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Home Range and Habitat Use Patterns of Eastern Box Turtles (*Terrapene Carolina Carolina*) on Prudence Island, Rhode Island

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Abstract

The eastern box turtle (*Terrapene carolina carolina*) is a long-lived, terrestrial turtle that is listed as 'Protected' in the state of Rhode Island. Although home ranges and general habitat use patterns have been previously documented for this species, variability among different studies indicates that these parameters are site and time-specific to some degree. The goal of this study was to determine home range and habitat use patterns of box turtles on Prudence Island, RI using standard radio-tracking techniques. Turtle locations were incorporated into a geographic information system and analyzed using non-parametric statistical methods. Mean turtle home ranges varied from 1.4 to 8.3 ha depending on the method used to calculate them and were in the range reported from other studies. Box turtles used 14 different habitat types on Prudence Island but were found in red maple swamps 57% of the time. These results illustrate the value of these forested wetlands for box turtles and suggest that this habitat continue to be protected and conserved to support the box turtle population on Prudence Island in perpetuity.

Introduction

The eastern box turtle (*Terrapene carolina carolina*; hereafter referred to as box turtle) is generally distributed throughout much of Rhode Island, but is more common in low-lying, sandy coastal regions (Klemens 1993). This species grows to less than 150-160 mm in average straight-line carapace length (SLC), and although colorations are variable, the highly rounded shell is typically patterned with yellow-orange patches interspersed on a brown-black background. Box turtles utilize a wide variety of habitat types including wetland, forest, shrub, and grassland habitats. Individuals of this species typically have small home ranges of approximately two hectares or less, although this can vary greatly (Dolbeer 1969; Madden 1975; Stickel 1989). Within their home range, box turtles require shady, wet areas to remain cool during hot summer temperatures and to obtain water, and sandy well-drained soils in which they burrow during the cold winter months (Klemens 1993).

Substantial areas on Prudence Island, Rhode Island are underlain by sandy, well-drained soils that support a mosaic of pitch pine-barrens habitat. In particular, large sections of the middle of Prudence Island, and most of the southwest corner of the island are characterized by pine-barrens. Box turtles are commonly found in pine-barrens habitats (Conant 1979), and this may be one reason that Prudence Island supports one of the highest densities of this species in the state of Rhode Island (Roger Greene, personal communication). Despite this dense population, no research has been conducted on the ecology of box turtles on Prudence Island.

The Narragansett Bay National Estuarine Research Reserve (NBNERR) encompasses 61% of the land on Prudence Island, including a large percentage of the island's pine-barrens, particularly in the 785 acre South Prudence Unit on the southern end of the island. The NBNERR is one of 27 Reserves that comprise the National Estuarine Research Reserve System (NERR or NERRS). One of the goals of the NERRS is to conduct research in order to promote better coastal and estuarine management and stewardship of important resources. This project seeks to address this goal by using radio tracking techniques to track individual box turtles and determine their home range size and habitat use patterns on Prudence Island. This study will provide information on

the ecology of eastern box turtles on Prudence Island, and will help the NBNERR manage its habitats in support of this protected species.

Methods

This study was conducted on the southern end of Prudence Island, within the South Prudence Unit of the NBNERR where box turtles are common and frequently observed (Raposa and Rehor 2004) (Fig. 1). Within this area, box turtles were tagged and tracked with radio tracking equipment purchased from the AVM Instrument Company, LTD. This included one radio receiver (model LA12-Q), a hand-held antenna and ten G3-1V transmitters that were mounted on the carapace of captured box turtles. From past wildlife surveys in the NBNERR (Raposa and Rehor 2004), it was observed that box turtles tended to be most active along roadsides during late spring and early summer as they emerge from hibernacula to begin mating. Efforts to find, capture and tag box turtles were therefore initiated during this time in 2005. Transmitters were attached to all captured turtles in the field with epoxy (Fig. 2), and the turtles were then released at the same location (Boarman et al., 1998). All tagged turtles were also individually marked using scute-notches and coded.

Tagged turtles were tracked during 2005 until signals were lost due to burial and hibernation. All tracking was suspended during the hibernation period in winter and restarted in spring 2006 when turtles began re-emerging. Since the transmitters only had a one-year life span, tracking was ended approximately two-weeks before the end of the one-year period for each transmitter. Turtles were tracked as frequently as possible, with a target frequency of one sighting per turtle per week. The number of recaptures varied considerably due to time of initial capture (and thus amount of time remaining before hibernation) and to the habitats where each turtle was located. In many cases, tracking was severely impaired or impossible due to excessive overgrowth of vines, briars, and other vegetation. There were some cases where a signal was detected, but an exact location could not be determined due to the vegetation. In other cases, signals were not detected, presumably because these turtles were in large areas of dense vegetation that were not conducive for signal transmittal and reception.

Each time an individual turtle was found, its location was documented with a Garmin handheld GPS. All locations were maintained in a geographic information system (GIS) database and labeled with the proper turtle ID code. Other environmental information was also recorded at each location, including the habitat type and associated dominant vegetation species. This information was then cross-checked with the NBNERR habitat maps that have previously been developed in ArcView using Kutcher et al. (2004).

Box turtle home ranges were determined using the Kernal (K-50 for 50% probability, K-95 for 95% probability) and Minimum Convex Polygon (MCP) methods, all of which are available in the Animal Movement Analysis Extension in ArcView 3.2a. All three methods used to calculate home ranges are commonly used and depend mainly on user preference. Each of the methods was used in this study to facilitate comparisons with other studies that used varying methods.

Box turtle habitat use was determined by clipping the NBNERR habitat coverage with all turtle location points and identifying the habitats underlying individual points. It was also determined if box turtles were using habitats in proportion to the relative amount of each habitat in the study area, or if they were using certain habitats more than would be expected. It is assumed here that the former case would indicate random habitat use, while the latter case would suggest (but not prove) actual habitat selection by box turtles. This was examined by randomly selecting the same number of additional point locations throughout the study area as the number of actual turtle locations. The habitat coverage was then clipped with these points as described above and coupled with the habitats derived from actual turtle points to provide two treatments (i.e., habitats where turtles were found and randomly located habitats). Similarity percentages (SIMPER) was used to identify the habitats that were contributing most to the difference between the two habitat assemblages (e.g., actual and random habitats). Analysis of Similarity (ANOSIM) was also used to statistically compare the overall composition of the habitat assemblages between the two treatments. SIMPER and ANOSIM are both part of the Primer version 6 statistical package.

Results

Eight box turtles (three females, five males) were captured and equipped with an individual transmitter set at a specific frequency between June and August, 2005. Five of the turtles were captured in early summer before July 12, when activity patterns were high. The remaining three were randomly found and tagged while tracking previously tagged turtles in August. Turtles ranged from 9 to 26 years old and from 118 to 158 mm SLC (Table 1). Tagged turtles were tracked from a total of 73.25 hours, including 59.5 hours in 2005 before hibernation, and 13.75 hours in 2006 after turtles emerged in spring. Only two turtles were found after winter, contributing to the small number of tracking hours in spring 2006. The number of recaptures per individual tagged turtles ranged from 4 to 18.

Box turtle home ranges varied considerably depending on which calculation method was used (Fig. 3). Based on the K-50 method, home range averaged 1.41 ha, and ranged from 0.04 to 5.22 ha (Table 2). Based in the K-95 method, home range averaged 8.29 ha, and ranged from 0.24 to 23.91 ha. In addition, home range size averaged 3.17 ha and ranged from 0.06 to 9.63 ha using the MCP method.

Box turtles used a total of 14 different habitat types as defined by Kutcher et al. (2004) (Table 3). Red maple swamp was by far the most frequently used habitat type (57% of all turtle locations were in this habitat). This was followed in decreasing order by oak-pine forest (9%), pitch pine-oak forest (8%), and bayberry shrubland (5%). At a broader level, box turtles were found using forests 77% of the time, followed by sapling and shrub areas (22%), and herbaceaous grasslands (1%). Turtles were found using palustrine habitats (i.e., freshwater wetlands) 62% of the time and in dry uplands 38% of the time. Within these overall habitat types, it was observed that the dominant microhabitats that were being used by box turtles include dense green briar (44% of all observations) and structural habitat edges (26%).

The habitats that were actually used by turtles were compared to habitats from the same number of randomly selected points in the study area. Based on SIMPER, the habitat type most different between these two groups was red maple swamp (responsible for 30% of the difference between the two habitat assemblages), followed to a lesser degree by pitch pine-oak forest (12%) and oak-pine forest (11%). This suggests that box turtles may have been using red maple swamps to a greater degree than expected based on the total amount of the habitat (it was used 57% of the time by box turtles, but only 38% of the time based on randomly selected locations (Fig. 4). However, the overall assemblage of habitats that box turtles were actually using was not significantly different from the overall habitat assemblage derived from randomly selected points in the study area (ANOSIM, Global R=-0.073, p=0.85).

Discussion and Management Implications

This study provides the first estimates of home range size and habitat use patterns of eastern box turtles on Prudence Island, RI. However, these findings must be interpreted carefully because they are based on only a small number of turtles and only from one area of the island. Further, a limited number of recaptures were obtained for many of the turtles. The small turtle sample size was a limitation inherent to the study; funds were only available to purchase 10 transmitters. One transmitter did not function properly, and two transmitters had to be used on one turtle after the antenna was broken off of the original transmitter. Thus, the sample size was limited to eight turtles.

In most cases, the number of recaptures for each turtle was low. In the case of turtle #6, this was due to predation and loss of the individual, while for turtles #7 and #8 this was due to the later date of initial capture (i.e., August). In other cases, the low number of recaptures was due to frequent difficulty in locating signals due to extremely overgrown vegetation. It was sometimes not possible to reach a turtle even though a signal had been detected due to impenetrable vegetation in the study area. Prudence Island is severely infested with multiple invasive and nuisance native species such as oriental bittersweet, multiflora rose, and green briar. These and other species often made tracking turtles difficult and sometimes impossible, and this compromised the amount of data that was collected. Interestingly, turtles were often found lying directly under these same habitats (dense mats of briar in particular), and did not seem to have their movements inhibited by these conditions.

Box turtle home ranges in this study that were calculated using the K-50 and MCP methods (these two are commonly used in turtle tracking studies) are similar to those reported in other studies for the same or similar species. For example, Kaye et al. (2001) reported average eastern box turtle home ranges in Massachusetts of 3.83 ha (averaged across seven turtles, including males and females), while (Stickel 1989) calculated average home ranges of 1.17 ha for the same species. Nieuwolt (1996) used MCP to calculate home ranges of the western box turtle that averaged 1.64 ha. And (Schwartz and Schwartz 1991) reported that home range size for the three-toed box turtle (*Terrapene c. triuguis*) ranged from 2.2 to 10.6 ha.

The size of an animal's home range depends in part on population density and habitat quality. If density is too high, or if habitat quality is poor, individuals may be forced to move into different

areas, leading to an apparent larger home range. These parameters were not estimated in this study, but since box turtle home ranges on Prudence Island were similar to those from other studies, it can be inferred that box turtle densities and/or habitat quality on Prudence Island are comparable to other locations. The latter surely seems likely (despite the dense understory of nuisance species such as green briar), since southern Prudence Island contains all the habitats that these turtles would need throughout the year including wet forested areas to stay cool in during hot summers and sandy, well-drained forested areas for winter hibernation. The extensive network of roadsides, grasslands, and trails on southern Prudence even seem beneficial for box turtles, which are often observed sunning themselves in these areas in early spring after emerging from hibernation (Raposa and Kutcher, personal observation).

In this study, box turtles may have been opportunistically using habitats in proportion to the area of habitat that was actually available. The exception may have been red maple swamps, which turtles used more frequently than might be expected based on the amount of this habitat in the study area (again, acknowledging the small sample size). The summertime use of this habitat corresponds well with results from other studies (e.g., Klemens 1993; Kaye et al 2001) and illustrates the importance of this habitat for this species. However, this study was not designed to examine box turtle habitat use patterns on a larger scale (i.e., island-wide). Tagging and tracking were specifically conducted in the South Prudence Unit of the Reserve where box turtles were known to be abundant. This area contains large amounts of pine-barrens and red maple swamp habitat, which are two of the major habitat types used by box turtles (Klemens 1993). An expanded study of box turtle habitat use on an island-wide scale would be necessary to determine if turtles are preferentially selecting landscapes that include pine-barren and red maple swamps relative to other landscapes on Prudence Island.

In order to continue to provide important habitat for the eastern box turtle, red maple swamps should be a priority for protection and conservation on Prudence Island. This is important in light of the threat of increasing development on the Island and the subsequent higher anthropogenic demand for freshwater resources, since increased human use of groundwater can lead to draw downs and a reduction of available surface water in wetlands. Surface water levels should also be monitored in red maple swamps on Prudence Island in order to further protect the quality of this important box turtle habitat in perpetuity.

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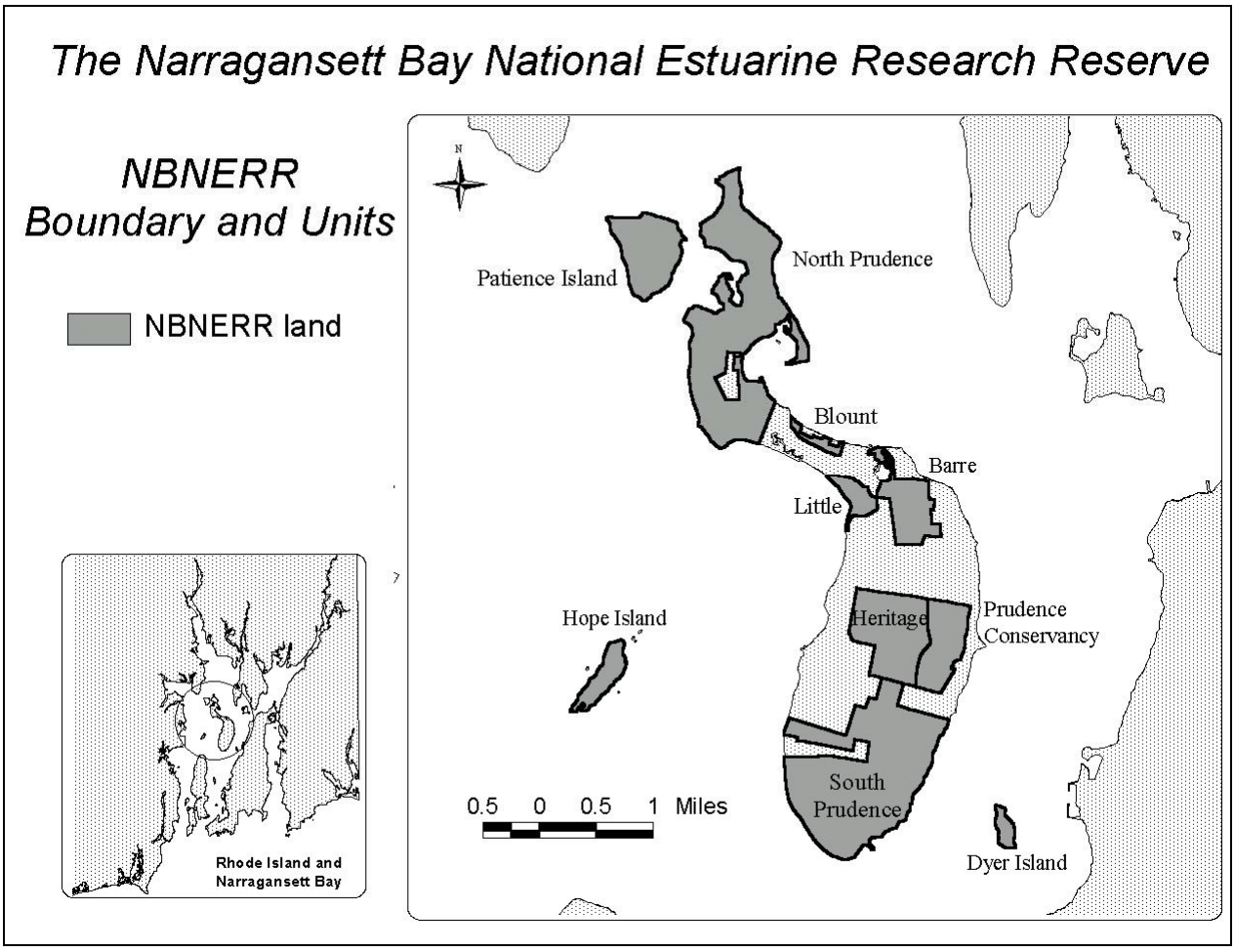

Figure 1. The Narragansett Bay National Estuarine Research Reserve on Prudence Island, RI. This study took place in the South Prudence Unit of the Reserve.

Figure 2. A G3-1V transmitter mounted with epoxy on the carapace of an eastern box turtle on Prudence Island.

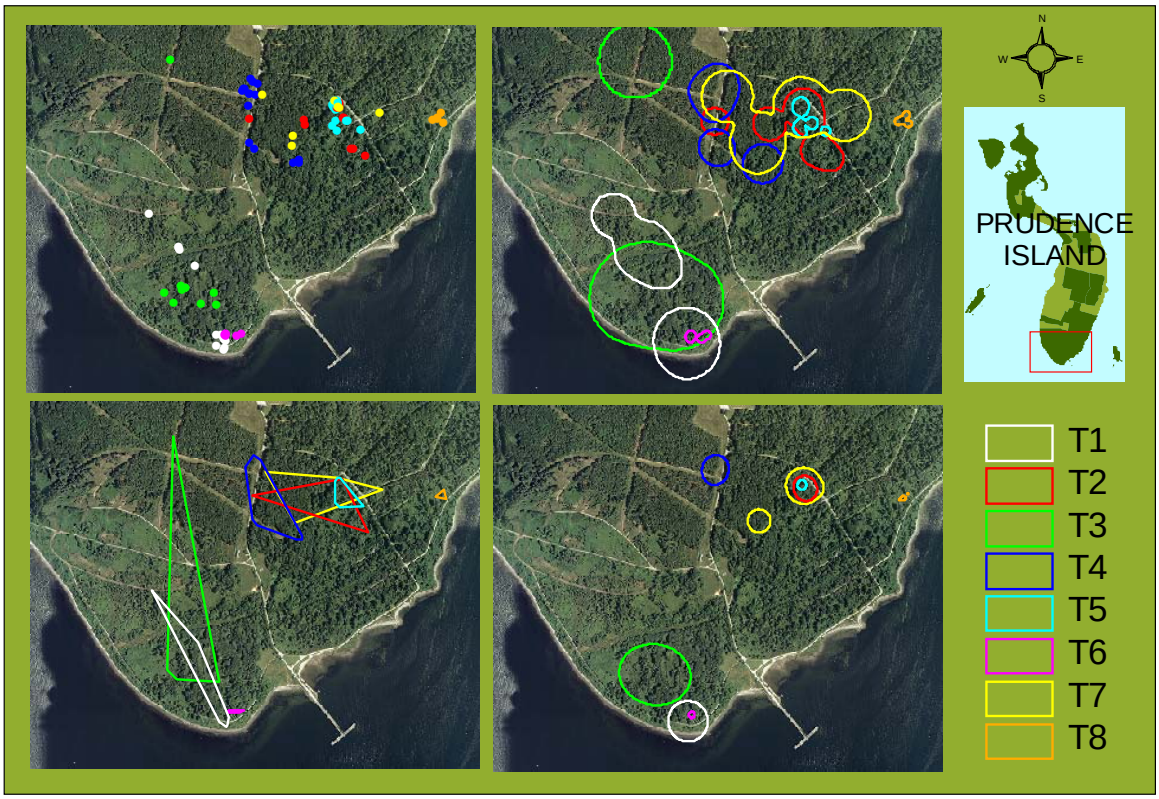

Figure 3. Aerial photographs of the study area on southern Prudence Island. Figures show color-coded home range data for eastern box turtles captured during this study: (clockwise from top left) GPS points, Kernel home range 95% probability, Kernel home range 50% probability, and minimum convex polygon home range.

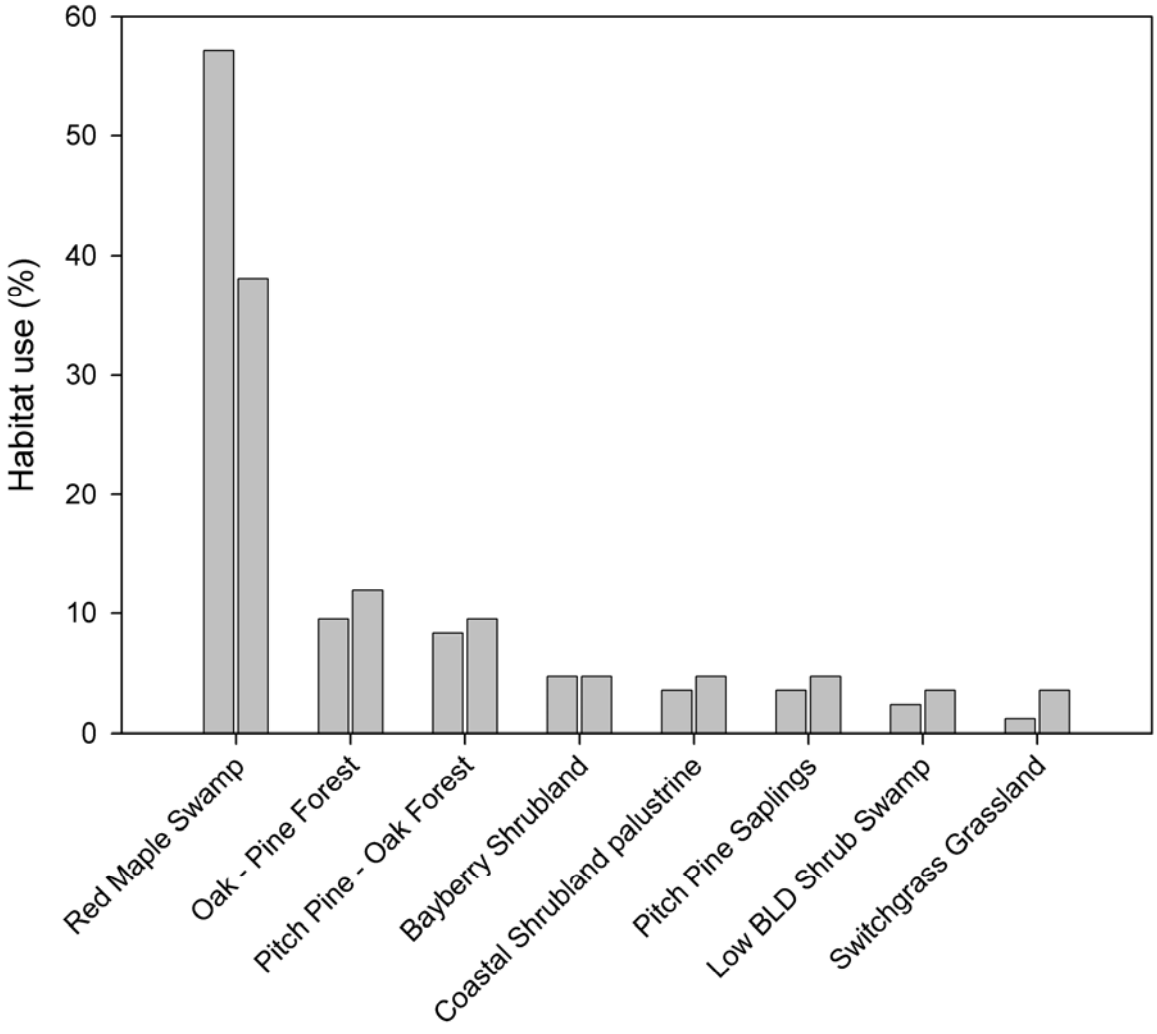

Figure 4. Habitat use patterns of box turtles on Prudence Island. For each habitat type, the left-hand bar indicates the percent of the time actual box turtles were found in this habitat. Right-hand bars indicate the percent of the time random points were located in each habitat. Note that box turtles were found in red maple swamps much more often relative to the random points.

Table 1. Characteristics of the eight eastern box turtles that were captured and tracked during this study.

Turtle #	Sex	Size (SLC, SWC; mm)	Estimated age (yrs)	Date of capture	Number of recaptures	Date of last recapture
1	male	138, 112	15	6.29.05	12	10.19.05
2	female	146, 113	unknown	6.29.05	13	10.07.05
3	female	138, 110	22	6.29.05	8	9.29.05
4	female	127, 109	unknown	7.6.05	14	11.10.05
5	male	149, 119	unknown	7.12.05	18	6.28.06
6	male	157, 126	18	8.22.05	6	10.28.05
7	male	158, 134	26	8.26.05	9	6.28.06
8	male	118, 93	9	8.31.05	4	10.28.05

Table 2. Home ranges of eight eastern box turtles tracked during the study. K-95 and K-50 represent Kernel home range estimates for 0.95 and 0.50 probabilities respectively, while MCP represents minimum convex polygon estimates.

Turtle	Home Range (Ha)		
#	K-50	K-95	MCP
1	1.93	13.20	2.72
2	0.71	6.34	4.03
3	5.22	23.91	9.63
4	0.96	6.89	3.52
5	0.11	0.98	0.72
6	0.05	0.30	0.06
7	2.24	14.43	4.58
8	0.04	0.24	0.06
mean	1.41	8.29	3.17

Table 3. Habitat types where eastern box turtles were located during this study. The hierarchical classification associated with each habitat is derived from Kutcher et al. (2004). Count is the total number of times an individual turtle was found in each habitat (there were 85 total turtle locations). BLD and NLD are broad-leaved deciduous and needle-leaved deciduous habitats, respectively.

System	Subsystem	Class	Subclass	Habitat	Count
Palustrine	Terrestrial	Forested Wetland	BLD	Red Maple Swamp	48
Upland	Upland	Forested Upland	Mixed	Oak - Pine Forest	8
Upland	Upland	Forested Upland	Mixed	Pitch Pine - Oak Forest	7
Upland	Upland	Shrubland	BLD	Bayberry Shrubland	4
Upland	Upland	Shrubland	BLD	Coastal Greenbrier Shrubland	3
Upland	Upland	Shrubland	BLD	Coastal Shrubland	3
Upland	Upland	Saplings and Scrub	NLE	Pitch Pine Saplings	3
Palustrine	Terrestrial	Shrub Wetland	BLD	Low BLD Shrub Swamp	2
Palustrine	Terrestrial	Shrub Wetland	BLD	Tall BLD Shrub Swamp	2
Upland	Upland	Shrubland	BLD	Greenbrier Shrubland	1
Upland	Upland	Forested Upland	BLD	Oak - Red Maple Forest	1
Upland	Upland	Forested Upland	NLE	Pitch Pine Woodland	1
Upland	Upland	Herbaceous Upland	Grassland	Switchgrass Grassland	1
Palustrine	Terrestrial	Shrub Wetland	BLD	Willow Swamp	1