

**FLORIDA BLACK BEARS (*URSUS AMERICANUS FLORIDANUS*) AT THE
URBAN- WILDLAND INTERFACE: ARE THEY DIFFERENT?**

By

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To Chris, for being my rock and not letting me give up
To my family, for always giving me the love and support to follow my dreams

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The purpose of this study was to extend knowledge of the behavioral ecology of Florida black bears at the urban-wildland interface in and around Ocala National Forest in north-central Florida. Specifically, I investigated activity patterns, home ranges, characteristics of movement, and survival rates of urban bears versus forest bears. I radio-collared a total of 50 bears (32 adults, 18 cubs) and modeled telemetric data using SAS, R, and ArcGIS. In terms of activity levels, I found that bears residing in the interior forest were more likely to be active at any given time of day and spent more time active overall than urban bears. Urban bears spent more time either inactive or highly active compared to bears in the interior forest. All bears in this study were more likely to be active during 0000-0559 hours. From 0600-1159 hours, forest bears were still more likely to be active, while urban bears showed a decrease in activity. From 1200-1759 hours, forest bears were still active while all urban bears were more likely to be inactive. All bears in forest and urban areas were decidedly more active from 1800-2359 hours. Although male and female bears spent a relatively equal amount of time active and inactive, females were more often active and male bears appeared to spend more time in the highly active state.

In terms of home ranges, I found that average home range size for forest bears was 18.26 km² for females and 31.50 km² for males. Average home range size for urban female bears was slightly larger than their forest counterparts at 21.51 km², and the same trend was true for male urban bears although to a higher degree at 97.51 km². Urban bears made more excursions out of a core area compared to forest bears. Urban bears were not as likely to be backtracking or concentrating their activity to core areas and appeared to walk straighter paths than forest bears. In terms of movement characteristics, I found that variation in movement rates of urban bears was significantly higher than that of forest bears. The variance in movement rates was significantly higher for males than females. Forest bears seem to show much more consistent behavior overall compared to urban bears. The results of my survival analysis indicated that bear survival was lowest in urban interfaces. This study illustrates some of the ways in which anthropogenic activities can impact wildlife populations living in close proximity to humans. Information generated in this study can help guide conservation and management of this subspecies within an increasingly human-dominated landscape. Movement data could help guide management plans especially those that pertain to protecting bear habitat at the urban-wildland interface. On a proximate timescale, managers should understand that bears already inhabiting urban habitats exhibit different behavioral and spatial responses to variations in environmental conditions than bears occupying interior forest. Management decisions that work for bears in the interior forest may not suffice for bears living at the urban interface. Management plans for the Florida black bear should allow for increased space requirements, more variable behavior, and higher mortality for bears in urban settings.

CHAPTER 1

INTRODUCTION AND OVERVIEW

The ranges of all large mammalian carnivores are becoming increasingly fragmented due to human population expansion (Woodroffe 2000; Cardillo et al. 2004). As human activities increase, the natural environment is reduced, divided, or degraded for wildlife. These alterations often lead to human–carnivore conflicts and carnivores often come out on the losing end. As a result, anthropogenic effects are the greatest threat to the persistence of many large carnivores (Woodroffe & Ginsberg 1998; Gittleman et al. 2005) . Conserving carnivores in increasingly fragmented and human-dominated landscapes is a challenge facing many wildlife professionals. This is an especially daunting problem for species that have large home ranges and disperse great distances, such as black bears.

American black bears (*Ursus americanus*) once ranged throughout all of North America, and fossil records indicate that black bears have been present for approximately 3 million years (Kurten & Anderson 1980). Historically, the Florida black bear (*Ursus americanus floridanus*) occurred throughout Florida and in portions of southern Mississippi, Alabama, and Georgia (Brady & Maehr 1985). The Florida black bear was at one time considered a distinct species, *Ursus floridanus* (Merriam 1896). It is currently considered one of three subspecies of *Ursus americanus* (Hall & Hall 1981; Kasbohm 2004). Subspecies status is based primarily on genetics differences (Hall & Hall 1981; Kasbohm 2004). Florida black bears do not show the pelage color variations of *Ursus americanus americanus*, and are almost entirely black. A large percent of the population displays a distinctive white chest blaze (Maehr & Brady 1984a). Despite a common misconception, Florida black bears are not smaller than other black bears; maximum

masses and average masses for both sexes are on the upper ends of weights for all subspecies of *Ursus americanus* (Pelton 1982). Males weigh an average of 113 kg and can exceed weights of 300 kg, while females weigh an average of 82 kg (Maehr & Wooding 1992). This appears to make Florida black bears an exception to Bergmann's Rule.

Concerns over declines in bear numbers and remaining habitat resulted in the Florida black bear being listed as 'state threatened' in 1974. The most serious threat to the continued existence of the Florida black bear is fragmentation and loss of habitat (Hellgren & Vaughan 1994; Wesley 1991). Habitat fragmentation and loss are driven by human population growth. An estimated 16.3 million people lived in Florida in 2001, and this number is projected to increase to more than 20 million by 2015 (US Census 2000). Roads, agricultural, and commercial and residential developments continue to encroach on and further degrade remaining black bear habitat (Simek et al. 2005, McCown et al. 2009). The distribution of the Florida black bear has been reduced by 83% from its historic distribution (Wooding 1993). With the subsequent development of much of its primary habitat, black bears in Florida are now restricted to six core and two remnant populations (Pelton & Van Manen 1997) (Figure 1-1).

To adequately conserve and manage these geographically isolated sub-populations requires a thorough understanding of black bear natural history and population dynamics. As anthropogenic influences on natural systems increase, it is imperative to understand the effects of human activities and apply this knowledge towards management decisions. Rapid human population growth both within and around remnant bear populations has resulted in an increasing number of human-bear interactions in recent years. Research on

some aspects of Florida black bear ecology has been conducted (Maehr & Brady 1984b; Wooding & Hardisky 1992; McCown et al. 2004); however data on black bear ecology at the urban-wildland interface are virtually nonexistent. It is generally known that black bear mortality increases and populations decline as forest-clearing activities and roads penetrate bear habitat (Schoen & Beier 1990; Simek et al. 2005). Mortality rates at such borders are thought to be high (McCown et al. 2004; Garrison et al. 2007; McCown et al. 2009), but this information is also very limited.

Black bears appear to have a high tolerance for natural habitat fragmentation, and may be able to coexist with humans if they are tolerated (Beckmann & Berger 2003). Although the types of human-bear conflicts are diverse, a major point of contention centers on food and/or refuse. Principal causes of nuisance bear behavior can largely be attributed to anthropogenic factors including human habituation due to feeding, degradation and loss of habitat, and increasing human interactions. In Florida, human-bear interactions have risen dramatically in recent years (McCown et al. 2004; McCown et al. 2009). In 2007, more than 1,000 calls concerning nuisance bears were received by Florida Fish and Wildlife Conservation Commission (FWC) offices (J.W.McCown, personal communication). Due to the continued increase of human populations in Florida and the subsequent decrease in available bear habitat, the number of reported nuisance bear activity continues to rise.

From the human standpoint, agencies responsible for resolving these human-wildlife conflicts face enormous management challenges. Relocation of nuisance bears has frequently been employed in Florida (Wooding et al. 1988; Annis 2007) and appears not to be the most effective management tool due to cost, time involved, and high rates of

recidivism among nuisance bears (Annis 2007). Like all mammalian carnivores, black bears are critical elements of functioning ecosystems and it is important to preserve this species in their ‘natural’ environments. Thus, the continual relocation of ‘nuisance’ bears does not fully address the complete array of human-bear problems and in fact may create more problems ecologically.

The Ocala National Forest (ONF) is home to the largest populations of black bears in the state of Florida (Simek et al. 2005; Dixon et al. 2006). This population, perhaps more than any other, experiences strong anthropogenic influences such as habitat division, degradation, and vehicular mortalities. The human population in the four counties surrounding ONF (Lake, Marion, Putnam, and Volusia counties) is expected to grow from approximately 1,059,300 to 1,853,800 or 75% between 2000 and 2030 (Smith and Rayer, 2005). This increase in human population will result in an increase in vehicular mortality and perhaps habitat degradation. Managing ONF black bears in the near future will involve anticipating the impacts of such changes and adjusting management decisions accordingly.

The first step towards resolution of human-bear conflicts is to learn more about how bears that inhabit suburban areas are behaving. Since little is known about the activity patterns of Florida bears living near people, I investigated several aspects of Florida bear ecology including activity patterns, movement, and home ranges. I wanted to determine whether bears shift their activities to avoid interactions with people, and whether bears avoid traveling near human habitation or are attracted to the new components in their landscape. I investigated whether there are daily or seasonal attributes to urban bear activity that may increase the frequency of human-bear

interactions, and whether these behaviors appear to be idiosyncratic or a general phenomenon among the species. Studies that examine the effects of individual processes such as these are valuable because they provide important ecological insights that can be incorporated into management decisions.

In addition to understanding how individual bears behave in suburban settings, understanding their population ecology in suburbia is vital to address the current state of black bears in Florida. Four demographic factors determine any population's growth or decline: birth, death, immigration, and emigration rates (Bunnell & Tait 1980; Watkinson and Sutherland 1995). These four factors can offer insight into whether a specific population is a sink or source (Watkinson and Sutherland 1995; Pulliam 1996, Remes 2000; Delibes et al. 2001a, b). A population is considered a sink when reproductive output is inadequate to maintain local population levels (Watkinson and Sutherland 1995; Pulliam 1996; Salminen & Haimi 2001). Alternatively, sink populations exist only as a result of immigration from a population where reproduction exceeds replacement (Purcell & Verner 1998; Ford et al. 2001; Sutherland et al. 2002) . Individuals in a sink will move to better habitat (the source) when space becomes available (Howe et al. 1991; Watkinson & Sutherland 1995; Pulliam 1996; Kristan 2003).

In this study, I also set out understand how variation in habitat affects population dynamics, and chose to investigate survival rates of black bears residing in the interior forest versus those at the urban interface . Based on previous studies of a variety of vertebrate species (Kerley et al. 2002; Kramer-Schadt et al. 2004; Letcher et al. 2007; Ruiz-Gutiérrez et al. 2008), it is plausible that bears inhabiting more fragmented habitat would have higher mortality rates. Although fecundity may be unaffected, high mortality

rates would result in lower population growth rates in comparison to those in less fragmented habitat. Studies that examine the additive and interactive effects of the suite of fragmentation processes together are also valuable for guiding future conservation efforts amidst increasing anthropogenic influences.

Answers to these questions would provide increased insight to developing conservation and management strategies for Florida black bears and perhaps other carnivores in a changing landscape. An understanding of black bear behavior and population dynamics, as related to habitat fragmentation and urbanization, would help guide management of Florida black bear populations in ONF and other increasingly human-dominated landscapes. In this study, I examined the range of Florida black bear adaptability, and predicted how changes in space and time variables influence bear behavior, survival, and reproduction. This study advanced knowledge of how bears use human-dominated landscapes, and offers insights into how managers might be able to better mitigate human-bear conflicts while maintaining the integrity of black bear populations in Florida.

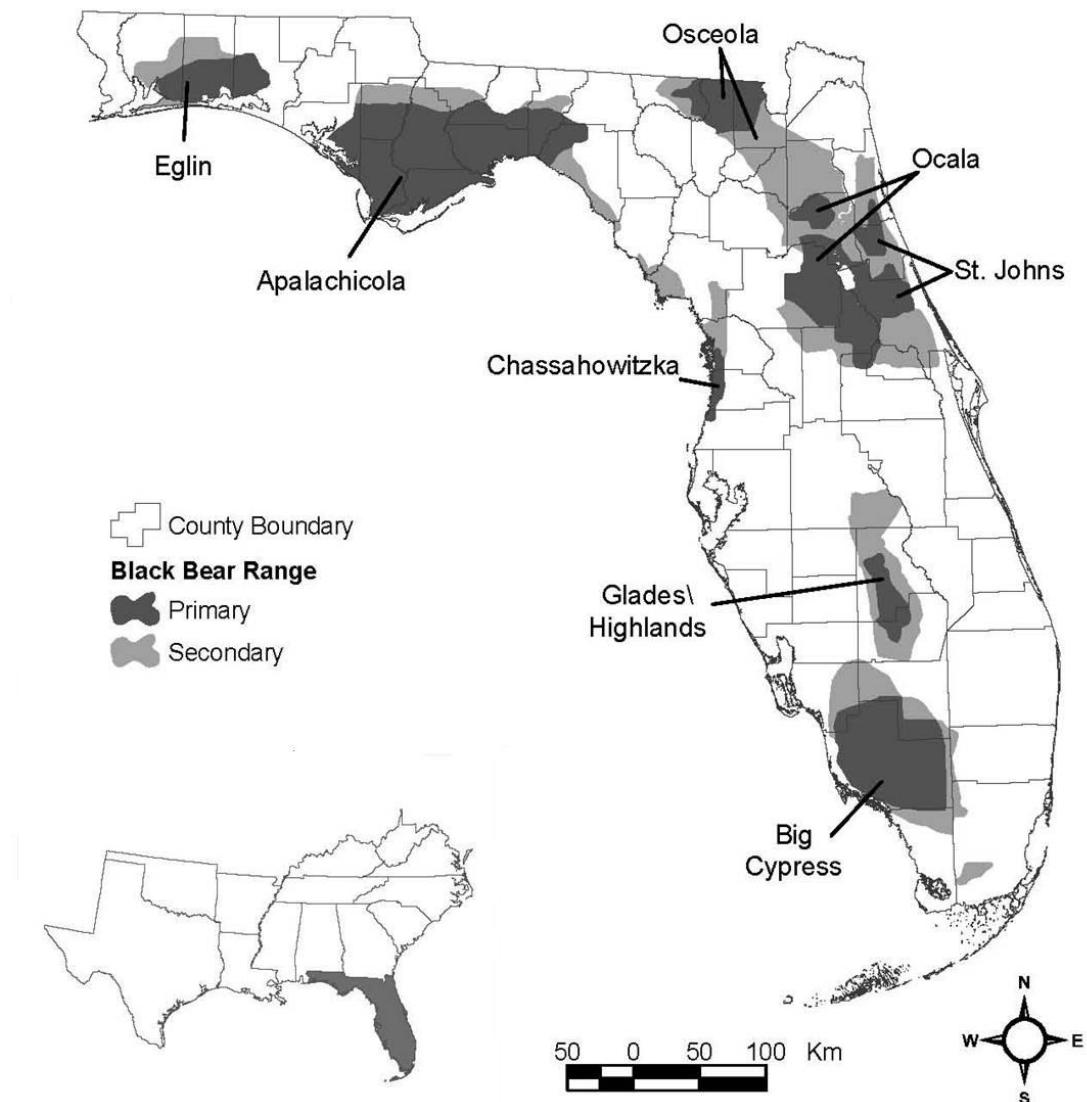


Figure 1-1. Current distribution of Florida black bear populations.

CHAPTER 2

FLORIDA BLACK BEAR ACTIVITY, HOME RANGE, AND MOVEMENTS

Background

Florida black bears were listed as ‘state threatened’ in 1974. The distribution of the Florida black bear has been reduced by 83% from its historic distribution (Wooring 1993). With the subsequent development of much of its primary habitat, black bears in Florida are now restricted to six core and two remnant populations (Pelton & Van Manen 1997), (Figure 1-1). To adequately conserve and manage these geographically isolated sub-populations, a thorough understanding of black bear natural history and population dynamics is required. As anthropogenic influences on natural systems increase, it is imperative to understand the effects of human activities and apply this knowledge towards management decisions. By investigating ways in which Florida black bears utilize habitats at the urban-wildland interface, managers can make more informed decisions regarding Florida black bear policies.

Understanding the ecology of a species begins with examining its spatial distribution. The purpose of this study was to examine several aspects of Florida black bear spatial ecology to better understand if or how living in proximity to people changes bear behavior. This information will be useful for managers who deal with bears conflict issues. Since little is known about the activity patterns of Florida bears living near people, I investigated several aspects of Florida bear ecology including activity patterns, movement, and home ranges. I set out to determine whether bears shift their activities to avoid interactions with people, and whether bears avoid traveling near human habitation or are attracted to the new components in their landscape. I investigated whether there are daily or seasonal attributes to urban bear activity that may increase the frequency of

human-bear interactions, and whether these behaviors appear to be idiosyncratic or a general phenomenon among the species.

Habitat Use and Diet

The Florida black bear resides in multiple habitat types such as hardwood and mixed swamps, palm forests, pine flatwoods, hardwood hammocks, and sand pine scrub (Maehr 1997; Maehr & Wooding 1992). Bears will rarely use open sandhills in Florida (Wooding & Hardisky 1988). Across North America black bears are omnivorous, but a majority of their diet consists of plant matter. When selecting food items, black bears typically follow the seasonal phenology of plants (Amstrup & Beecham 1976; Landers et al. 1979; Pelton 1982, 1986). Soft mast such as berries and other fruits comprise the majority of food items eaten in the summer; while hard masts such as acorns usually dominate fall/winter diets. In spring the major food item is usually new green leaves and shoots of various plant species. The Florida black bear exhibits similar trends, but the characteristically mild climate results in soft mast being available over longer time periods (Maehr & Brady 1984b; Maehr & Wooding 1992; Stratman 1998; Scheick 1999; Stratman & Pelton 1999). In late summer and fall saw palmetto (*Serenoa repens*) fruits are heavily eaten. The majority of the remaining portion of their diet is blueberries (*Vaccinium* spp.), blackberries (*Rubus* spp.), gallberries (*Ilex glabra*), cabbage palm (*Sabal palmetto*) hearts, tupelo (*Nyssa* spp.) fruits, and acorns (*Quercus* spp.) (Maehr & Brady 1984a; Maehr & Brady 1984b; Maehr & Wooding 1992). Invertebrates make up a smaller but regular portion of their diet, especially walking sticks (*Anisomorpha buprestoides*), wasps (*Vespula* spp.), bees (*Apis mellifera*), and ants (*Camponotus abdominalis floridanus*). Vertebrates consumed include armadillos (*Dasyurus*

novemcinctus), white-tailed deer (*Odocoileus virginianus*) and feral pigs (*Sus scrofa*), however this consumption is rare, opportunistic, and is mostly carrion.

Social Structure and Home Range

With the exception of females with cubs, black bears are solitary except during the summer for courtship and mating. Across the black bears' distribution, home range size varies widely in relation to habitat quality and quantity (Pelton 1982). As a function of food abundance and sex, home ranges of bears may be fairly restricted (Rogers 1987a; Young & Ruff 1982), but there is often a significant amount of range overlap among individuals regardless of sex (Reynolds & Beecham 1980; Garshelis & Pelton 1981; Wharburton & Powell 1985; Klenner 1987; Mollohan & LeCount 1989). In Florida, bear home ranges show considerable overlap in all remaining populations (Wooding & Hardisky 1988; Maehr 1997;) Adult male bears have considerably larger home ranges than adult females, with male territories overlapping the home ranges of several females (Pelton 1982). Florida black bears have home ranges that are similar in size to those of bears in other areas of North America (Wooding & Hardisky 1988; Maehr 1997).

Activity and Movements

After winter denning and throughout the fall, black bear activity levels steadily increase in response to metabolic requirements and range sizes usually expand accordingly (Rogers 1987a). In some areas, this can include a complete shift in home ranges as seasonal food availability shifts spatially (Garshelis & Pelton 1981; Klenner 1987; Maehr 1997; Mollohan & LeCount 1989). In ONF bears usually shift from pine flatwoods during winter and spring to sandpine scrub in the summer and fall (Wooding & Hardisky 1988).

Seasonal increases in adult male activity patterns are likely related to reproductive efforts in the summer and foraging requirements in the fall. Greater mobility of bears at this time makes them more susceptible to anthropogenic forms of mortality, such as roadkill and poaching (Pelton 1982; Rogers 1987b; Simek et al. 2005). Long distance movements by females are rare (Rogers et al. 1987).

Dispersal is an important factor that plays a key role in population regulation (Bunnell & Tait 1981; Kemp 1976; Lecount 1982; Beecham 1983; Rogers 1987a). Black bear dispersal or movements away from their natal area usually occurs between 2 to 4 years of age (Pelton 1982; Rogers 1987a; Rogers et al. 1987). Sub-adult females usually remain in the immediate area of their mother's home range (Moyer et al. 2006), whereas sub-adult males generally disperse much greater distances. This is generally believed to be a response to social pressure from resident adult boars (Pelton 1982), although it may also be a result of socially independent reasons (Rogers 1987a). In one Florida study, dispersal distances of 4 sub-adult males ranged from 22 to 56 km (Wooding & Hardisky 1988). In another study, a sub-adult male dispersed more than 140 km (Maehr et al. 1988). No female Florida black bear is known to have dispersed more than 60 km (Maehr 1997).

Anthropogenic Influences

The most serious threat to the continued existence of the Florida black bear is fragmentation and loss of habitat driven by human population growth (Wesley 1991; Hellgren & Vaughan 1994). Research suggests that living in proximity to people has the potential to change carnivore behavior and ecology (Gittleman et al. 2005). Black bears living at the urban-wildland interface may shift their activities to avoid interactions with people, but may also be attracted to the new components in their landscape such as

human refuse. Behavioral shifts may occur daily, seasonally, or even on a year-to-year basis. With regards to black bears, negative interactions with humans become increasingly frequent in suburban areas. Such conflicts can arise from intentional or unintentional feeding to vehicular collisions. The first step towards resolution of human-bear conflicts is to learn more about the behavior of bears that inhabit suburban areas. Studies that examine the effects of individual traits are valuable because they provide important ecological insights that can be incorporated into management decisions.

Hypotheses

In regards to bear activity, I hypothesized that urban bears would be more active at night as compared to forest bears. This difference in behavior could represent an adaptive strategy to living in proximity to humans, who are themselves less active at night. This would result in decreased interactions between bears and people in suburban environments. Since urban bears presumably avoid humans during daylight hours, I further hypothesized that urban bears would be less active overall compared to bears in the interior forest. In terms of sex, I hypothesized that male bears would be more active than females. The territories of male bears often encompass the smaller ranges of one or more females (Pelton 1982). While males are on constant patrol against other males, they must routinely travel relatively great distances to all corners of their home range. It has been suggested that female bears are typically more sedentary (Rogers 1987a) and this is especially true during the breeding and denning season. Even throughout the year, good den sites, typically in pine flatwoods or swampy habitats with a thick, dense mid-story of scrub palmetto (*Sabal etonia*) and/or Florida rosemary (*Ceratiola ericoides*), can be found in relatively close proximity (Garrison 2004).

Furthermore, I hypothesized that sub-adult bears would be more active overall compared to adult bears. The thinking is that sub-adults of many vertebrate species often occupy fringe or suboptimal habitat, while adults reside in established territories within comparatively prime habitat (Reynolds & Beecham 1980; Beechum 1983). Consequently, sub-adult bears residing in suboptimal habitat would likely need to spend more time foraging for food or acquiring other needed resources, which would be inherently scarce given that the habitat is less than ideal. In addition, as sub-adult bears search for unoccupied territory in which to claim as their own, they are more often on the move compared to adults. Conversely, adult bears have a familiar territory, and locations of resources within such a territory are well known. Adult bears would not spend as much of their time foraging, and would thus be allowed more time to allot to social interactions such as courtship and mating. The behavioral characteristics of sub-adult bears living in the forest and at the urban-wildland interface would probably be similar, as both groups would be pushed to lower quality habitat in both environments. Even if behavioral differences exist between adult bears in the two environments, I would not expect to see the same trend among sub-adults.

Regarding home ranges, I hypothesized that urban bears would have larger home ranges compared to forest bears as suggested by Moyer et al. (2007). This trend is likely related to the relative availability of food and other resources. I hypothesize that in relation to natural food resources in the interior forest, anthropogenic food resources in urban areas (which include human refuse, pet food, bird seed, dumpsters, etc) are more unpredictable across the landscape (Moyer 2004). In addition, natural foods such as berries, grapes and masts probably occur at higher densities near natural areas (Dixon et

al. 2006; Moyer et al. 2007). Water resources may also be more consistently encountered in the natural landscape as opposed to the urban interface. The result is that urban bears would require more area to meet their daily requirements, and would thus have larger areas of activity.

As previously mentioned, male bears have been observed to have larger home ranges as compared to females and their ranges often encompass the smaller ranges of two or more reproductive females. I hypothesize that male bears in my study will have larger home ranges than females. I hypothesize further that sub-adult bears will range farther than adult bears. However, this is not to suggest that sub-adult bears have larger home ranges, since these bears may or may not have established home ranges. I hypothesize that since sub-adults may be in search of unoccupied territory, they are more often “on the move” and travel greater distances as a result. I anticipate, however, that adult bears will show consistent cores of activity within the home range, while sub-adults will lack a focused area of activity and will exhibit more wandering behavior.

In terms of movement characteristics, I hypothesize that urban bears will show less variable movement patterns than forest bears, and again this is in relation to juxtaposition of food and water resources in the fringe areas. In urban environments, I predict that resources are more concentrated and linear. In the interior forest, resources are more thinly spread out and scattered. I hypothesize that suburban bears will show less variation in movement patterns as they follow their linear suburban resource base. I hypothesized that male bears will show more variation in movement patterns compared to females, because not only do they have to forage for food and resources, but they must constantly patrol their territories as well.

I hypothesized that sub-adult bears will exhibit more variable movement patterns as compared to adults, because they have not yet secured a home range.

Methods and Materials

Study Site

This study was conducted in the Ocala National Forest (ONF) in north-central Florida and in and around the adjacent bordering towns of Lynne and Paisley. ONF is the largest public land holding in central Florida and supports the highest density of black bears, with approximately 468 km² of nearly contiguous bear habitat (McCown et al. 2004; Moyer 2004; Dixon et al. 2006). The predominant forest cover types in ONF are swamp forests and pine flatwoods (Moyer et al. 2004; Dixon et al. 2006). Specifically, habitat consists of approximately 60% sand pine (*Pinus clausa*) / scrub oak (*Quercus* sp.), 22% slash pine (*P. elliotti*) flatwoods, 10% wetland hardwoods, and 5% prairies (Aydelott et al. 1975; Moyer et al. 2007; Hostetler et al. 2009). There is a heavy human influence in ONF as it is managed for timber and a variety of recreational activities (McCown et al. 2004; Hostetler et al. 2009).

Lynne (population 350) is located to the west of ONF and encompasses a mixture of privately owned land in the residential community and US Forest Service property (McCown et al. 2004; Moyer 2004). Bear habitat in Lynne consists of small parcels of slash pine flatwoods under ownership of ONF, corporations, and individuals (McCown et al. 2004; Moyer 2004). Paisley is located to the south of ONF and is a similar matrix as Lynne, but is more linearly developed with a more defined urban-wildland edge. Habitat in Paisley (population 734) is for the most part individually owned. The urban-wildland interface in these two towns is effectively discontinuous bear habitat, interspersed in a network of moderate volume roads and residential, industrial, and/or commercial

development (Moyer 2004). There is a greater degree of fragmentation in Lynne and Paisley due to human developments such as roads, houses, and businesses than in ONF (Moyer 2004).

Field Methods

Captures

I trapped bears between June 2005 and October 2006, and concentrated my efforts between June and August each year. In 2005 I trapped in both Lynne and Paisley, and in 2006 I trapped in Lynne and the interior forest. Trapping in summer was usually restricted to between 1800 h and 0600 h to decrease the potential of heat stress to bears. I utilized sentinel radio-collars attached with string to the snare; these were designed to activate immediately once a bear was trapped. Using this method, I was able to immobilize most bears within an hour of their capture. Capture methods followed recommendations of the American Society of Mammalogists (Gannon & Sikes 2007) and were approved by the Institutional Animal Care and Use Committee at the University of Florida.

Trap locations were determined by investigating areas within the study area for bear sign (e.g. tracks, scats). Once areas were targeted for trapping they were pre-baited to entice resident bears to stay in the area. To prevent attracting bears to trap sites from great distances, sites were pre-baited for no more than three days prior to trapping. Areas were pre-baited with a combination of doughnuts, blueberry extract, bacon grease, and commercial deer lure.

Bears in the wildland-urban settings were captured using two methods. The first method was via culvert traps, or large cylindrical traps attached to a trailer. The cylinder is approximately 2 meters long and a meter in diameter. A drop door is located in the

front and a release device is located in the back. When a bear entered the culvert and took the bait off the triggering device, the door dropped and trapped the animal inside. All traps were baited with doughnuts.

The second method of capture was a modified Aldrich spring activated leg-snares (Johnson and Pelton 1980; McCown et al. 2004). For this method, I attached a cable foot loop to two anchor cables that were wrapped around two trees. Baited with doughnuts, the foot loop was placed within an artificial “trail” composed of clipped branched and vegetation. As a bear stepped through the strategically positioned foot loop, the cable cinched around the bear’s wrist, and thus captured the bear. Caution was taken to ensure that the distance between the trees was great enough to prevent a trapped bear from reaching either one. This reduced the likelihood of bone fractures that can occur when bears thrash and torque ensnared limbs.

After capture, bears were immobilized with an injection of a 1:1 mixture of Tiletamine hydrochloride and Zolazepam hydrochloride (Telazol™). Drug was administered at 3.0-3.5 mg/kg of estimated bear weight via a blowpipe, jab-stick, or remote injection gun (McCown et al. 2004). Once the bear was anesthetized, an ophthalmic ointment was administered to moisturize eyes, vital signs (temperature, respiration and pulse rate) were monitored, and morphological data were collected. A pre-molar was extracted for age determination, a hair sample was collected for genetic data, the upper lip was tattooed for permanent identification, and both ears were tagged with plastic identification tags. Each bear was given a unique color combination of ear tags for individual recognition from observations. Paired 4 mm punch biopsies were taken in six locations (muzzle, chin, peri-ocular, crown, inter scapular, flank) from bears

in Lynne as part of a bio-medical investigation into the demodectic mange organism,

Demodex ursi in collaboration with Mark Cunningham D.V.M.

Following the completion of marking and handling procedures, I remained in proximity to immobilized bears until they were able to stand on their own. Where safety during recovery was a concern, I deterred other bears from attacking the recuperating bear.

Telemetry

VHF motion-sensitive radio-collars (150-151 Mhz; Telonics™, Mesa, Arizona), weighing less than 5% of the bear's body mass, were fitted around the neck and tagged bears were released within 20 meters of capture location. Collars were equipped with a mortality sensor and fitted with an oiled leather connector, designed to wear-away after two years. This prevented collars from remaining on bears beyond the collar's expected battery life and allowed collars to stretch slightly on growing sub-adult bears.

Locations were obtained for all radio-collared bears at least 1-3 times per week for the entire duration of the study. Depending on the availability of roads and other logistical constraints, a preselected sub-sample of individuals were monitored more intensively 2-4 nights per week to document hourly movements during the period of major activity (presumably at night).

Bear movements and activities were monitored using portable telemetry equipment. Some locations were obtained from the air using a Cessna-172 aircraft equipped with wing-strut mounted 2-element yagi antennas, and by ground triangulation using a 3-element, hand-held, yagi antenna (Telonics™ Inc., Mesa, Arizona) and a Communications Systems™ Inc. receiver. Ground triangulations were made using > 3 compass bearings obtained within a 30-minute interval to minimize location error as a

result of bear movement. Ground locations were collected during both day and nighttime periods. I selected 17-hours as the minimum time interval between locations for biological independence among locations as suggested by Swihart et al. (1988). Aerial locations were collected on specific bears approximately twice per month during daylight hours. However, extreme movements, severe weather, and lack of funding often restricted aerial locations to once per month.

Diels

I divided the day into four, six-hour blocks: 1 (0000 to 0559 h), 2 (0600 to 1159 h), 3 (1200 to 1759 h), and 4 (1800 to 2359 h). I chose to divide the day this way in order to capture equal periods of full day, full night, and dawn and dusk. Throughout the study, sunrise occurred in block 2 between 0630 h (June) and 0741 h (November). Sunset occurred between 1730 h (December) and 2032 h (July), and fell in block 4 in all months except December and January. For each bear per season, I randomly selected a starting block (i.e. 1 - 4); I would then follow that bear for at least 2 consecutive blocks, collecting locations once per hour. I would then follow the same bear for the remaining 2 blocks at the next available time within the month. Some bears wandered out the area while tracking, therefore only a partial diel could be completed. In this scenario the block would not be used and I would restart at that location the next time the bear could be located.

By collecting hourly locations on bears I documented hourly activity, estimating the exact time a bear became active. In addition, hourly locations allowed me to determine movement rates and travel paths.

Data Analysis

Activity patterns

I investigated activity patterns by computing contingency tables in SAS (SAS procedure FREQ ; SAS Development Team, 2002). FREQ produces contingency tables indicating how categorical variables are related or associated and whether the association is significant. FREQ computes chi-squared (Pearson) tests for *n*-way association measures and contingency tables. Contingency tables were used to draw conclusions regarding patterns of bear activity (Engeman & Swanson 2003).

I first defined the dependent variable “Activity”, which had three possible values, “Inactive”, “Active”, and “Highly Active”. “Active” status was determined by having a characteristic faster pulse (signal) rate compared to “Inactive”, indicating that the bear was moving around to some degree. “Highly Active” was a high pulse rate per minute in concert with a signal that went in and out, indicating a bear was physically on the move. I defined one predictor variable as “Locale”, divided into three categories including “Forest”, “Lynne”, and “Paisley”. Other predictor variables included “Gender”, divided into “Male” or “Female” and the variable “Status” was divided into “Sub-adult” or “Adult”. Finally, the variable “Block” was defined to represent the time of day.

Home range

Home ranges of forest bears and urban bears were examined using the 95% fixed kernel density estimator (Worton 1989) and the 95% minimum convex polygon for comparison to other studies (Millspaugh & Marzluff 2001, McCown et al. 2004; Moyer et al. 2004; Moyer et al. 2007). A minimum of 25 locations were collected seasonally for each bear to determine home range, since an asymptote in black bear home range size estimation using the fixed kernel density method is reached at 25 locations (Koehler and

Pierce 2003). A sample size of 36 individual bears was statistically ideal for this study. This was calculated using G*power, and was determined with an alpha value of .10, effect size of .5, and power value of .85. G*Power was designed as a general program for statistical tests commonly used in behavioral research (Erdfelder, Faul, & Buchner 1996), and can be used to determine sample sizes and associated confidence intervals.

Differences between home range size among bears from different locales, sex, or age classes were calculated using Student's t-test in Excel (Microsoft 2009).

Movements

Rate of Movement Analysis- In order to maintain consistency and avoid bias, I investigated movements from sequences of bear observations of the same length of time. The most common length of observation sequences occurring in one day was twelve hours. In other words, I conducted 56 sequences in which a bear was located twelve times in one 24-hour block. These sequences were used to analyze movement.

I selected four measures to investigate rates of bear movement. Specific measures examined included the following, and were calculated using ArcGIS (ESRI 2009) and Excel (Microsoft 2009) (Whittington et.al 2004):

- 1.) Path length: Path length is simply the sum of distances between successive locations.
- 2.) Movement rate: This measure is the mean rate of travel, or the sum of lengths of distances between successive observations (total path length) divided by the total time spent on the path. This measure assumes straight-line travel between consecutive locations.
- 3.) VAR: This measure is the variance in rate of motion.

4.) CoVr: This measure represents the coefficient of VAR. Since there was a chance that variation of rates of motion might increase with overall rate of motion, this measure considers the variability in rate of motion without being influenced by the magnitude of rate of movement.

Three variables were used as predictors, including “Gender”, “Age”, and “Locale”. Since all four aforementioned measures appeared to have skewed distributions, I used the logarithm of each measure for analysis. All four measures represent characteristics of an animal's motion. Since I am interested in how the means of all of these measures are affected by variables such as “Gender”, “Age”, and “Locale”, an analysis of variance was calculated for each characteristic. In this analysis, “Gender”, “Age”, and “Locale” are predictor variables while activity level is the dependent variable. I used the same 56 sequences, as described above, to examine characteristics of bear movement. I used general linear models (R procedure `glm`, R Development Core Team, 2004) to simultaneously assess the influence of several factors on various movement measures. Models were fitted compared using the `anova` (R procedure `anova`, R Development Core Team, 2004). Regression coefficients, as produced by fitted models, were used to draw conclusions regarding patterns and characteristics of bear movement (Nelder and Wedderburn 1972; Turchin 1998).

Characteristics of Movement Analysis. In order to investigate characteristics of bear movement, I selected several measures to test how much territory an animal occupies, how much an animal moves within that territory, and how much and in what way an animal moves about its specified territory (tortuosity). Tortuosity measurements have been used for other carnivores such as wolves and lions (Whittington et.al 2004;

Valeix et.al. 2010). Specific measures examined included the following, and were calculated using ArcGIS (ESRI 2009) and Excel (Microsoft 2009) (Whittington et.al 2004):

- 1.) First-Last: Distance from first to last point.
- 2.) MaxDist: Maximum distance between any two of the points. This is an indicative measure of territory size.
- 3.) Path length: Sum of lengths of distances between successive points. This measures how much an animal moves.
- 4.) MCPA: Area of minimum convex polygon, or a measure of territory size.
- 5.) NC: Number of times a path crosses itself. This is one measure of tortuosity, and indicates trends of core activity or excursions.
- 6.) MRL: Mean resultant length. This quantity is based on the idea of turning angles, and describes how a bear moves. If a travel path is almost straight, turning angles will tend to be very small. If turning angles tend to be large, then the path has many sharp changes in direction, and tortuosity is high. If a path is almost straight, turning angles are typically small and MRL is near one. If turning angles are large, MRL is small (near zero).
- 7.) ALC: ALC is absolute loop complexity. This is the number of times the loops in a path intersect each other, another measure of tortuosity.
- 8.) SI: A straightness index derived from First-Last Location/Path length, or the ratio of the distance from start to finish points to the total distance moved. If SI is low, the path is very crooked.

9.) ASI: Alternative straightness index. This value is equal to MaxDist/Path length.

ASI is much like SI. The distance from the first to last point of a random walk may vary simply by chance, even if path is not very tortuous. The maximum distance between two path points tends to provide a more robust index.

10.) MCPAM: This is modified area of minimum convex polygon. MCPAM is equal to MCPA divided by the square of MaxDist. If movement is characterized by long, straight paths, the minimum convex polygon formed by the path will be very long and thin. The area of the MCP will be small, the maximum distance between two path points will be long, and thus the value of MCPAM will be very small. If however the animal confines itself to a small area, rather than making excursions, the path will almost fill a compact shape - a circle or rectangle - whose width is equal to the maximum distance. In this case, MCPAM will be relatively large.

11.) RLC: This is relative loop complexity. It is defined to be ALC/ maximum possible value of ALC.

I used the same 56 sequences, as described above, to examine characteristics of bear movement. Since I am interested in how the means of all of these characteristics (groups) are affected by variables such as “Gender”, “Age”, and “Location”, I used general linear models (R procedure `glm`, R Development Core Team, 2004) to simultaneously assess the influence of several factors on various movement measures. In this analysis, “Gender”, “Age”, and “Location” are predictor variables while activity level is the dependent variable. Models were fitted compared using the `anova` (R procedure `anova`, R Development Core Team, 2004). Regression coefficients, as produced by fitted models, were used to draw conclusions regarding patterns and

characteristics of bear movement (Nelder and Wedderbum 1972; Turchin 1998). Anova was also used to analyze MRL, but here I used the transformed log of the predictor variable. Since NC and ALC must be nonnegative integers, these two are actually count variables. Here, a poisson distribution with overdispersion (quasipoisson) was used. The overdispersion avoids giving coefficients spurious levels of significance.

Regression coefficients, as produced by fitted models, were used to draw conclusions regarding patterns and characteristics of bear movement as influenced by predictor variables (Nelder and Wedderbum 1972; Turchin 1998). The effects of different levels of categorical predictor variables such as locale, sex, or age status can be directly compared by comparing their associated regression coefficients. If for example the coefficient for locale variable “Lynne” and locale variable “Paisley” are both positive, but the coefficient of variable “Lynne” is greater, then it can be said that variable “Lynne” exerts a greater positive influence on the associated movement (dependent) variable than does variable “Paisley”.

Results

I trapped for a total of 441 trap nights, resulting in bears captures 67 times. A total of 32 bears were equipped with radio-collars; 25 at the urban-wildland interface (12 female, 13 males), including 12 adults (7 female, 5 male), 11 sub-adults (5 female, 6 male), and 3 yearlings (2 female, 1 male). Seven bears were captured in ONF, including 6 adults (3 female, 3 male) and one sub-adult male. Trap bias for sex did not appear to be significant. A higher proportion of bears at these interfaces appeared to be sub-adults or yearlings (41%; n= 24) compared with bears captured in the forest (25%; n = 8).

Incidental captures were limited to one coyote (*Canis latrans*) and two humans (*Homo*

sapiens), neither species was immobilized. We had 38 traps sprung but empty and our trap success was 15.65%.

Activity Patterns

Contingency tables. I found a significant association between locale and activity ($p < 0.001$) (Table 2-1). In other words, the distribution of counts among different activity levels differed significantly for the three locales, meaning that locale seemed to exert an influence on activity patterns of bears. Although the association between these variables was significant, the mean was not significantly different among the three locales (Table 2-1). The raw count however suggested that bears that reside in the interior forest were more likely to be active at any given time of day (Table 2-1). Conversely, bears in Lynne and Paisley were more likely to be inactive at any given time of day, although the proportion of time spent active versus inactive was fairly even, especially in Paisley. Urban bears also spent more time in the highly active state compared to bears in the interior forest, although this relationship was not significant (Table 2-1).

I found a significant association between time block and activity ($p < 0.001$) (Table 2-2). In other words, the distribution of counts among the different levels of activity differed significantly for the four time blocks for all bears. In addition, the mean level of activity was also significantly different between time blocks (Table 2-2). The block by activity table describes the pattern observed for all forest and urban bears. Overall, at any point in time within block 1 (0000-0559 h), bears are more likely to be active (Table 2-2). During block 2 (0600-1159 h), bears spent a more or less equal amount of time in the active and inactive state. Inactive behavior dominated block 3 (1200-1759 h), and block 3 was the most inactive block of all four blocks. Bears were

once again more likely to be more active at any given point in time during block 4 (1800-2359 h).

I found a significant three-way association between locale, block, and activity ($p = < 0.001$) (Tables 2-3; 2-4; 2-5; 2-6). Even though these variables were significantly associated, the means were not significantly different. Trends indicated however that all bears in the study may be more likely to be active during Block 1 (Table 2-3). In Block 2, forest bears were still more likely to be active, while urban bears both in Lynne and Paisley showed a decrease in activity (Table 2-4). During Block 3, forest bears were still active while all urban bears were more likely to be inactive (Table 2-5). All bears in forest and urban areas were decidedly more active during Block 4, and all had the highest chance of being highly active at this time (Table 2-6).

I found a significant association between sex and activity ($p = < 0.001$) (Table 2-7). In addition, the mean level of activity varied significantly by sex (Table 2-7). Although male and female bears spent a relatively equal amount of time active and inactive, females were more often active and male bears appeared to spend more time in the highly active state (Table 2-7).

A strong association was found between age status and activity ($p = 0.052$) (Table 2-8). In addition, the mean level of activity also varied significantly between age classes (Table 2-8). Adult bears were slightly more often inactive compared to sub-adults, and conversely sub-adults were slightly more active compared to adults. Time spent in the highly active state was, however, roughly equal between age classes (Table 2-8).

All of the above conclusions are based on p -values for “general association” and “row mean scores differ” for differences among and between variables, respectively

(Tables 2-1 through 2-8). Illustrative histograms summarizing total time spent at each activity level are given for male and female bears in both urban and forest settings (Figure 2-2 through 2-5).

Home Ranges

The average home range size for forest bears was 18.26 km^2 for females and 31.50 km^2 for males. The average home range size for urban female bears was slightly larger than their forest counterparts at 21.51 km^2 , and the same trend was true for male urban bears although to a higher degree at 97.51 km^2 . Due to small sample sizes and the fact that no adult male bears were captured in Paisley, I pooled Lynne and Paisley bears for the preceding urban averages. The difference between adult male and adult female home range was highly significant ($p = 0.016$). Home ranges for sub-adult bears averaged 43.52 km^2 . No significant difference was detected between sub-adult and adult home range size; however a significant difference in home range size was detected between sub-adult males and adult males ($p = 0.034$). Interestingly, the home ranges for sub-adult females averaged 71.67 km^2 , the highest average for any group. This average was elevated by a single sub-adult female whose home range was the second largest in the study, after an adult boar.

Movements

Male bears moved significantly faster than females ($p = 0.049$). Males tended to move significantly greater distances than females on any given day ($p=0.035$) (Table 2-9). No significant differences were documented for path length or rate of travel among adults and sub-adults or among bears of different locales.

The variance (VAR) in movement rates of Lynne bears was significantly higher than that of forest bears ($p = 0.029$) (Table 2-9). This trend was also apparent for Paisley

bears, although the trend was not significant ($p = 0.075$) (Table 2-9). The variance in movement rates was significantly higher for males than females ($p=0.007$) (Table 2-9). No difference was observed for this measure between adult and sub-adult bears.

When considering CoVr, the variability of movement for male bears is no longer significant. ($p = 0.141$) (Table 2-9). However, most other predictor variables became significant under this measure. The movements of sub-adult bears were significantly more variable than those of adults ($p = 0.037$) (Table 2-9). The movements of urban bears were significantly more variable than those of forest bears, but this trend was not significant for only Paisley bears ($p = 0.014$ for Lynne, $p = 0.066$ for Paisley) (Table 2-9).

Characteristics of Movement Analysis . Most of the p-values were large for the analysis of travel characteristics, i.e. most of the models had almost no predictive value. The major exceptions were for locale. Lynne bears, for example, were shown to have significantly smaller MCPAM ($p = 0.036$) (Table 2-10), indicating that Lynne bears made more excursions out of a core area compared to forest bears. Paisley bears showed the same trend as Lynne bears for MCPAM, although this was not significant ($p = 0.074$) (Table 2-10). ALC, or the number of times a path loop intersects itself, was shown to be significantly smaller for Paisley bears ($p = 0.035$) (Table 2-10), and indicated that these bears were not as likely to be backtracking or concentrating their activity to core areas. Instead, Paisley bears appeared to walk straighter paths than forest bears. The straightness index was significantly greater for Paisley bears ($p = 0.007$) (Table 2-10), and indicated a higher degree of directional travel. NC (an index of path crossing) was significantly smaller for Paisley bears ($p = 0.014$) (Table 2-10), and indicated that Paisley bears

walked straighter paths and infrequently crossed their own paths. Both Lynne and Paisley bears showed a significantly higher value for ASI ($p = 0.036$, $p = 0.013$, respectively) (Table 2-10). Lynne and Paisley bears appeared to walk straighter paths than forest bears, and Paisley bears walked the straightest path of the three groups.

Gender and age status were shown to influence characteristics of movement according to some models. Gender was borderline significant for ALC ($p = 0.051$) (Table 2-10), meaning that male bears seemed to walk straighter paths, and did not concentrate activity to core areas to the extent that female bears appeared to be doing. NC was highly significant for male bears ($p = 0.002$) (Table 2-10), meaning that males walked straighter paths than females. Gender was also significant for RLC ($p = 0.002$) (Table 2-10), and the model indicated that male bears were significantly less likely to cross their own path in the span of a day compared to females.

Age was only significant as a predictor of movement characteristics in the MCPAM model. Sub-adult bears had a significantly smaller MCPAM ($p = 0.042$) (Table 2-10), and this indicated that they were making more excursions out of a core area of activity. P-values were generally large for the MRL model, and thus the MRL variable lacked statistical significance (Table 2-10).

Discussion

Activity Patterns

The data showed that bears residing in the interior forest were more likely to be active at any given time of day, and spent more time active per diel than urban bears. Urban bears spent a relatively equal amount of time active and inactive, with inactive being slightly more common. Urban bears also spent more time in the highly active state compared to bears in the interior forest. This trend may be a result of avoidance of

perceived anthropogenic threats such as humans and barking dogs. Forest bears face few natural threats other than conspecifics (Freedman et al. 2003; McCown et al. 2004; Dixon et al. 2006; Garrison et al. 2007). Urban bears may feel more threatened in open habitats such as backyards, particularly when in close proximity to humans and domestic animals. These bears may experience relatively stressful foraging and may move quickly through open habitats, and this may help explain the movement characteristics observed in this study.

All bears in the study were more likely to be active during Block 4 (1800-2359 h) and Block 1 (0000-0559 h) than at other times of the day. The highest activity was during Block 4, roughly from dusk until midnight. This result is consistent with the species' nocturnal behavior (Dobey et al. 2005), and the results suggest that black bears in ONF are the most active during the first half of night. Perhaps this trend indicates that most nocturnal foraging is accomplished early on, thus allowing for a decrease in activity during early morning hours. During Block 2 (0600-1159 h), however, forest bears are still more likely to be active while urban bears both in Lynne and Paisley are largely inactive. During Block 3, forest bears are still active while all urban bears are more likely to be inactive. These trends indicate that forest bears are spending relatively more time, including daylight hours, active and presumably foraging. As previously suggested, forest resources may be more clumped and widely dispersed in comparison to suburban habitats. This may result in interior bears having to spend a relatively larger portion of their day acquiring resources and thus remaining active. However, forest bears may simply be able to remain active during the day because they are not faced with the presence of humans, who like most primates, are primarily diurnal. The trend that urban

bears exhibit decreased activity during daylight hours either means that they are able to accomplish most of their resource acquisition at night, due to concentrated and linear spacing of resources, or that they cannot afford to be active during the day for risk of exposure to humans, or both. That urban bears spend the majority of Block 3 (1200-1759 h) completely inactive suggests that avoidance of humans may be the strategy employed at a time when human activity is probably at its peak. Perhaps if urban black bears are in fact able to satisfy their food requirements solely during nocturnal hours in urban environments due to spacing of resources, and are thus able to avoid people during daylight hours, they have the capacity to co-exist with humans in suburbia. This limited activity may also explain the difference in home range size between urban and forest bears, suggested in this study and others (Moyer 2004; Moyer et al. 2007). Since urban bears appear less active across the 24 h day, presumably in response to human presence, they may compensate for this limited window of activity by occupying larger home ranges than forest bears. In other words, to acquire necessary resources, urban bears may need to cover larger areas in a shorter amount of time. Moyer (2004) and Moyer et al. (2007) suggested relationships between home range size and food availability, and this relationship may well extend to patterns in movement as well as territory occupied.

Male and female bears seemed to spend a relatively equal amount of time active and inactive across the three locales. However, females were slightly more often active and male bears appeared to spend more time in the highly active state. These trends may be a product of home range size. While male bears have more area to cover for social reasons (Freedman et al. 2003; Dobey et al. 2005), they may spend more of their active time in a highly active state.

There was some evidence to suggest that adult bears may be more often inactive compared to sub-adults, and conversely that sub-adults may be slightly more active compared to adults. Time spent in the highly active state was roughly equal. Sub-adult bears may be spending more time active for the reason that they do not have an established territory at this stage of life (Freedman et al. 2003; Moyer 2004; Dobey et al. 2005; Moyer et al. 2007), and food resources are effectively not available to them consistently and reliably in the same area, without the risk of encountering territorial conspecifics (Moyer et al. 2008). This translates into the need for sub-adult bears to remain in an active state in their search for resources throughout available habitat.

Home Range

The home range sizes of Florida black bears are similar to those of bears in other regions of North America (Maehr 1997; Wooding & Hardisky 1988) and in Florida (Moyer 2004; Moyer et al. 2007). In this study, bear home ranges showed considerable overlap (in size and space) in all populations (Figure B-1 through Figure B-32). Adult male bears had significantly larger home ranges than adult females, and male territories overlapped the smaller home ranges of several females. Urban black bears, especially those in Lynne, had significantly larger home ranges than bears in the interior forest and these results are in agreement with those reported by Moyer (2004) and Moyer et al. (2007). This trend supports my hypothesis that home ranges would be larger in urban areas, and suggests that urban bears may rely less on human food sources than previously thought (an isotope test would verify this). Moyer et al. (2007) concluded that the space-use pattern of female Florida black bears varies, with larger home ranges during autumn, and during years of mast failures or other unfavorable environmental conditions. Inhabiting the urban interface, what is essentially a sub-optimal fringe habitat, may bring

about the same behavior responses in black bears as does events like seasonal food shortages, mast failures, or any other unfavorable event that causes bears to increase their range to meet their daily requirements. Moyer et al. (2007, 2008) suggest that site-specific differences in the size of seasonal home range are due to differences in habitat characteristics and the degree of habitat fragmentation. Urban bears certainly live in a more fragmented environment (Dixon et al. 2006; Moyer 2004), and may be living in a constant state of unfavorable environmental conditions at the interface based on observed behavior. This trend is apparent not only in the results reported here, but in the fact that when masts do occur in the forest, bears living at the interface will return for those abundant resources (Dixon et al. 2006; Moyer et al. 2007; personal observation).

There was no significant difference in size of areas used between adult and sub-adult bears overall, probably a product of lengthy excursions made by sub-adult bears. This could be due to a tendency for sub-adult bears to wander farther in search of new territories, avoiding adults, and being forced into less optimal habitats with fewer resources (Freedman et al. 2003; Moyer 2004; Dobey et al. 2005). Interestingly, sub-adult females had larger home ranges than sub-adult males.

Movements

Rates of Movement. Male bears moved faster and farther than females in both urban and forest locales. Though male and female bears showed similar levels of inactivity, females were more often active while males were more often highly active. The suggestion was made that when males are active they are highly active, and analysis of detailed movement patterns corroborated this suggestion. Male bears cover larger areas than females in their daily/weekly routines (Freedman et al. 2003; Moyer 2004; Dobey et al. 2005). When male bears move, they move faster and farther than females.

The movements of male bears were highly variable. However, when I allowed for the inherent faster motion of male bears, the increase in variability almost disappeared and the variability in movement of male bears was no longer significant.

Absolute differences in distances traveled and rates of movement did not exist between adults and sub-adults, or between bears of different locales. However, the movements of Lynne bears were significantly more variable compared to forest bears, even after controlling for rate of travel. Though not significant, Paisley bears also appeared to be more variable in their movement compared to forest bears. The lack of significance may simply be due to a relatively small sample size for Paisley bears. If significant, the regression coefficient for Paisley bears (1.085, Table 2-9) implies that Paisley bears are in fact more variable in their movement rates than Lynne bears.

Urban bears may exhibit greater variability in movement rates for the same reasons that they show variability in levels of activity as previously discussed. Urban bears navigate habitats characterized by a matrix of open, human-occupied spaces (Dobey et al. 2003; Dixon et al. 2007; Moyer et al. 2007). Food resources are also assumed to be comparatively linear. Urban bears may be moving quickly through backyards or other areas deemed risky due to human occupation. Overall, urban bears were inactive more often, but when they were active they appeared more erratic in their movements and travel rates, for example they exhibited behavior that may be described as “stop and go”. Forest bears seem to show more consistent behavior overall compared to urban bears. In other words, black bears become more variable in their movement patterns when they occupy more variable habitat.

Future studies are encouraged to attempt larger sample sizes, or to combine comparable data with data from this study, in order to achieve a large enough sample size to test two-way interactions among rate of movement variables.

Characteristics of Movement. My data indicate that bears in Paisley tend to travel straighter paths than bears elsewhere. Also, my data indicate that travel paths for bears in Lynne were straighter than paths of forest bears, but not as straight as those of Paisley bears. These results are consistent with locale characteristics. The town of Paisley shares a distinct border with adjacent ONF, where roads and properties lie in a linear grid. Lynne, on the other hand, is characterized as more of a matrix of backyards, disturbed areas, and forest patches (Moyer 2004; Simek et al. 2005; Moyer et al. 2007). Path characteristics of bears may be consistent with different foraging patterns employed in these differing landscapes.

The extent to which an animal tends to cross its own path seems to be related to gender. That male bears appear to walk straighter paths than females may again corroborate those earlier findings that when male bears are moving, they are moving far and fast. As I discussed previously, males moved significantly greater distances than females, and at faster rates. When considering the relative number of times males cross their own path, it is highly significant that males do not overlap their tracks as often as females. Highly directional travel may be a product of home range size. While female bears restrict their movements to a smaller area (Moyer et al. 2007), male bears have larger home ranges and therefore more area to cover (Freedman et al. 2003; Dobey et al. 2005). This may make them less likely to cross their own travel path.

The long, thin-shaped minimum convex polygons of younger animals may be a product of dispersal, and is corroborated by movement data as well. Although not quite significant, sub-adult bears appear to walk straighter paths than adults. This implies that younger bears exhibit more wandering or exploratory behavior, rather than utilizing a stable, or established home range. Black bear dispersal occurs at the sub-adult stage (Pelton 1982; Rogers 1987a; Rogers et al. 1987). Dispersal is believed to be a response to social pressure from resident adult boars (Pelton 1982), although may be a result of socially independent reasons (Rogers 1987a). In one Florida study, dispersal of 4 sub-adult males ranged from 22 to 56 km (Wooding & Hardisky 1988). A straight-line movement of such distances will result in a long, narrow “home range” as calculated by MCP.

In terms of the sequences used to analyze motion data, the distribution of bears among the three locales was roughly even. However, though there were about as many males as females in the forest, there were fewer males in the urban fringe areas. Also, sub-adults were about as numerous as adults in the forest, but adults were about twice as numerous in Lynne, and sub-adults were almost absent in Paisley. Such patterns made it difficult to test models with two-way interactions, which would have provided a deeper insight into the movement patterns of black bears.

Management Implications

The results of this study will be useful to managers. Movement data could help guide management plans especially those that pertain to protecting bear habitat at the urban-wildland interface. On a proximate timescale, managers should understand that bears already inhabiting urban habitats exhibit different behavioral and spatial responses to variations in environmental conditions than bears occupying interior forest (Dobey et

al. 2005; Moyer et al. 2007). In other words, management decisions that work for bears in the interior forest may not suffice for bears living at the urban interface. Management plans for the Florida black bear should allow for increased space requirements for bears in urban settings.

As previously discussed, human populations in Florida are predicted to continually grow, and these projections include the towns of Lynne and Paisley. The study area of ONF is already bisected by State Road 40 (SR-40), a two-lane paved road with a traffic rate of more than 5,100 vehicle trips per day (Figure 2-1; Florida Department of Transportation, 2003). SR-40 has also been approved by the State of Florida to be widened from two lanes to four lanes to accommodate ever-increasing traffic loads (Hostetler et al. 2009). If forest extraction activities expand in the future, an even greater human presence in traditional bear habitat could be felt. With more people, more roads, and a greater degree of fragmentation, we may expect to see an increasing “urbanization” of bear behavior throughout ONF. In other words, as human presence increases, bears in the interior forest may begin to exhibit more variable movement patterns, expand home ranges, and in essence begin to behave more like those individuals that already occupy the urban interface. The end result would likely be that in this situation ONF would support fewer bears as home ranges expand and movement increases in response to fragmentation and degradation of habitat.

Even though a large number of bears were collared for this study, there still were several key limitations. First, once bears were divided by age, and sex, the sample size in each category was under ten individuals- not enough for strong statistical inference. Second, since bears were not equipped with GPS collars it was not possible to know

where they were at all times. Some bears, particularly large adult males, were ‘lost’ for days at a time when they were in areas not accessible to vehicles.

Illuminating the spatial and temporal requirements of the Florida black bear and how these requirements change with proximity to people is necessary for a complete understanding of the ecology and behavior of this threatened species. Ultimately, this information is needed to guide conservation and management of this subspecies within an increasingly human dominated landscape.

Summary: The purpose of this study was to extend knowledge of the behavioral ecology of Florida black bears at the urban-wildland interface in and around Ocala National Forest in north-central Florida. I radio-collared a total of 50 bears (32 adults, 18 cubs) and modeled telemetric data using SAS, R, and ArcGIS. In terms of activity levels, I found that bears residing in the interior forest were more likely to be active at any given time of day and spent more time active overall than urban bears. Urban bears spent more time either inactive or highly active compared to bears in the interior forest. All bears in this study were more likely to be active during 0000-0559 hours. From 0600-1159 hours, forest bears were still more likely to be active, while urban bears showed a decrease in activity. From 1200-1759 hours, forest bears were still active while all urban bears were more likely to be inactive. All bears in forest and urban areas were decidedly more active from 1800-2359 hours. Although male and female bears spent a relatively equal amount of time active and inactive, females were more often active and male bears appeared to spend more time in the highly active state. In terms of home ranges, I found that average home range size for forest bears was 18.26 km^2 for females and 31.50 km^2 for males. Average home range size for urban female bears was slightly larger than their forest

counterparts at 21.51 km^2 , and the same trend was true for male urban bears although to a higher degree at 97.51 km^2 . Urban bears made more excursions out of a core area compared to forest bears. Urban bears were not as likely to be backtracking or concentrating their activity to core areas and appeared to walk straighter paths than forest bears. In terms of movement characteristics, I found that variation in movement rates of urban bears was significantly higher than that of forest bears. The variance in movement rates was significantly higher for males than females. Forest bears seem to show much more consistent behavior overall compared to urban bears. Information generated in this study can help guide conservation and management of this subspecies within an increasingly human-dominated landscape. Movement data could help guide management plans especially those that pertain to protecting bear habitat at the urban-wildland interface. On a proximate timescale, managers should understand that bears already inhabiting urban habitats exhibit different behavioral and spatial responses to variations in environmental conditions than bears occupying interior forest. Management decisions that work for bears in the interior forest may not suffice for bears living at the urban interface. Management plans for the Florida black bear should allow for increased space requirements, more variable behavior, and higher mortality for bears in urban settings.

Table 2-1. Activity levels of adult and subadult black bears in ONF as influenced by locale. Activity status in 3 categories as determined by radio telemetry data is given per locale with frequencies, percentages for pooled years.

		Inactive	Active	Highly Active
Forest	Frequency	222	317	23
	Percentage	39.50	56.41	4.09
Lynne	Frequency	656	574	159
	Percentage	47.23	41.32	11.45
Paisley	Frequency	382	362	88
	Percentage	45.91	43.51	10.58

*Tables and statistics were calculated using the SAS procedure “FREQ”. ‘Row Mean Scores Differ’ indicates whether the overall level of activity differs between levels of the row variable. ‘General Association’ is a test for whether there is some kind of association between the two variables in the table. ‘Probability’ shows whether either statistic is significant. Row Mean Score Differ: 2DF; 0.029 Value; 0.986 Probability. General Association: 4DF; 49.425 Value; <0.001 Probability

Table 2-2. Activity levels of adult and subadult black bears in Ocala National Forest and adjacent towns of Lynne and Paisley, north central Florida, USA, 2005-2007 as influenced by time of day. Activity status in 3 categories as determined by radio telemetry data is given per locale with frequencies, percentages for pooled years.

		Inactive	Active	Highly Active
Block 1	Frequency	85	122	28
	Percentage	36.17	51.91	11.91
Block 2	Frequency	437	446	61
	Percentage	46.29	47.25	6.46
Block 3	Frequency	590	442	1115
	Percentage	52.91	39.64	7.44
Block 4	Frequency	148	243	98
	Percentage	30.27	49.69	20.04

*Tables and statistics were calculated using the SAS procedure “FREQ”. ‘Row Mean Scores Differ’ indicates whether the overall level of activity differs between levels of the row variable. ‘General Association’ is a test for whether there is some kind of association between the two variables in the table. ‘Probability’ shows whether either statistic is significant. Row Mean Score Differ: 3DF; 111.164Value; <0.001 Probability. General Association: 6DF; 127.373Value; <0.001 Probability

Table 2-3. Activity levels of adult and subadult black bears in Ocala National Forest and adjacent towns of Lynne and Paisley, north central Florida, USA, 2005-2007 as influenced by locale during hours 0000-0559. Activity status in 3categories as determined by radio telemetry data is given per locale with frequencies, percentages for pooled years.

		Inactive	Active	Highly Active
Forest	Frequency	30	40	1
	Percentage	42.25	56.34	1.41
Lynne	Frequency	41	55	22
	Percentage	34.75	46.61	18.64
Paisley	Frequency	14	27	5
	Percentage	30.43	58.70	10.87

*Tables and statistics were calculated using the SAS procedure “FREQ”. ‘Row Mean Scores Differ’ indicates whether the overall level of activity differs between levels of the row variable. ‘General Association’ is a test for whether there is some kind of association between the two variables in the table. ‘Probability’ shows whether either statistic is significant. Score Differ: 2DF; 1.205Value; 0.5474 Probability. General Association: 4DF; 50.496Value; <0.001 Probability

Table 2-4. Activity levels of adult and subadult black bears in Ocala National Forest and adjacent towns of Lynne and Paisley, north central Florida, USA, 2005-2007 as influenced by locale during hours 0600-1159. Activity status in 3categories as determined by radio telemetry data is given per locale with frequencies, percentages for pooled years.

		Inactive	Active	Highly Active
Forest	Frequency	72	101	9
	Percentage	39.56	55.49	4.95
Lynne	Frequency	246	239	39
	Percentage	46.95	45.61	7.44
Paisley	Frequency	119	106	13
	Percentage	50.00	44.54	5.46

*Tables and statistics were calculated using the SAS procedure “FREQ”. ‘Row Mean Scores Differ’ indicates whether the overall level of activity differs between levels of the row variable. ‘General Association’ is a test for whether there is some kind of association between the two variables in the table. ‘Probability’ shows whether either statistic is significant. Score Differ: 2DF; 1.205Value; 0.5474 Probability. General Association: 4DF; 50.496Value; <0.001 Probability

Table 2-5. Activity levels of adult and subadult black bears in Ocala National Forest and adjacent towns of Lynne and Paisley, north central Florida, USA, 2005-2007 as influenced by locale during hours 1200-1759. Activity status in 3 categories as determined by radio telemetry data is given per locale with frequencies, percentages for pooled years.

		Inactive	Active	Highly Active
Forest	Frequency	84	110	5
	Percentage	42.21	55.28	2.51
Lynne	Frequency	287	167	41
	Percentage	57.98	33.74	8.28
Paisley	Frequency	219	165	37
	Percentage	52.02	39.19	8.79

*Tables and statistics were calculated using the SAS procedure “FREQ”. ‘Row Mean Scores Differ’ indicates whether the overall level of activity differs between levels of the row variable. ‘General Association’ is a test for whether there is some kind of association between the two variables in the table. ‘Probability’ shows whether either statistic is significant. Score Differ: 2DF; 1.205Value; 0.5474 Probability. General Association: 4DF; 50.496Value; <0.001 Probability

Table 2-6. Activity levels of adult and subadult black bears in Ocala National Forest and adjacent towns of Lynne and Paisley, north central Florida, USA, 2005-2007 as influenced by locale during hours 1800-2359. Activity status in 3categories as determined by radio telemetry data is given per locale with frequencies, percentages for pooled years.

		Inactive	Active	Highly Active
Forest	Frequency	36	66	8
	Percentage	32.73	60.00	7.27
Lynne	Frequency	82	113	57
	Percentage	32.54	44.84	22.62
Paisley	Frequency	30	64	33
	Percentage	23.62	50.39	25.98

*Tables and statistics were calculated using the SAS procedure “FREQ”. ‘Row Mean Scores Differ’ indicates whether the overall level of activity differs between levels of the row variable. ‘General Association’ is a test for whether there is some kind of association between the two variables in the table. ‘Probability’ shows whether either statistic is significant. Score Differ: 2DF; 1.205 Value; 0.5474 Probability. General Association: 4DF; 50.496 Value; <0.001 Probability

Table 2-7. Activity levels of adult and subadult black bears in Ocala National Forest and adjacent towns of Lynne and Paisley, north central Florida, USA, 2005-2007 as influenced by gender. Activity status in 3categories as determined by radio telemetry data is given per locale with frequencies, percentages for pooled years.

		Inactive	Active	Highly Active
Female	Frequency	827	832	146
	Percentage	45.82	46.09	8.09
Male	Frequency	433	421	124
	Percentage	44.27	43.05	12.68

*Tables and statistics were calculated using the SAS procedure “FREQ”. ‘Row Mean Scores Differ’ indicates whether the overall level of activity differs between levels of the row variable. ‘General Association’ is a test for whether there is some kind of association between the two variables in the table. ‘Probability’ shows whether either statistic is significant. Score Differ: 1DF; 5.636 Value; 0.017Probability. General Association: 2DF; 15.413 Value; <0.001 Probability

Table 2-8. Activity levels of black bears in Ocala National Forest and adjacent towns of Lynne and Paisley, north central Florida, USA, 2005-2007 as influenced by age status. Activity status in 3 categories as determined by radio telemetry data is given per locale with frequencies, percentages for pooled years.

		Inactive	Active	Highly Active
Adult	Frequency	857	795	175
	Percentage	46.91	43.51	9.58
Sub-adult	Frequency	403	458	95
	Percentage	42.15	47.91	9.94

*Tables and statistics were calculated using the SAS procedure “FREQ”. ‘Row Mean Scores Differ’ indicates whether the overall level of activity differs between levels of the row variable. ‘General Association’ is a test for whether there is some kind of association between the two variables in the table. ‘Probability’ shows whether either statistic is significant. Score Differ: 1DF; 3.873 Value; 0.049 Probability. General Association: 2DF; 5.903 Value; 0.052 Probability

Table 2-9. Regression coefficients and associated significance of the variables used to describe the influence of gender (male/female), age status (adult/subadult), and locale on four movement characteristics of Ocala National Forest black bears in the towns of Lynne and Paisley in the Ocala National Forest, north-central Florida, USA, 2005-2007. Regression coefficients were produced using additive and ANOVA-fitted general linear models in ‘R’.

		Male (vs. female)	Sub-adult (vs. adult)	Lynne (vs. interior forest)	Paisley (vs. interior forest)
“Path Length”	<i>Estimate</i>	0.508	-0.264	0.217	0.226
	<i>Std. Error</i>	0.235	0.213	0.229	0.297
	<i>t value</i>	2.157	-1.239	0.945	0.759
	<i>p</i>	0.035	0.221	0.349	0.451
“Rate of Motion”	<i>Estimate</i>	0.482	-0.226	0.220	0.257
	<i>Std. Error</i>	0.238	0.216	0.232	0.300
	<i>t value</i>	2.022	-1.049	0.946	0.855
	<i>p</i>	0.049	0.299	0.349	0.396
“VAR”	<i>Estimate</i>	1.324	0.013	1.035	1.085
	<i>Std. Error</i>	0.474	0.429	0.462	0.597
	<i>t value</i>	2.795	0.031	2.242	1.816
	<i>p</i>	0.007	0.975	0.029	0.075
“CoVR”	<i>Estimate</i>	0.180	0.233	0.298	0.286
	<i>Std. Error</i>	0.121	0.109	0.118	0.152
	<i>t value</i>	1.494	2.132	2.532	1.876
	<i>p</i>	0.141	0.037	0.014	0.066

* The row headed ‘Estimate’ are estimates for regression coefficients of levels of predictors. Coefficients are used to describe the slope of the regression. Positive values have positive influences on movement characteristics, and vice versa. Predictor variables in parentheses represent baseline values (0’s) against which primary predictor variables can be compared. For example, numbers in the third column represent male bears as compared to female bears. The value under ‘p’ shows whether the coefficient is significantly different from zero. A large p -value (> 0.05) can be taken to mean not significant.

Table 2-10. Regression coefficients and associated significance of variables used to describe the influence of gender (M/ F), age status (adult/subadult), and locale on seven movement characteristics of black bears in the towns of Lynne and Paisley and in the Ocala National Forest, north-central Florida, USA, 2005-2007. Regression coefficients were produced using additive and ANOVA-fitted general linear models in ‘R’.

		Intercept	Male (vs. female)	Sub-adult (vs. adult)	Lynne (vs. interior forest)	Paisley (vs. interior forest)
“MCPAM”	<i>Estimate</i>	3.434e-03	8.407e-06	-6.954e-04	-7.796e-04	-8.649e-04
	<i>Std. Error</i>	3.618e-04	3.755e-04	3.333e-04	3.634e-04	4.744e-04
	<i>t value</i>	9.492	0.022	-2.086	-2.145	-1.822
	<i>Pr(>ItI)</i>	7.383	0.982	0.042	0.036	0.074
“ALC”	<i>Estimate</i>	2.528	-0.911	-0.349	-0.391	-1.204
	<i>Std. Error</i>	0.323	0.456	0.368	0.363	0.556
	<i>t value</i>	7.819	-1.993	-0.947	-1.078	-2.165
	<i>Pr(>ItI)</i>	2.782e-10	0.051	0.347	0.285	0.035
“SI”	<i>Estimate</i>	0.145	0.078	0.022	0.071	0.190
	<i>Std. Error</i>	0.052	0.054	0.048	0.052	0.068
	<i>t value</i>	2.775	1.446	0.472	1.354	2.780
	<i>Pr(>ItI)</i>	0.007	0.154	0.638	0.181	0.007
“NC”	<i>Estimate</i>	2.162	-0.753	-0.295	-0.304	-0.674
	<i>Std. Error</i>	0.179	0.238	0.195	0.197	0.265
	<i>t value</i>	12.040	-3.155	-1.511	-1.540	-2.544
	<i>Pr(>ItI)</i>	1.585e-16	0.002	0.136	0.129	0.014
“ASI”	<i>Estimate</i>	0.257	0.079	0.073	0.093	0.144
	<i>Std. Error</i>	0.043	0.045	0.039	0.043	0.056
	<i>t value</i>	5.939	1.761	1.827	2.149	2.549
	<i>Pr(>ItI)</i>	2.553e-07	0.084	0.073	0.036	0.013
“RLC”	<i>Estimate</i>	1.709	-0.709	-0.233	-0.114	-0.173
	<i>Std. Error</i>	0.148	0.219	0.172	0.165	0.254
	<i>t value</i>	11.530	-3.237	-1.356	-0.693	-0.682
	<i>Pr(>ItI)</i>	1.354e-14	0.002	0.182	0.492	0.498
“MRL” (logit)	<i>Estimate</i>	-0.337	-0.381	-0.114	0.003	0.130
	<i>Std. Error</i>	0.254	0.263	0.234	0.255	0.333
	<i>t value</i>	-1.327	-1.447	-0.490	0.014	0.391
	<i>Pr(>ItI)</i>	0.190	0.153	0.625	0.988	0.697

* The row headed ‘Estimate’ are estimates for regression coefficients of levels of predictors. Coefficients are used to describe the slope of the regression. Positive values have positive influences on movement characteristics, and vice versa. Predictor variables in parentheses represent baseline values (0’s) against which primary predictor variables can be compared. For example, numbers in the third column represent male bears as compared to female bears. The value under ‘p’ shows whether the coefficient is significantly different from zero. A large p -value (> 0.05) can be taken to mean not significant.

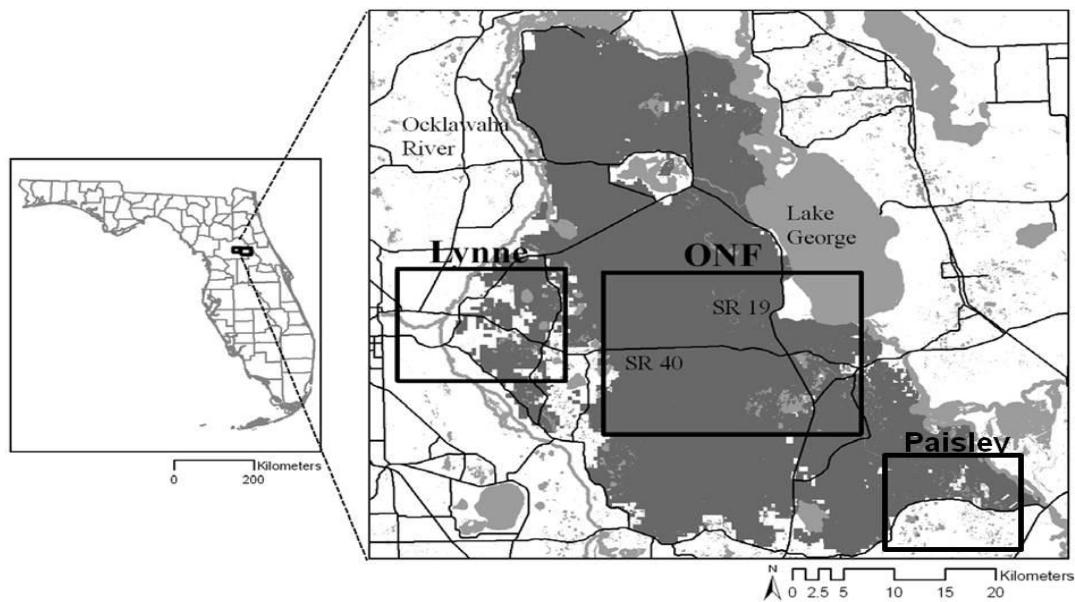


Figure 2-1. The Ocala National Forest and adjacent study areas of Lynne and Paisley, Florida, USA.

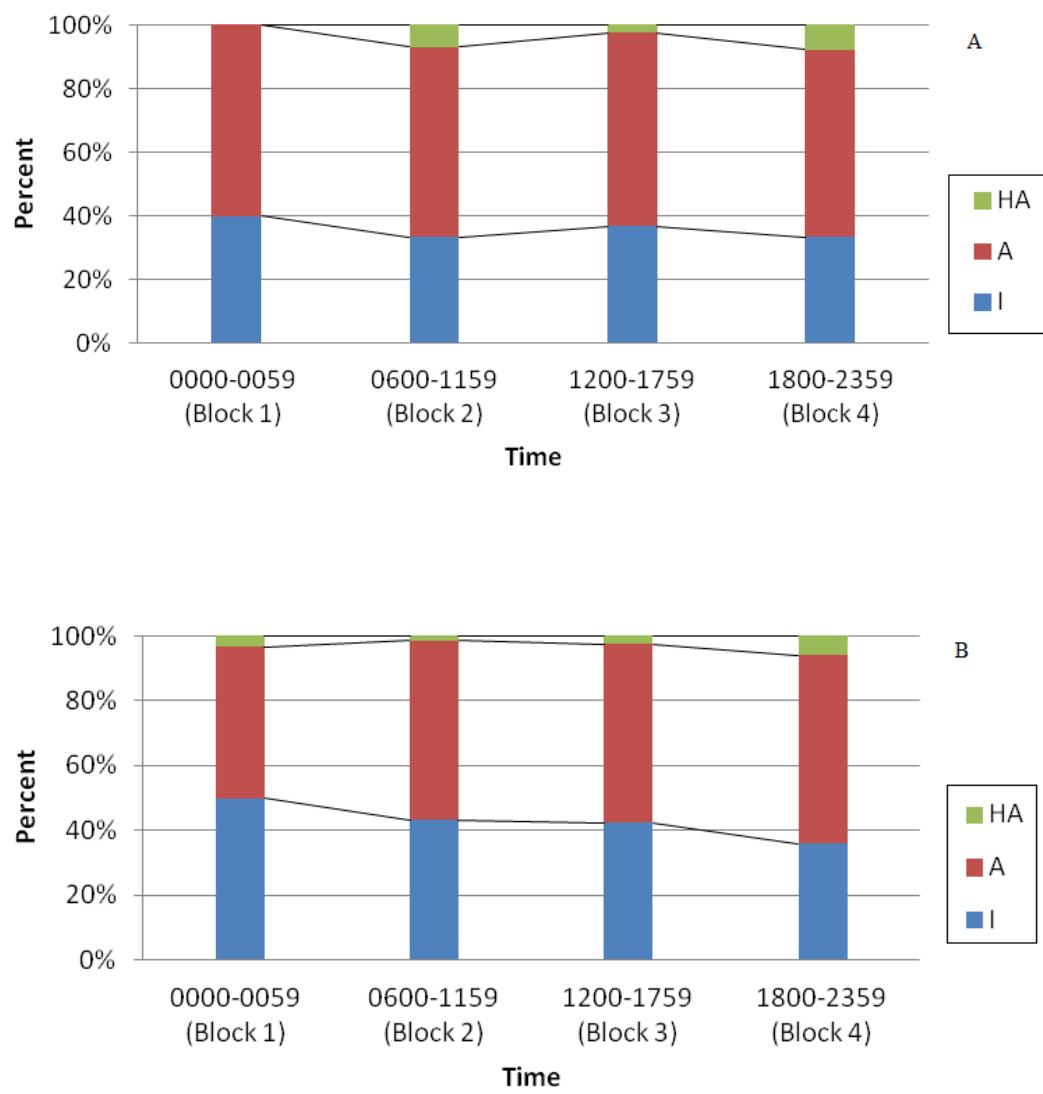


Figure 2-2. Histogram showing inactive, active and highly active activity levels across four blocks of time observed of Florida black bears in the interior Ocala National Forest, north-central Florida, USA, 2005-2007. A) Females. B) Males.

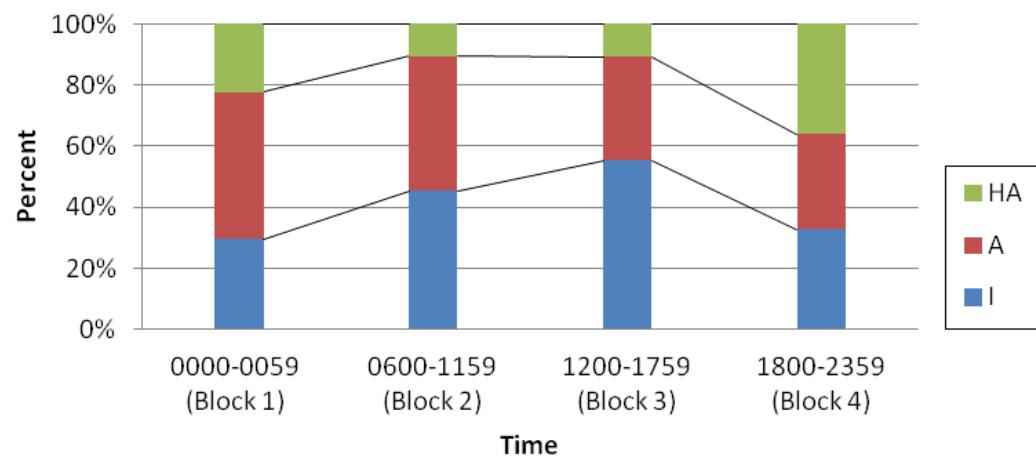
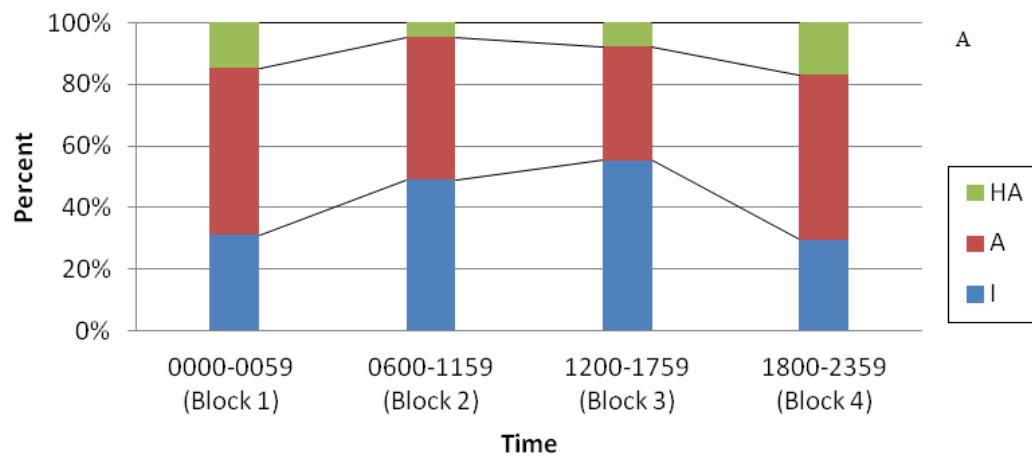


Figure 2-3. Histogram showing inactive, active and highly active activity levels across four blocks of time observed of Florida black bears in the towns of Lynne and Paisley, north-central Florida, USA, 2005-2007. A) Females. B) Males.

CHAPTER 3

FLORIDA BLACK BEAR SURVIVAL AND REPRODUCTION

Background

The most serious threat to the continued existence of the Florida black bear is fragmentation and loss of habitat (Wesley 1991; Hellgren & Vaughan 1994; Young & Clark 2000; McCown et al. 2004; Dixon et al. 2006) , which subsequently leads to shifts in survival rates (Hostetler et al. 2009). As roads, agricultural, commercial and residential developments continue to encroach on and further degrade remaining black bear habitat, so has the number of human-bear interactions risen dramatically in recent years (Annis 2007; McCown et al. 2009). These interactions range from vehicular collisions, feeding (intentional or unintentional), and illegal harvest, although bear harvest has not been permitted at ONF since 1971 (Wooding 1993). Most human-bear interactions result negatively for both parties, and additively may have negative effects on a population level for bears (Annis 2007). Research indicates that living in proximity to people has the potential to change carnivore ecology on several levels (Gittleman et al. 2005; Moyer et al. 2007; Hostetler et al. 2009).

It is important to explore the effects of habitat on population dynamics in variable landscapes (Williams and Nichols 1984). ONF displays a variation in habitats across a landscape mosaic of human habitation and interior forest (Dobey et al. 2005; Dixon et al. 2006; Moyer et al. 2007). Understanding black bear population ecology in suburbia is vital to address the current state of black bears in Florida, because bears residing at the urban interface seem to behave differently (Moyer et al. 2007) and face a unique set of hazards and risks (McCown et al. 2004; Dixon et al. 2006). Four demographic factors determine any population's growth or decline: birth, death, immigration, and emigration rates (Bunnell & Tait 1980). These four factors can offer insight into whether a specific population is a sink or source (Pulliam 1996, Remes 2000;

Delibes et al. 2001a, b), a dynamic that represents a foundation for landscape ecology (Wiens et al. 1993). A population is considered a sink when reproductive output is inadequate to maintain local population levels (Pulliam 1996; Delibes et al. 2001; Salminen & Haimi 2001). If survival rates for bears at the urban interface are in fact considerably lower, then that would offer insight into whether the urban interface is a sink for Florida black bears. Alternatively, sink populations exist only as a result of immigration from a population where reproduction exceeds replacement (Pulliam 1996; Ford et al. 2001; Purcell & Verner 1998). This may also be the case in ONF as the bear population is thought to be at carrying capacity (McCown et al. 2004; Dixon et al. 2007), and dispersing individuals have nowhere else to go except into fringe habitat at the interface (Dixon et al. 2006). Individuals in a sink will move to better habitat (the source) when space becomes available (Howe et al. 1991; Pulliam 1996; Kristan 2003). Since bears are at carrying capacity, it is unlikely that new space will become available in better habitat. During mast years however, or seasonally when natural foods such as berries are abundant, bears will temporarily move to the interior forest from the interface (Dixon et al. 2006; personal observation). This may be an effect of forest bears utilizing smaller territory sizes based on ample food supplies (Moyer 2004; Moyer et al. 2007), thus allowing the area of the forest to temporarily support more bears. In a source-sink dynamic, populations persist in poor habitat as long as immigrants from better habitat continually immigrate (Shmida and Ellner 1984; Pulliam 1988; Pulliam and Danielson 1991; Pulliam 1996).

Survival and Mortality

Although black bears can live 20 years, the highest mortality rates occur at 3-4 years (Maehr & Wooding 1992). Black bear survival in ONF is probably lowered as a result of necessary dispersal by young bears (McCown et al. 2004). Black bear dispersal, or movements away from their area of birth, usually occurs between 2 to 4 years of age (Pelton 1982; Rogers 1987a;

Rogers et al. 1987). Sub-adult females usually remain in the immediate area of their mother's home range (Moyer et al. 2007), whereas sub-adult males generally disperse much greater distances (Maehr et al. 1988; Maehr 1997). This is generally believed to be a response to social pressure from resident adult boars (Pelton 1982), although it may also be a result of social independence (Rogers 1987a). In one Florida study, dispersal of 4 sub-adult males ranged from 22 to 56 km (Woolding & Hardisky 1988). In another study, a sub-adult male dispersed over 140 km (Maehr et al. 1988). No female Florida black bear is known to have dispersed over 60 km (Maehr 1997). Dispersal is an important demographic factor that plays a key role in population regulation (Beecham 1983; Bunnell & Tait 1981; Kemp 1976; Lecount 1982; Rogers 1987a).

Dispersal by bears at this age leads to increased probability of encountering people, especially when humans are encroaching into bear habitat (McCown et al. 2004; Dixon et al. 2006; Annis 2007). Collisions with vehicles are a primary source of bear mortality in ONF (McCown et al. 2004, McCown et al. 2009). Previous studies have demonstrated demographic effects of habitat fragmentation and other anthropogenic influences, including reduced survival and population growth for a variety of vertebrate species (e.g., Kerley et al. 2002; Kramer-Schadt et al. 2004; Letcher et al. 2007; Ruiz-Gutiérrez et al. 2008). Bears inhabiting more fragmented habitat may have higher mortality rates, and thus lower population growth rates, than those in the less fragmented habitat. The primary focus of this chapter is to examine aspects of Florida black bear population ecology, with particular focus on survival estimates in urban versus forest settings. My overall goal was to use Florida black bears as a model to better understand demographic consequences of anthropogenic influence.

Hypotheses

In this study, I attempted to describe survival probabilities for both adult and juvenile bears residing at wildlife-urban interfaces in Florida. I hypothesized that bears living in close

proximity to humans will suffer higher rates of mortality than those bears living within the interior forest (McCown et al. 2004; Dixon et al. 2006; McCown et al. 2009). Survival estimates generated in this study will help to determine whether the urban-wildland interface could represent a sink for Florida black bears, and offer insight into whether these bears could sustain themselves in the absence of a constant influx from the interior forest.

Methods and Materials

Study Site

This study was conducted in the Ocala National Forest (ONF) in north-central Florida and in and around the adjacent towns of Lynne and Paisley on its borders. Ocala National Forest is the largest public land holding in central Florida and supports the highest density of black bears, with approximately 468 km² of nearly contiguous bear habitat (Dixon et al. 2006). ONF is managed for timber production as well as a variety of recreational activities, and human impacts are evident (McCown et al. 2004).

Lynne is located to the west of ONF and encompasses a matrix of privately owned land in the residential community and US Forest Service property (Moyer 2004; Dixon et al. 2006). Bear habitat in Lynne consists of small parcels of slash pine flatwoods under ownership of ONF, as well as corporate lands, and individual properties (Moyer 2004; Moyer et al. 2007). Paisley is located to the south of ONF and is a similar matrix as Lynne, but is more linearly developed with a more defined urban-wildland edge. Habitat in Paisley is, for the most part, individually owned. The urban-wildland interface in these two towns is effectively discontinuous bear habitat, interspersed in a network of moderate volume roads and residential, industrial, and/or commercial development. There is a greater degree of fragmentation in Lynne and Paisley due to human developments such as roads, houses, and businesses than in ONF (Moyer 2004). All three study sites were close enough for occasional movements of bears between the sites, and while

genetically distinct populations do not exist (Dixon et al. 2007), all females maintained their home ranges within the study area in which they were captured.

Field Methods

Capture

Bears in the wildland-urban setting were captured using culvert traps and Aldrich snares. Culvert traps are large cylindrical traps attached to a trailer. The cylinder is approximately 2 meters long and a meter in diameter. A drop door is located in the front and a release device is located in the back. When a bear enters the culvert and takes the bait off the locking device, it trips a door to drop, trapping the animal inside. All traps were baited with doughnuts.

The second method of capture was a modified Aldrich spring activated leg-snares (Johnson and Pelton 1980; McCown et al. 2004). For this method I attached a cable foot loop to two linked anchor cables that were each looped around anchor trees; caution was taken to ensure that the distance between them was great enough to prevent a trapped bear from reaching either tree. This reduced the likelihood of bone fractures that can occur when bears thrash and torque ensnared limbs.

I trapped intermittently between June 2005 and August 2006, concentrating my efforts between June and August each year. In 2005 I trapped in both Lynne and Paisley, and in 2006 I trapped in Lynne and the interior forest. Summer trapping was usually restricted to between 1800 h and 0600 h to decrease the potential of heat stress to bears. I utilized sentinel radio-collars attached with string to the snare; these were designed to activate immediately once a bear was trapped. This enabled me to immobilize most bears within an hour of their capture.

After capture, bears were immobilized with an injection of a 1:1 mixture of Tiletamine hydrochloride and Zolazepam hydrochloride (Telazol™). Drug was administered at 3.0-3.5 mg/kg of estimated bear weight via a blowpipe, jab-stick, or remote injection gun (McCown et

al. 2004). Once the bear is anesthetized, an ophthalmic ointment was administered to moisturize eyes, vital signs (temperature, respiration and pulse rate) were monitored, and morphological data were collected. Bears were measured, weighed, and evaluated for body condition and reproductive status. Body condition was quantified on a scale 1 to 5 (1 = excellent, thick subcutaneous fat over entire body; 2 = good, moderate subcutaneous fat; 3 = fair, minimal subcutaneous fat but well muscled; 4 = poor, no appreciable subcutaneous fat; and 5 = emaciated). A pre-molar was extracted for age determination (Willey 1974). Females were examined for vulva swelling as an indicator of estrus (Jonkel & Cowan 1971). Nipples were examined for lactation, length and color. These indicators of reproductive status, and subsequent documentation of cub production, were used to estimate age of first reproduction, inter-litter interval and fecundity. A hair sample was collected for genetic data, the upper lip was tattooed for permanent identification, and both ears were tagged with plastic identification tags. Each bear was given a unique color combination of ear tags for individual recognition from observations. Paired 4mm punch biopsies were taken in six locations (muzzle, chin, peri-ocular, crown, inter scapular, flank) from bears in Lynne as part of a bio-medical investigation into the demodetic mange organism, *Demodex ursi* in collaboration with Mark Cunningham (D.V.M., Florida Wildlife Commission). VHF motion-sensitive radio-collars (150-151 Mhz; TelonicsTM, Mesa, Arizona) were fitted around the neck and tagged bears were released within 20 meters of capture location. Collars were equipped with a mortality sensor and fitted with an oiled leather connector, which is designed to wear-away after two years. Immobilized bears were watched until they were able to stand. Where safety during recovery was a concern, I deterred other bears from attacking the immobilized bear while it was groggy.

Telemetry

I located radio-collared bears 1-3 times per week using standard ground triangulation methods or aerially with a single engine Cessna 172 aircraft equipped with wing-mounted antennas, from June 2005 to August 2007. These data provided information on denning status of females, as indicated by repeated use of one site for an extended amount of time, and locations of dens. I investigated the presence of cub from late January to the end of February by listening for cub vocalizations in the vicinity of known radio-collared females (Garrison 2004). To reduce disturbance to the female and cubs, I quietly clipped the under story vegetation and established a small trail within 10-30 m of the approximate den site.

Locating dens and collaring cubs

Natal dens of radio-collared females were checked from March to April to count and mark cubs. I obtained the number of cubs from den visits and/or observations made during capture or tracking of the adult female. Females left the den during or shortly after I was in viewing distance of the dens, and therefore were not immobilized. Cubs were translocated from the dens to a nearby work up area (<50 m from den). For each cub, morphometric measurements, sex, mass, teeth eruption, abnormalities, health and body condition were noted. Body condition of the cubs was evaluated using the same scale as adults (1 = excellent to 5 = emaciated), but was based more on size and muscle mass than amount of fat (Garrison 2004). For permanent identification, all cubs had a transponder chip inserted subcutaneously between the shoulder blades. I determined age of cubs by using a mixed regression model based on hair length and ear length (Bridges et al. 2002); this formula has demonstrated its accuracy in Florida black bear cubs (Garrison 2004). Cubs were returned to the maternal den following examination and marking, usually within 45 minutes. Sows were monitored with ground telemetry until she returned to the

den site. The family group was then monitored daily to ensure they remained together in spite of the disturbance.

Cubs weighing more 1.5 kg and that had opened their eyes were marked with lightweight radio-collars. Cubs that were too small were revisited at a later date in order to ensure that collar weight was less than 4% of total cub body mass. The collars included a sliding mechanism designed to expand with cub development (Genov & Gancev 1987; Higgings-Vashon et al. 2003; Garrison et al. 2007). All cubs were equipped with a 64 gram collar, with a two-hour mortality sensor (Telonics™, Mesa, Arizona). For an additional safety measure, I used a 20 mm piece of elastic cotton as a break-away device on all cub collars.

After sows and cubs emerged from their den, I located the family unit at least 5 times per week for the first two months (April and May). After that, cubs were located every other day. This schedule ensured that cubs were monitored during the period when mortality was known to be greatest (Garrison et al. 2007, LeCount 1982, Elowe 1987). Once a collar began to transmit a mortality signal (i.e., marked difference in pulse rate) or if a cub was located away from the mother, I immediately located and retrieved the collar. No live cub was ever found away from its mother. Cub mortality was assessed from monitoring of radio-collared cubs across all locales in the study area. I documented mortality events by ground checking all collars that went into mortality mode. Upon finding a dead cub or dropped collar, I recorded field sign, such as tracks, scat, blood, and hair. I assisted in necropsies on all bear carcasses.

Data analysis

To test the hypothesis that bears residing in urban-wildland interfaces have lower survival rates (McCown et al. 2004; Dixon et al. 2006; McCown et al. 2009), data were collected by monitoring the activities of radio-collared bears in the urban interface in Lynne, Paisley as well as bears residing in the interior forest. These data were used to construct a survival model. I used

the Cox proportional hazard model (with staggered entry) for estimating survival rates of collared bears, and for testing the effects of location, sex, and age on survival (Therneau and Grambsch, 2000; Hostetler et al. 2009). I also utilized Kaplan-Meier survival estimates (Kaplan & Meier 1958). Comparisons revealed that survival estimates were very similar to Cox proportional hazard estimates. I constructed Kaplan-Meier survival curves for my study animals by location (forest & urban) and sex (male & female) (Kaplan & Meier 1958). All data were analyzed using SAS (Allison 1995).

If the hypothesis is true, these data were expected to show a significantly lower survival rate in Lynne and Paisley than annual rates reported for bears in the interior ONF. It is important to note that bears in the interior forest and in suburban areas do not represent different populations. All bears are presumably free to inhabit either area. While there are likely intra-specific social limitations to bear movement, there are no un-crossable physical barriers between the three locales and all bears in the study are considered a single population.

Results

Demographics: I radio-collared a total of 50 bears (32 adults, 18 cubs). Sex ratio for collared adults was even (16 males, 16 females). I placed radio-collars on 7 adult bears in the interior ONF, 14 adult bears in Lynne, and 11 adult bears in Paisley. Bears were monitored for a total of 58,382 radio days. I documented 6 mortalities of radio-collared adult bears, 3 in Lynne, 3 in Paisley, and 0 in the interior forest (Table 3-1). All six instances of mortality resulted from anthropogenic forces.

I radio-collared 18 cubs (9 M, 9 F) from 10 different dens. Of these, 14 cubs were from the urban interface (6 M, 8F) and 4 cubs were from the forest (3 M, 1 F). Sex composition of individual litters at the urban interface consisted of two singleton females (F), and twins of an all-male (MM) litter and two one-male and one-female (MF) litters. Triplets consisted of one all-

female litter (FFF) and a one-male two-female (MMF) litter. Sex composition of individual litters in the forest consisted of two singleton males (M), and twins of a one-male and one-female (MF) litter. Three female urban bears (U817, U818, and U821) denned but lost their cubs before they could be examined in 2007. Female urban bear U813 lost her singleton female cub in 2006 and reproduced again in 2007, however her den was located on private property and could not be accessed. She was observed 2 months later with 2 cubs but the sex and fate of these cubs was unknown and thus they were not included in analyses. Average litter size (average number of cubs per litter) of bears by locale was 2.25 (range 1-3) in Lynne; 1.75 (range 1-2) in Paisley; 1.33 (range 1-2) in the forest. The average litter size for pooled urban bears was 2.0 (range 1-3). This value was identical to an average of 2 reported by Garrison et al. (2007). Additional cubs were encountered during the field season, but I was not able to collar these cubs due to a variety of factors. I documented 5 mortalities of cubs; one in the interior forest, three in Lynne, and one in Paisley (Table 3-1). All cubs survived the first two months, but all fatalities occurred within the first six months (Table 3-1). No cubs retained their collars for a full year.

Analysis of data from my study indicated that neither sex nor location (ONF vs. Lynne, ONF vs. Paisley, or ONF vs. Lynne vs. Paisley) had significant effects on bear survival. Overall estimated annual survival for all locales was 0.884 (SE 0.048, 95% CI 0.795 – 0.984). Estimated male survival was 0.839 (SE 0.083, 95% CI 0.690 – 1). Estimated female survival was 0.918 (SE 0.055, 95% CI 0.817 – 1). Since there were no deaths of interior forest bears in my sample, their estimated survival is 1 (SE = 0). Male survival in Lynne was estimated at 0.891(SE 0.072), and in Paisley it was 0.834 (SE 0.086). Bear survival was lowest in urban interfaces (Table 3-2). Kaplan-Meier survival curves with 95% confidence intervals are shown for urban vs. forest bears as well as male vs. female bears across locales (Figure 3-1, Figure 3-2).

Discussion

Low population densities, large home ranges, and potential conflicts with humans render large mammalian carnivores particularly vulnerable to the effects of anthropogenic habitat fragmentation (Noss et al. 1996; Woodroffe and Ginsberg, 1998; Crooks, 2002).

As Florida's rural population continues to expand, it is imperative to understand the potential, and in some cases the likely effects on local wildlife. In this study, I attempted to document some specific effects modern civilization has on black bear population ecology. My results provide some insight into the ways in which anthropogenic activity can impact wildlife populations existing in close proximity to humans. My hypothesis was neither supported nor rejected, as I found no significant decrease in survival probabilities at the urban-wildland interface. Though I discovered no significant difference in survival among locales, my results are suggestive. Subsequently, data from this study were pooled with data from previous years to construct a similar analysis of survival rates for Lynne versus interior forest Florida black bears (Hostetler et al. 2009). Hostetler et al. (2009) reported an annual survival rate of 0.966 (95% CI = 0.921-1) for adult female bears in the interior forest and 0.776 (95% CI = 0.644-0.936) for adult female bears in Lynne. The difference between sites was significant (Hostetler et al. 2009). In addition, the annual survival rate estimated for the combined population (i.e., data pooled from both sites) was 0.744 (95% CI = 0.484 – 1.0) for 2-year old females and 0.914 (95% CI = 0.855 – 0.977) for older females (Hostetler et al. 2009). Cub data from this study were also pooled by Hostetler et al. (2009) in a similar manner. Of the 50 cubs used in the analysis, 13 mortalities occurred in ONF and 8 occurred in Lynne, from causes including intraspecific aggression (a leading cause), malnutrition, trauma, and vehicular accident. A lack of statistical significance in my study appears to be a result of small sample size.

Importantly, no natural instance of adult mortality was documented in this study, all adult deaths occurred at the urban-wildland interface, and all were due to anthropogenic factors. In the towns of Lynne and Paisley, a greater degree of anthropogenic activities exists, most notably higher road density and traffic volume (Dixon et al. 2007; McCown et al. 2009). I documented that despite the presence of roads, vehicles, and people, bears are still able to exist in suburban habitat. These bears are more often exposed to potentially lethal obstacles compared to bears that reside in the interior forest (Simek et al. 2005; McCown et al. 2009). The difference in habitat may not be extreme for this species, as bears seem to utilize natural resources such as food and den sites at the very edge of civilization. Higher rates of mortality, though not significant in this study, lead me to hypothesize that urban-wildland interfaces may still serve as a sink habitat. Hostetler et al. (2009) reported that the population growth rate at Lynne was less than one, while the rate in ONF was greater than one, indicating a possible source-sink dynamic. Follow-up studies are recommended given the suggestive nature of my results.

Survival estimates generated in this study were used to determine whether bear populations existing in the urban-wildland interface could/can sustain themselves in the absence of a source population. One important key to a sink is the potential that individuals in a sink will move to better habitat (the source) when space becomes available (Howe et al. 1991; Pulliam 1996; Kristan 2003). It is possible that many bears living at the interface are only there temporarily, as documented for sub-adults in this study. A higher proportion of bears at these interfaces appeared to be sub-adults or yearlings (41%; n= 24), compared with bears captured in the forest (25%; n = 8). If the urban-wildland interface is not optimal habitat for Florida black bears, then I would expect to see two groups of bears inhabiting the area; sub-adults and perhaps older adult bears past their prime. In ONF the bear population is thought to be at carrying capacity

(McCown et al. 2004; Dixon et al. 2007). In this scenario, young individuals are typical displaced as they are pushed out of optimal habitat by dominant adult bears and dispersing individuals have nowhere else to go except into fringe habitat at the interface (Dixon et al. 2006). While some adult bears at the urban-wildland interface may have established permanent territories for themselves, many sub-adults may be more temporary inhabitants of this edge habitat. It is plausible that some sub-adults are able to grow to maturity at the urban-wildland interface, and subsequently return to the interior forest in search of a territory. Thus, they would return to the source population when large enough to displace another adult from its territory. If this dynamic does occur, then individuals in the sink are moving to better habitat (the source) when space becomes available (Howe et al. 1991; Pulliam 1996; Kristan 2003). Alternatively, individuals may return to the source during mast years, or seasonally when natural foods such as berries are abundant (Dixon et al. 2006; personal observation); an effect of forest bears utilizing smaller territory sizes based on ample food supplies (Moyer 2004; Moyer et al. 2007). If mortality is higher at the urban-wildland interface, then the interface could be serving as a population sink if the number of individuals moving to the interface is higher than those that return to occupy an interior territory. More research is recommended in this area.

Negative relationships between the attractiveness and quality of habitats have been labeled as “ecological traps” (Gates and Gysel 1978, Schlaepfer et al. 2002). Ecological traps are defined as poor-quality habitat that nonetheless attract individuals (Smith and Sibly 1985, Morrison et al. 1992; Kristan 2003). The individual choice separates the concept of the trap from a source-sink dynamic (Kristan 2003). Traps can form by any combination of changes in cues (thereby providing a super-normal stimulus that strongly attracts individuals to habitat in spite of its poor quality) or changes in habitat quality (Misenhelter and Rotenberry 2000). Whether or not

urban interfaces are ecological traps is open for debate, and depends upon the causality of why bears are drawn to the urban interface. Are bears forced to the edges of the forest due to a lack of available space, or are they drawn towards human habitation as a result of artificial food resources? At large population sizes, or those approaching carry capacity, the range of habitats used increases, generally with increased population size. This pattern has been referred to as the “buffer effect” (Brown 1969, Krebs 1971). Since black bears in ONF are thought to be at carrying capacity (McCown et al. 2004), some individuals are probably pushed into habitats that are marginal or less than preferred. Anthropogenic influences in occupied habitat often have negative consequences for the occupant (Misenhelter and Rotenberry 2000). Living at the interface is likely less of a choice as it is a necessity given no other option, but more research is recommended into the specific factors that draw bears from the forest to the urban interface. Because bear density is high and suitable habitat is restricted, the Ocala population has the highest number of reported nuisance activity in the state. In the three years prior to this study, nuisance bear complaints resulted in the relocation of more than 85 bears from this area (Annis 2007).

Factors Influencing Survival

All documented forms of mortality were caused by anthropogenic influences. None of the survival tests performed in this study (ONF vs. Lynne, ONF vs. Paisley, or ONF vs. Lynne vs. Paisley) were significant, which is not surprising given the small sample sizes and large confidence intervals. Males were shown to have a lower survival estimate at the urban-wildland interface than females (Table 3-2), but this may be partially explained by their characteristic movement patterns (see Ch. 2). Male bears tend to move farther and faster than females. They typically occupy larger ranges and are more often on the move (Moyer 2004; Dobey et al. 2005). The urban-wildland interface presumably has more potentially lethal obstacles compared to the

interior forest, by way of vehicle collision, poaching, and other anthropogenic factors (Simek et al. 2005; McCown et al. 2009). Male bears may, theoretically, encounter such threats more often than females as a result of greater movement rates. In my personal observations, female bears are comparatively secretive and more difficult to capture, while male bears were often more bold. Such differences would lead to male bears being exposed to potential lethal situations more often than females at the urban-wildland interface. Annual adult female survival rates observed in my study fall within the range reported from other populations in the southeast US, although the survival rate for adult females in Lynne was low for an un-hunted population (Pelton et al. 1997).

My data account for relatively few individuals over a small amount of time. That no relationship was found in this study should not be misinterpreted. Hostetler et al. (2009) suggest that the ONF population may sustain a low level of anthropogenic mortality (e.g., increased road-related mortality or nuisance bear removal). However, increases in mortality due to increased human impacts over time may reduce population growth rate at the urban-wildland interface. If development continues as projected, and if the interior forest recedes as the urban-wildland interface expands, then the population as a whole could probably not sustain itself faced with the level of adult mortality I reported in this study. All adult bears that died in my study did so due to anthropogenic factors. Data from this study was pooled with data collected in previous years to better determine survival estimates of bears inhabiting the urban-wildland interface (Hostetler et al. 2009).

Factors Influencing Cub Survival

Most of the cubs collared in this study were from Lynne, and all cub mortalities were documented from this locality. Thus, results were suggestive that cub survival of bears at the urban-wildland interface is higher than that from that in interior ONF. Too few data were available to draw inferences on relationships between habitat fragmentation and cub survival.

Denning sites are typically ground nests in areas of dense shrubs such as saw palmetto thickets, or on high ground within swampy areas (Garrison 2004; Wooding & Hardisky 1992). Tree cavities are not utilized as denning sites as frequently as they are in other regions, and it has been suggested that this is due to the reduction of such trees by past and present timber practices (Maehr & Wooding 1992; Pelton 1982; Weaver et al. 1990). Black bears are adaptable animals, able to feed, mate, and reproduce in close proximity to people without ever being seen or detected. In one example drawn from my research, I was able to hear the television of a nearby home while working up cubs in a bear den in Lynne. Based on my observations, black bears are very adaptable in their choice of den sites. It is unclear from a scientific standpoint whether fragmented habitat reduces the number of suitable den sites, or if it reduces overall quality of den sites. Ecological traps may be more common where human activities have changed habitat characteristics (Pulliam 1996, Remes 2000, Delibes et al. 2001a, b), and traps have been known to lead to losses in reproduction (Delibes et al. 2001a, b). Urban interfaces may represent habitat that has anthropogenically altered characteristics that has subsequently led to lower reproductive rates (Garrison et al. 2007). More research is needed in this area.

Black bears have one of the lowest reproductive rates known among terrestrial mammals (Bunnell & Tait 1981; Eiler et al. 1989; Jonkel & Cowan 1971). Although sexual maturity is reached at about 3 to 5 years of age, first reproduction of females can be as late as 7 or 8 years (Bunnell & Tait 1981; Pelton 1982). Florida black bear females usually produce their first cubs at 3 or 4 years of age, when they reach necessary body condition (Maehr & Wooding 1992). The age of first reproduction can be as early as 2 years, which is earlier than those reported from other populations (Garrison et al. 2007). Three of the four cubs that died in Lynne came from two adult sows >10 years old. Typically, first-time mothers have the least success in

reproduction, so this was an unexpected statistic. There may be many factors that determine the success of a reproductive event not measured in this study, such as fitness of the mother and various stochastic events like drought or food shortages. The degree of which such factors differ across locales is not known, but stochastic are known to effect both survival and fecundity of animal populations. Such stochastic events were not measured in this study, and due to time constraints their effects on bears would be difficult to quantify. Seasonal mast failures may eliminate reproduction for multiple years (Rogers 1987a). My study represented a snapshot in time, and does not reveal the effects of long-term cycles of masting trees on local bear populations or reproductive activities.

Replicated field studies of large carnivores that permit rigorous statistical inference are rarely possible. For this reason, my findings are suggestive, but will importantly add to our understanding of Florida black bear ecology. A better understanding of the population-level effects of anthropogenic activities on bears, as well as the projected increases of such effects including a higher number of traffic-related bear fatalities, would help guide management of Florida black bear populations in ONF and other increasingly human-dominated landscapes. In this study, I demonstrated no statistical difference in survival among bears at the urban-wildland interface and those in the forest. Potential increased yearling and adult mortality due to anthropogenic causes at the urban-wildland interface may become more apparent in the future, especially with increasing habitat fragmentation and roadways characteristic of the study area. Measures to increase survival of adult Florida black bears in ONF may include educational campaigns, highway underpasses, better traffic management including reduced speed limits, and increased penalization for illegal killing of bears.

Summary: The purpose of this study was to extend knowledge of the behavioral ecology of Florida black bears at the urban-wildland interface in and around Ocala National Forest in north-central Florida. The results of my survival analysis indicated that bear survival was lowest in urban interfaces. This study illustrates some of the ways in which anthropogenic activities can impact wildlife populations living in close proximity to humans. Information generated in this study can help guide conservation and management of this subspecies within an increasingly human-dominated landscape. Movement data could help guide management plans especially those that pertain to protecting bear habitat at the urban-wildland interface. On a proximate timescale, managers should understand that bears already inhabiting urban habitats exhibit different behavioral and spatial responses to variations in environmental conditions than bears occupying interior forest. Management decisions that work for bears in the interior forest may not suffice for bears living at the urban interface. Management plans for the Florida black bear should allow for increased space requirements, more variable behavior, and higher mortality for bears in urban settings.

Table 3-1. Number of recorded mortality of radio-collared Florida black bears by site, age, and cause of death in Ocala National Forest, and adjacent towns of Lynne, and Paisley, Florida, USA, 2005-2007.

Cause	Adult Females			Adult Males			Cubs		
	ONF	Lynne	Paisley	ONF	Lynne	Paisley	ONF	Lynne	Paisley
Abandonment / death of mother									
Other malnutrition									
Intraspecific aggression							1		
Unknown								1	
Other natural									
Trauma/poison			1			2			
Vehicular accident	1				2			2	
Illegal harvest									
Predation (<i>Alligator mississippiensis</i>)							1		
Total	1	1		2	2		4		

Table 3-2. The effects of locale, age status, and gender on annual survival estimates of radio-collared Florida black bears in the interior Ocala National Forest and the adjacent towns of Lynne and Paisley, north-central Florida, USA using pooled data from 2005-2007.

GROUP	SURVIVAL	SE	LOWER CI	UPPER CI
All Adult Bears	0.90335	0.045407	0.8186	0.99688
All Bears (including yearlings)	0.88409	0.048179	0.79453	0.98374
Male Bears	0.83923	0.083826	0.69001	1
Female Bears	0.9181	0.05475	0.81683	1
Male Adult Bears	0.88429	0.075916	0.74734	1
Female Adult Bears	0.91702	0.055538	0.81438	1
All ONF Bears	1	0.00004	0.99992	1
All Lynne Bears	0.8916	0.07152	0.76188	1
All Paisley Bears	0.83406	0.08613	0.68124	1
ONF Adult Bears	1	0.00004	0.99992	1
Lynne Adult Bears	0.8936	0.07037	0.76578	1
Paisley Adult Bears	0.87536	0.08115	0.72992	1
All Urban Bears	0.86311	0.0561	0.75988	0.98037
Adult Urban Bears	0.88517	0.05332	0.7866	0.99608

* Cox proportional hazard model with staggered entry was used to generate survival estimates.

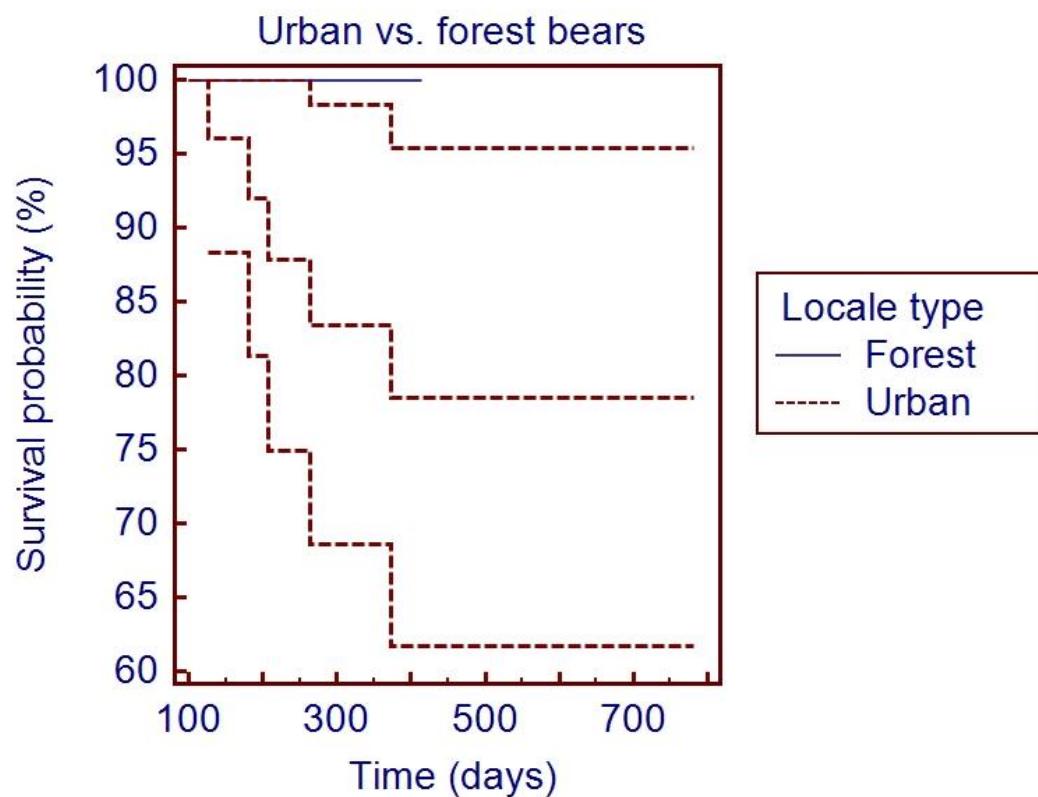


Figure 3-1. Kaplan-Meier survival curve for radio-collared Florida black bears in the urban towns of Lynne and Paisley vs. the interior Ocala National Forest, north-central Florida, USA, 2005-2007.

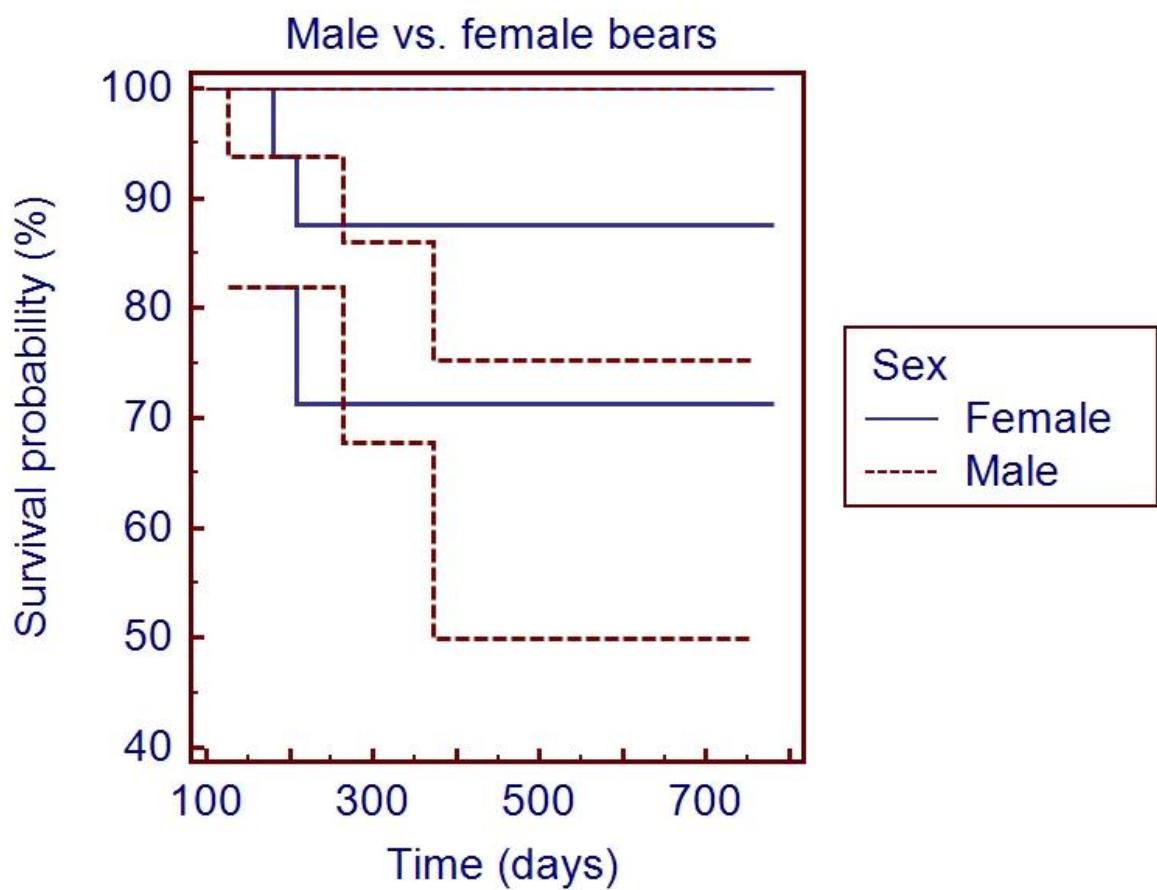


Figure 3-2. Kaplan-Meier survival curve for radio-collared male and female Florida black bears in Ocala National Forest and the adjacent towns of Lynne and Paisley, north-central Florida, USA, 2005-2007.

CHAPTER 4

CONCLUSIONS, MANAGEMENT, AND FUTURE RECOMMENDATIONS

Low population densities, large home ranges, and potential conflicts with humans render large mammalian carnivores particularly vulnerable to the effects of anthropogenic habitat fragmentation (Noss et al. 1996; Woodroffe and Ginsberg, 1998; Crooks, 2002).

As Florida's rural population continues to expand, it is imperative to understand the potential, and in some cases the likely effects on local wildlife. In this study, I attempted to document some specific effects that modern civilization has on black bear population ecology. Specifically, I addressed behavioral shifts and survival estimates of bears living in the interior forest versus those living in close proximity to people. Bears from all locales in my study shared some common behaviors. For example, male bears were always more active than females, and sub-adults were more active than adults. All bears in my study were more active during the first half of night than in the second half. However, differences emerged when comparing bears by locale. I demonstrated a difference in behavior attributed to forest bears versus urban bears. Urban black bears, especially those in Lynne, had significantly larger home ranges than bears in the interior forest. Forest bears seem to show much more consistent behavior overall compared to urban bears. I found evidence that bears residing in the interior forest were more likely to be active at any given time of day, and spent more time active per diel than urban bears. Urban bears spent a relatively equal amount of time active and inactive, with inactive being slightly more common. During Block 2 (0600-1159 h), forest bears are still more likely to be active while urban bears both in Lynne and Paisley are largely inactive. During Block 3, forest bears are still active while all urban bears are more likely to be inactive. These trends indicate that forest bears are spending more time, including daylight hours, active and presumably foraging. As previously suggested, forest resources are probably more clumped and widely dispersed in

comparison to suburban habitats. This may result in interior bears having to spend a relatively large portion of their day acquiring resources and thus remaining active. Urban bears spend the majority of Block 3 (1200-1759 h) completely inactive, and yet urban bears also spent more time in the highly active state compared to bears in the interior forest. Movements of Lynne bears were significantly more variable compared to forest bears, and Paisley bears also appeared to be more variable in their movement compared to forest bears, and may be more variable in their movement rates than Lynne bears. In other words, black bears in this study were more variable in their movement patterns when they occupy more variable habitat, such as human suburbs.

All of these trends point to a marked active time and marked inactive time for urban bears, compared to a relatively even spread of activity for forest bears. Such differences point to black bear adaptability. Forest bears may simply be able to remain active during the day because they are not faced with the presence of humans, who are primarily diurnal. Avoidance of humans may be the strategy employed by urban bears, especially at times when human activity is probably at its peak. However, when urban bears are presented with opportunity to move or to acquire food and resources, it seems as though they do so quickly and efficiently. Perhaps if urban black bears are in fact able to satisfy their food requirements solely during nocturnal hours in urban environments due to spacing of resources, and are thus able to avoid people during daylight hours, they have the capacity and behavioral plasticity to co-exist with humans in suburbia.

Though I discovered no significant difference in survival among locales, my results are suggestive. No natural instance of adult mortality was documented in this study, and all adult deaths occurred at the urban-wildland interface and all were caused by anthropogenic forces. Data from this study were pooled with data from previous years to construct a similar analysis of

survival rates for Lynne versus interior forest Florida black bears (Hostetler et al. 2009). They reported an annual survival rate of 0.966 (95% CI = 0.921-1) for adult female bears in the interior forest and 0.776 (95% CI = 0.644-0.936) for adult female bears in Lynne. The difference between sites was significant (Hostetler et al. 2009). In addition, the annual survival rate estimated for the combined population (i.e., data pooled from both sites) was 0.744 (95% CI = 0.484 – 1.0) for 2-year old females and 0.914 (95% CI = 0.855 – 0.977) for older females (Hostetler et al. 2009). In the towns of Lynne and Paisley, a greater degree of anthropogenic activities exists, most notably including higher road density and traffic volume. I documented that despite the presence of roads, vehicles, and people, bears are still able to make a living in suburban habitat. The difference in habitat may not be extreme for this species, as bears seem to utilize natural resources such as food and den sites at the very edge of civilization. These bears are presumably more often exposed to potentially lethal obstacles compared to bears that reside in the interior forest (Simek et al. 2005; McCown et al. 2009). Increasing yearling and adult mortality due to anthropogenic causes at the interface may lead this population from stable or increasing to declining, especially with increasing habitat fragmentation.

Survival estimates generated in this study were used to determine whether bear populations existing in the urban-wildland interface could/can sustain themselves in the absence of a source population. One important key to a sink is the potential that individuals in a sink will move to better habitat (the source) when space becomes available (Howe et al. 1991; Pulliam 1996; Kristan 2003). It is possible that many bears living at the interface are only there temporarily, as documented for sub-adults in this study. A higher proportion of bears at these interfaces appeared to be sub-adults or yearlings (41%; n= 24), compared with bears captured in the forest (25%; n = 8). If the urban-wildland interface is not optimal habitat for Florida black bears, then I

would expect to see two groups of bears inhabiting the area; sub-adults and perhaps older adult bears past their prime. In ONF the bear population is thought to be at carrying capacity (McCown et al. 2004; Dixon et al. 2007). In this scenario, young individuals are typical displaced as they are pushed out of optimal habitat by dominant adult bears and dispersing individuals have nowhere else to go except into fringe habitat at the interface (Dixon et al. 2006). While some adult bears at the urban-wildland interface may have established permanent territories for themselves, many sub-adults may be more temporary inhabitants of this edge habitat. It is plausible that some sub-adults are able to grow to maturity at the urban-wildland interface, and subsequently return to the interior forest in search of a territory. Thus, they would return to the source population when large enough to displace another adult from its territory. If this dynamic does occur, then individuals in the sink are moving to better habitat (the source) when space becomes available (Howe et al. 1991; Pulliam 1996; Kristan 2003). Alternatively, individuals may return to the source during mast years, or seasonally when natural foods such as berries are abundant (Dixon et al. 2006; personal observation); an effect of forest bears utilizing smaller territory sizes based on ample food supplies (Moyer 2004; Moyer et al. 2007). If mortality is higher at the urban-wildland interface, then the interface could be serving as a population sink if the number of individuals moving to the interface is higher than those that return to occupy an interior territory. More research is recommended in this area.

Management Recommendations

My results show that bears living at the urban-wildland interface are probably different. First, forest bears were active for a longer portion of the day versus urban bears that spent more time inactive or highly active. That forest bears are active for a greater portion of the day suggests they are spending more time securing their resource needs. Second, urban bears have

larger home ranges and traveled greater distances in a shorter time frame than forest bears, which could serve to avoid interactions with people.

These few examples illustrate some of the ways in which anthropogenic activity can impact wildlife populations living in close proximity to humans. Information generated in this study can help guide conservation and management of this subspecies within an increasingly human-dominated landscape. The results of this study will be useful to managers. Movement data could help guide management plans especially those that pertain to protecting bear habitat at the urban-wildland interface. On a proximate timescale, managers should understand that bears already inhabiting urban habitats exhibit different behavioral and spatial responses to variations in environmental conditions than bears occupying interior forest (Dobey et al. 2005; Moyer et al. 2007). In other words, management decisions that work for bears in the interior forest may not suffice for bears living at the urban interface. Management plans for the Florida black bear should allow for increased space requirements for bears in urban settings.

As previously discussed, human populations in Florida are predicted to continually grow, and these projections include the towns of Lynne and Paisley. The study area of ONF is already bisected by State Road 40 (SR-40), a two-lane paved road with a traffic rate of more than 5,100 vehicle trips per day (Figure 2-1; Florida Department of Transportation, 2003). SR-40 has also been approved by the State of Florida to be widened from two lanes to four lanes to accommodate ever-increasing traffic loads (Hostetler et al. 2009). If forest extraction activities expand in the future, an even greater human presence in traditional bear habitat could be felt. With more people, more roads, and a greater degree of fragmentation, we may expect to see an increasing “urbanization” of bear behavior throughout ONF. In other words, as human presence increases, bears in the interior forest may begin to exhibit more variable movement patterns,

expand home ranges, and in essence begin to behave more like those individuals that already occupy the urban interface. The end result would likely be that in this situation ONF would support fewer bears as home ranges expand and movement increases in response to fragmentation and degradation of habitat.

Measures to increase survival of adult Florida black bears in ONF may include highway underpasses and better traffic management. Several large wildlife crossing structures are planned for an approximately 22.8km section of SR-40 to mitigate the effects of this highway on bears and other species (McCown et al. 2009). This effort is needed to minimize bear mortality, aid in dispersal, and to help ensure genetic connectivity of the population (McCown et al. 2009; Hostetler et al. 2009). Such underpasses will benefit all bears, but based on my results and results reported by Hostetler et al. (2009), this effort will especially benefit young, dispersing bears. The use of underpasses may help to boost recruitment into the breeding population. While this effort will help black bears in ONF, recruitment does not appear to be the limiting factor as much as loss of habitat (Hostetler et al. 2009). Black bears are thought to currently inhabit all available remaining suitable habitat in ONF (McCown et al. 2009).

Behavioral aspects come into play when dealing with the management issue of ‘nuisance bears’. Nuisance bears are dealt with regularly in the towns of Lynne and Paisley. A nuisance bear is any bear that has been observed and reported by a private citizen. Based on the results from my research, bears appear to change their behavior and forage patterns to avoid contact with people, presumably making an active investment in an attempt to remain unnoticed by human beings. However, bears that live in close proximity to people are more likely to be observed and deemed a nuisance. Some bears inevitably become accustomed to suburbia and do not make attempts to remain elusive. Such bears may be observed eating from bird feeders or pet

bowls in backyards. These bears are more likely to be reported by private citizens and are thus more likely to be labeled as a nuisance. Most nuisance bears are sub-adult males, and based on my movement data this is the group most likely to be observed by a person based on higher rates of movement and lack of fixed territories. While conducting my field research, I observed female bears living in extreme proximity to people without ever being seen or detected. In one example, I was able to hear the television of a nearby home while working up cubs in a bear den in Lynne. These findings corroborate the belief that black bears are a generalist species and are naturally well suited to habitat fragmentation and to living in proximity to people. Black bears may be able to coexist with humans if they are tolerated (Beckmann & Berger 2003), so a primary priority for wildlife managers besides habitat conservation is public education.

Education

Education can lead to toleration in regards to bears and people living in close proximity. During the course of my field research, I visited several local schools and organizations to give basic bear education workshops to local residents. With a basic knowledge of bear ecology, combined with an understanding of what a typical bear is ‘doing’ in the neighborhood, local people can become active agents of change. I educated many people in my study area on basic techniques to reduce negative bear encounters and reduce bear dependency on unnatural food sources such as garbage, pet food, and bird seed. In addition to the primary task of collecting scientific data in the field, I considered this outreach a critical aspect of my research.

Recommendations for Further Research

Future studies are encouraged to attempt larger sample sizes, or to combine comparable data with data from this study, in order to achieve a large enough sample size to test hypotheses. My survival results illustrate the importance of this suggestion, where no differences in survival

were detected for bears in this study, but differences emerged when my data was pooled with data from previous years.

Bear behavior is probably driven strongly by food resources. I recommend for future studies that food use and consumption be quantified for each locale, and this is a logical next step in the study of urban black bear ecology. This would lead to valuable information and would make relationships between food source utilization and behavior across locales more clear. In this study, I was only able to hypothesize that activity patterns observed in this study were the result of foraging patterns. This hypothesis could be tested in future studies using isotope analysis. Isotope analysis involves collection bear feces or blood to determine what the bear has consumed. By determining and quantifying food intake by forest and urban bears, one could determine whether urban bears are in fact utilizing different food sources and shifting their foraging behavior to do so. Part of this suggested research would be to quantify food resources in forest and urban settings to determine whether some food resources are selected for in across locales, and whether any differences exist between locales in food selection. The quantification of mast events, berry production, and even artificial food sources like trash and pet food would likely reveal some interesting patterns and certainly would add to the results reported in this study.

APPENDIX A DETAILED FIELD METHODOLOGY

Captures

I trapped bears between June 2005 and August 2006, and concentrated my efforts between June and August each year. In 2005 I trapped in both Lynne and Paisley, and in 2006 I trapped in Lynne and the interior forest. Summer trap nights were usually restricted to the hours of 1800 and 0600 to decrease the potential of heat stress to bears. I utilized sentinel radio-collars attached with string to the snare; these were designed to activate immediately once a bear was trapped. Using this method, I was able to immobilize most bears within an hour of their capture.

Trap locations were determined by investigating areas within the study area for bear sign. Once areas were targeted for trapping they were pre-baited to entice resident bears to stay in the area. To prevent attracting bears to trap sites from large distances, sites were pre-baited for no more than three days prior to trapping. Areas were pre-baited with a combination of doughnuts, blueberry extract, bacon grease, and commercial deer lure.

Bears were captured using two methods. The first method was via culvert traps, or large cylindrical traps attached to a trailer. The cylinder is approximately 2 meters long and a meter in diameter. A drop door is located in the front and a release device is located in the back. When a bear enters the culvert and takes the bait off the triggering device, a dropping door trapped the animal inside. All traps were baited with doughnuts. The second method of capture was a modified Aldrich spring activated leg-snares (Johnson and Pelton 1980; McCown et al. 2004). For this method, I attached a cable foot loop to two anchor cables that were wrapped around two trees. Baited with doughnuts, the foot loop was placed within an artificial “trail” composed of clipped branched and vegetation. As a bear stepped through the strategically positioned foot loop, the cable cinched, thus capturing the bear. Caution was taken to ensure that the distance

between the trees was great enough to prevent a trapped bear from reaching either one. This reduced the likelihood of bone fractures that can occur when bears thrash and torque ensnared limbs.

After capture, bears were immobilized with an injection of a 1:1 mixture of Tiletamine hydrochloride and Zolazepam hydrochloride (Telazol™). Drug was administered at 3.0-3.5 mg/kg of estimated bear weight via a blowpipe, jab-stick, or remote injection gun (McCown et al. 2004). Once the bear was anesthetized, an ophthalmic ointment was administered to moisturize eyes, vital signs (temperature, respiration and pulse rate) were monitored, and morphological data was collected. A pre-molar was extracted for age determination, a hair sample was collected for genetic data, the upper lip was tattooed for permanent identification, and both ears were tagged with plastic identification tags. Each bear was given a unique color combination of ear tags for individual recognition from observations. Paired 4mm punch biopsies were taken in six locations (muzzle, chin, peri-ocular, crown, inter scapular, flank) from bears in Lynne as part of a bio-medical investigation into the demodectic mange organism, *Demodex ursi* in collaboration with Mark Cunningham D.V.M.

VHF motion-sensitive radio-collars (150-151 Mhz; Telonics™, Mesa, Arizona) were fitted around the neck and tagged bears were released within 20 meters of capture location. Collars were equipped with a mortality sensor and fitted with an oiled leather connector, designed to wear-away after two years. This prevented collars from remaining on bears beyond the collar's expected battery life and allowed collars to stretch slightly on growing sub-adult bears.

Upon release from the procedure, I remained in proximity to immobilized bears until they were able to stand on their own. Where safety during recovery was a concern, I deterred other bears from attacking the recuperating bear.

Telemetry

VHF motion-sensitive radio-collars (150-151 Mhz; Telonics™, Mesa, Arizona) were fitted around the neck and tagged bears were released within 20 meters of capture location. Collars were equipped with a mortality sensor and fitted with an oiled leather connector, designed to wear-away after two years. This prevented collars from remaining on bears beyond the collar's expected battery life and allowed collars to stretch slightly on growing sub-adult bears.

Locations were obtained for all radio-collared bears at least 1-2 times per week for the entire duration of the study. Depending on the availability of roads and other logistical constraints, a pre selected sub-sample of individuals will be monitored more intensively 2-4 nights per week to document hourly movements during the period of major activity (presumably at night).

Bear movements and activities were monitored using portable telemetry equipment. Radio-collared bears were located 1 to 3 times per week for the duration of the study. from the air using a Cessna-172 aircraft equipped with wing-strut mounted 2-element yagi antennas, and by ground triangulation using a 3-element, hand-held, yagi antenna (Telonics™ Inc., Mesa, Arizona) and a Communications Systems™ Inc. receiver. Ground triangulations were made using > 3 compass bearings obtained within a 30-minute interval to minimize location error as a result of active bear movement. Ground locations were collected during both day and nighttime periods. I selected 17-hours as the minimum time interval between locations for biological independence among locations (Swihart et al. 1988). Aerial locations were collected on specific bears approximately twice per month during daylight hours. However, extreme movements, severe weather, and lack of funding often restricted aerial locations to once per month.

I divided the day into four, six-hour blocks: 1 (0000 to 0559 h), 2 (0600 to 1159 h), 3 (1200 to 1759 h), and 4 (1800 to 2359 h). In this way, I had a block of time that encompassed

the transition from night to day, full day, the transition from day to night, and full night. For each bear per season, I randomly selected a starting block. I would then follow that bear for at least 2 consecutive blocks, collecting locations once per hour. I would then follow the bear for the remaining 2 blocks at the next available time within the month. Some bears would wander out the area while tracking, therefore only a partial diel could be completed. In this scenario the block would not be used and I would restart at that location the next time the bear could be located.

By collecting hourly locations on bears I could document hourly activity, estimating the exact time a bear became active. In addition, hourly locations allowed me to determine movement rates and travel paths.

Locating Dens and Collaring Cubs

I visited natal dens of radio-collared females from March to April to count and mark cubs. I obtained the number of cubs from den visits and/or observations made during capture or tracking of the adult female. Females left the den during or shortly after I was in viewing distance of the dens, and therefore were not immobilized. Cubs were translocated from the dens to a nearby work up area (<50 m from den). For each cub, morphometric measurements, sex, mass, teeth eruption, abnormalities, health and body condition were noted. Body condition for the cubs was evaluated using the same scale as adults (1 = excellent to 5 = emaciated), but was based more on size and muscle mass than amount of fat (Garrison 2004). For permanent identification, all cubs had a transponder chip inserted subcutaneously between the shoulder blades. I determined age of cubs by using a mixed regression model based on hair length and ear length (Bridges et al. 2002), this formula has demonstrated its accuracy in Florida black bear cubs (Garrison 2004). Cubs were returned to the maternal den within 45 minutes. Sows were

monitored with ground telemetry until she returned to the den site. The family group was then monitored daily to ensure they remained in spite of the disturbance.

Cubs weighing more 1.5 kg and that had opened their eyes were equipped with lightweight radio-collars. Cubs that were too small were revisited at a later date, in order to ensure that collar weight was less than 4% of total cub body mass. The collars employed a sliding mechanism designed to expand with cub development (Genov & Gancev 1987; Higgings-Vashon et al. 2003; Garrison et al. 2007). All cubs were equipped with a 64 gram collar, with a two hour mortality sensor (TelonicsTM, Mesa, Arizona). None of the collars deployed failed. For an additional safety measure, I used a 20 mm piece of elastic cotton as a break-away device on all collars.

After sows and cubs emerged from their den, I located the family unit at least 5 times per week for the first two months (April and May). After that, cubs were located every other day. This schedule helped provide the most intensive monitoring the period where expected mortality was the greatest (LeCount 1982; Elowe 1987; Garrison et al. 2007). Once a collar transmitted a mortality signal or if a cub was located away from the mother, I immediately located and retrieved the collar. No live cub was ever documented away from its mother. Upon finding a dead cub or dropped collar, I recorded field sign, such as tracks, scat, blood, and hair. I performed necropsies on all possible cub carcasses.

APPENDIX B HOME RANGE MAPS

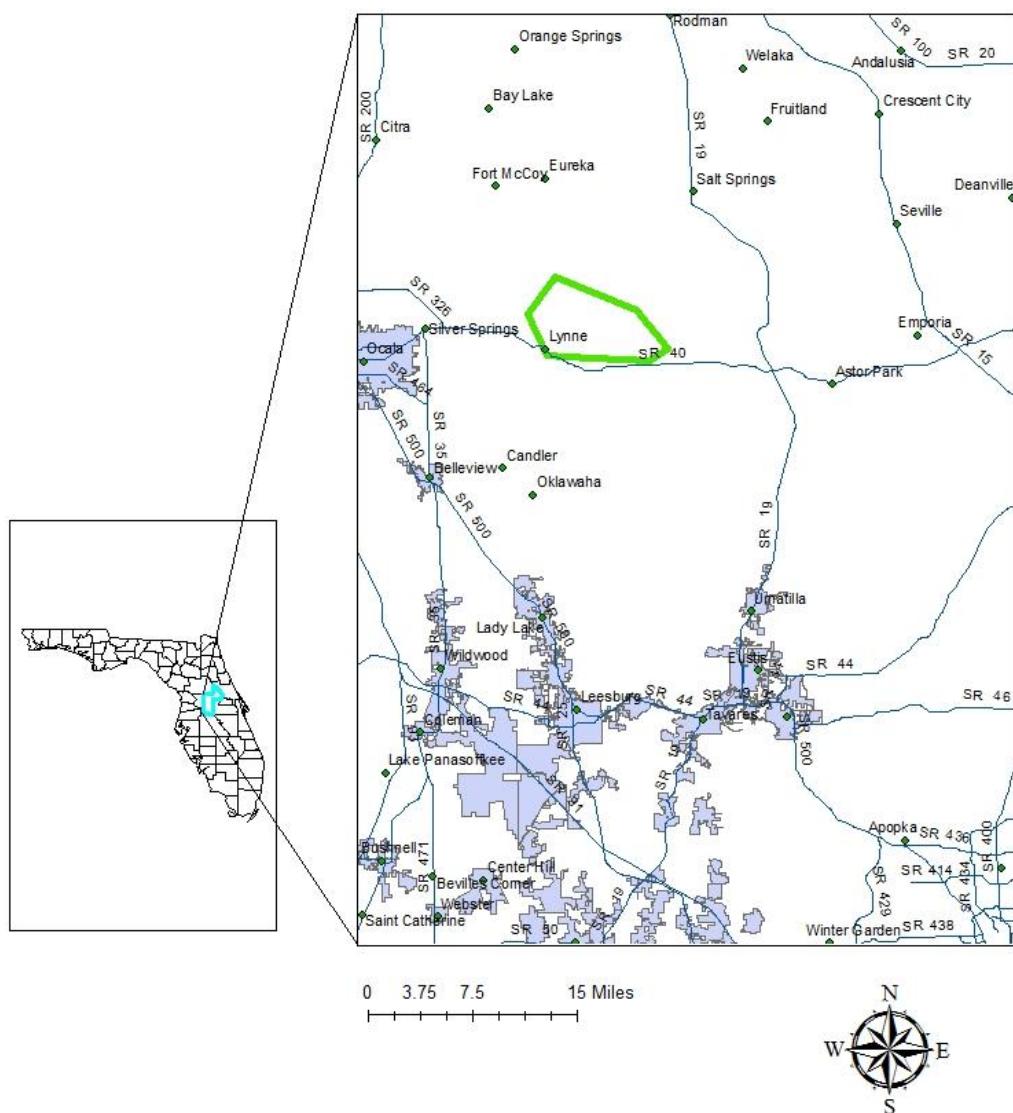


Figure B-1. Home range of Florida black bear “801” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

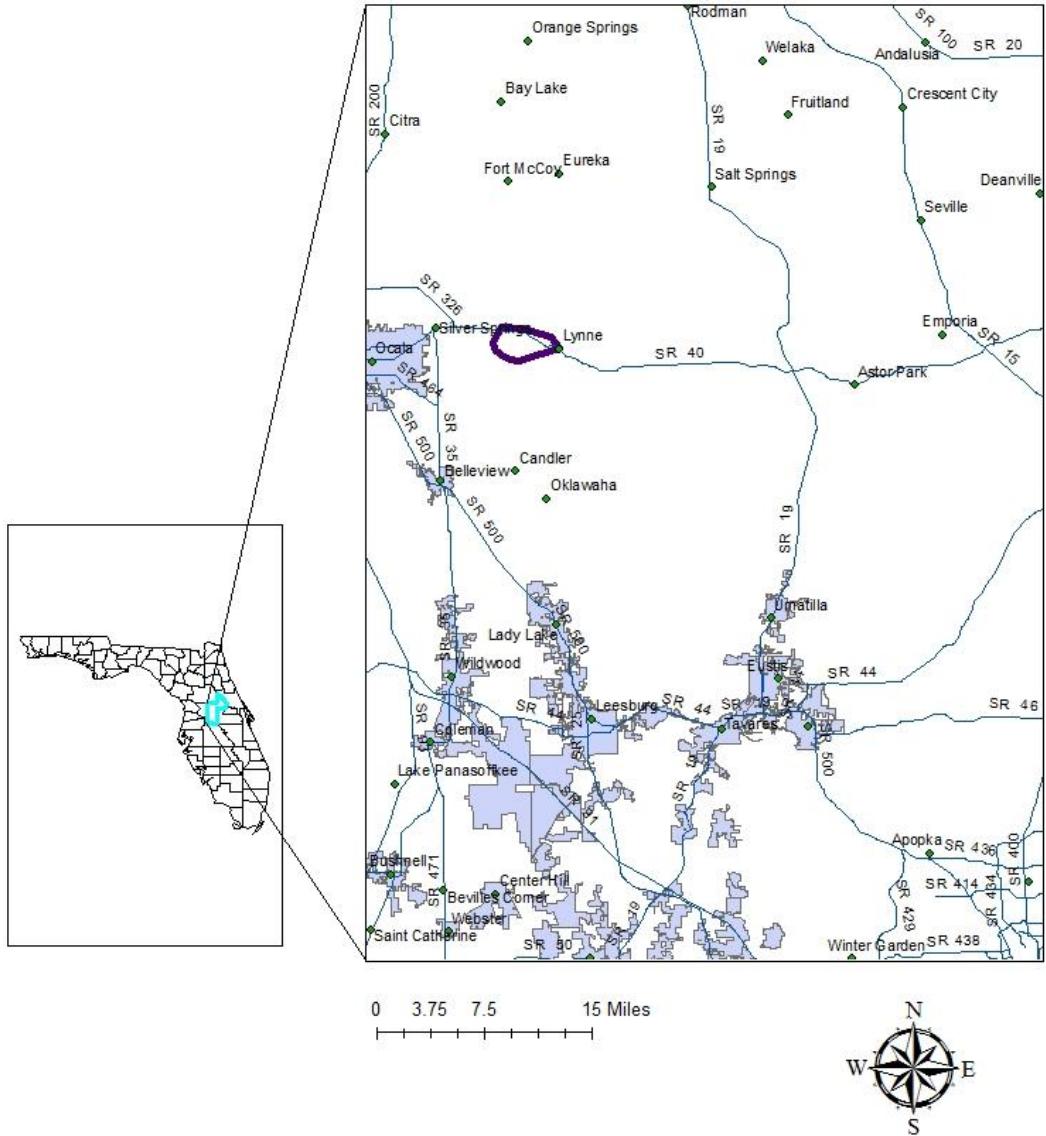


Figure B-2. Home range of Florida black bear "802" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

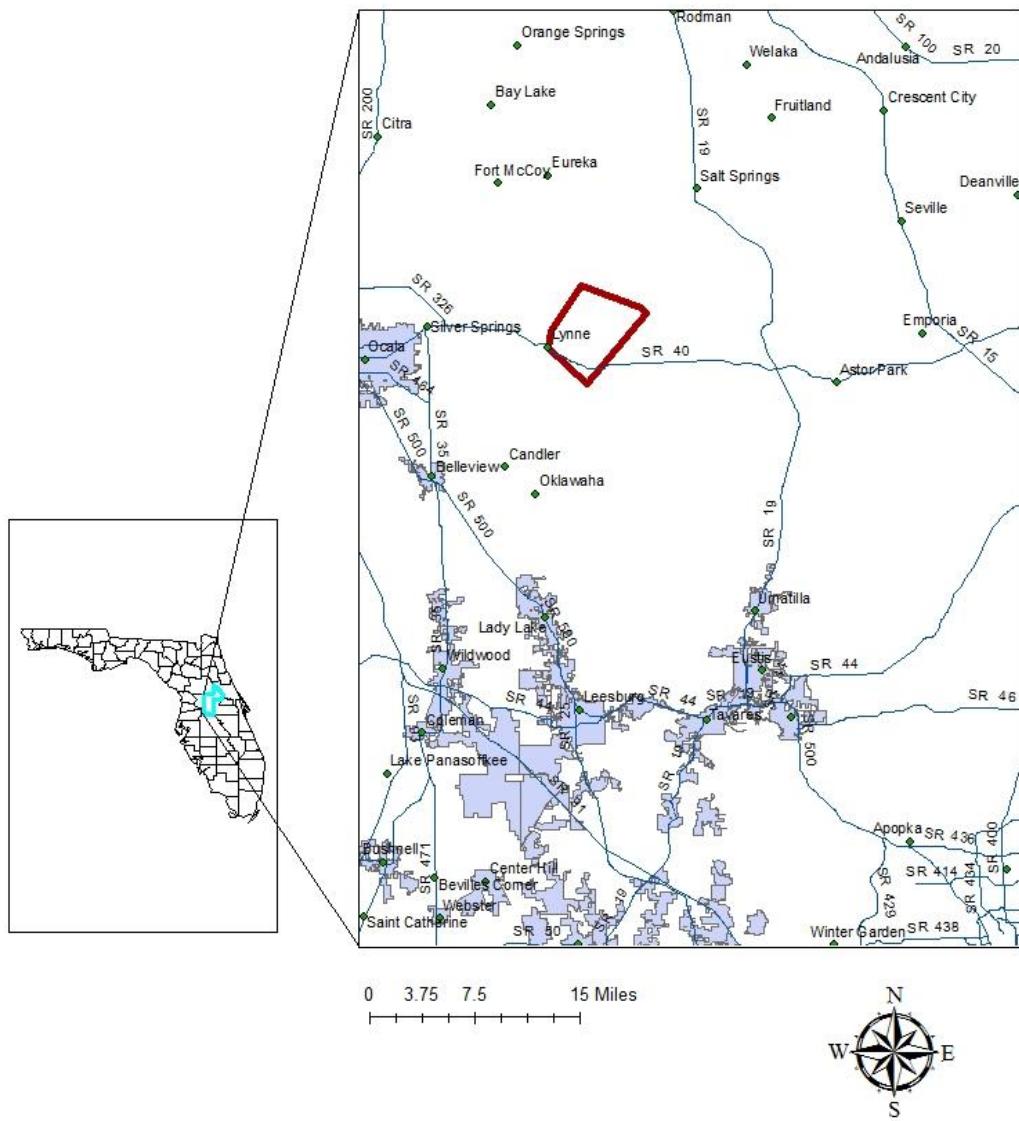


Figure B-3. Home range of Florida black bear “803” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

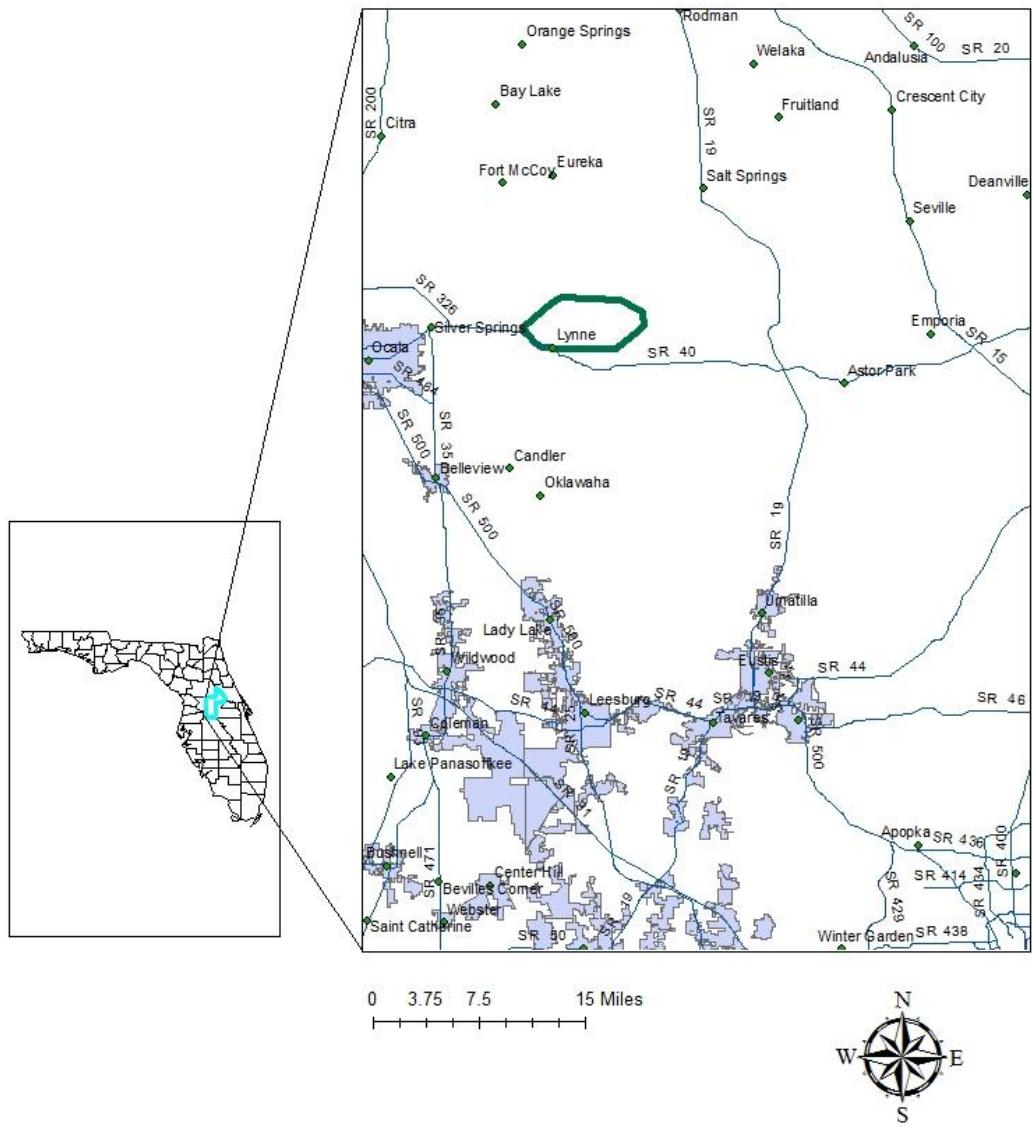


Figure B-4. Home range of Florida black bear "804" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

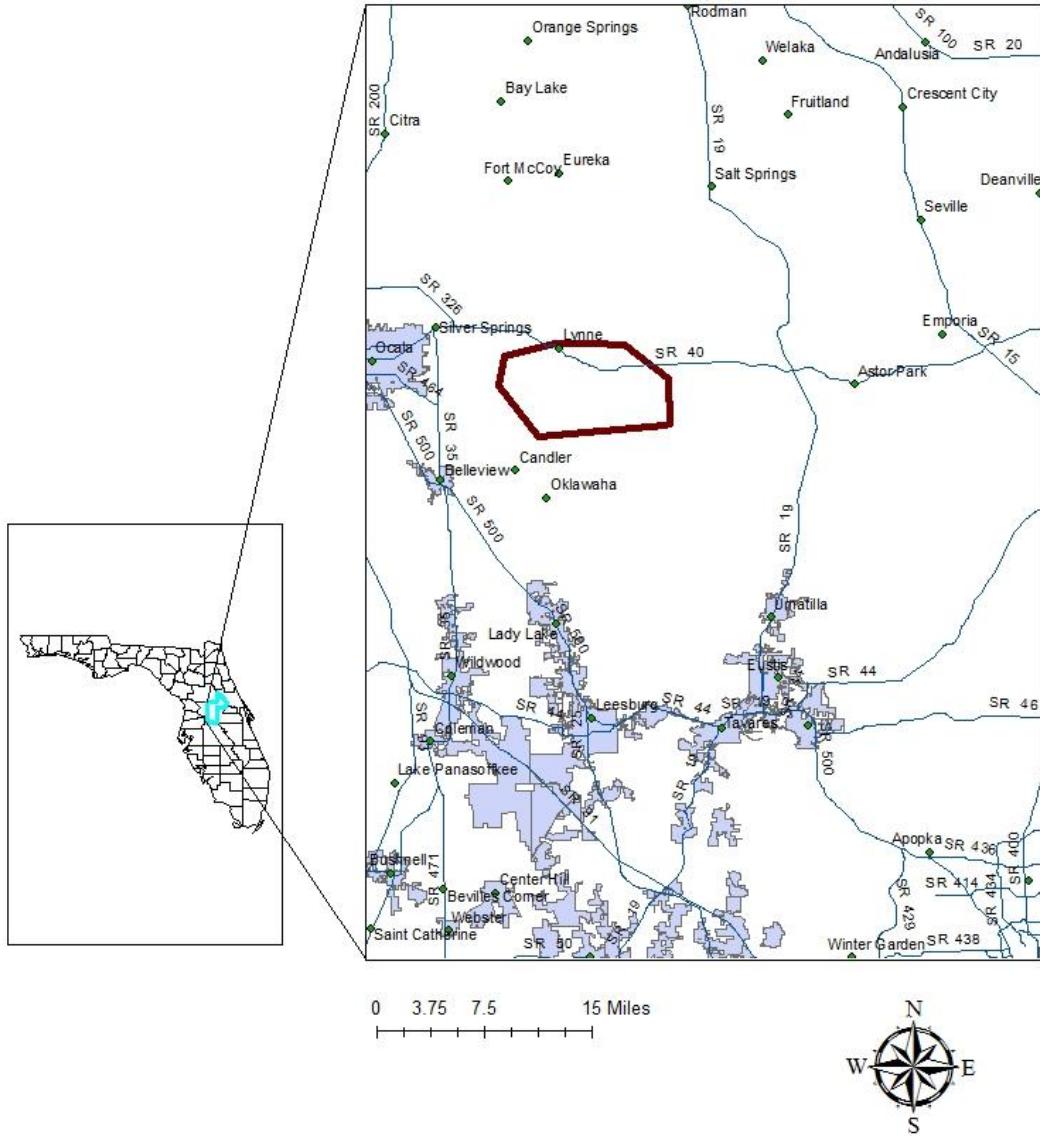


Figure B-5. Home range of Florida black bear "805" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

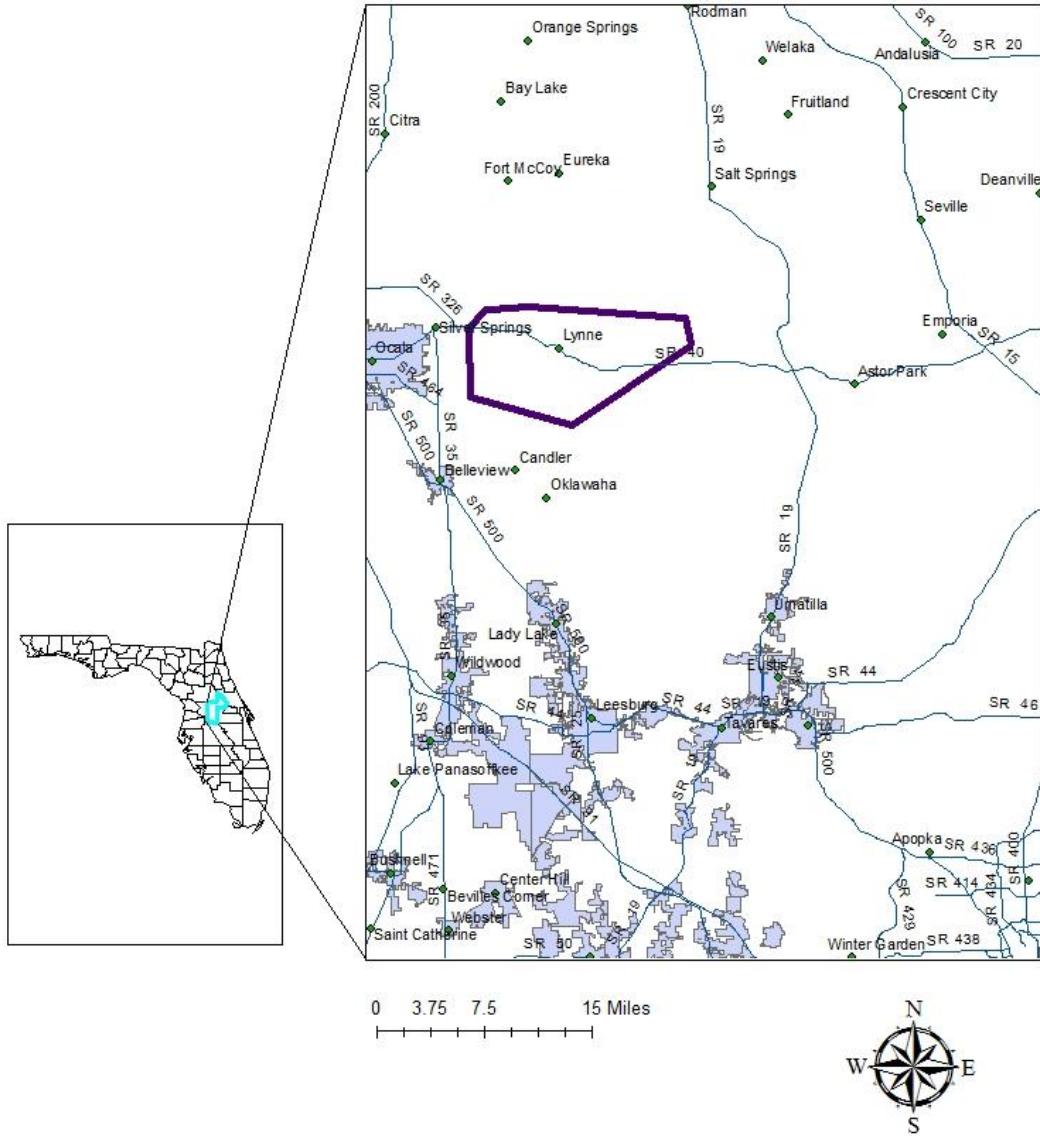


Figure B-6. Home range of Florida black bear "806" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

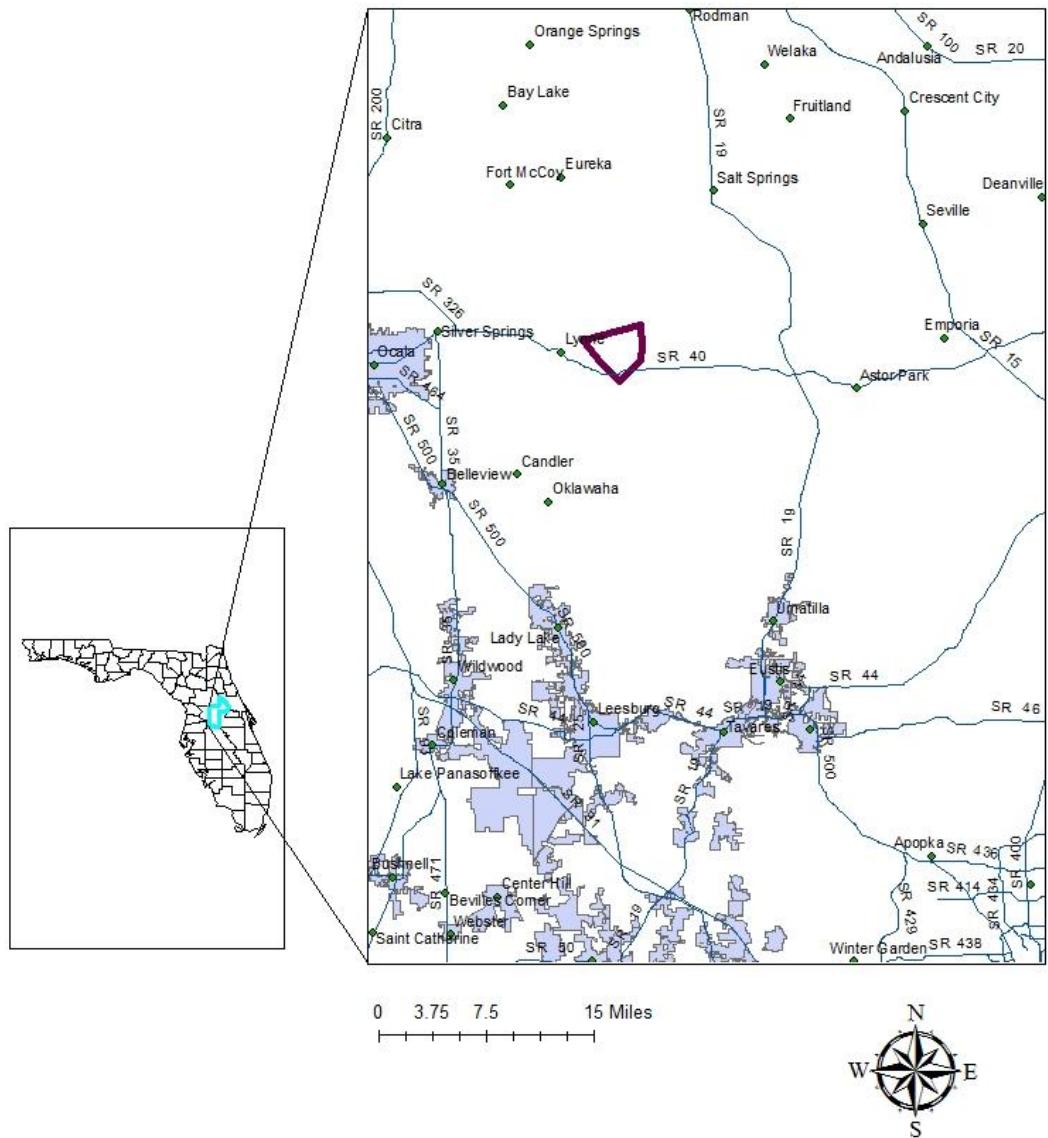


Figure B-7. Home range of Florida black bear “807” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

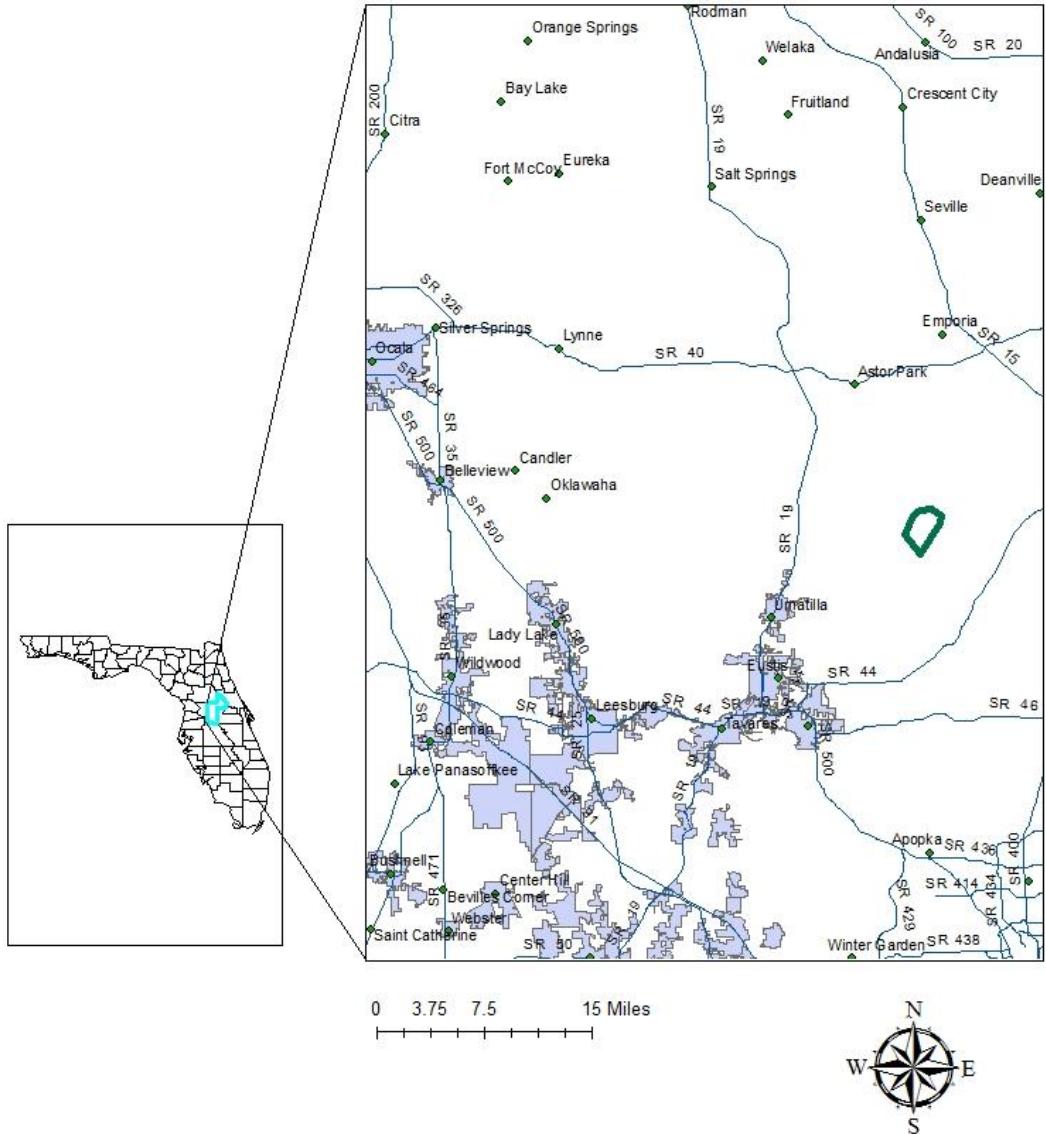


Figure B-8. Home range of Florida black bear "808" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

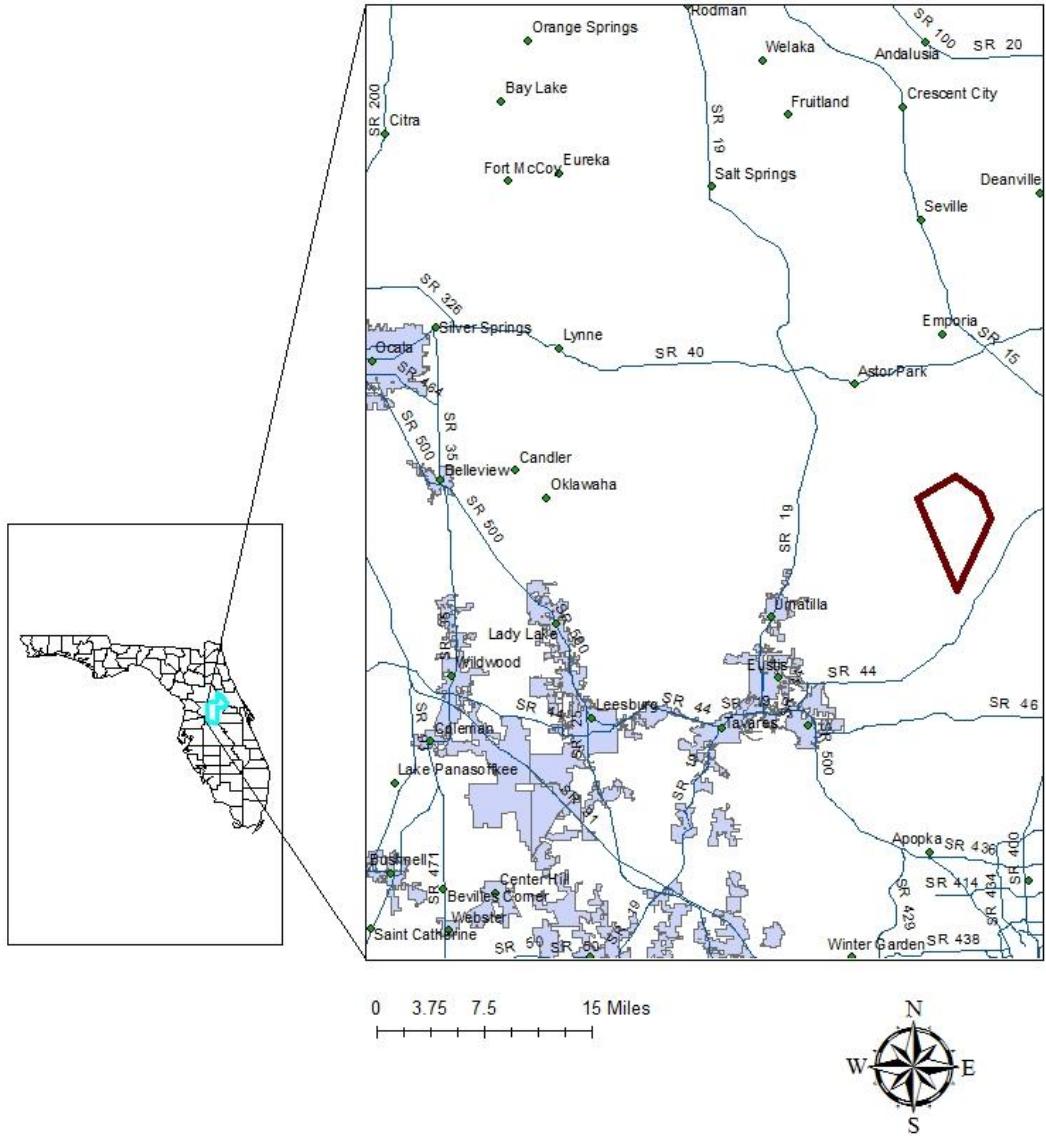


Figure B-9. Home range of Florida black bear “809” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

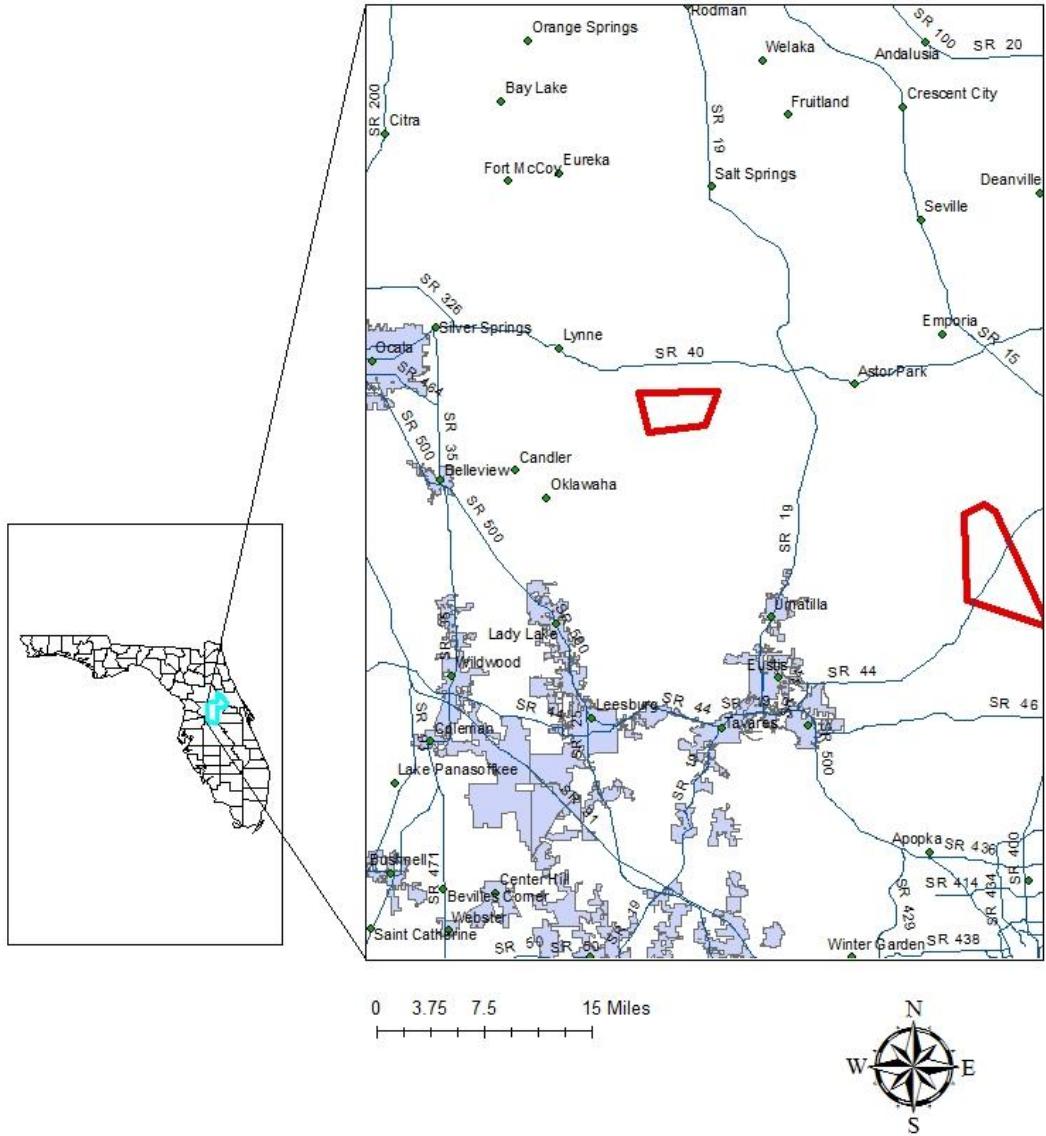


Figure B-10. Home range of Florida black bear "810" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

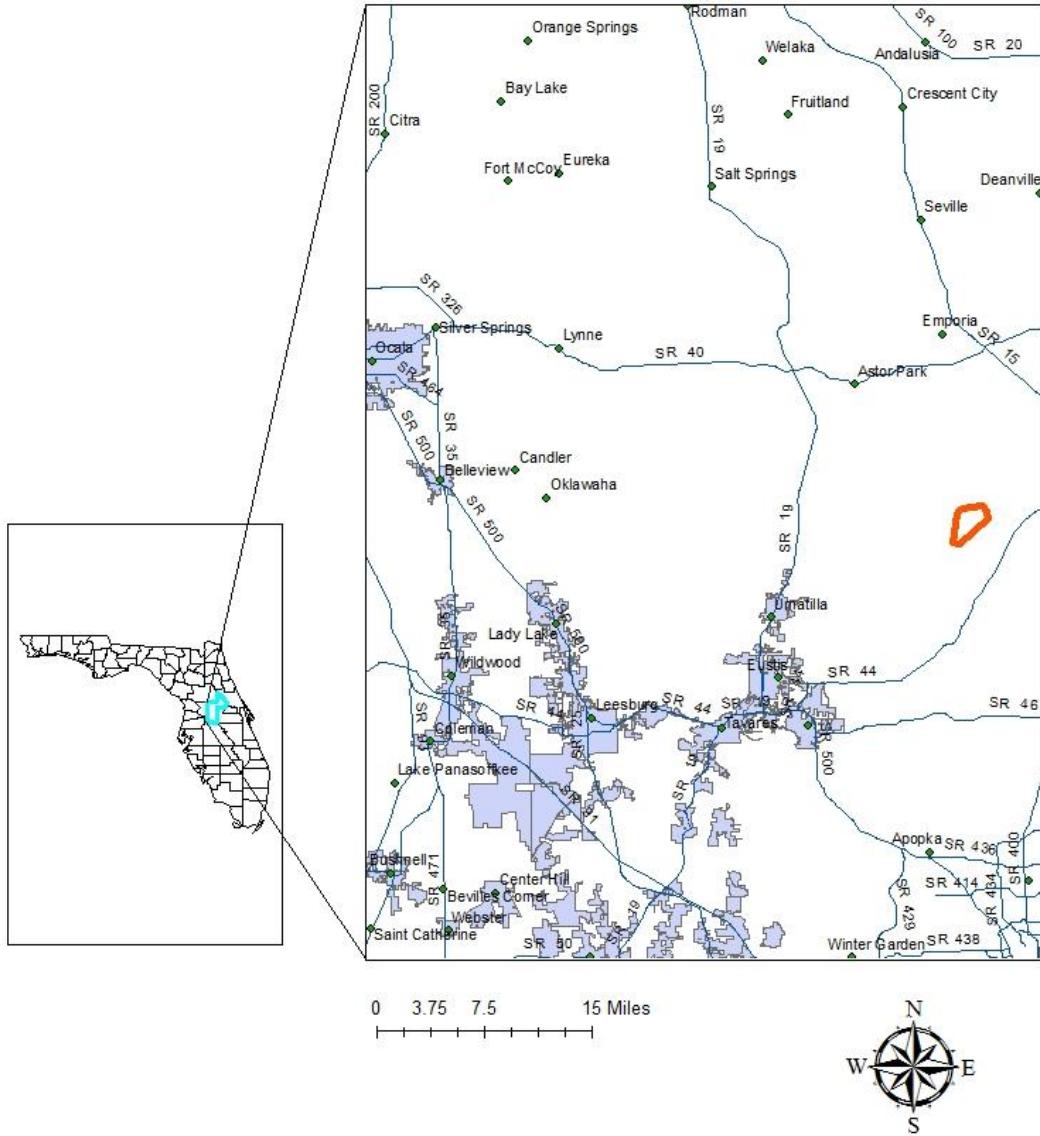


Figure B-11. Home range of Florida black bear "811" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

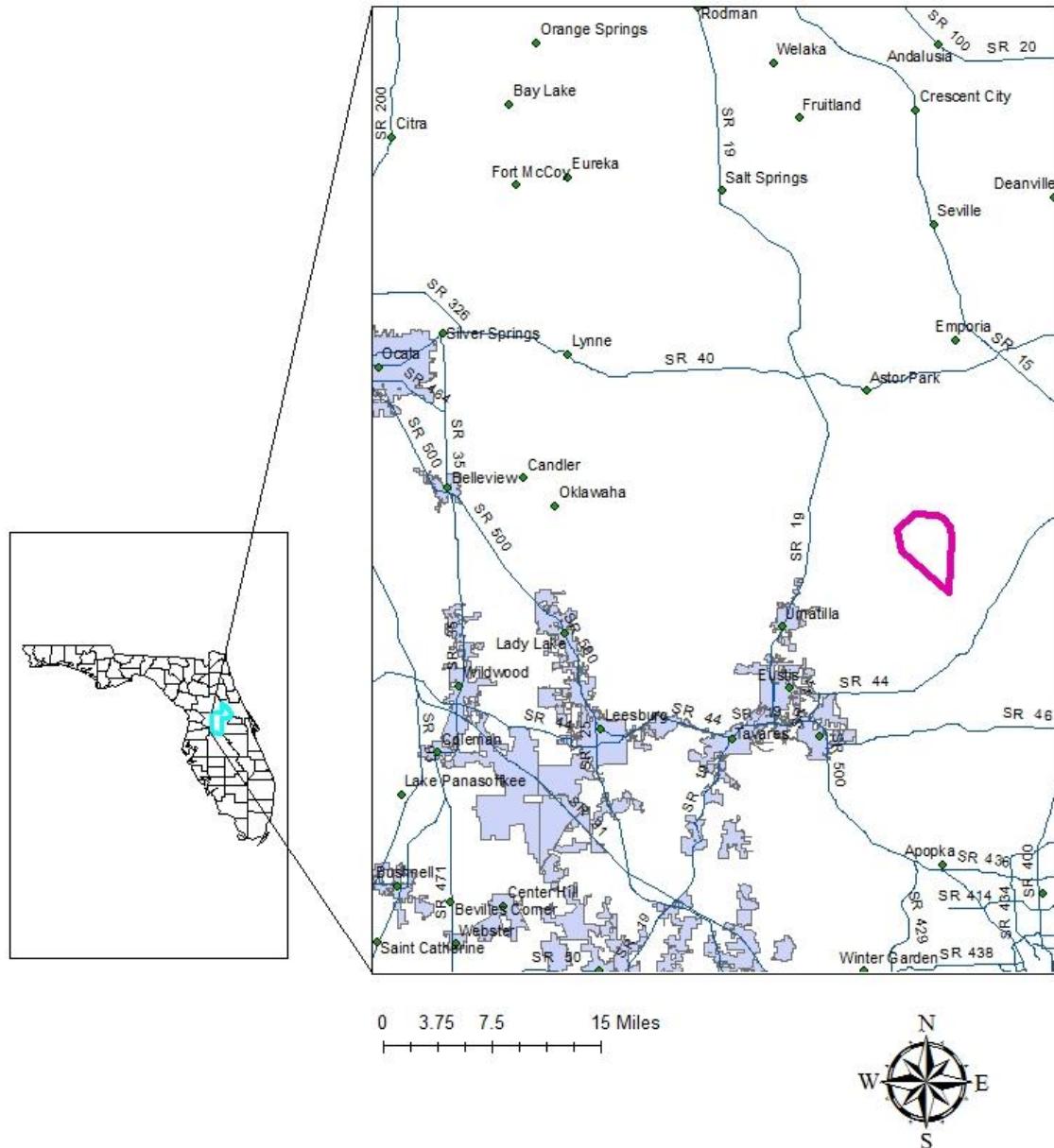


Figure B-12. Home range of Florida black bear “812” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

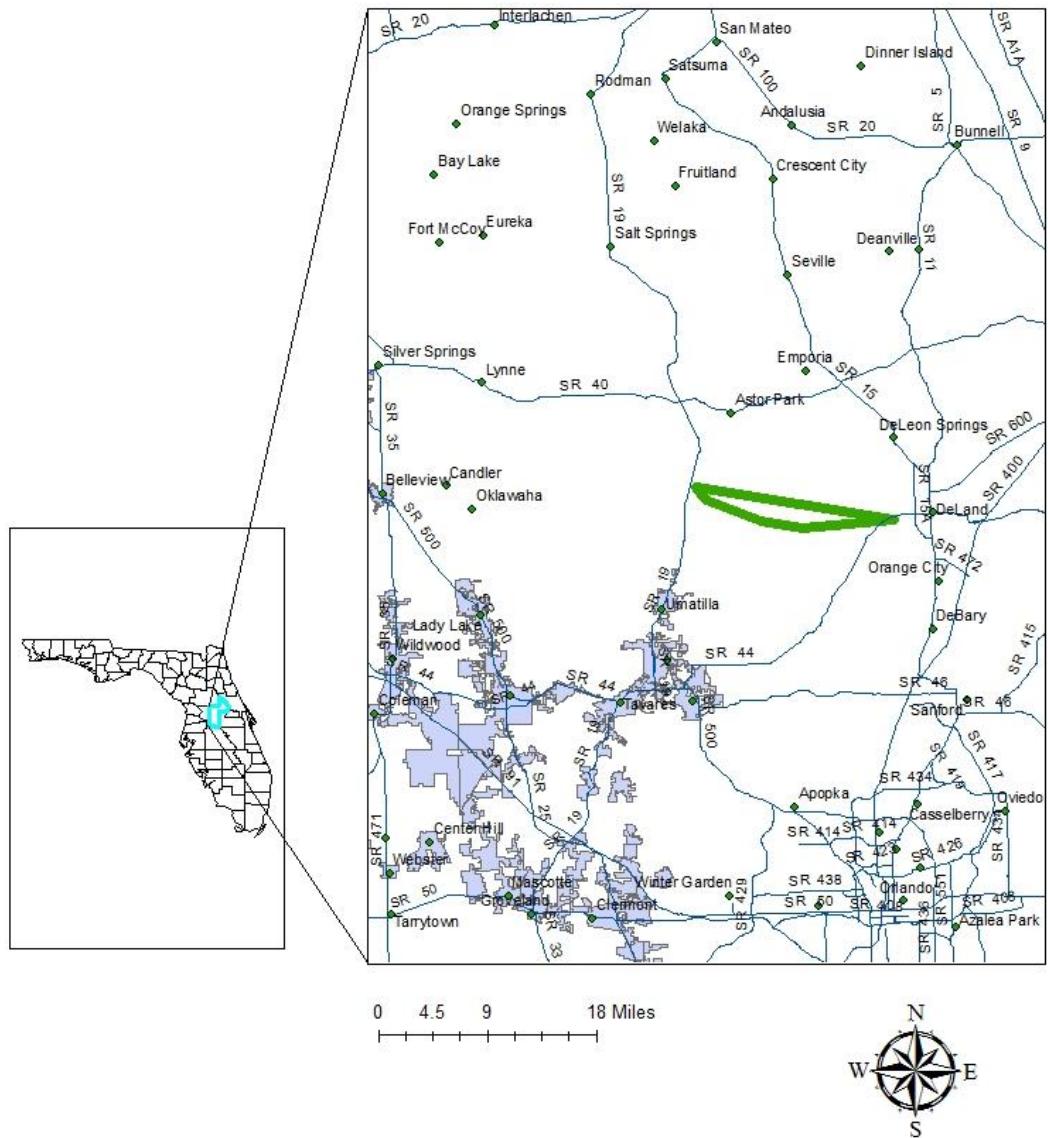


Figure B-13. Home range of Florida black bear "813" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

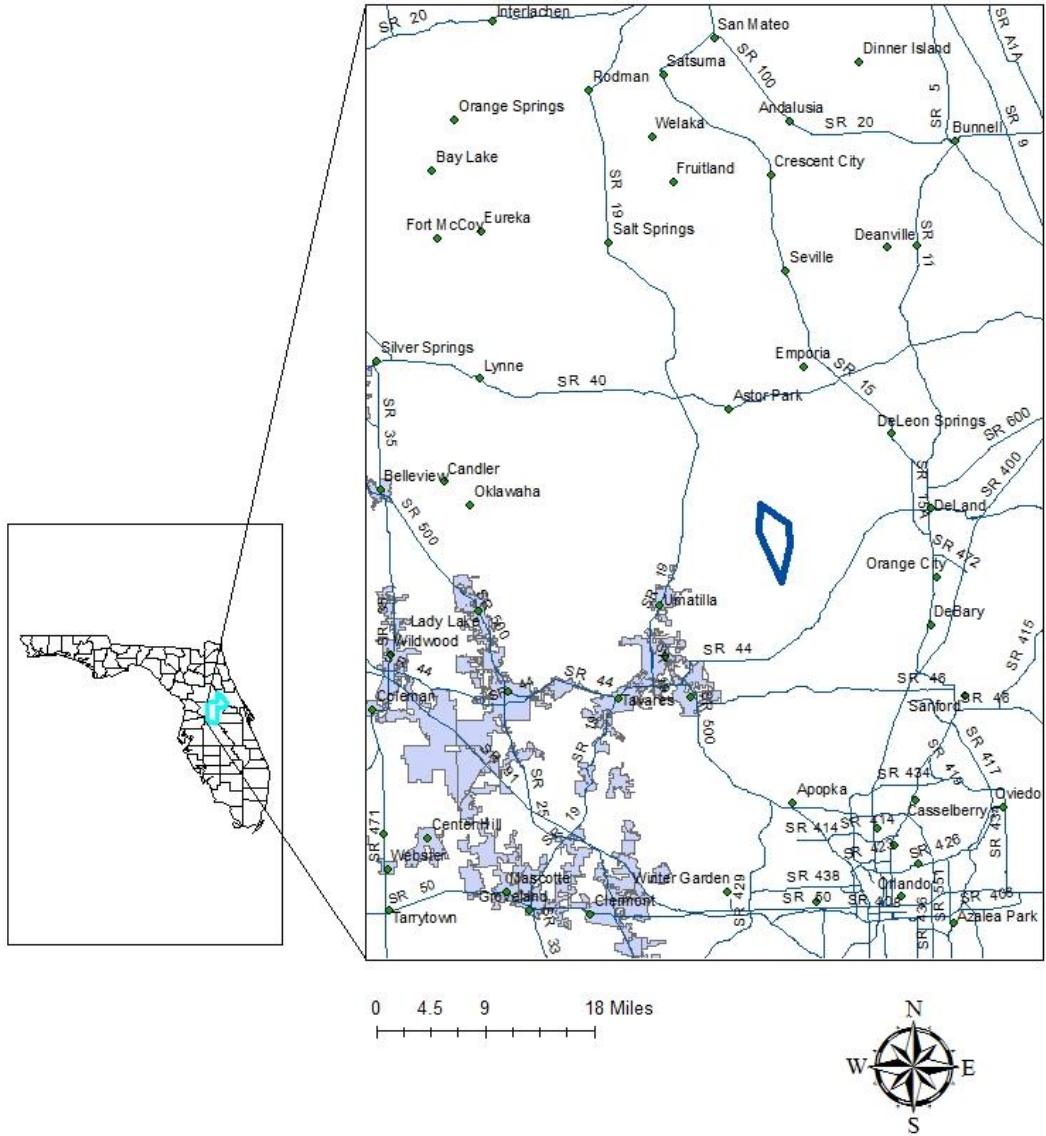


Figure B-14. Home range of Florida black bear "814" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

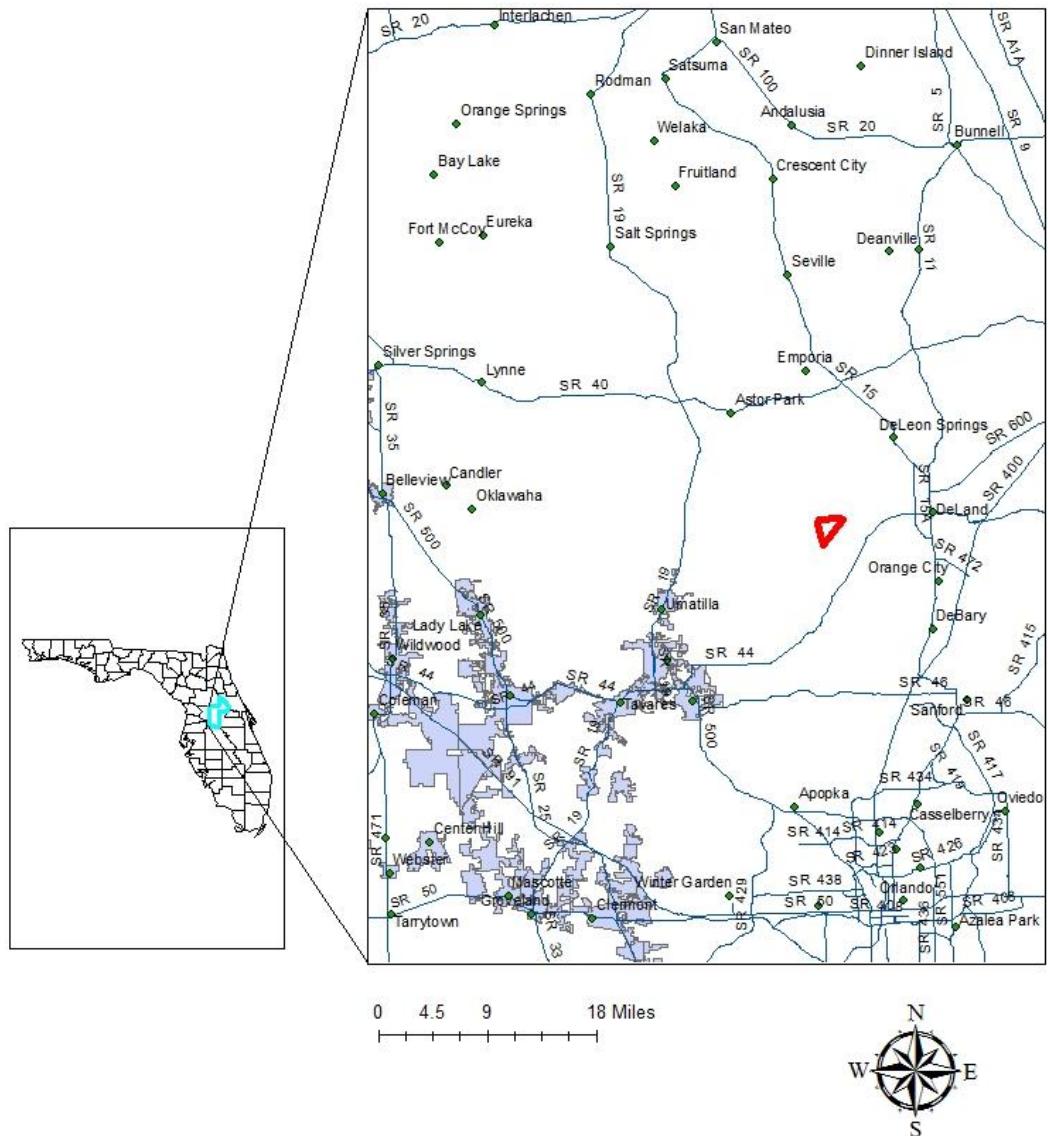


Figure B-15. Home range of Florida black bear “815” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

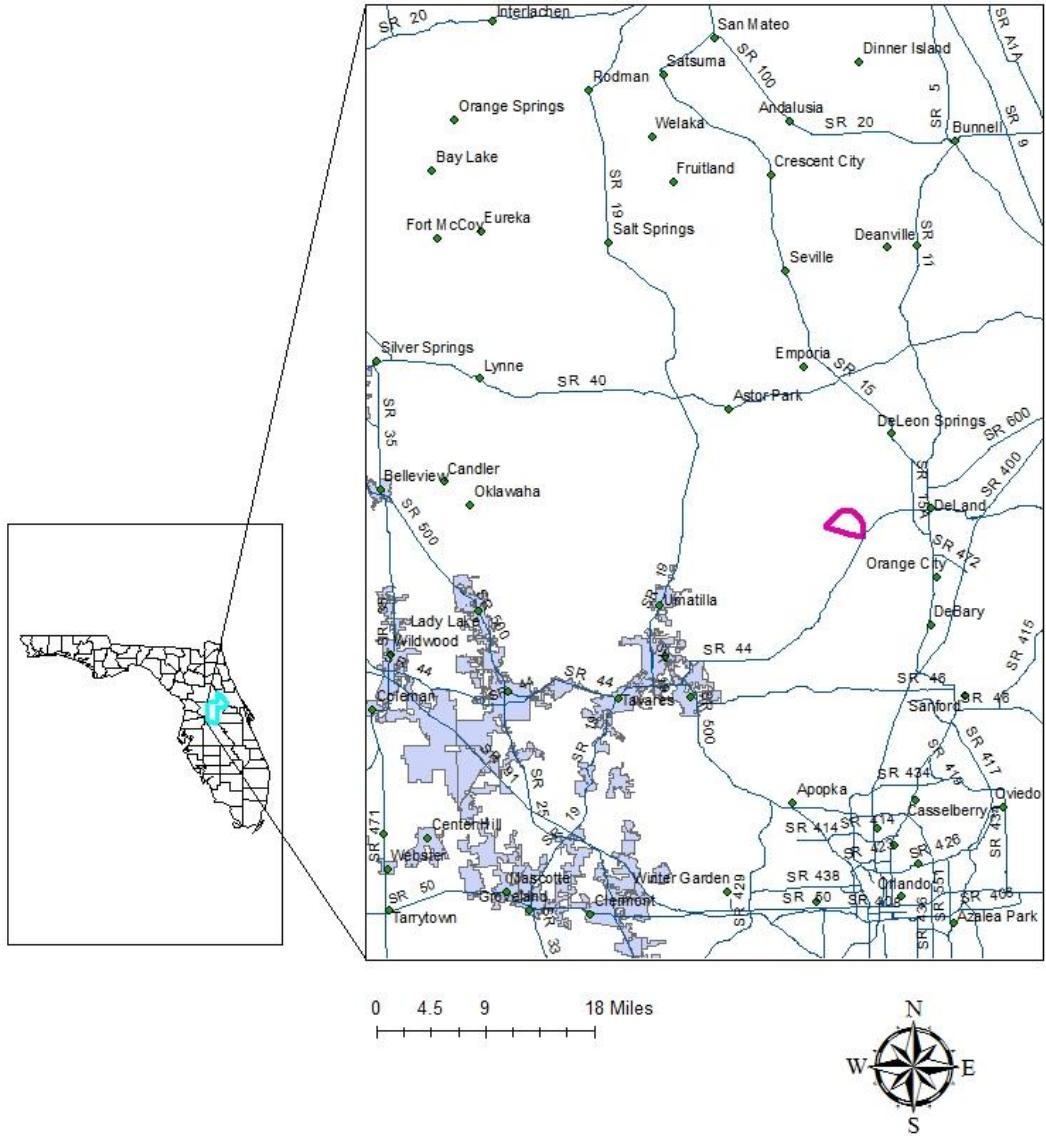


Figure B-16. Home range of Florida black bear "816" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

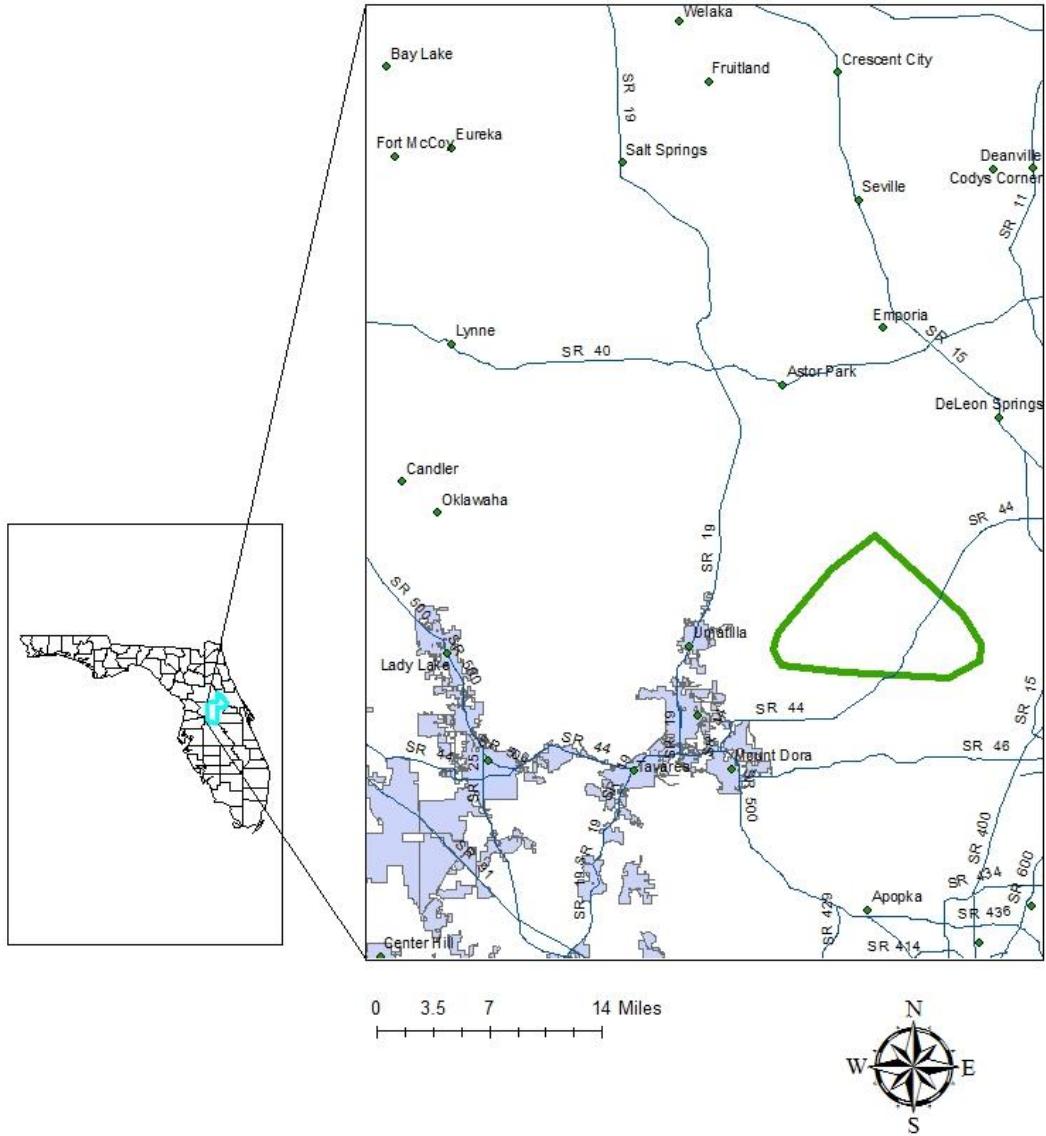


Figure B-17. Home range of Florida black bear "817" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

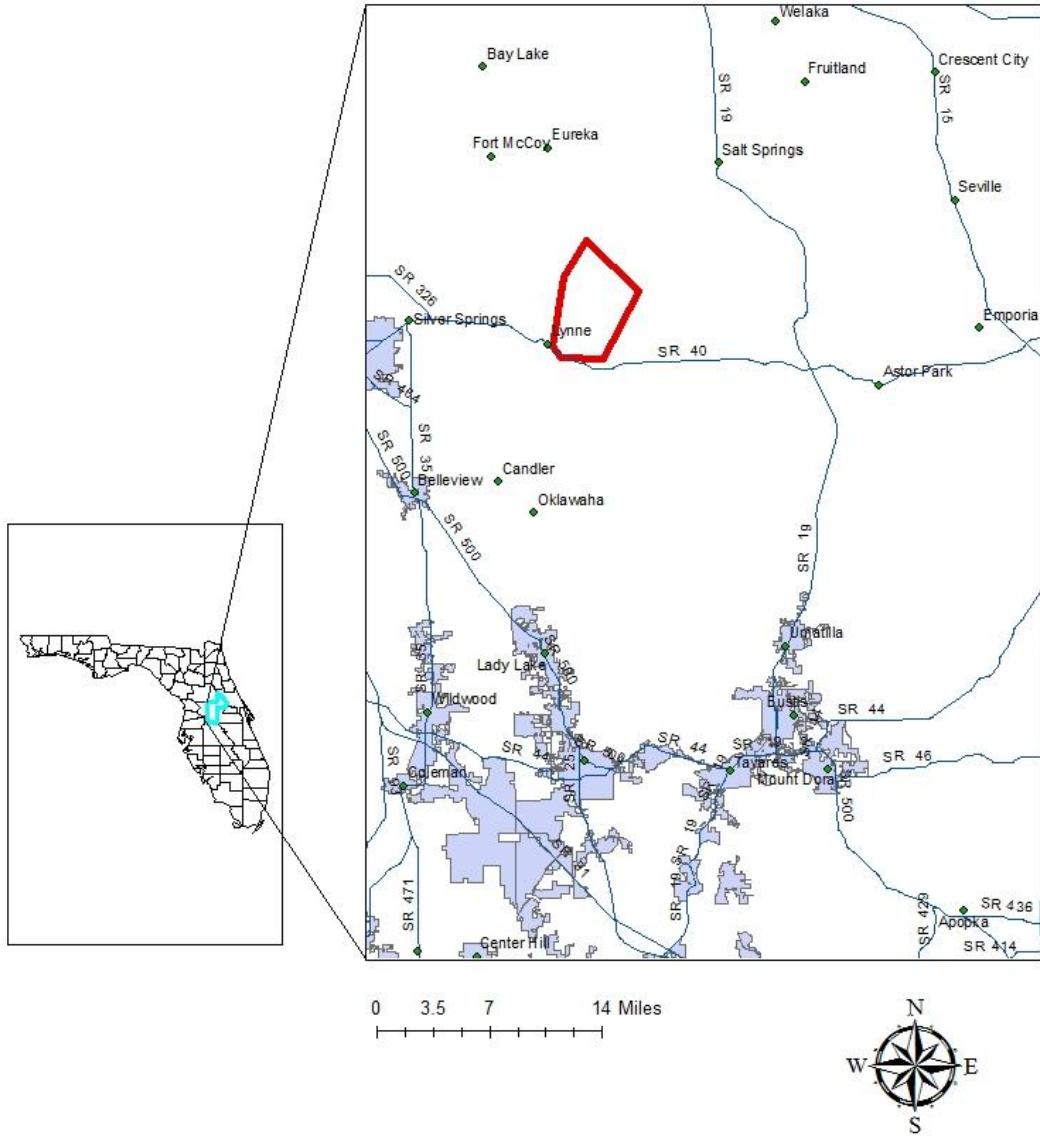


Figure B-18. Home range of Florida black bear "818" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

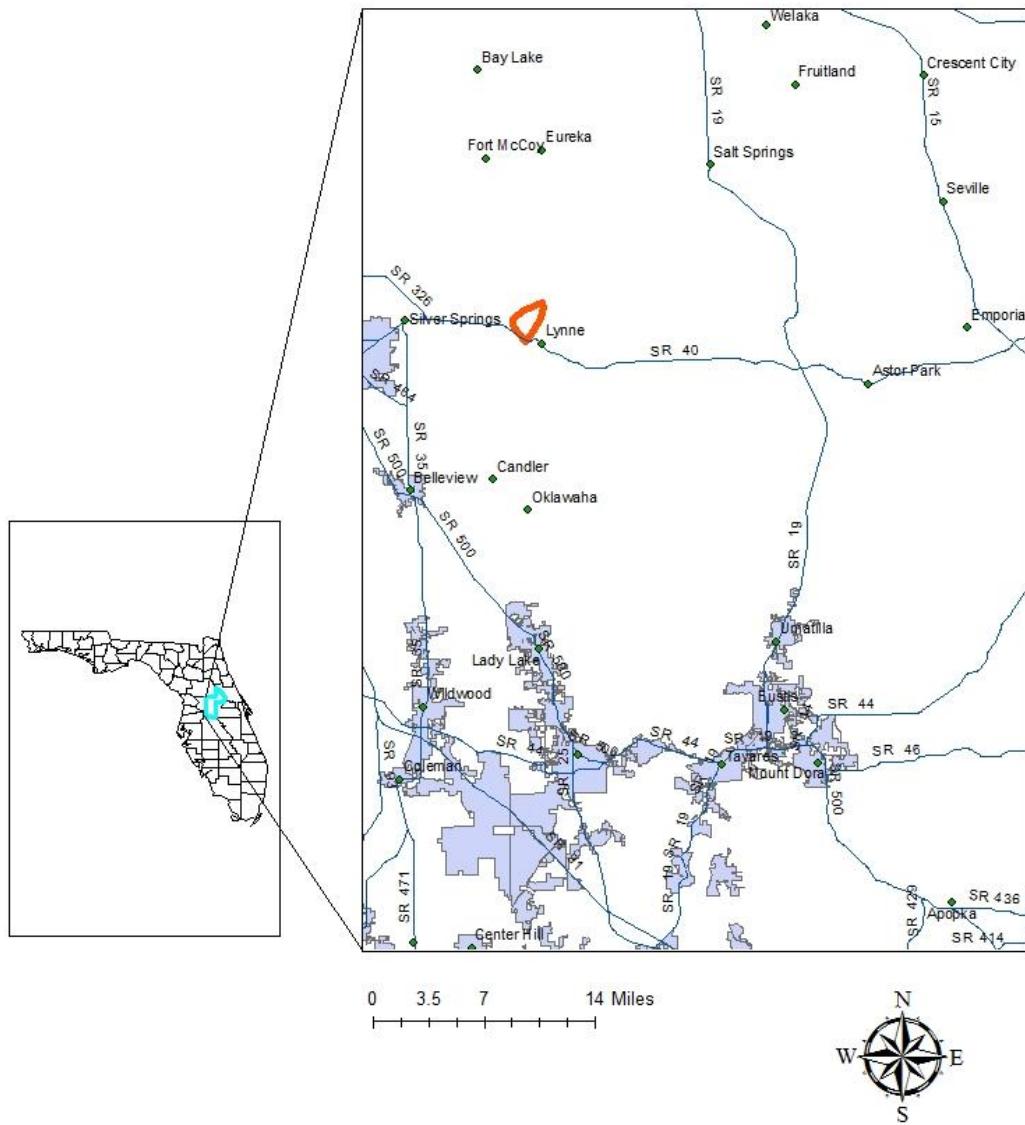


Figure B-19. Home range of Florida black bear “819” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

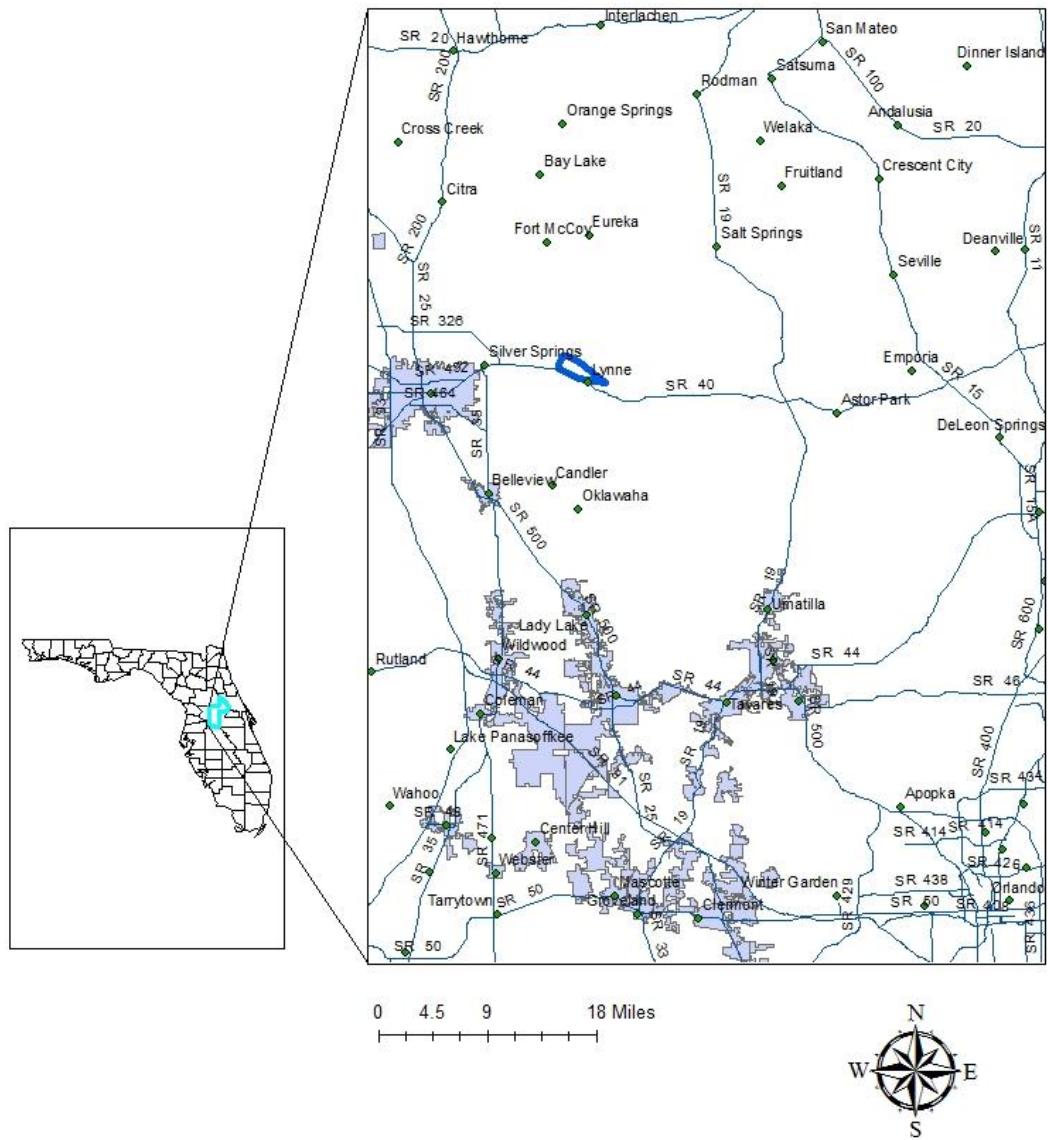


Figure B-20. Home range of Florida black bear "820" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

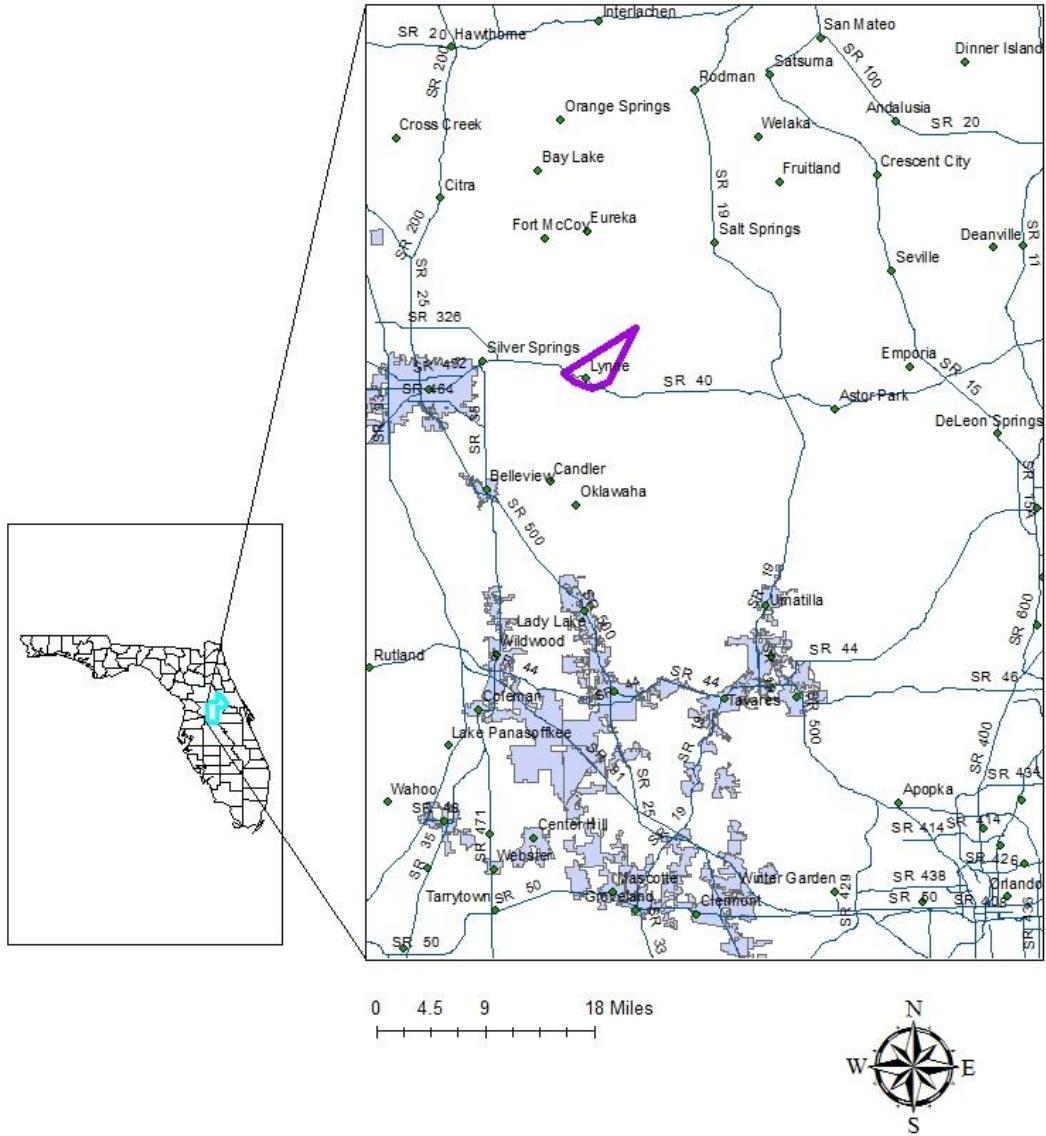


Figure B-21. Home range of Florida black bear "821" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

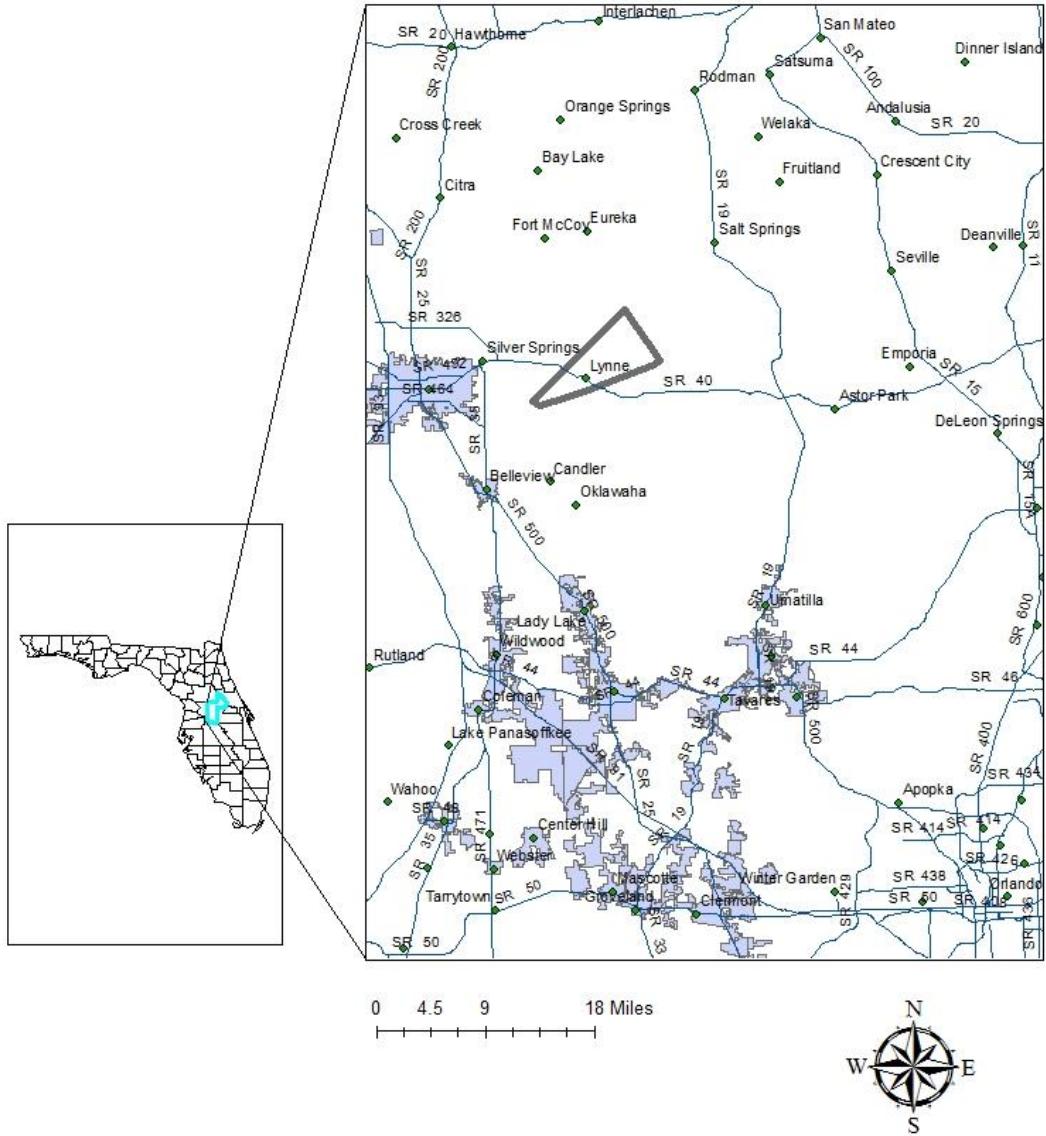


Figure B-22. Home range of Florida black bear "822" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

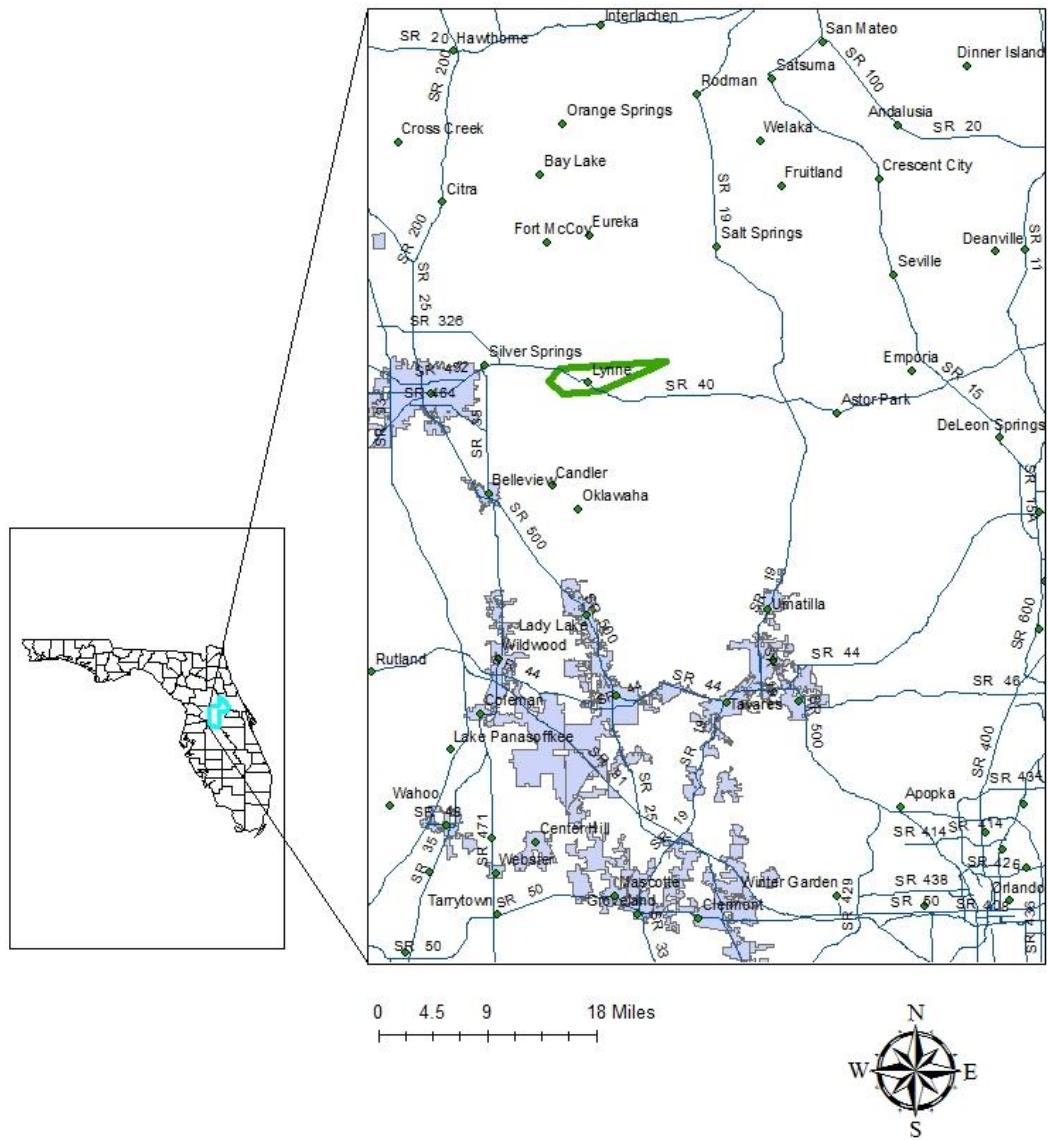


Figure B-23. Home range of Florida black bear "823" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

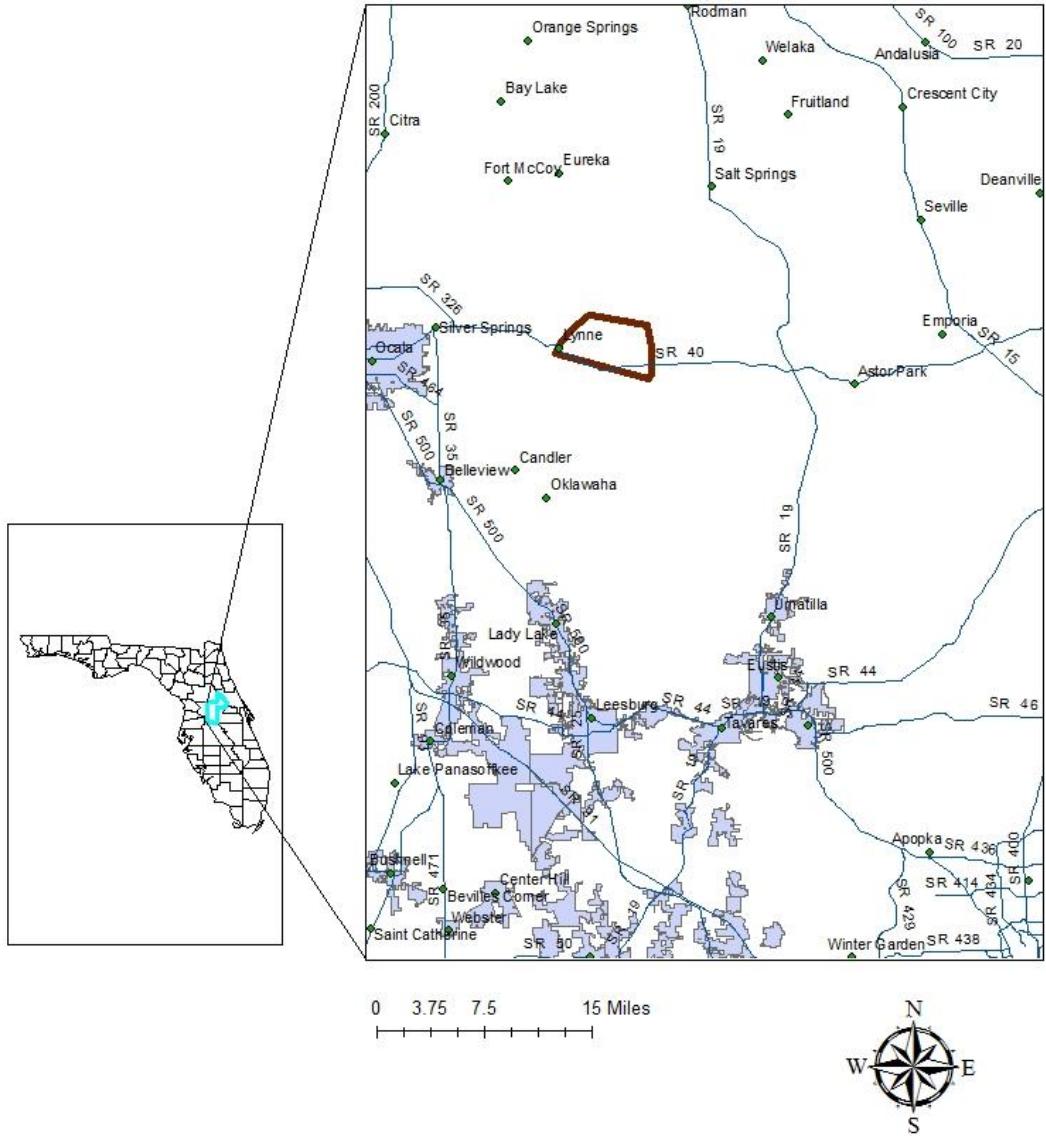
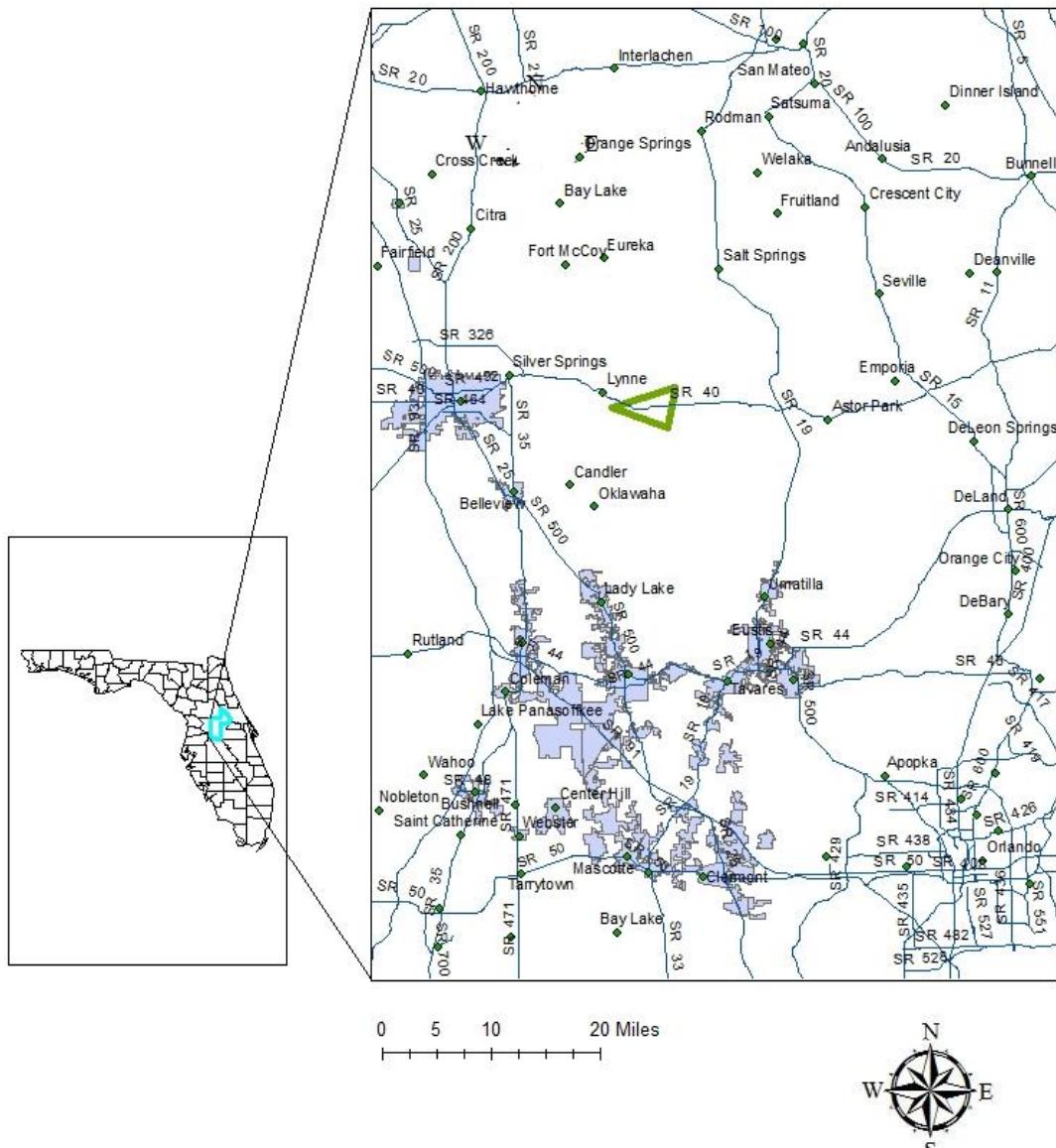


Figure B-24. Home range of Florida black bear "824" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.



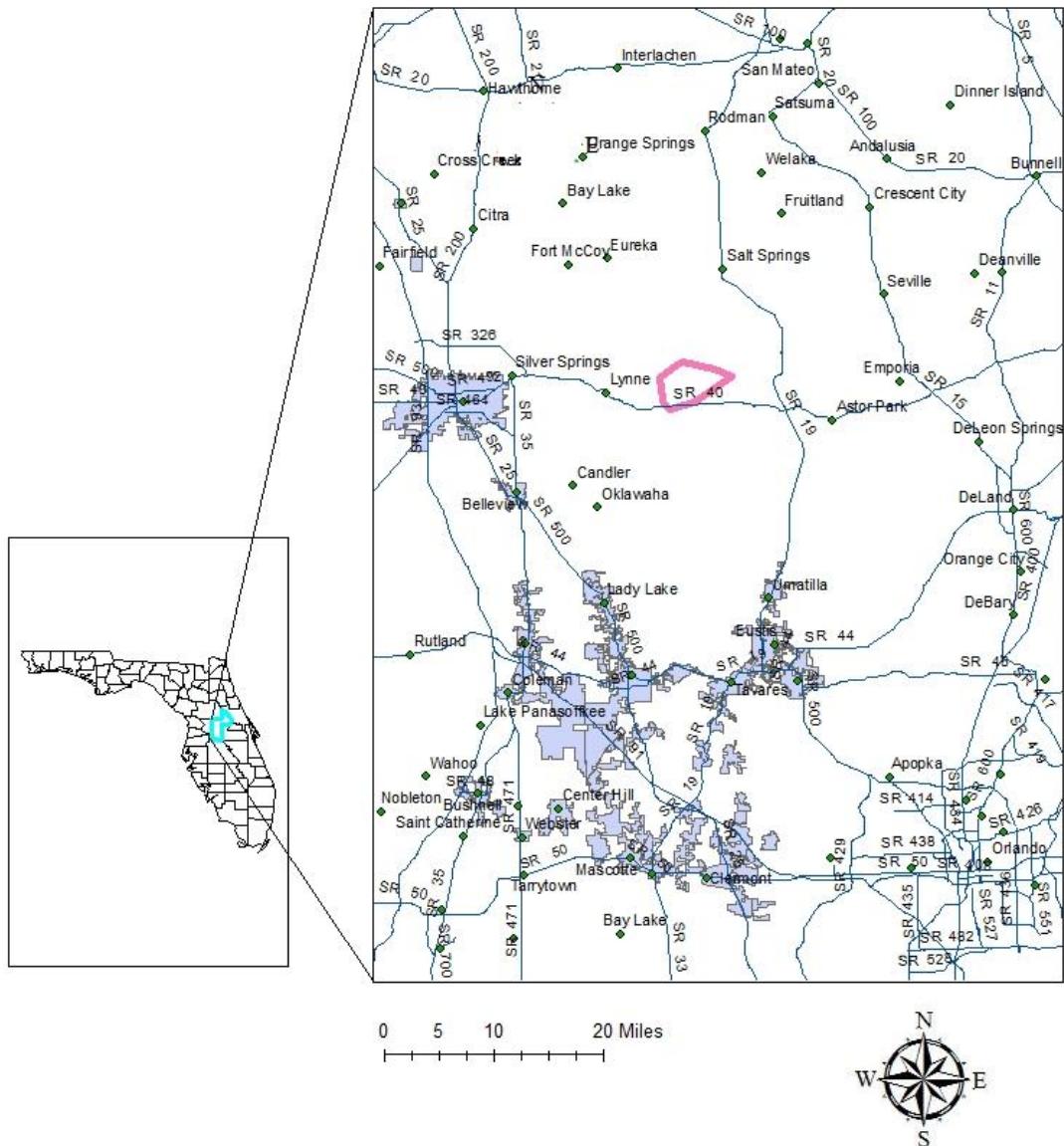


Figure B-26. Home range of Florida black bear “826” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

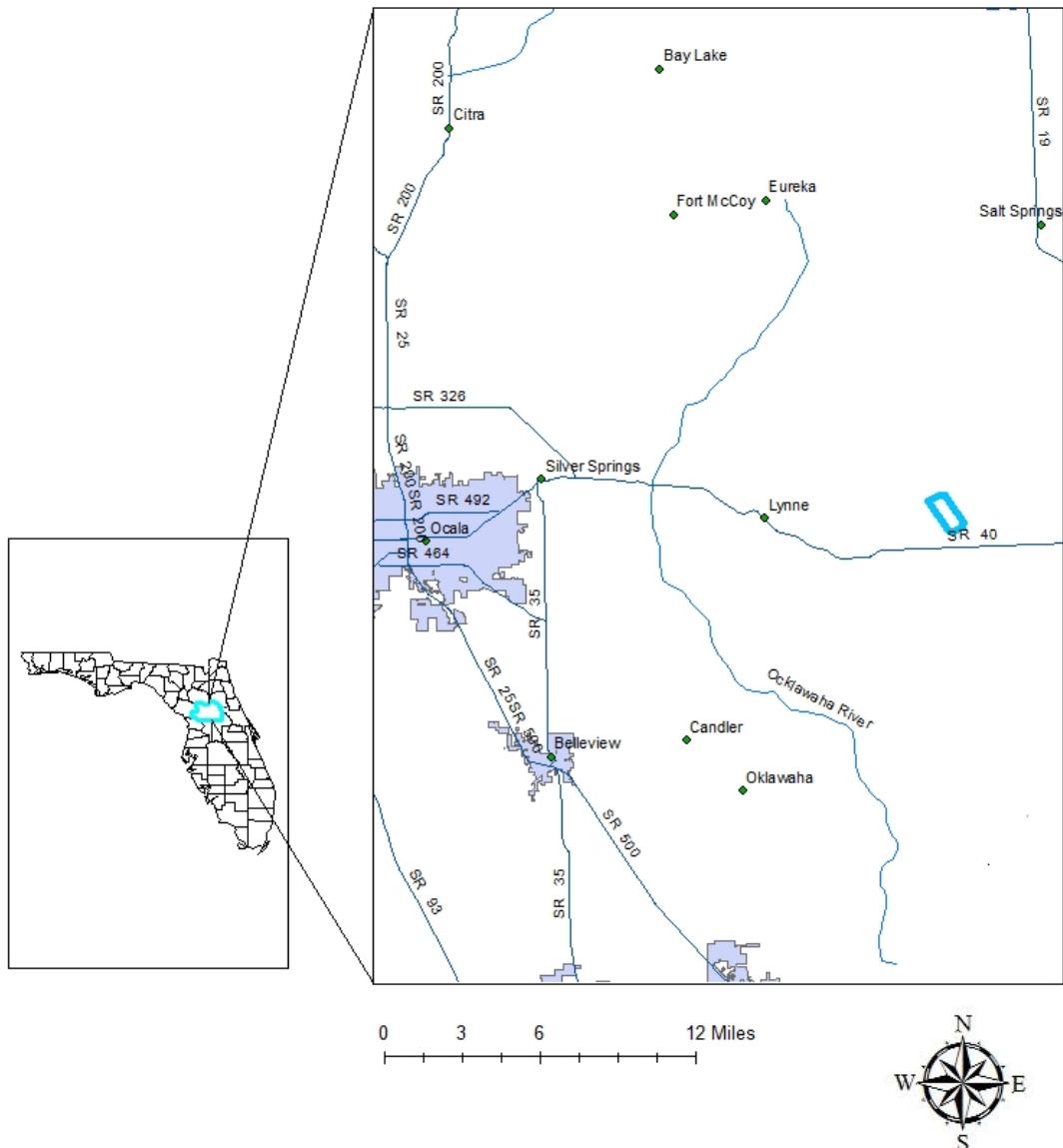


Figure B-27. Home range of Florida black bear "827" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

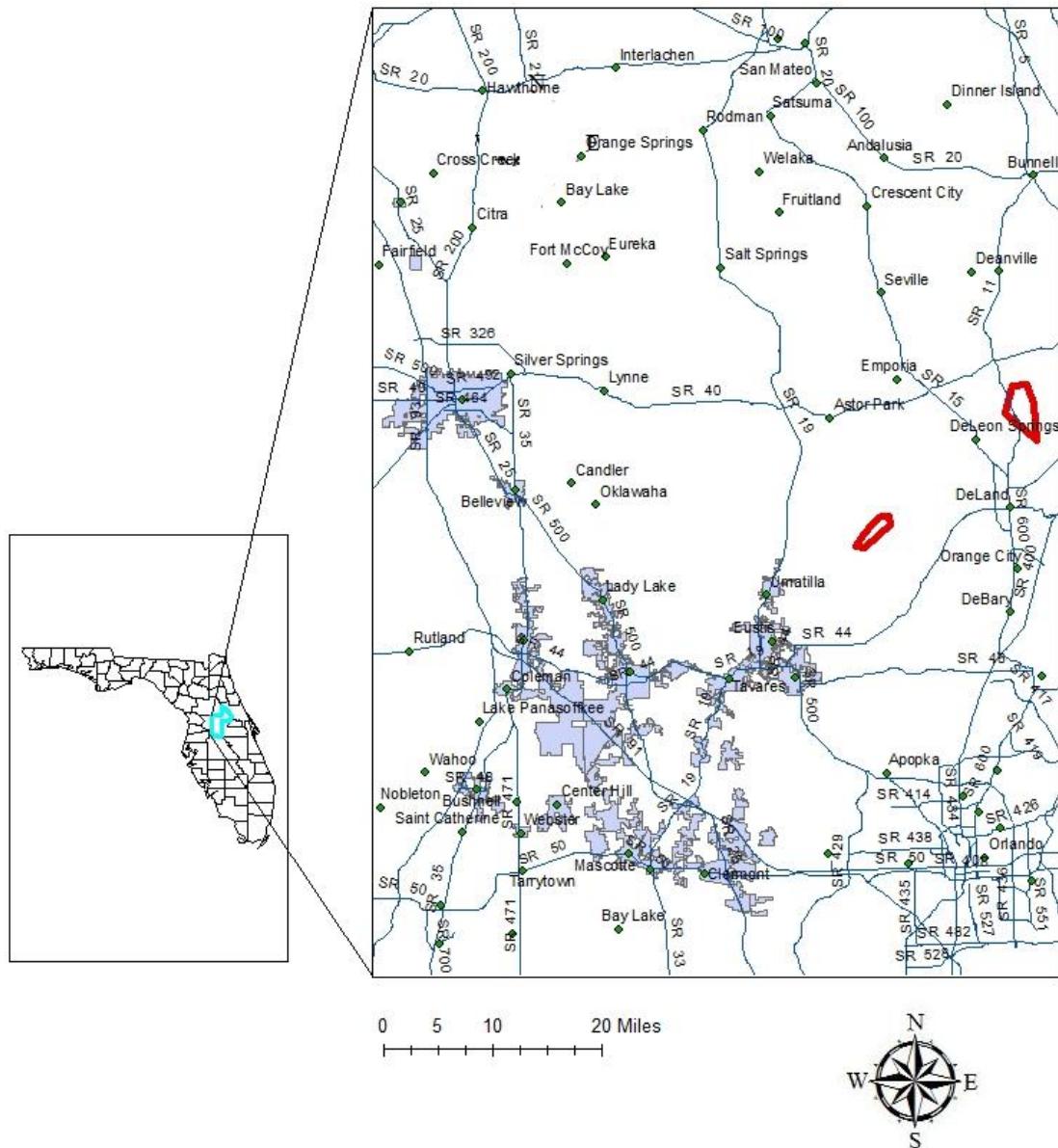


Figure B-28. Home range of Florida black bear "828" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

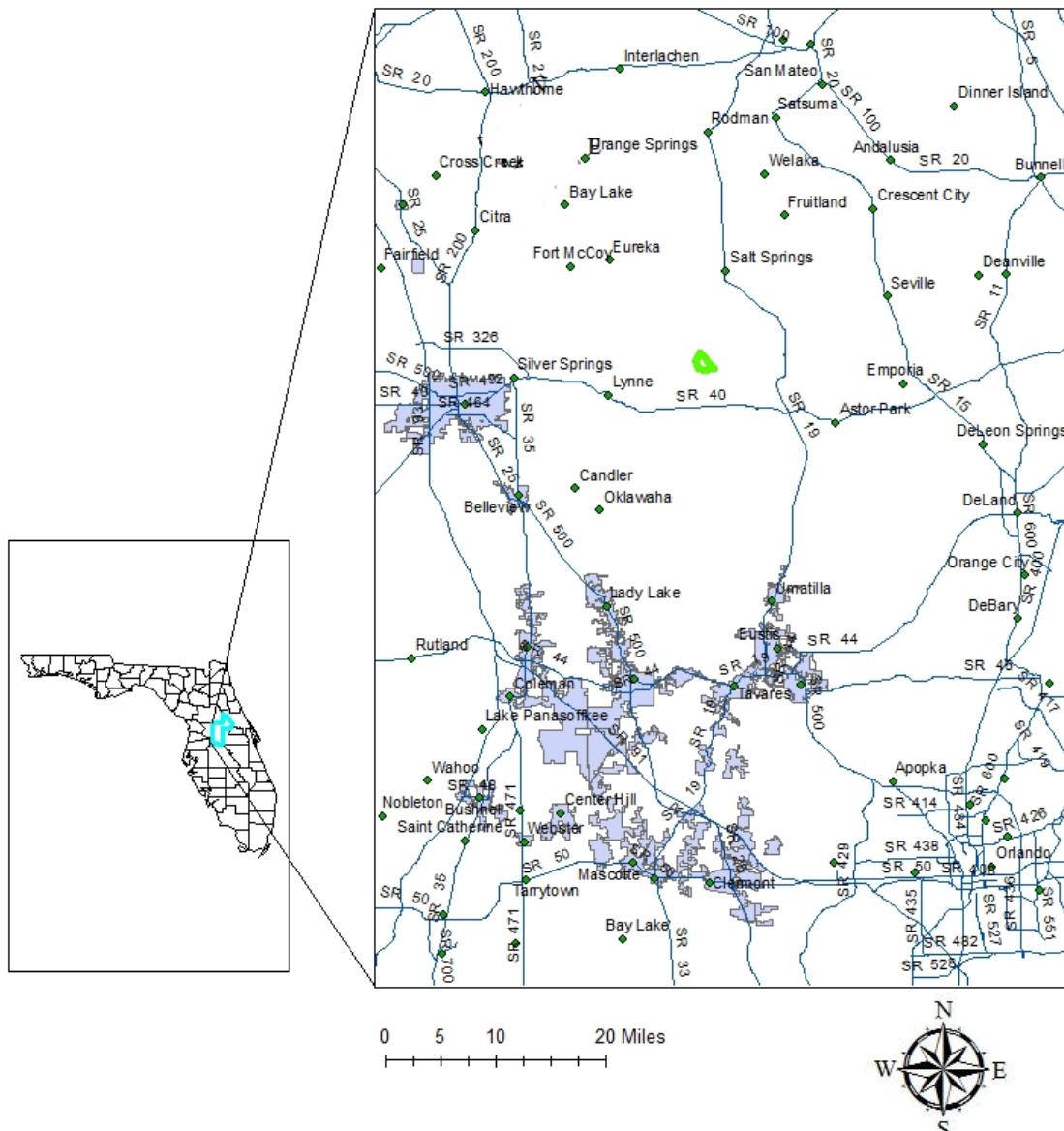


Figure B-29. Home range of Florida black bear "829" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

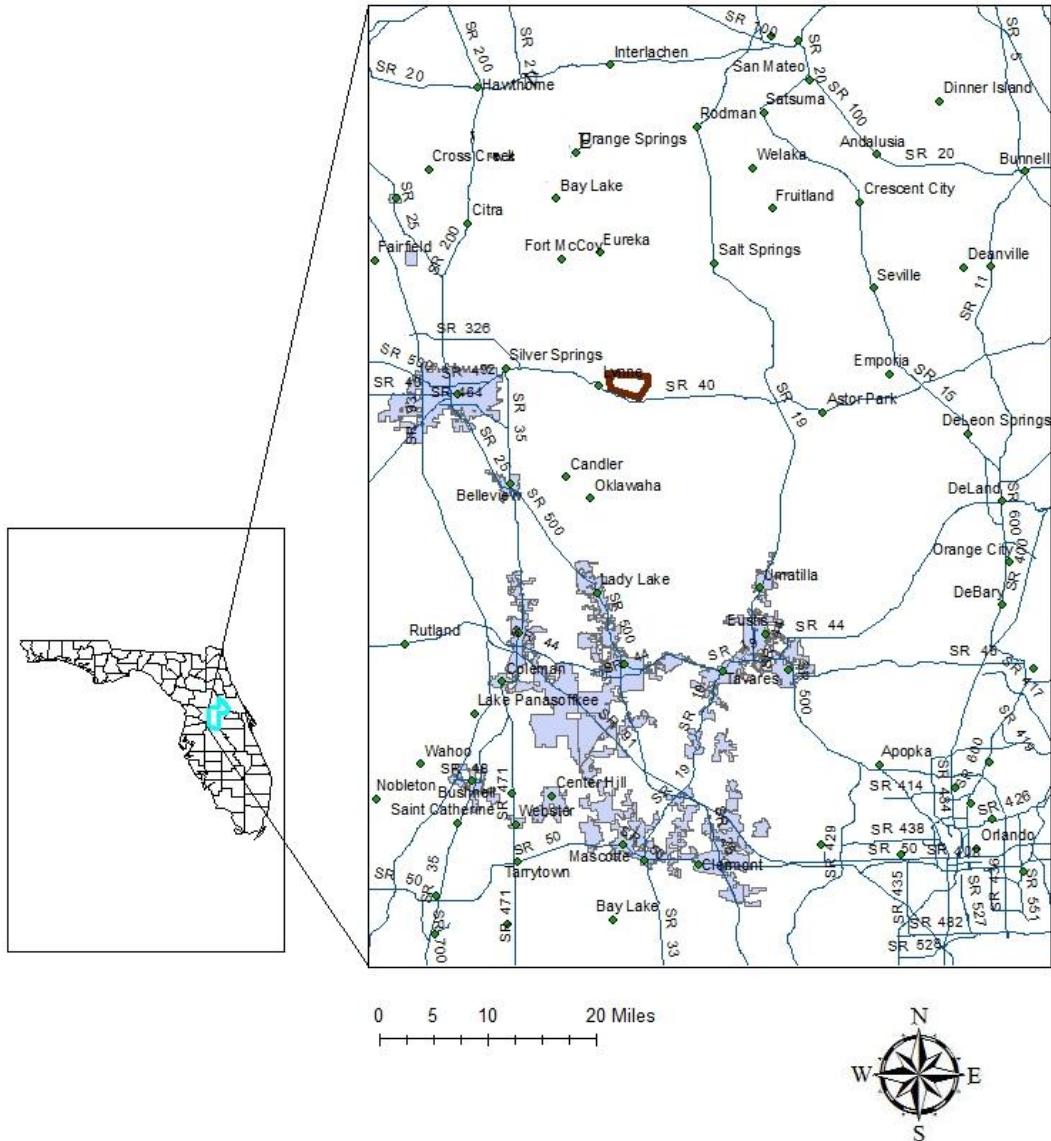


Figure B-30. Home range of Florida black bear “830” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

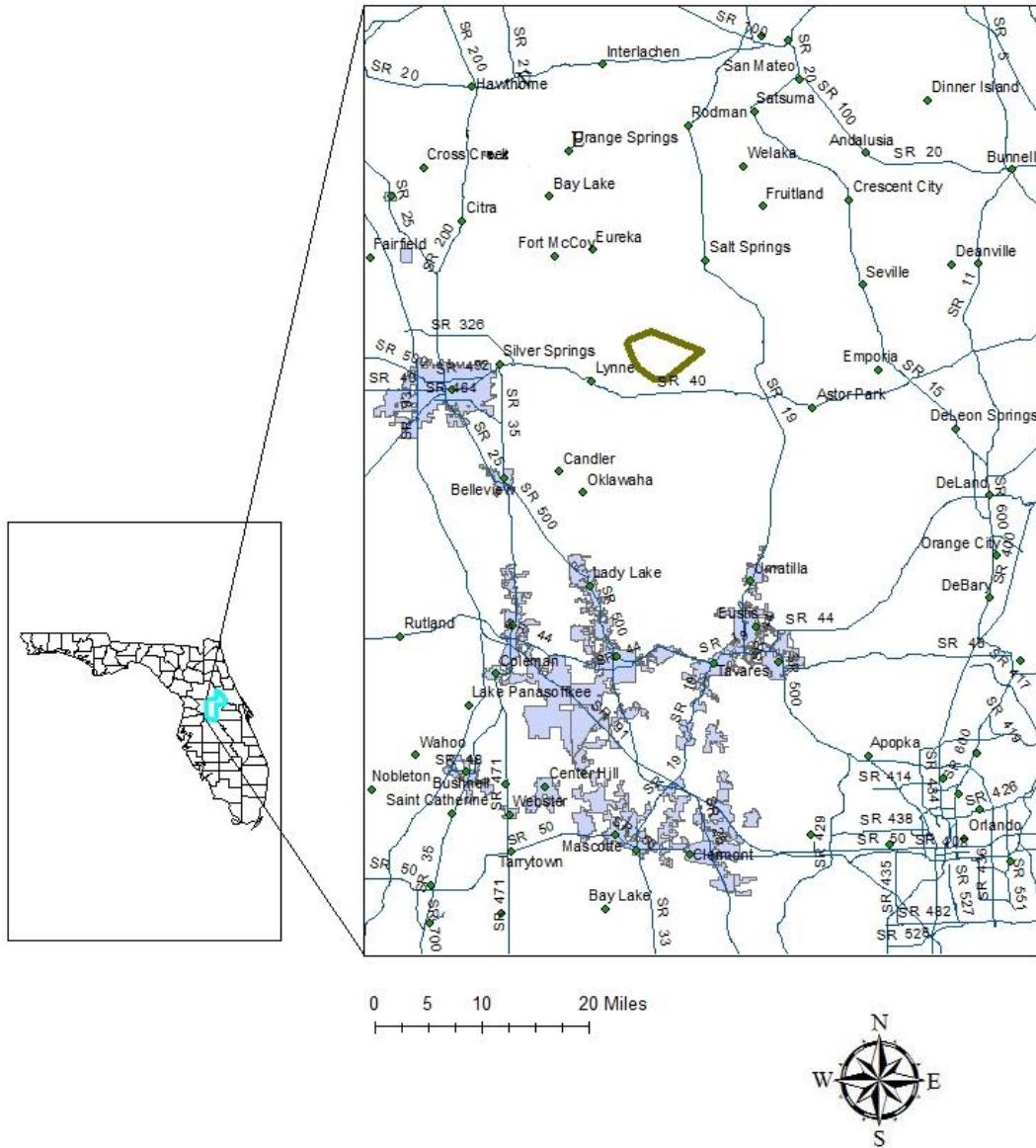


Figure B-31. Home range of Florida black bear “831” in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

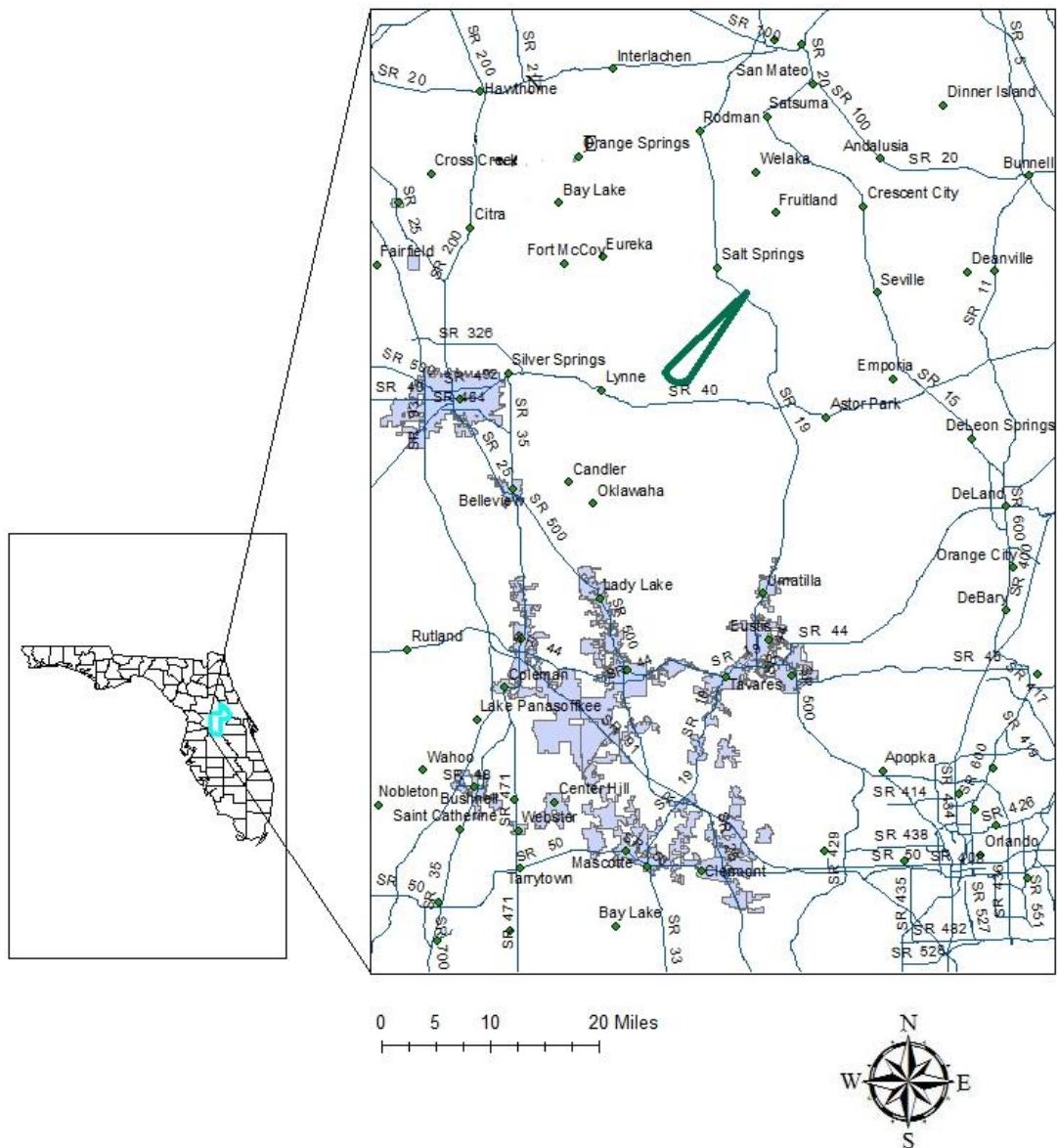


Figure B-32. Home range of Florida black bear "832" in the Ocala National Forest and surrounding urban areas, north-central Florida, USA, as calculated by minimum convex polygon using telemetric data from 2005-2007.

APPENDIX C PERMITS

Permits were used in this project for Florida black bear capture and radio-collar attachment. They were obtained from the following agencies:

- Florida Fish and Wildlife Conservation Commission
- University of Florida Institutional Animal Care and Use Committee
- Ocala National Park

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BIOGRAPHICAL SKETCH

Aletris Marie Neils was born in 1981 outside of Phoenix, Arizona. She grew up on a pecan farm with her parents and sisters. Her interest in wildlife was shaped by innumerable hours exploring the wilderness that was her backyard and by animal fact files and books that captured her dreams. Her compassion for animals was built by the friendships she shared with the family dogs, cats, chickens, goats, and other animals that came to cross her path in life. She graduated Central High School in 1999. Aletris began her career working as an education specialist for the Phoenix Zoo, shortly after she began tracking pumas and jaguars in southern Arizona and northern Mexico. She received a Bachelor of Science in Conservation Biology in May 2003 from Arizona State University. Aletris has worked with both state and federal wildlife organizations including Arizona Game and Fish, Florida Fish and Wildlife Conservation Commission, and US Geological Survey. Aletris is primarily interested in resolutions for human-carnivore conflicts. In 2008, Aletris founded Conservation CATalyst, a nonprofit organization dedicated to research, education, and conservation pertaining to the world's carnivores. She received her Master of Science in December 2011. Aletris is currently enrolled in a PhD program at the University of Arizona where her research focuses on ecology and conservation of caracals and other carnivores on Namibian farmlands. She lives in Tucson, Arizona with her partner Christopher and their menagerie of animal friends.