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Home range and habitat preferences of Eastern Box Turtles (*Terrapene carolina* Linnaeus, 1758) in the Piedmont Ecological Province of North Carolina (USA)

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Abstract. The Eastern Box Turtle (*Terrapene carolina*) has a broad geographic distribution in North America. Although relatively common in some portions of its range, it has experienced drastic population declines in others, presumably in large part due to habitat loss and fragmentation. Understanding the relationship between habitat preferences and movement patterns is important to the conservation of this species. We used radio telemetry to obtain information on the habitat preferences and movement patterns of Eastern Box Turtles at three sites in the Piedmont of North Carolina (USA). We summarized the proportion of radio telemetry locations for turtles in various habitats to coarsely assess turtle habitat associations. We also measured turtle habitat preferences by comparing habitat use to availability with compositional analysis. Although compositional analysis did not support preference for specific habitat types, turtles were located more frequently in lowland and upland deciduous hardwood forests. We also estimated turtle home ranges as 100% minimum convex polygons (MCPs), and calculated an average home range size of 2.68 ha, with substantial variation among individuals. Habitat and movement studies of Eastern Box Turtles are not common in the Piedmont and our results add important information to the growing body of literature on these topics.

Keywords. Eastern Box Turtles; *Terrapene carolina*; radio telemetry; habitat preferences; movement patterns

Introduction

The Eastern Box Turtle (*Terrapene carolina*) is native to the midwestern and eastern United States (USA), with a broad historic distribution (Ernst and Lovich, 2009). Although once common throughout much of its range, this species has experienced declines over the last several decades. For example, population declines of 50% (Stickel, 1978) to 75% (Hall, Henry and Bunck, 1999) have been estimated for certain locations. As a result, the Eastern Box Turtle is listed as "vulnerable" by the International Union for the Conservation of Nature and Natural Resources (IUCN; van Dijk, 2010). Several state regulatory agencies in the Northeast (Connecticut, New Hampshire, New Jersey, New York, Massachusetts, and Pennsylvania) and Midwest (Ohio, Indiana, and Michigan) United States have listed it as a species of "Special Concern." It is also considered "Protected" in Rhode Island, and "Endangered" in Maine.

Explanations for observed declines in Eastern Box Turtle populations vary, but are partially related to habitat loss. The species is frequently described as preferring mesic woodlands, yet specific habitat preferences may vary based on season, microhabitat conditions, and time of day (reviewed by Dodd, 2001; Donaldson and Echternact, 2005). Erb et al. (2011) used a geographic information system (GIS) to analyze the landscape-level decrease in suitable habitat for this species in Massachusetts. They estimated that suitable Eastern Box Turtle habitat decreased by 36.8% from 1971 to 1999, a decline that has likely continued.

Rapid loss of suitable habitat for wildlife is often associated with areas of high human populations. For example, the state of North Carolina in the eastern United States is reported to have one of the highest human densities per area and one of the fastest growing human

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populations of any state in the USA (U.S. Census Bureau, 2010). This human population growth and densification has resulted in associated loss of habitat throughout the state as natural landscapes are converted to urban, suburban, and exurban environments. The Piedmont ecological province of the eastern and southern United States is located between the Appalachian Mountain and Atlantic Coastal Plain provinces. This large province extends from Virginia to Alabama, and includes North Carolina. The Piedmont has experienced the most rapid human population growth and natural habitat loss of the three southeastern ecological provinces since the 19th Century (reviewed by Conroy et al., 2003), and is projected to lose more forested land than any region in the southeastern United States (Wear and Greis, 2002). The Eastern Box Turtle occurs throughout the Piedmont province (Palmer and Braswell, 1995; Beane et al., 2010), which makes it vulnerable to the potential habitat alteration that may occur there. Thus, studies focused on the habitat needs of Eastern Box Turtles within this province are important, as they can produce results necessary to mount effective conservation efforts.

Much like habitat requirements, information on the movement patterns of a given species is essential to understanding its ecology. This, in turn, helps elucidate important points regarding its conservation, such as the minimum area required to adequately buffer said species from anthropogenic influences. Data on home ranges (i.e., the area an animal utilizes during its period of activity) are a critical component of an organism's movement patterns and spatial ecology. Several studies focused on the movement patterns of Eastern Box Turtles have estimated home range size (see review by Dodd, 2001; Ernst and Lovich, 2009). Ernst and Lovich (2009) attempted to summarize the data in past studies by averaging all home range sizes reported for female and male turtles in all studies across the species' range. Based on their summary, female turtles have an average home range size of between 0.002 and 19.2 ha, whereas males have an average home range between 0.48 and 14.9 ha. The wide range of estimates by turtle sex may be due to the variety of methods used to estimate home range in the studies Ernst and Lovich (2009) summarized. However, it may also suggest that substantial geographical variation exists in the movement patterns of this species. If true, there is a need for studies that acquire movement data from a wide range of geographic locations.

Although the Eastern Box Turtle receives legal protection in many northeastern states, it is considered common, and not protected, in the southeastern states of Virginia, North Carolina, South Carolina, and Georgia. The Eastern Box Turtle's relatively high abundance in the Southeast makes it a suitable test-subject, yet there remains limited information on its habitat needs and movement patterns in the region (e.g., Budischak et al., 2006; Rossell, Rossell and Patch, 2006; Brisbin et al., 2008; Hester, Price and Dorcas, 2008). This is particularly true in the Piedmont province of the southeastern USA, including North Carolina. Considering the continued habitat loss that is projected to occur in the Piedmont, it is particularly important to study the ecology of this species now, before its numbers in this region decline further. In an effort to address these needs, we tracked Eastern Box Turtles with radio telemetry at three study locations in the Piedmont of North Carolina during 2010 and 2011.

Materials and Methods

Study sites.— We monitored the movements of box turtles at three study locations within the Piedmont province of North Carolina (two in Alamance County and one in Randolph County), USA. The first study site was a 9.83 ha property owned by Elon University (Alamance County), referred to as the "Elon Site." The second study location was an 80.82 ha natural area (also in Alamance County), owned by the Alamance County Recreation and Parks Department, referred to as the "Haw Site" due to its close proximity to the Haw River. Our third location was a 184 ha property (Randolph County) owned by the North Carolina Zoological Society, referred to as the "Zoo Society Site." Radio tracked turtles did not cross the legal property boundaries for any site where they were tracked. Therefore, we estimated study site size and habitat proportions within each study site, using the legal boundaries of ownership as study site boundaries (Table 1).

We assessed the habitat types present on each site via aerial photograph interpretation in a GIS (ArcMap 9.x and 10.x; ESRI, 2011) and subsequent ground-referencing. Each site contained various proportions of mesic upland and lowland deciduous forest, riparian, grassland/old field, edges, and disturbed habitats (Table 1; Figs. 1, 2, and 3). Lowland deciduous forest was comprised of both mesic forest and alluvial forest tree species, such as Ironwood (*Carpinus caroliniana*), Red Maple (*Acer rubrum*), and Sycamore (*Platanus*

Table 1. Habitat composition of the three study sites in the Piedmont of North Carolina as determined by GIS (Alamance and Randolph counties, USA).

Haw Site		
Habitat Type	**Hectares**	**% Area**
Disturbed	0.047	0.06%
Edge	0.465	0.58%
Grassland	3.846	4.75%
Lowland Forest	22.755	28.12%
Riparian	8.409	10.39%
Upland Forest	45.391	56.10%
Total	80.914	100%
Elon Site		
Disturbed	0.627	4.00%
Edge	0.968	6.17%
Grassland	3.845	24.51%
Lowland Forest	2.724	17.36%
Riparian	1.229	7.83%
Upland Forest	6.296	40.13%
Total	15.690	100%
Zoo Society Site		
Disturbed	7.980	4.33%
Edge	0.601	0.33%
Grassland	3.548	1.93%
Lowland Forest	26.919	14.62%
Riparian	6.827	3.71%
Upland Forest	138.235	75.08%
Total	184.111	100%

occidentalis; Spira, 2011). Upland deciduous forest was dominated by oak-hickory communities, which include White Oak (*Quercus alba*), Southern Red Oak (*Q. falcata*), and Mockernut Hickory (*Carya tomentosa*; Spira, 2011). Riparian habitat (terrestrial habitat within 10–15 m of stream banks) was also wooded, with vegetative species similar to those in lowland deciduous forests. We classified "disturbed" habitats as those exposed to intense and repeated management, such as frequent mowing, that are typical of residential lawns. Although old field/grassland habitats in the Piedmont exist due to past disturbance, this habitat at our study sites was not currently influenced by anthropogenic activities (aside from annual mowing). Vegetation within this habitat type was primarily Rough-leaved Goldenrod (*Solidago rugosa*), Meadow Beauty (*Rhexia mariana*), Broomsedge (*Andropogon virginicus*), Ragweed (*Ambrosia artemisifolia*), and Carolina Horsenettle (*Solanum carolinense*). Therefore, we did not consider this type of habitat to be "disturbed" at the same level as areas of manicured home-owner lawns. We defined the habitat existing along the boundaries between forested and grassland habitats as "edge." GIS analyses revealed that the proportion of habitat types associated with each site varied (Table 1).

Radio telemetry.— Radio telemetry was used to track the spatial patterns of box turtles because it can accurately measure home range and habitat selection (McComb, Vesely and Jordan, 2010). At each study location, we opportunistically captured box turtles during visual encounter surveys conducted in spring and summer 2010. Each turtle was weighed (nearest g),

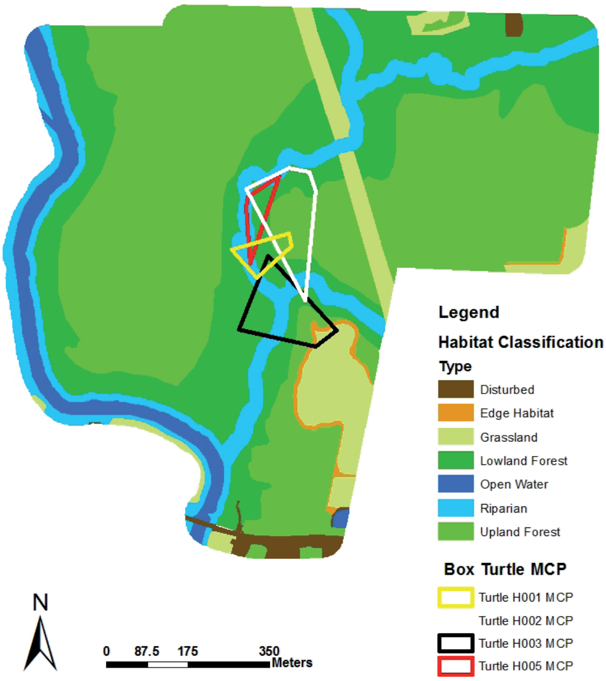

Figure 1. Map depicting delineated habitat types and home ranges (minimum convex polygons; MCPs) of radio-tracked turtles at the "Elon Site" study location (Alamance County, North Carolina, USA).

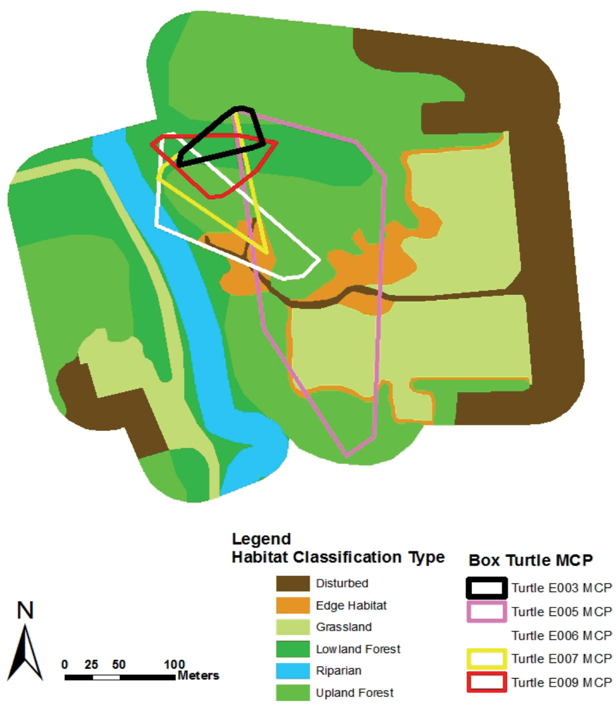

Figure 2. Map depicting delineated habitat types and home ranges (minimum convex polygons; MCPs) of radio-tracked turtles at the "Haw Site" study location (Alamance County, North Carolina, USA).

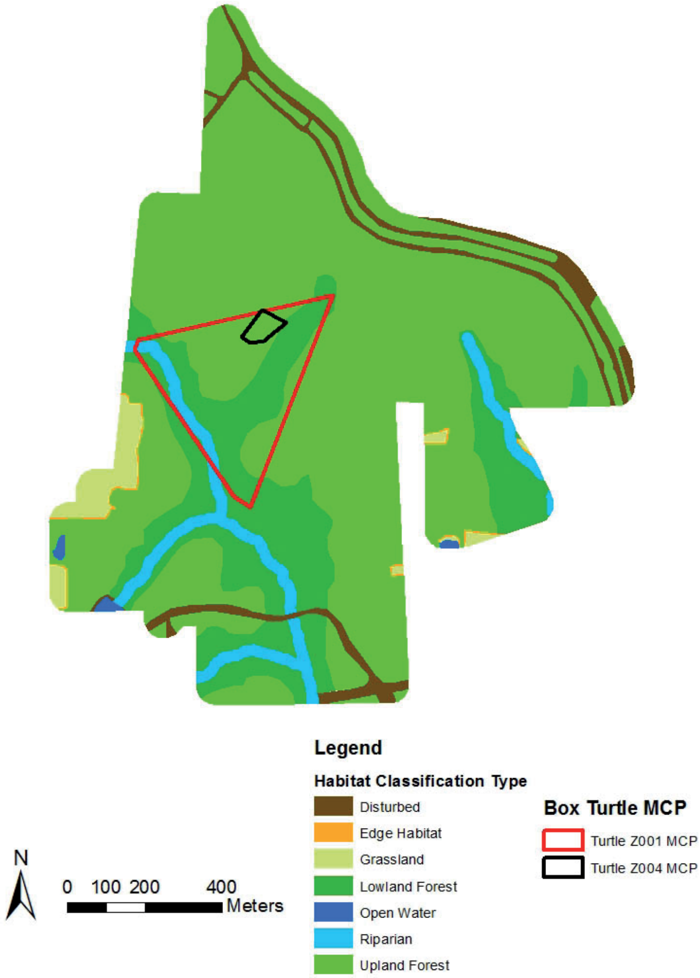

Figure 3. Map depicting delineated habitat types and home ranges (minimum convex polygons; MCPs) of radio-tracked turtles at the "Zoo Society Site" study location (Randolph County, North Carolina, USA).

measured (0.1 cm) and assessed visually to determine sex based on morphological characteristics (plastron concavity and vent position relative to posterior edge of carapace). Although juvenile turtles were observed on a small number of instances, we selected only adult turtles of adequate weight for attachment of radio transmitters (i.e., transmitter weight was < 5% of turtle body weight). We affixed a radio transmitter (RI-2B, Holohil Systems, Ltd, Carp, Ontario, Canada) to the carapace of selected adult turtles with epoxy. A total of 11 box turtles were tracked across all three sites (6 F: 5 M), and the number of turtles tracked per site varied (Zoo Site, n=2; Haw Site, n=4; Elon Site, n=5).

All radio-tagged individuals were located weekly with a Wildlife Materials Inc., TRX-1000S telemetry receiver (Carbondale, Illinois, USA) and a three-pronged Yagi antennae. The decision to track turtles weekly was based on a six-year radio telemetric study of Eastern Box Turtles that is ongoing within this region of North Carolina. This project has also located turtles approximately once per week and found that over time turtles have rarely travelled outside of the home range boundaries established during the first year of tracking (J.D. Groves, unpublished data). Although we made weekly fixes with telemetry equipment during the active season, we only monitored turtles every three to eight weeks during the inactive season (November to March) to determine when emergence from hibernacula occurred. Relocations that occurred during the inactive period were not included when quantifying turtle habitat associations and movement patterns.

On every occasion that a turtle was located with telemetry equipment, we recorded habitat type and precise latitude and longitude location coordinates with a Global Positioning System receiver (GPS; Garmin GPSMap 76C, Olathe, Kansas, USA; Decimal Degrees, World Geodic System 1984). We tracked box turtles from May through November 2010 at the Zoo Society Site (resulting in approximately six months of tracking data collected during the active season). We tracked turtles from July 2010 through July 2011 at the Elon and Haw sites (1 year; although habitat associations and movement patterns were only quantified from 8 months of tracking data collected during the active seasons in each year). The location data acquired for box turtles in the field were then imported into a GIS. For analysis, we converted all GIS data to the State Plane North Carolina Zone coordinate system with a datum of NAD83 and spatial units of meters. We overlaid these data with delineated habitat polygons to determine proportion habitat available and home range analyses.

Summary of habitat preference and estimation of home range size.— We analyzed habitat preferences for turtles at our study sites via Aebischer's compositional analysis (Aebischer, Robertson, and Kenward, 1993; Millspaugh and Marzluff, 2001). This was accomplished by comparing proportional habitat use exhibited by individual radio-tracked box turtles to the habitat available to individual box turtles. Availability was measured in GIS by creating a circular buffer based on a centroid (or geographic center) of all radio-tracked observations for an individual turtle. The radius of the circular buffer was calculated as the distance from the centroid to the farthest radio-tracked location. This helped insure that the buffer included all areas where a turtle was observed and all areas potentially available to an individual based on its movement patterns. It also allowed us to pool comparisons of habitat use vs. availability for turtles across study sites (as opposed to comparing habitat use to habitat availability at the level of the individual study site). Repeated observations of an animal in a known over-wintering location were excluded from habitat analyses. Compositional analyses were conducted in a combination of Microsoft Excel 2007 (Microsoft Corporation, Washington, D.C.) and PASW Statistics 18, Release Version 18.0.0 (O SPSS, Inc., 2009, Chicago, IL,www.spss.com).

We estimated each box turtle's home range as a 100% minimum convex polygon (MCP) by creating polygons with Hawth's Tool extension for ArcGIS (Beyer, 2004) and the Geospatial Modeling Environment (Beyer, 2012). Although kernel density estimation is another commonly employed method for measuring wildlife home ranges (Millspaugh and Marzluff, 2001), it is reported to be unsuitable for home range studies focused on herpetofauna (Row and Blouin-Demers, 2006). We conducted an independent-sample t-test (assuming unequal variances) to compare male and female MCPs across all sites in SPSS v 20.0 (α = 0.05; IBM Corporation, Armonk, NY, USA). We also attempted to compare box turtle MCPs among sites, but due to low sample sizes at the Zoo Society Site, we only statistically compared MCPs for turtles at the Haw and Elon Sites (independent-sample t-test assuming unequal variances, α = 0.05; SPSS v 20.0, IBM Corporation, Armonk, NY, USA).

Results

The number of telemetry fixes per turtle ranged from a minimum of 13 to a maximum of 32 (average = 20.3 fixes/turtle, Table 2) throughout the duration of the study. Compositional analysis did not detect a significant difference in box turtle use of habitats available (Wilks' $\lambda = 0.322$, $F = 2.523$, $P = 0.145$). Yet, this could be due to the fact that we tracked a small number of turtles. Habitats where turtles were most frequently relocated were forested (either upland or lowland deciduous forest; Figure 4). Turtles were least often found in association with disturbed habitats, grasslands, and edges.

The average MCP size across all sites was 2.68 ha (Table 2), while comparisons of MCPs between the Elon Site and Haw Site showed no significant difference in size ($t = -2.002$, df = 7, $P = 0.672$). In addition, average male (4.327 ha; SE = 2.34) and female (1.30 ha; SE = 0.522) MCP sizes did not differ statistically across all sites ($t = -1.257$, df = 4, $P = 0.081$), although male home ranges were slightly larger.

Discussion

Our findings coincide with previous studies that have reported a general association for mesic hardwood forests (Stuart and Miller, 1987; reviewed by Dodd, 2001). Specific associations with lowland mesic deciduous hardwood forest was recorded by Rossell et al. (2006), which indicates that turtles prefer microhabitats with low surface temperature and high humidity. Other studies have found a relationship between environmental conditions (air temperature, surface temperature, humidity) and level of activity (Reagan, 1974; Weiss, 2009). As a result, we expected turtles to be found most

Table 2. 100% Minimum Convex Polygon home range estimates and number of locations for individual Eastern Box Turtles tracked with radio telemetry at each of three sites in the Piedmont of North Carolina (Alamance and Randolph counties), USA. Average (± SD) home range sizes per study site also reported.

Turtle ID	Sex	No. of Locations	Min. Convex Polygon (ha)
Elon 005	Male	20	3.161
Elon 007	Male	29	0.858
Elon 003	Female	17	0.209
Elon 006	Female	15	0.900
Elon 009	Female	13	0.403
Average for this site		18.8	1.106±1.185
Haw 001	Male	32	1.222
Haw 002	Male	25	2.864
Haw 003	Female	30	2.640
Haw 005	Female	16	3.196
Average for this site		25.75	2.48±0.870
Zoo 001	Male	14	13.532
Zoo 004	Female	14	0.503
Average for this site		14	7.017±9.212

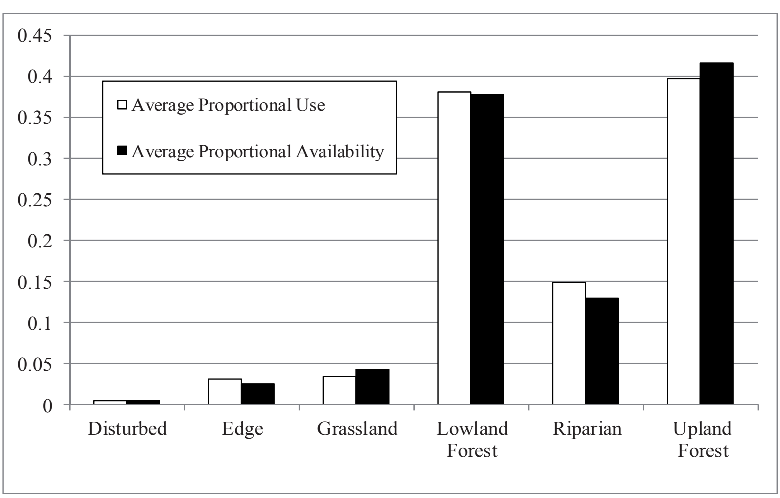

Figure 4. Proportional habitat availability and habitat use by Eastern Box Turtles (*Terrapene carolina*) across three study locations within the Piedmont province of North Carolina, USA.

often in deciduous hardwood forests. We did not find a statistical preference for lowland vs. upland forest, which may have been largely due to the small number of turtles we tracked.

Reagan (1974) reported that a combination of temperature, humidity, and cover dictate the selection of habitat by this species. Further research may help definitively elucidate what these factors are related to (e.g., feeding opportunities, a lack of appropriate woody debris or burrows for cover in riparian corridors, etc.). Given the projected rate at which forested habitat (which this species associates with) will be lost in the region (Wear and Greis, 2002), the threat of extirpation for Eastern Box Turtle populations in the Piedmont will continue to grow. Further research that is able to track a larger number of turtles for a longer period of time than was possible in our study is warranted.

Our MCP estimates are within the range of values proposed as an average among the studies that Ernst and Lovich (2009) reviewed; however, our results differ from other studies focused in the Piedmont of North Carolina. For example, Hester, Price, and Dorcas (2008) report an average MCP size of 6.424 ha for non-translocated Eastern Box Turtles, which is much larger than average MCP size calculated during our study. In addition, similar telemetry studies conducted on Eastern Box Turtles from several geographic locations report variation in average areas of activity. An average MCP size of 0.38 ha was estimated for Eastern Box Turtles in Tennessee, USA (Davis, 1981), which is much smaller than our findings. On the other hand an average MCP estimate of 4.05 ha in New York, USA (Madden, 1975) and an average "established activity range" of 2.0 ha for three females in an urban park (Ferebee and Henry, 2008) are similar to our findings.

We were not able to detect a difference in home range size based on turtle sex, and were also not able to detect differences in home range size between turtles at a very large undisturbed site and a smaller, more disturbed site. These results imply that home range sizes of the Eastern Box Turtles we tracked were not significantly influenced by sex or the amount of suitable habitat available within the our specific study locations. However, it appears that substantial individual variation exists in home range size (Table 2), and it is likely that our sample sizes are too small to detect differences. Past studies on Ornate Box Turtles (*Terrapene ornata*) revealed that individuals in highly fragmented landscapes have larger home ranges than individuals in larger contiguous habitat patches (Curtin, 1997). In contrast, research on Eastern Box Turtles in Delaware and Massachusetts revealed that movements actually decreased with degree of urbanization or fragmentation (Iglay, Bowman and Nazdrowicz, 2007; Willey, 2010).

There may also be sex-specific factors that influence movement patterns. For example, Stickel (1950) reported that females will make forays outside of their normal home range to deposit eggs. It is also possible that males will make forays in search of females during the mating season. We observed several occasions where individuals undertook large bouts of movement. However, we were not able to definitively correlate these movements with mating or nesting, as we did not observe these behaviors during our study. In some cases, turtles we tracked undertook large bouts of movements repeatedly to the same general locations, suggesting they were patrolling their normal home range. In one example, an individual made a long-distance movement late in the season to an over-wintering location (see Turtle E005, Fig. 2; Table 2). Overwintering sites for all other turtles that we tracked were within their normal home ranges.

Our results provide additional important information regarding the habitat needs and spatial ecology of this species, particularly for the Piedmont region, which is experiencing rapid human population growth and concomitant habitat loss (see also Brisbin et al., 2008). This information may be helpful as a baseline, which can be built upon by future researchers. These data can also help guide the design of conservation strategies for this species that require information about habitat and spatial needs. For example, protection of woodland habitat appears to be important for the persistence of Eastern Box Turtles. Our results and review of past literature also reveal that the spatial requirements for Eastern Box Turtles show considerable individual variation. Efforts to conserve this species, particularly in regards to the size of land parcels necessary to support individuals, must consider this variation. To make conservative estimates of required area may necessitate that movement data from the most mobile individual turtles in past studies dictate the size of land parcels to protect. However, as suggested by Dodd (2001), long-term studies that incorporate larger sample sizes are necessary to more thoroughly investigate the habitat preferences and movement patterns of Eastern Box Turtles in this region of the southeastern USA.

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References

Aebischer, N.J, Robertson, P.A., Kenward, R.E. (1993): Compositional analysis of habitat use from animal radio-tracking data. Ecology **74**:1313–1325.

Beane, J.C., Braswell, A.L., Mitchell, J.C., Palmer, W.M., Harrison III, J.R. (2010): Amphibians and Reptiles of the Carolinas and Virginia, 2nd Edition. Chapel Hill, University of North Carolina Press.

Beyer, H.L. (2004): Hawth's Analysis Tools for ArcGIS. Available at: http://www.spatialecology.com/. Last accessed 15 August 2011.

Beyer, H.L. (2012): Geospatial Modeling Environment (Version 0.7.2.0). Available at: http://www.spatialecology.com/gme. Last accessed 10 December 2012.

Brisbin Jr., I.L., Kennamer, R.A., Peters, E.L., Karapatakis, D.J. (2008): A long-term study of Eastern Box Turtles (*Terrapene c. carolina*) in a suburban Neighborhood: survival characteristics and interactions with human and conspecifics. In: Urban Herpetology, p. 373-385. Mitchell, J.C., Jung Brown, R.E., Bartholomew, B., Eds., Herpetological Conservation No. 3. Published by the Society for the Study of Amphibians and Reptiles.

Budischak, S.A., Hester, J.M., Price, S.J., Dorcas, M.E. (2006): Natural history of *Terrapene carolina* (box turtles) in an urbanized landscape. Southeastern Naturalist **5**:191–204.

Conroy, M.J., Allen, J C.R., Peterson, T., Pritchard Jr. L., Moore, C.T. (2003): Landscape change in the southern Piedmont: challenges, solutions and uncertainty across scales. Conservation Ecology **8**:3.

Curtin, C.G. (1997): Biophysical analysis of the impact of shifting land use on ornate box turtles, Wisconsin, USA. In: Proceedings: Conservation, Restorations, and Management of Tortoises and Turtles, p. 31–36, Van Abbema, J., Ed., New York, New York Turtle and Tortoise Society.

Davis, M. (1981): Aspects of the social and spatial experience of eastern box turtles, *Terrapene carolina carolina*. Ph.D. Dissertation, University of Tennessee, Knoxville, Tennessee, USA.

Dodd, C.K. (2001): North American Box Turtles: A Natural History. Norman, University of Oklahoma Press.

Donaldson, B.M., Echternacht, A.C. (2005): Aquatic habitat use relative to home range and seasonal movement of Eastern Box Turtles (*Terrapene carolina carolina*: Emydidae) in eastern Tennessee. Journal of Herpetology **39**:278–284.

Erb, L., Willey, L., Buckley, J., French, T., Haggerty, S., Jones, M., Regosin, J., Woolsey, H. (2011): Eastern box turtle conservation plan for Massachusetts. Prepared for the Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program. 227 p.

Ernst, C.H., Lovich, J.E. (2009): Turtle of the United States and Canada. Baltimore, John Hopkins University Press.

ESRI (2011): ArcGIS, version 9.3. Environmental Systems Research Institute, Redlands, CA.

Ferebee, K.B., Henry, P.F.P. (2008): Movements and distribution of *Terrapene carolina* in a large urban area, Rock Creek National Park, Washington, D.C.. In: Urban Herpetology, p. 365-373. Mitchell, J.C., Jung Brown, R.E., Bartholomew, B., Eds., Herpetological Conservation Circular No. 3. Published by the Society for the Study of Amphibians and Reptiles.

Hall, R.J., Henry, P.F.P., Bunck, C.M. (1999): Fifty-year trends in a box turtle population in Maryland. Biological Conservation **88**:165–172.

Hester, J.M., Price, S.J., Dorcas, M.E. (2008): Effects of relocation on movements and home ranges of Eastern Box Turtles. The Journal of Wildlife Management **72**:772–777.

Iglay, R.B., Bowman, J.L., Nazdrowicz, N.H. (2007): Eastern Box Turtle (*Terrapene carolina carolina*) movements in a fragmented landscape. Journal of Herpetology **41**:102–106.

Madden, R. (1975): Home range, movements, and orientation in the eastern box turtle, *Terrapene carolina carolina*. Unpublished PhD dissertation, The City University, New York, New York, USA. 217 pp.

McComb, B., Vesely, D., Jordan, C. (2010): Monitoring Animal Populations and Their Habitats: A Practitioner's Guide. CRC Press, Boca Raton.

Millspaugh, J.J., Marzluff, J.M. (2001): Radio Tracking and Animal Populations.
Academic Press, New York.

Palmer, W.M., Braswell, A.L. (1995): Reptiles of North Carolina. University of North Carolina Press, Chapel Hill.

Reagan, D.P. (1974): Habitat selection in the three-toed box turtle, *Terrapene carolina triunguis*. Copeia **1974**:512–526.

Rossell, Jr., C.R., Rossell, I.M., Patch, S. (2006): Microhabitat selection by eastern box turtles (*Terrapene c. carolina*) in a North Carolina mountain wetland. Journal of Herpetology **40**:280–284.

Row, J.R., Blouin-Demers, G. (2006): Kernels are not accurate estimators of home-range size for herpetofauna. Copeia **2006**:797–802.

Spira, T.P. (2011): Wildflowers and Plant Communities of the Southern Appalachian Mountains
and Piedmont. University of North Carolina Press, Chapel Hill, North Carolina, USA.

Stickel, L.F. (1978): Changes in a box turtle population during three decades. Copeia **1978**:221–225.

Stickel, L.F. (1950): Population and home range relationships of the box turtle, *Terrapene c. carolina* (Linnaeus). Ecological Monographs **20**:351-378.

Stuart, M.D., Miller, G.C. (1987): The eastern box turtle, *Terrapene c. carolina* (Testudines: Emydidae), in North Carolina. Brimleyana **13**:123–131.

U.S. Census Bureau. (2010): Estimates of resident population change for the United States, Regions, States and Puerto Rico and Region State Rankings: 1 July 2008 to 1 July 1 2009. Available at: http://www.census.gov/popest/states/NST-pop-chg.html. Last accessed on 27 June 2011.

van Dijk, P.P. (2010): *Terrapene carolina*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. Available at: www.iucnredlist.org/apps/redlist/details/21641/0. Last accessed on 23 July 2011.

Wear, D.N., Greis, J.G. (2002): The Southern Forest Resource Assessment. U.S. Forest Service, Asheville, North Carolina.

Weiss, J.A. (2009): Demographics, activity, and habitat selection of the eastern box turtle (*Terrapene c. carolina*) in West Virginia. Unpublished M.Sc. thesis, Marshall University, West Virginia.

Willey, L. (2010): Spatial ecology of eastern box turtles (*Terrapene c. carolina*) in central Massachusetts. Unpublished PhD dissertation, University of Massachusetts, Amherst, Massachusetts.

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