in long-term auxiliary dens (≥10 days); and (3) in short-term auxiliary dens (<10 days). Denning ended once kittens began to change locations daily, at which point they were considered to be (4) traveling with the female. During this stage kittens were still left for periods of time, but not in the same place on consecutive days, and they remained relatively stationary while the female was away. Once kittens started moving without the female, they were considered to be traveling independently. This period was divided into two stages: (5) traveling independently < 1 day, and (6) traveling independently >1 day. The final stage (7) was when kittens were completely independent and no longer located with the female.

Home ranges were determined using 95% minimum convex polygons and computed for four periods or "season" throughout the year: denning season (March – May), early season kitten (June – August), late kitten season (September – November), and mating season (December – February). Land use for each animal in each season was measured by calculating the percentage locations and home range in each of three categories: natural land, urban area, and altered open-space or areas of non-natural vegetation, such as golf courses, parks, and low-density housing.

RESULTS AND DISSCUSION

In 2004 and 2005 we located 14 kittens from 4 litters. Ten of these kittens from 3 litters were successfully implanted with radio transmitters and monitored along with the females for movement and survival. Both kittens from 1 litter were too small to implant and their disposition was unknown. The remaining two non-implanted kittens were believed to have been depredated

along with most of their litter and therefore are included in the following survival rates (see B132 narrative). The overall survival rate for these litters was low (0.167) and mortality was largely due to coyote predation. Ninety percent of the mortality occurred within the first three months (3 mo survival rate 0.250). In the following three months (3-6 mo of age) the survival rate increased dramatically (0.667), with only 10% of the overall mortality occurring during this time. There was no mortality after six months of age through dispersal. This pattern was similar to what has been seen in other *Lynx* studies. Jackson et al. (1985), Blackwell et al. (1991), and Fredrickson and Mack (1995) all found higher mortality in younger bobcat kittens. Palomares et al. (2005) found Iberian lynx mortality to be highest before three months of age and again just prior to dispersal. They observed no mortality between three and ten months of age. Both in the Palomares et al. (2005) lynx study and in this study, kittens began traveling with the females around three months of age, coinciding with the drop in mortality rates. Average litter sizes at this time were two and one kitten(s) respectively, which was reduced from the average litter sizes at birth of 3.1 and 2.45. In this study, all three implanted litters were reduced to one kitten by the time they were accompanying the female, and in two cases the kitten began following the female shortly after they became the one remaining kitten.

Den use in the study area was similar to that seen in other studies of *Lynx*. Natal dens were used for 14-20 days, similar to the 17-20 days Fernández et al. (2002) found for Iberian lynx. The duration of auxiliary den use was variable (2-17 days), but generally decreased with kitten age. The same trend was seen in Iberian lynx (Fernández et al. 2002), and in Eurasian lynx (Schmidt 1998). By the time the kittens were six weeks of age, females were using auxiliary dens only 2-9 days each and by 12 weeks of age all females had abandoned using dens altogether. The average distance between dens was 191.7 m, with a range of 37-646 m. Den use correlated with kitten age and therefore was likely driven by kitten development, but environmental factors may have accounted for some variation, especially within developmental stages.

Kittens started traveling daily with the females around the beginning of June, at 9-12 weeks of age. In two of the litters this occurred shortly after the litter size was reduced to one kitten. At 25-26 weeks of age (two litters) kittens began to travel independent of the female, but still reunited with her daily. Over the next seven weeks they increasingly spent more time moving on their own and by 33 weeks were spending periods greater than a day traveling independently. The one kitten tracked through independence was last located with the female on December 20th at nine months (40 wks) of age. Once kittens started moving with the female, the extent of their movement generally increased with age. However when they started to become largely independent there was a slight reduction in the distances traveled (Fig. 1). The amount of time females spent with kittens varied among females, but was typically similar in the denning and early kitten seasons (62-94% of paired locations) and reduced in the late kitten and mating seasons (43-81% of paired locations; Table 1). Land use also varied among females, but was similar between mothers and kittens (Table 2).

B108 (2004; Fig. 2)

B108 had a pre-denning home range of 445.5 ha, which consisted of 31.0% urban area. It encompassed much of an 18-hole golf course surrounded by affluent single-family housing and the northern portion of a large natural patch. In addition, a network of riparian corridors ran through the golf course and residential areas. Her natal den was located at the very northern edge of the patch just 195 m south of the nearest house. On April 6th four kittens (2 male, 2 female) were located in a hollow beneath a patch of giant rye (*Leymus condensatus*). All kittens were healthy but were considered too small to be implanted with transmitters. Following approach by the research team the female moved the four kittens north 454 m to a hollow within a standing live oak. The tree was located within a riparian area bisecting the golf course. Two weeks after the first attempt to radio-mark the kittens, the team approached the new den, and successfully implanted all four kittens with radio-transmitters. After the procedure, the family remained at this

site for four additional days, before moving east along the creek to a new auxiliary den. In total the female used four auxiliary dens along the golf course. When the kittens were seven weeks of age, two of the kitten transmitters were recovered on mortality and a third was missing. Both of the recovered transmitters were found chewed with no kitten remains around, indicating likely predation by coyotes. The disposition of the third kitten was presumed to be the same. The only known surviving kitten, male B151, began traveling with the female two weeks later and was always located with her subsequently. During the denning season, the female's home range size shrank to 317.7 ha, but included roughly the same proportions of land use. The kittens had a range of about 1.8 ha with 8.0% urban area. The female and her remaining kitten continued to travel together, using the riparian areas heavily, for another six weeks. During this time they used a home range of 212 ha with 48.1% urban area. At 17 weeks of age, the kitten was found dead with a bite wound to the back, emaciated, and with severe mange over most of his body. Two weeks later the female was found dead, also emaciated and with severe mange.

B117 (2004; Fig. 3)

Female B117's pre-denning home range was 150.0 ha, and consisted of 10.6% urban area. Her range was completely within a single large natural habitat patch with small strips of housing along the edges and completely surrounded by busy multilane roads on all sides. Her natal den was in a large wood rat nest located deep inside a drainage on the eastern edge of the patch and was 300 m from the nearest house. On April 5th we approached the den and found three kittens (1 male, 2 female), all of which appeared healthy. The male was implanted with a radio transmitter, but the two female kittens were too small to be implanted. One week later we approached the den again to implant the remaining kittens. The female had moved the den to the opposite slope of the same drainage, to a smaller wood rat nest, but only about 37 m from the original site. Following our second visit, the female once again moved the kittens to a new auxiliary den 100 m away and remained here for 17 days until moving the kittens over the northern ridge. At this point she continued to use short-term auxiliary dens (2-7 days) for another six weeks, alternating between the north and south sides of a single ridge. At 10 weeks of age B145, the male kitten, was found dead with an intestinal torsion, which was possibly a complication from the implant surgery. Two weeks later partial remains of one of the female kittens, B147, were found on the northern side of the ridge and circumstantial evidence strongly indicated coyote predation. The female's denning season home range was reduced to 87.3 ha and made up of almost exclusively natural habitat (>99%). The kittens were maintained in an area of 3.9 ha of all natural habitat.

At 12 weeks of age, the remaining kitten (B146) began traveling with the female and was located with her more than 90% of the time during the next 12 weeks. One month later the female and single kitten left the natural patch and were located in a riparian area running through housing to the east. The pair never returned to the original patch. For the next four months they used a network of small natural patches and riparian corridors. During this period, the female's home range was 143.9 ha, 39.1% urban, and the kitten's home range was 142.6 ha, 46% urban.

At 7.5 months of age, the kitten was located in a medium-sized natural patch to the south, and she remained in this area for at least the next six weeks until her transmitter failed. In this area she started spending more time away from the female and made more substantial movements when alone. The female returned often at first, but slowly began to spend more time to the north in the network of small patches and left the kitten to the southern medium patch. By the time the transmitter failed in late December, at nine months of age, the female and kitten were only occasionally located together. Once largely independent from her mother, the kitten's home range shrunk to 44.2 ha (12 locations), 17.0% urban, whereas the mother maintained a range of 115 ha, 15.5% urban. The mother eventually died of mange four months after the kitten's transmitter had failed. B146 was eventually recaptured and collared one year later in this same patch. However she now occasionally traveled to her natal patch and therefore had a

considerable range size of 383.2 ha. She was only tracked for three months until her collar presumably failed prematurely.

B132 (2005; Fig. 4)

Female B132's pre-denning home range was 130.0 ha and consisted 6.0% urban area. It was positioned along a large main ridge, which descends into many secondary ridges and is surrounded on three sides by urban development and housing. The remaining side to the east connects to a large core area of natural habitat. Her natal den was located high in a drainage on the western edge of the main ridge, 440 m from the nearest house. We approached her den on April 4th and found five kittens, all male, deep inside a large wood rat nest. Only two of the five were deemed large enough to undergo the implant surgery. Two days later the female was located to the far northeast, and both of the kitten transmitters were found on mortality and recovered a short distance from the den. The transmitters were extensively chewed and no kitten remains were found, indicating predation, likely by coyotes. The female had moved the den over the northern ridge 646 m away. On April 18th we approached the new den and found only one kitten, B162, who was implanted with a radio transmitter at this time. The other two non-implanted kittens were assumed to have succumbed to predation as well. Following our visit the female moved the den once again 134 m to the west, where she remained for 10 days. She then continued to use short-term auxiliary dens (3-8 days) for another 4.5 weeks until the kitten was 11 weeks old. During the denning season, the female reduced her home range to 89.9 ha, 97.7% natural, and the kittens range was 3 ha, 100% natural.

At 11 weeks the kitten began moving with the female daily. She still continued to leave him occasionally, and when he was alone the kitten remained relatively stationary. In mid-September, at six months of age, the kitten began making more extensive movements on his own. He continued to slowly increase his independence and by mid-November, at eight months old, was traveling independently for greater than a day at a time. He was located occasionally with the female until December 20th, at which point his transmitter died. Two and half weeks after he was last located with the implant, the kitten (B162) was recaptured and collared in the same area. Following this recapture he was never located with the female again. He continued to reside in the northern portion of her home range for 10 months. In March 2006 the female proceeded to den with a new litter, but was lost a month later when her radio-collar presumably failed. In September at 1.5 years of age, B162 began dispersing to the north. After a period of lengthy erratic movements, he began to settle in January 2007, at just under 2 years of age, along the edge of a Simi Valley horse community about 4.5 km to the northeast.

CONCLUSIONS

The bobcat population I studied may currently be of borderline viability and therefore future disturbance or urban conversion may preclude sufficient reproductive output and disrupt the long-term viability of bobcats in this area. Adults have been shown to function well in this type of urbanized environment (Riley et al. 2003), but low kitten survival and increased disease incidence may eventually create a population sink here, and bobcats will only remain in this area as long as there is sufficient connectivity to source populations in core areas of habitat. Crooks (2002) found bobcats to be a carnivore of intermediate sensitivity to fragmentation and recognized this species as an ideal focal organism with which to evaluate the degree of functional landscape-level connectivity remaining in coastal southern California. Knowledge of their current population health and future viability may therefore provide an important understanding of the ecological system as a whole. Agencies such as the National Park Service will need to work with local residents and business owners to ensure minimal impact of growing interface communities. Specifically they will need to maintain adequate areas of natural cover to allow bobcats refuge from high urban coyote densities, and contiguous patches large enough for multiple den sites.

TABLES AND FIGURES

Table 1: Percentage of paired locations (taken within 1h of each other) per season that female bobcats and their kittens in urban southern California where found together or in close proximity of each other. Mating seasons consist of only those locations prior to complete independence of the kitten.

	Denning		Early kitten		Late kitten		Mating	
Female	n	% w/kitten(s)	n	% w/kitten(s)	n	% w/kitten(s)	n	% w/kitten(s)
B108	17	94.12	25	88.00	-	-	-	-
B117	19	89.47	43	93.02	32	81.25	9	44.44
B132	20	65.00	45	62.22	28	42.86	4	50.00

Table 2: The seasonal percentages of the home range (HR) and the points (Pts) in each of three land use categories for female bobcats and their kittens in urban southern California.

	Female (B108)		Kitten (B151)		Female (B117)		Kitten (B146)		Female (B132)		Kitten (B162)	
	Pts	HR	Pts	HR	Pts	HR	Pts	HR	Pts	HR	Pts	HR
Natural												
Denning	83.33	55.85	80	47.86	96.30	99.82	100	100	100	97.72	100	100
Early kitten	40.48	44.63	40.74	38.84	68.75	60.33	72.92	53.33	93.18	91.05	100	99.23
Late kitten	-	-	-	-	75.00	69.54	71.79	69.27	100	70.36	100	98.55
Mating	-	-	-	-	89.47	81.30	100	82.97	100	100	100	100
Urban												
Denning	10.00	31.26	20	18.61	3.70	0.18	0	0	0	0	0	0
Early kitten	42.86	35.29	48.15	37.79	31.25	39.05	27.08	46.51	4.55	5.61	0	0
Late kitten	-	-	-	-	25.00	25.22	28.21	5.06	0	21.48	0	1.45
Mating	-	-	-	-	7.89	15.48	0	17.03	0	0	0	0
Altered												
Denning	6.67	12.89	0	33.52	0	0	0	0	0	2.28	0	0
Early kitten	16.67	20.08	11.11	23.37	0	0.62	0	0.16	2.27	3.34	0	0.77
Late kitten	-	-	-	-	0	5.24	0	25.68	0	8.16	0	0
Mating	-	-	-	-	2.63	3.22	0	0	0	0	0	0

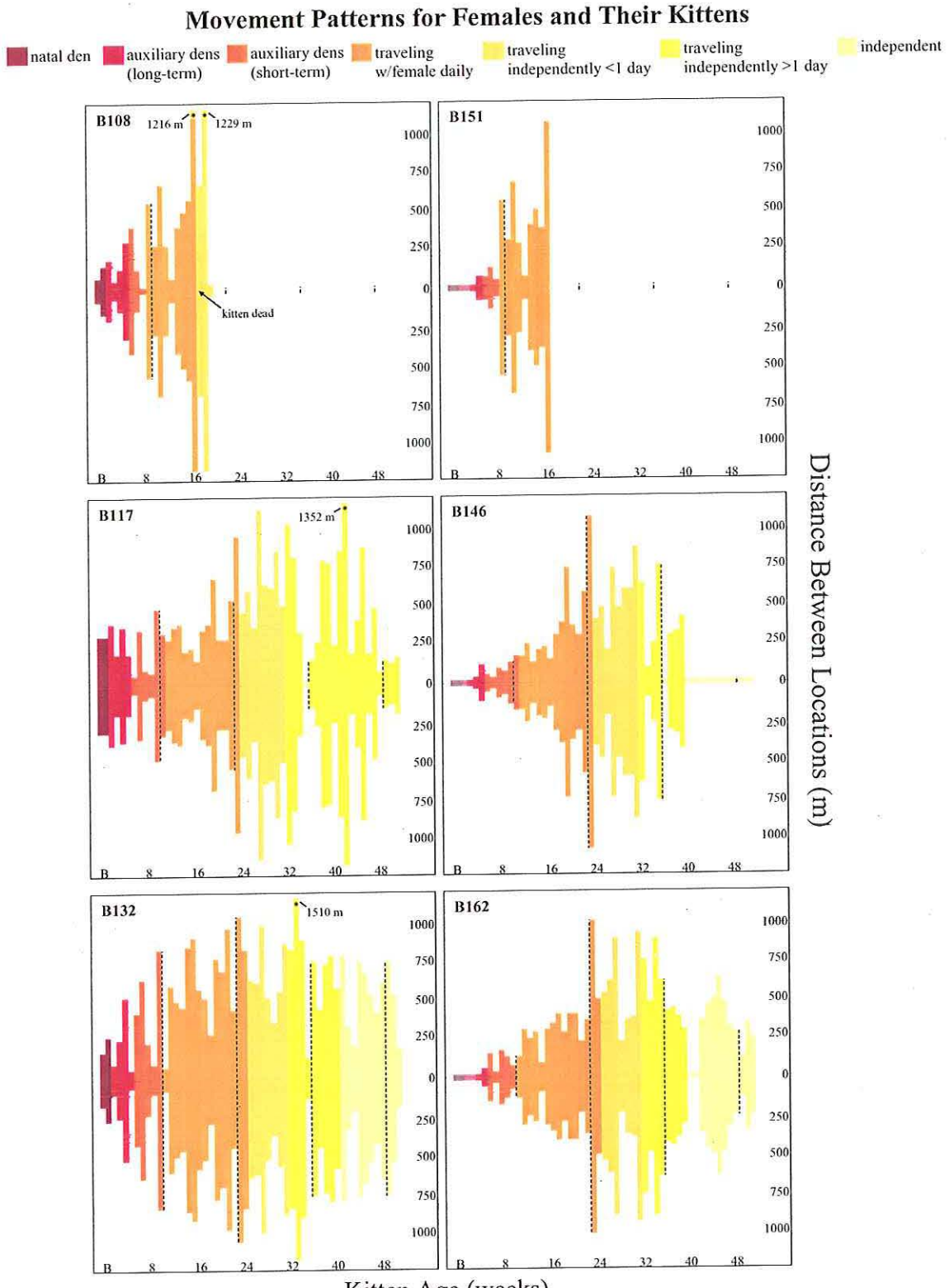

Figure 1: Average distance per week between independent locations for female bobcats in urban southern California (left) and their kittens (right). Kitten developmental stages are indicated by color and seasonal (denning, early kitten, late kitten, mating) changes by dashed lines. (* indicates the graph line has been truncated at 1200 m, actual values are as given)

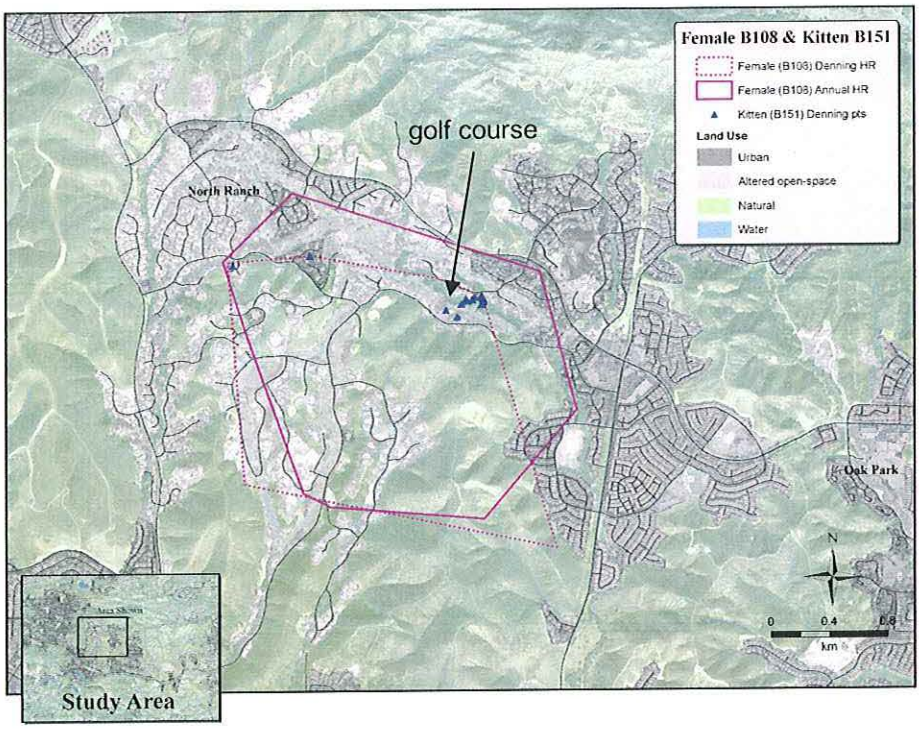

Figure 2: Home ranges (95% MCP) and denning season locations for female bobcat B108 and her kitten B151 in urban southern California (2004).

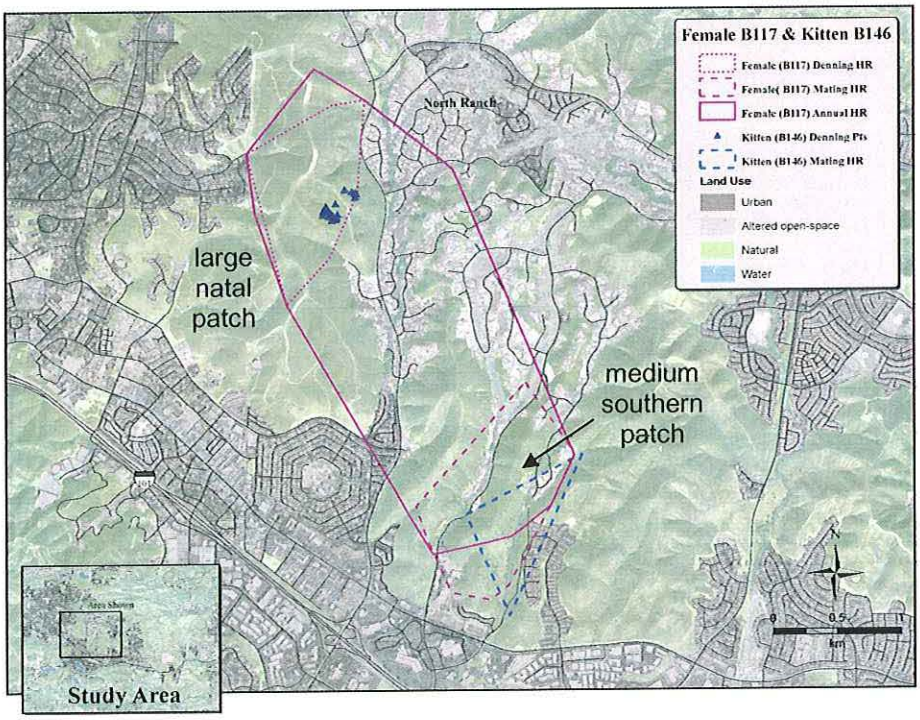

Figure 3: Home ranges (95% MCP) and denning season locations for female bobcat B117 and her kitten B146 in urban southern California (2004).

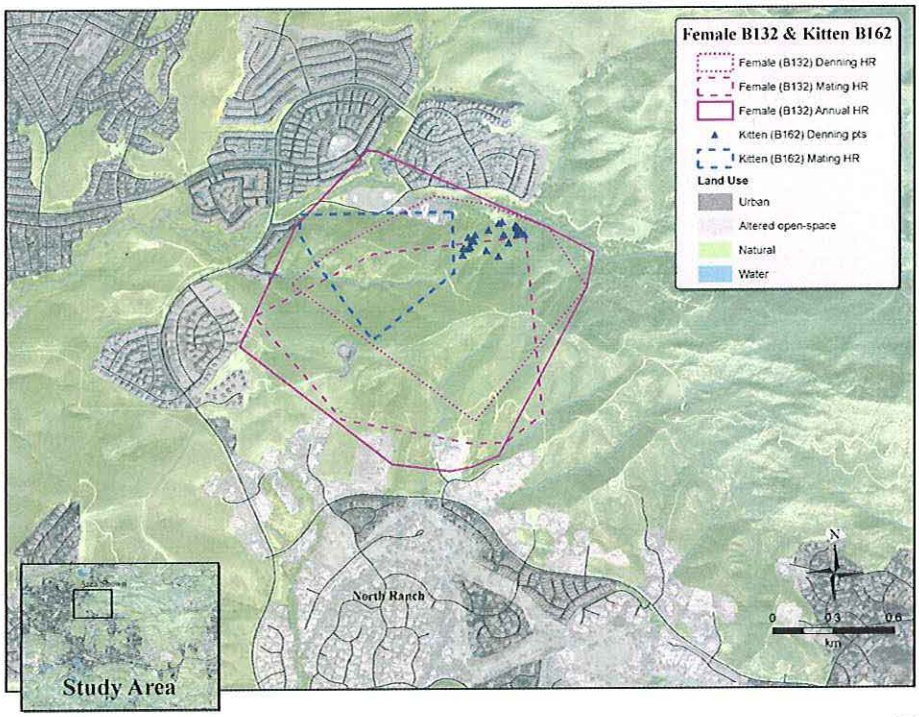

Figure 4: Home ranges (95% MCP) and denning season locations for female bobcat B132 and her kitten B162 in urban southern California (2005).

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