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Movement Patterns in Resident and Translocated Three-Toed Box Turtles (Terrapene Carolina Triunguis)

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MOVEMENT PATTERNS IN RESIDENT AND TRANSLOCATED THREE-TOED BOX TURTLES (*TERRAPENE CAROLINA TRIUNGUIS*)

by

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Abstract

MOVEMENT PATTERNS IN RESIDENT AND TRANSLOCATED THREE-TOED BOX TURTLES (*TERRAPENE CAROLINA TRIUNGUIS)*

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Wildlife relocations, repatriations, and translocations (RRTs) are strategies that are often used for by conservation managers as a method of reestablishing viable animal populations. The effectiveness of RRT studies has been called into question by some researchers, but more data are needed on the strategy to fully understand its utility. I compared the movement patterns, home range sizes, and body condition between a group of resident and translocated adult three-toed box turtles (*Terrapene carolina triunguis*). Each turtle from both groups was radio-tracked at least 2-3 times per month except during the winter months. Minimum convex polygons home range sizes estimated with Geographic Information System (GIS) showed no statistical difference between resident (7.89 ± 9.17 ha) and translocated (14.22 ± 7.13 ha) groups (t = 1.43, df = 10, P = 0.18). Similarly, no statistical difference was seen in mean distance moved (t = 0.27, df = 10, P =

0.79), or maximum distance moved (t = 01.0, df = 10, P = 0.34) between the two groups. After eighteen months of radio-tracking none of the translocated turtles left the study site. These results suggest that translocation may be a viable conservation strategy for three-toed box turtles.

Chapter One

Introduction:

Box Turtles:

Box turtles are members of the Order Testudines and are placed in the Emydidae family. While emydids are typically aquatic pond and marsh turtles, box turtles are primarily terrestrial turtles. Box turtles can be distinguished from other emydids by several morphological features including a high domed, bony box-like shell with a movable hinge and the absence or degeneration of cloacal bursae, which allow for underwater respiration (Dodd, 2001). There are four extant species of box turtle that are currently recognized (DeQueiroz, 1997, Dodd, 2001).

The Eastern box turtle, *Terrapene carolina* includes six extant subspecies: 1) *T. c. carolina,* the Eastern box turtle (Linnaeus, 1859), 2) *T. c. bauri*, the Florida box turtle (Taylor, 1895), 3) *T. c. major,* the Gulf Coast box turtle (Agassiz, 1857), 4) *T. c. mexicana,* the Mexican box turtle (Gray, 1864), 5) *T. c. yucatana,* the Yucatan box turtle (Boulenger, 1895), and 6) *T. c. triunguis*, the three-toed box turtle (Agassiz, 1857). A seventh subspecies of *T. carolina* is known (i.e., the giant box turtle, *T. c. putnami*, (Hay, 1906) but is believed to be extinct. The Western box turtle, *Terrapene ornata,* includes two sub-species: 1) *T. o. ornata*, the ornate box turtle and 2) *T. o. luteola,* the desert box turtle (Smith and Ramsey, 1952). The third and fourth extant species are *T. coahuila,* the Coahuilan box turtle (Schmidt and Owens, 1944), and *T. nelsoni,* the spotted box turtle (Stejneger, 1925). The focus of the research described herein will be on a subspecies of *T. carolina,* namely the three-toed box turtle, *T. c. triunguis*.

Terrapene carolina has the widest range of all the box turtle species, being found from southern Maine south to the Florida Keys on the east coast and then west to Michigan, Illinois, eastern Kansas, Oklahoma and Texas. At its western range limit it can be found as far south as the Mexican states of Campeche, Quintana Roo, San Luis Potosi, Tamaulipas, Vera Cruz, and Yucatan in Mexico. *Terrapene carolina* also occurs in isolated localities in New York and western Kansas (Ernst and Lovich, 2009). *Terrapene carolina* is a long-lived species averaging 40-50 years, although there are records of box turtles living up to 86 years (Klemens, 1993). *Terrapene carolina* is an omnivorous species consuming invertebrates, fruits, seeds, fungi and small vertebrates and are known to be agents of seed dispersal (Braun and Brooks Jr., 1987). *Terrapene carolina* prefer mesic woodlands with closed canopy but often venture into pastures and riparian zones (Dodd, 2001, Ernst and Lovich, 2009). Hatchling and juvenile classes are not readily found in the wild due to their cryptic nature (Rispin, 2003, Bolanowski, 2005).

Box turtle populations of all species and subspecies have declined dramatically over the past several decades. In one study, 50% reduction in estimated population size of Eastern box turtles was recorded over 13 years due to habitat destruction and over-collecting (Williams and Parker, 1987). Stickel reported a similar reduction after 30 years, and found a decline of more than 75% over 40 years (Stickel, 1978, Hall et al., 1999). All American box turtles are currently listed on CITES Appendix II. Despite this protection, populations are continuing to decline and they are becoming threatened/endangered in many areas.

Chelonian Decline:

Habitat loss and fragmentation, predation, invasive species, disease and over-harvesting for the pet trade play a significant role in chelonian decline including box turtle decline with box turtle populations decreasing dramatically over the past several decades (Behler, 1993, Gibbons et al., 2000, Seigel and Dodd, 2000, Dodd, 2001, Ernst and Lovich, 2009). The 2011 International Union for Conservation of Nature (IUCN) Red List classifies *T. carolina* as Vulnerable, *T. ornata* as Near Threatened, *T. coahuila* as Endangered with a Very High Risk of Extinction, and *T. nelsoni* as Data Deficient (although it was listed as Threatened on the 2006 Red List). In the United States the various subspecies of *T. carolina* and *T. ornata* are listed as Species of Special Concern in NH, CT, MI, TX, and MA, Protected in IN, and State Endangered in ME, WI, IL.

There are currently 328 recognized extant species of turtles in the world. Approximately half this number are facing extinction (Rhodin et al., 2011). The decline of turtles is a relatively recent issue first noted in the latter half of the twentieth century (Behler, 1993, Gibbons et al., 2000, Klemens, 2000). Largely influenced by anthropogenic effects but also from natural ones, chelonian decline has been documented on every continent where turtles occur. Distinguishing between natural causes of decline and the impact humans have on turtle populations is not always clear.

The most serious problems impacting box turtle survival include habitat loss attributed to the clear cutting of forests and development of suitable habitat, habitat fragmentation caused by road construction and other corridors, increasing numbers of subsidized predators that prey on box turtle eggs, hatchling and the juvenile classes, the introduction of disease and over collection for the pet trade.

Habitat loss, habitat fragmentation and habitat degradation have had a significant negative impact on turtle populations (Ernst and Lovich, 2009). In fact, It has been suggested that 23% of the tortoise species, 32% of the freshwater turtle species, and most sea turtle species are negatively affected somewhere in their range by a subsidized predator and or predation (Swingland and Klemens, 1989, Ernst and Lovich, 2009). Introduction of disease is another factor affecting chelonian decline, and can be observed in turtle populations worldwide (Ernst and Lovich, 2009). Diseases such as Upper Respiratory Tract Disease (URTD) and Iridovirus have been diagnosed in many turtle species including box turtles (Feldman et al., 2006, Johnson et al., 2009). The pet trade may have the greatest impact on Chelonian decline (Behler, 1993). It has been estimated that over 100,000 *Terrapene* were exported for pets between 1986 and 1993 (Dodd, 2001). One conservation-based method employed in assessing the health of turtle populations is the use of, relocation, repatriation and translocation (RRT's).

RRTs:

RRTs, are tools used by researchers as conservation measures to address population decline. The objective of RRTs is to establish, reestablish or augment a population so that it can sustain itself (Reinert, 1991). The definition of RRT varies by author (Griffith et al., 1989, Dodd and Seigel, 1991, Reinert, 1991). Reinert (1991) advocates the standardization of the terminology associated with RRTs. He suggests following Dodd's definition for relocation as the movement of animals out of harm's way, preferably to an area of suitable habitat Dodd (2001). Reinert defines repatriation as the intentional release of individuals of a species into an area formerly occupied by that species (Reinert, 1991). Reinert suggests that repatriation is a specific type of translocation, which he and other researchers define as the release of individuals of a species in a location different from their place of origin.

Advocates of RRTs suggest that they are useful methods in combating wildlife decline (Griffith et al., 1989, Burke, 1991, Trenham and Marsh, 2002, Cook, 2004) but are not ideal solutions. Burke argues that researchers must take a broader view of success with regard to RRT studies. He points out that it depends on how success is defined and what parameters are being used to define success (Burke, 1991).

It has been suggested by Griffith et al. (1989), that RRT success varies between taxa in different trophic levels, and that the age of animals when they are relocated is important. Translocations can be deemed successful if they result in self-sustaining populations (Griffith et al., 1989). Native game species were more likely to be successfully translocated then were threatened, endangered, or sensitive species. Increased habitat quality was associated with greater success. Translocations into the center of species geographical ranges were more successful then were those on the periphery of ranges (Griffith et al., 1989).

A number of box turtle translocations have been reported as being successful. One short term radio-tracking study conducted in Wisconsin determined there was no significant difference in dispersal distance between box turtles *T. ornata*, released in June verses August (Hatch, 1996). The average home-range size for June and August released individuals was determined to be 2.6 ha (Hatch, 1996). Another study conducted in Brooklyn, NY found a 71.8% survival rate for translocated turtles, and that the reproductive output was comparable to wild populations of *T. carolina* (Cook, 2004). Cook found of the 53 radio-tagged *Terrapene*, 25 (47.2%) established home ranges, 13 (24.6%) left the study site Floyd Bennett field, and 15 (28.3%) died before establishing a home range or leaving the site.

A study in Missouri suggests that average distance moved and total distance moved did not differ between years for translocated turtles (Rittenhouse et al., 2007). It was concluded that adult three-toed box turtles (*T. c. triunguis*) translocated from a continuously forested area to a highly fragmented site had increased movement distances and home-range sizes compared to resident turtles. (Rittenhouse et al., 2007). To evaluate the effects of relocation home-range size, movement patterns, bearing and survivorship, twenty Eastern box

Turtles were radio-tracked for one year between May 2004 and June 2005 at Davidson College Ecological Preserve (DCEP) (89 ha) in Mecklenburg County NC (Hester et al., 2008). They concluded relocated box turtles had average home ranges approximately three times larger than resident turtles. There was no difference in distance moved between both cohorts. Relocated turtles moved on average 9.38 m more per day than residents, however there was no difference in average movement per day in any given month between both groups (Hester et al., 2008). One relocated turtle returned to its original home range and another made it half way back before being depredated. Another study conducted in Whitehouse, TX concluded that acclimation had little effect on site-acceptance regardless of release treatment or sex in *T. c. triunguis* and no difference in home range size was found for either cohort (Keyes, 2007).

Detractors of RRTs argue that they are "halfway technologies" because they don't address all the issues associated with manipulating a population (Seigel and Dodd, 2000). In other words, RRTs address the symptoms of population decline rather than its causes. Introducing individuals into a population raises concerns related to introduction of disease, changing the genetic structure of the resident population and outbreeding depression (Dodd, 2001). Dodd and Seigel have suggested that in the case of reptile and amphibian translocations, they are unable to find any examples of successful RRTs (Dodd and Seigel, 1991). Dodd and Seigel define success as being measured in the long-term and that many studies prematurely claim success.

Two Texas-based studies with hatchling and juvenile three-toed box turtles ended prematurely due to predation by subsidized predators. In the first study, a 100% mortality rate was observed after 14 weeks because of predation from raccoons (Rispin, 2003). In the second, 100% mortality was reported because of predation presumably by raccoons after 14 months (Bolanowski, 2005).

Objectives:

To determine or further solidify if RRTs could be viable conservation methods for re-establishing box turtle populations within their specific ranges and habitats, I monitored the movement patterns and condition of a cohort of resident and translocated adult three-toed box turtles (*T. c.* triunguis). Based on the results of Keyes (2007), who conducted his research at the same study site with the same subspecies, I hypothesize that we will not see differences between resident and translocated cohorts. This will be important information for conservation managers addressing issues related to box turtle conservation.

Chapter 2

Materials and Methods:

Study Animals:

Five resident box turtles were collected from the study site and five translocated box turtles were obtained from various locations in the East Texas area with two obtained from a pet owner in Flowermound, Texas (Figure 1; Table 1). All turtles were weighed and morphometric measurements (e.g., plastron length, carapace length, carapace width and body weight) were recorded both at the start and end of the study, which allowed me to calculate and compare body condition (mass/length) between the two groups at both time periods (Table 2.). Turtles were marked by engraving a unique alphanumeric combination on the carapace with a Dremel 290 engraver (Dremel, Racine, WI). Each individual was outfitted with a radio transmitter and tracked at least two to three times per month except during the winter months, December through March when all turtles were buried in burrows. During the winter months, turtles were tracked once per month to see if they moved a short distance. Hand-built transmitters were obtained from Blackburn and Associates, Nacogdoches, TX weighing approximately 3.6 g with a battery life of approximately two years. Transmitters were attached on the highest point of the carapace with camouflage duct tape, and wrapped around the carapace posterior to the hinge so as to not impede closing of the carapace. The transmitter's 15 cm antenna trailed behind the carapace. Weight additions attributed to the transmitter package did not exceed the recommended 7% of the turtle’s body weight (Eckler et al., 1990).

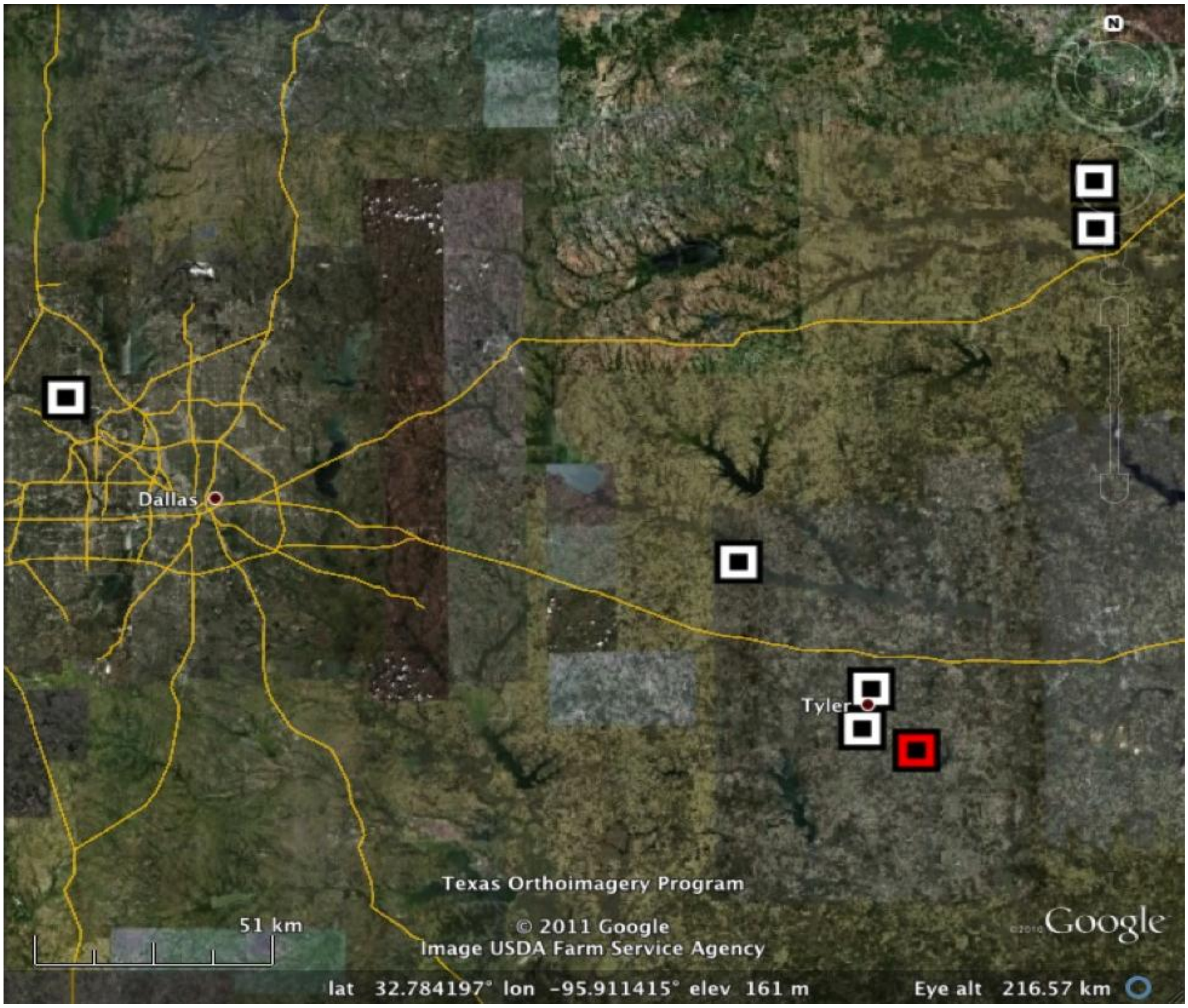

Figure 1. Translocated three-toed box turtle (*Terrapene carolina triunguis*) capture points within the state of Texas. Red square represents box turtles release point; white squares represent box turtle capture points.

TABLE 1. Capture points and date of acquisition of translocated *Terrapene carolina triunguis.*

Turtle	Location Caught	Capture Point Decimal Degrees
T101	Obtained from Flowermound TX in October of 2008.	33.070261 -97.049000
T104	Obtained from Flowermound TX on 5/23/09.	33.070261 -97.049000
T106	Stand of woods behind Chili's. Loop 323 & Brookside Dr. Tyler TX. Date unknown.	32.305806 -95.307797
T107	Found at HWY 14 & Loop 323 Tyler, TX on 6/4/09 late morning.	32.389786 -95.286042
T108	Obtained on 6/7/09 @ 9:45h.	32.663433 -95.580417
T109	Obtained on 6/10/09. 1 min N. of Sulfur River; Rt.44 & 7 miles E. of Boxelda	33.461333 -94.776533
T110	Obtained on 6/10/09 while crossing CR4315 ~ 7mi W. of HWY 259. ~ 4 min N. of Sulfur River.	33.360133 -94.747417

TABLE 2. Body condition (mass/length) for resident and translocated three-toed box turtles (*Terrapene carolina triunguis*) at start and end of translocation study with difference between times noted. "N/A" indicating a turtle was lost during the course of the study.

Turtle ID	**Initial Body Condition**	**Final Body Condition**	**Difference**
R18	2.1	2.1	0
R102	2.3	N/A	N/A
R103	2.4	2.6	0.2
R105	2.8	N/A	N/A
R111	3.5	3.5	0
T101	3.4	3.4	0
T104	3.6	N/A	N/A
T106	3.6	3.7	0.1
T107	2.1	N/A	N/A
T108	2.8	2.8	0
T109	4.2	4.1	-0.1
T110	2.9	2.9	0

Study Site:

Turtles were released into a 340-hectare study site, Camp Tyler (Figure 2). Camp Tyler is an outdoor school owned and operated by the Camp Tyler Foundation of Tyler, Texas. Camp Tyler is located on a peninsula extending to a 921-hectare lake, Lake Tyler, in the Piney woods ecoregion of East Texas. Pastureland comprises approximately 50 ha of the study site. The remaining area is mixed forest comprised of mostly secondary growth with low-level canopy. The forest floor consists of leaf litter, fallen trees, and dense understory vegetation. Dominant vegetation of the site includes but is not limited to American beauty-berry *(Callicarpa americana)*, American sweetgum *(Liquidambar styraciflua)*, bayberry wax-myrtle *(Myrica pensylvanica)*, Carolina cherry-laurel *(Prunus caroliniana)*, cat greenbrier *(Smilax glauca*), common greenbrier *(Smilax rotundiofolia)*, common sassafras *(Sassafras albidum)*, Eastern redbud (*Cercis canadensis)*, Eastern red-cedar *(Juniperus virginiana)*, farkleberry *(Vaccinium arboretum)*, flowering dogwood *Cornus florida)*, Japanese honeysuckle *Lonicera japonica)*, laurel greenbrier *(Smilax laurifolia)*, mockernut hickory *(Carya tomentosea)*, muscadine grape *(Vitis rotundifolia)*, mustang grape *(Vitis mustangensis),* pignut hickory *(Carya glabra)*, poison ivy *(Toxicodendron radicans)*, post oak grape *(Vitis aestivalis)*, rust blackshaw viburnum *(Viburnum rufidulum)*, saw greenbrier *(Smilax bona-nox)*, shortleaf pine *(Pinus echinata)*, slash pine *(Pinus elliotii)*, Southern wax-myrtle *(Myrica cerifera)*, Virginia creeper *(Parthenocissus quinquefolia)*, winged elm *(Ulmus alata)*, wooly American hophornbeam *(Ostrya virginiana)*, and yaupon holly *(Ilex vomitoria)* Bolanowski (2005).

Figure 2. Aerial photographic map of Camp Tyler showing roads forest, pastureland and a portion of Lake Tyler.

Movements and Tracking:

All translocated turtles were released in the study site at (32.257767, -95.186233). Radio-tracking was accomplished with a Telonics TR-5 receiver (Telonics Co., AZ) and a five-element Yagi antenna (AF Antronics Inc., Urbana

II). Once visually located, a turtles geographic coordinates were determined with a Garmin Etrex Vista HCX Positioning System (GPS) unit (Garmin, Olathe, KS). Turtles that did not move from their prior position were recorded at the location of the previous encounter.

Analysis:

ArcView GIS software version 9.2 (ESRI, 380 New York Street, Redlands, CA 92373-8100) was used to calculate linear distance moved, maximum distance moved and mean distance moved. Microsoft Excel (Microsoft Inc., Redmond, WA) was used to compare home range sizes and distances moved using two sample *t*-tests. Maps of turtle movement patterns were created using Google Earth 6.0.3 (Google Inc. Mountainview. CA).

Chapter 3

Results

Distance moved and home ranges:

Data are represented in x□ ± 95% CI throughout. Mean distance traveled did not differ between resident (11.0 ± 5.77 m^2) and translocated (10.73 ± 3.1 m^2) turtles (t = 0.27, df = 10, P = 0.79; Figure 3). Similarly maximum distance traveled also did not differ between resident (188.85 ± 174.30 m^2) and translocated (130.10± 57.0 m^2) turtles (t = 01.0, df = 10, P = 0.34; Figure 4). In terms of the area that each of the two groups utilized there was again, no significant difference in home range size between resident (7.89 ± 9.17 ha) and translocated (14.22 ± 7.13 ha) turtles (t = 1.43, df = 10, P = 0.18; Figure 5; Appendix A, Figures 8 -19).

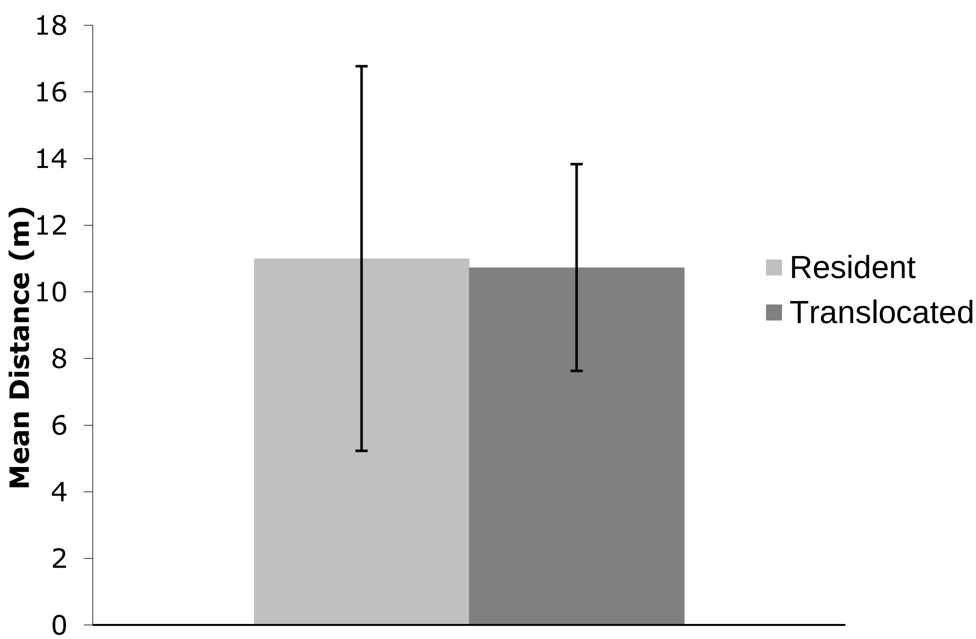

Figure 3. Mean distance traveled (m) ± 95% CI by resident and translocated three-toed box turtles (*Terrapene carolina triunguis*) at Camp Tyler,

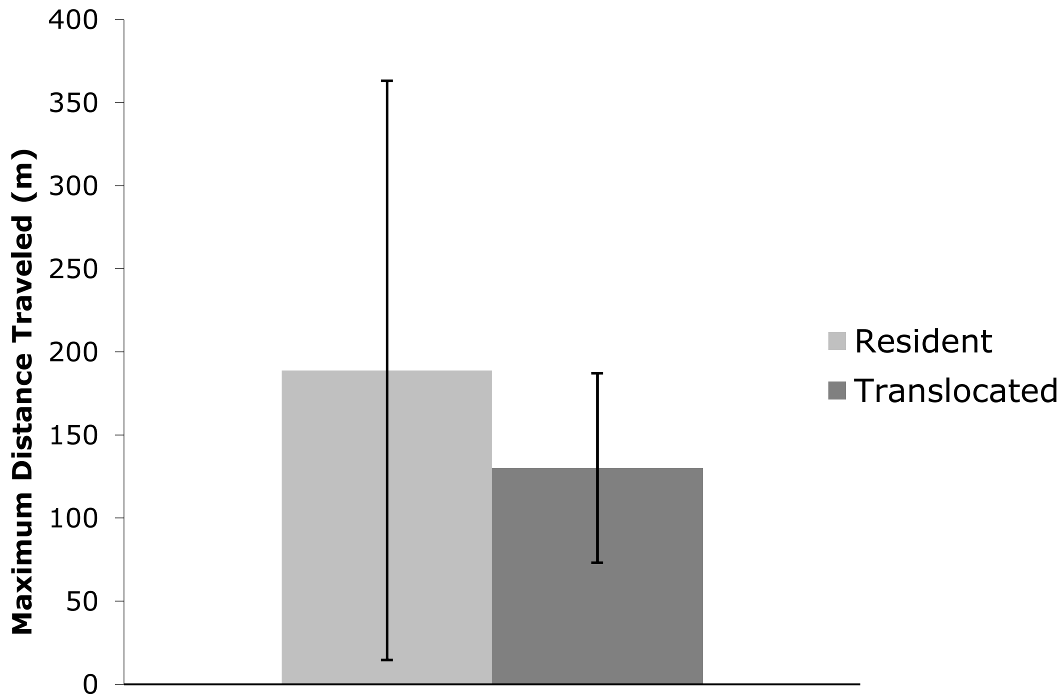

Figure 4. Maximum distance traveled (m) ± 95% CI by resident and translocated three-toed box turtles (*Terrapene carolina triunguis*) at Camp Tyler, Whitehouse, Texas.

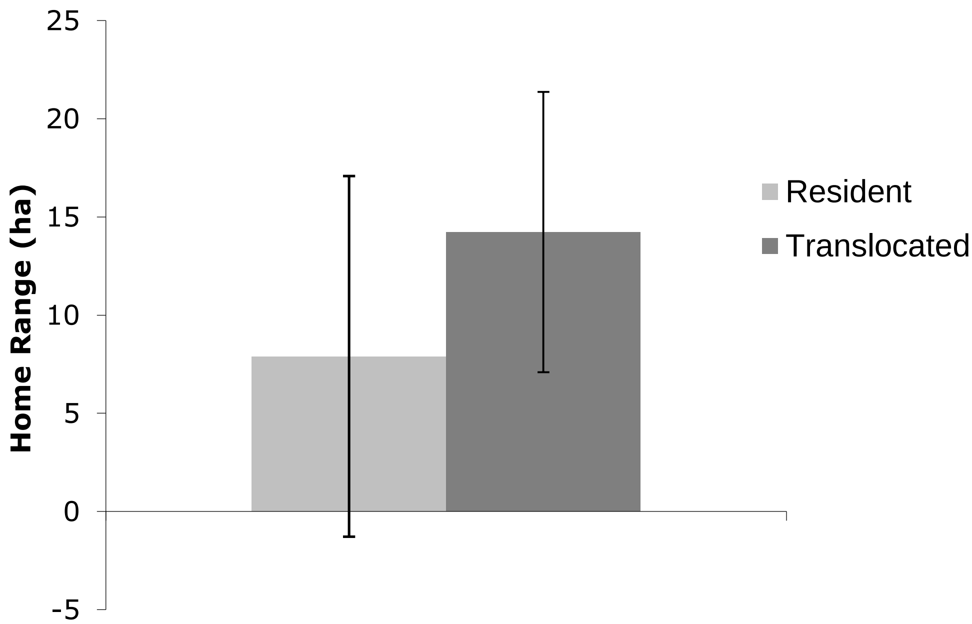

Figure 5. Mean home range size (ha) ± 95% CI for resident and translocated three-toed box turtles (*Terrapene carolina triunguis*) at Camp Tyler, Whitehouse, Texas.

Effect of temperature on movement:

There was a significant positive linear relationship between ambient temperature and mean total distance moved for both resident (r^2 = 0.3, P = 0.02) and translocated (r^2 = 0.3, P = 0.02) box turtles (Figure 6) with ambient temperature explaining 54.43% and 55.16% of the variation in movement of resident and translocated box turtles, respectively. Similarly, there is a significant positive linear relationship between soil temperature and average total distance moved for both resident (r^2 = 0.42, P < 0.01) and translocated (r^2 = 0.37, P < 0.01) box turtles (Figure 7) with soil temperature explaining 65.03% and 60.99% of the variation in movement of resident and translocated box turtles, respectively.

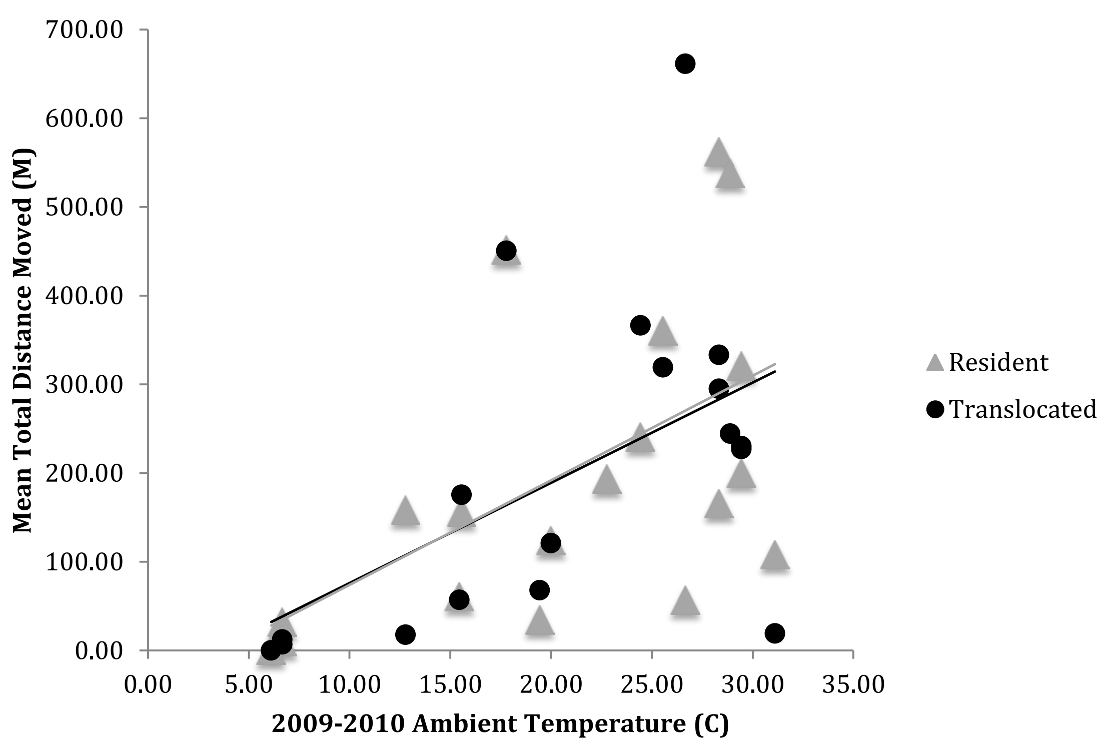

Figure 6. Relationship between ambient temperature (C) and mean distance moved (m) by resident (r^2 = 0.3, P = 0.02) and translocated (r^2 = 0.3, P = 0.02) three-toed box turtles (*Terrapene carolina triunguis*).

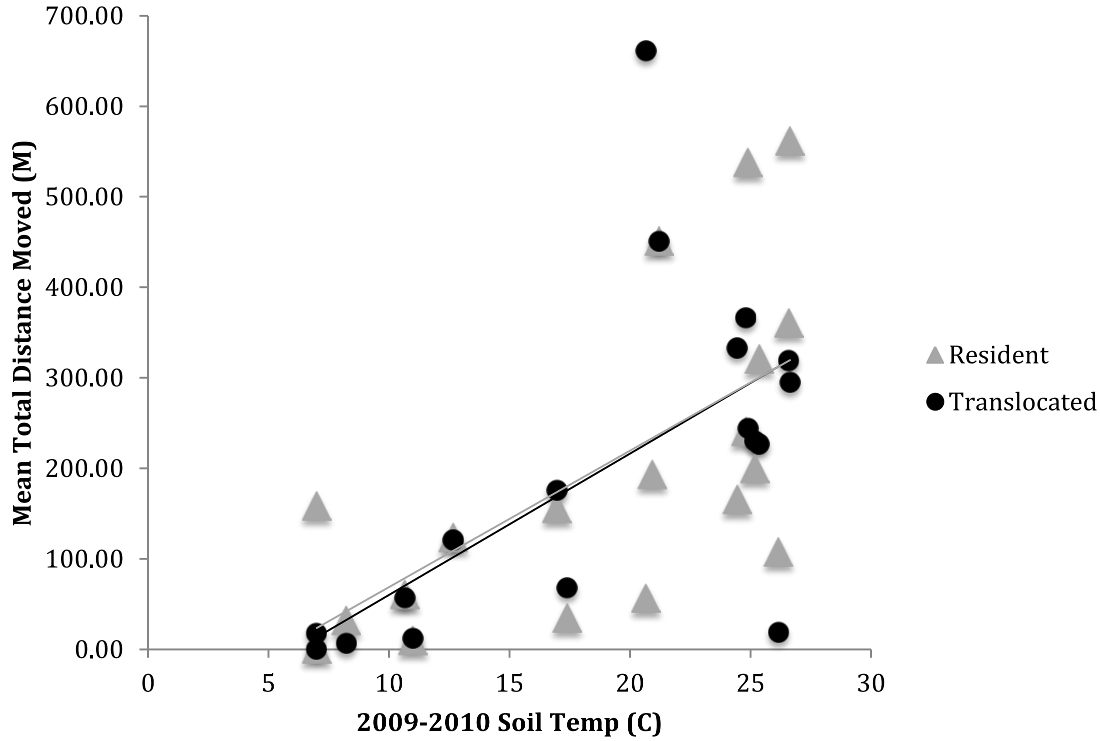

Figure 7. Relationship between soil temperature (C) and mean distance moved (m) by resident (r^2 = 0.42, P < 0.01) and translocated (r^2 = 0.37, P < 0.01) three-toed box turtles (*Terrapene carolina triunguis*).

Preliminary observational data on turtle condition suggests no detectable difference between resident and translocated individuals from the beginning of the study to the end (Table 2).

Chapter 4

Discussion

Data from the current study suggest that there is no significant difference between resident and translocated three-toed box turtles in terms of daily mean distance traveled, maximum distance traveled, and home range size. Similarly, data on turtle body condition suggest no detectable difference between resident and translocated individuals from the beginning of the study to the end. Finally, both ambient and six-inch soil temperatures affect daily distance moved for each test group in a similar fashion.

Mean distance moved for resident and translocated turtle groups did not differ in the current study, which coincides with the findings of Hatch (1996), Rittenhouse et al. (2007), and Hester et al. (2008). Home range sizes were also not significantly different for either group, which was concordant with the work conducted by Keyes (2007) at the same study site. However, others have detected behavioral differences between translocated and resident turtles, which does not correspond with the data collected for the current study.

Specifically, both Rittenhouse et al. (2008) and Hester et al. (2008) found that translocated turtles had larger home ranges than resident turtles. There are a number of factors that may possibly explain the differences between these studies and the current one. For example, suitability of habitat can influence turtle movements (i.e., if suitable forest canopy or ground cover is unavailable, turtles may continue to move in search of more suitable habitat). In fact, in the Rittenhouse et al. (2008) study, translocated turtles were moved to a fragmented landscape from a more continuously forested habitat. At Camp Tyler this may not a problem because, although there are many open areas, many of these contain suitable understory plants and tall native grasses that allow box turtles to remain hidden. Similarly, geographic location, the distance moved from original capture location, species/subspecies used, and study duration can also influence home range results. My research along with that of Keyes (2007) was conducted in East Texas. Rittenhouse's research was conducted in Missouri, and Hester's research was conducted in North Carolina with a different subspecies (*T. c. carolina*). Additionally Hester did not translocate turtles; she relocated turtles to a different part of the original study site not to a new study site. This may not have been a far enough distance to prevent turtles from attempting to return to their original point of capture. Rittenhouse et al. (2008) radio-tracked box turtles for two months, while Hester radio-tracked turtles for one year. The current study, along with Keyes (2007) study, were both eighteen months long. Given that a variety of abiotic variables may influence turtle behavior, the current study also attempted to provide natural history data on one of these factors, namely the influence of temperature on movement (Legler, 1960, Blair, 1976, Doroff and Keith, 1990, Budischak et al., 2006).

It has long been recognized that box turtle activity periods are linked to external temperature and that they are often forced to estivate during extremely hot, dry periods and hibernate in winter under the soil and vegetative debris of woodlands or prairies (Dodd, 2001, Ernst and Lovich, 2009). In this study, as temperature increased from 15.5°C to 30°C turtle movements increased, but above this range, movement ceased. Therefore, the unusually hot weather during my study may have led to turtle estivation above 30°C. Specifically, the mean maximum temperature for the 7-month turtle activity period beginning in April and ending in October, averaged between 35.27°C in 2009 and 35.39°C during 2010. This is 2°C higher for the same time period when compared to the two years preceding my study. In fact, when turtles were located over the hottest months, they were often found in exactly the same location as the previous encounter and often in the very same position. It is unlikely that they made short movements during this time only to be found in exactly the same position as the previous encounter.

Given that home range size did not differ between resident and translocated cohorts, it appears that translocation may be a viable conservation strategy for three-toed box turtles. Preliminary data on turtle condition suggests no detectable difference between resident and translocated individuals from the beginning of the study to the end adding further support to the use of RRTs and translocation for turtle conservation. Dodd and Seigel have suggested that in the case of reptile and amphibian translocations, they are unable to find any examples of successful RRTs (Dodd and Seigel, 1991). However, a recent re-evaluation of the suitability of translocations for reptile and amphibian management suggests that this may not be the case (Germano and Bishop, 2008). With box turtles, for example, a study conducted in Brooklyn, NY found a 71.8% survival rate for translocated turtles, and that the reproductive output was comparable to wild populations of *T. carolina* (Cook, 2004), so there is some hope for successful use of RRTs.

Recommendations for future studies include more substantial sample sizes, equal representations of males and females, long-term study duration, and more frequent tracking. While it is possible to track large game animals via satellite, the technology is not yet available for tracking smaller wildlife species (Millspaugh and Marzluff, 2001, Rodgers, 2001). When this technology becomes available for use with smaller animals, we may be able to report more translocation successes.

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Appendix A: Box Turtle Movement Maps

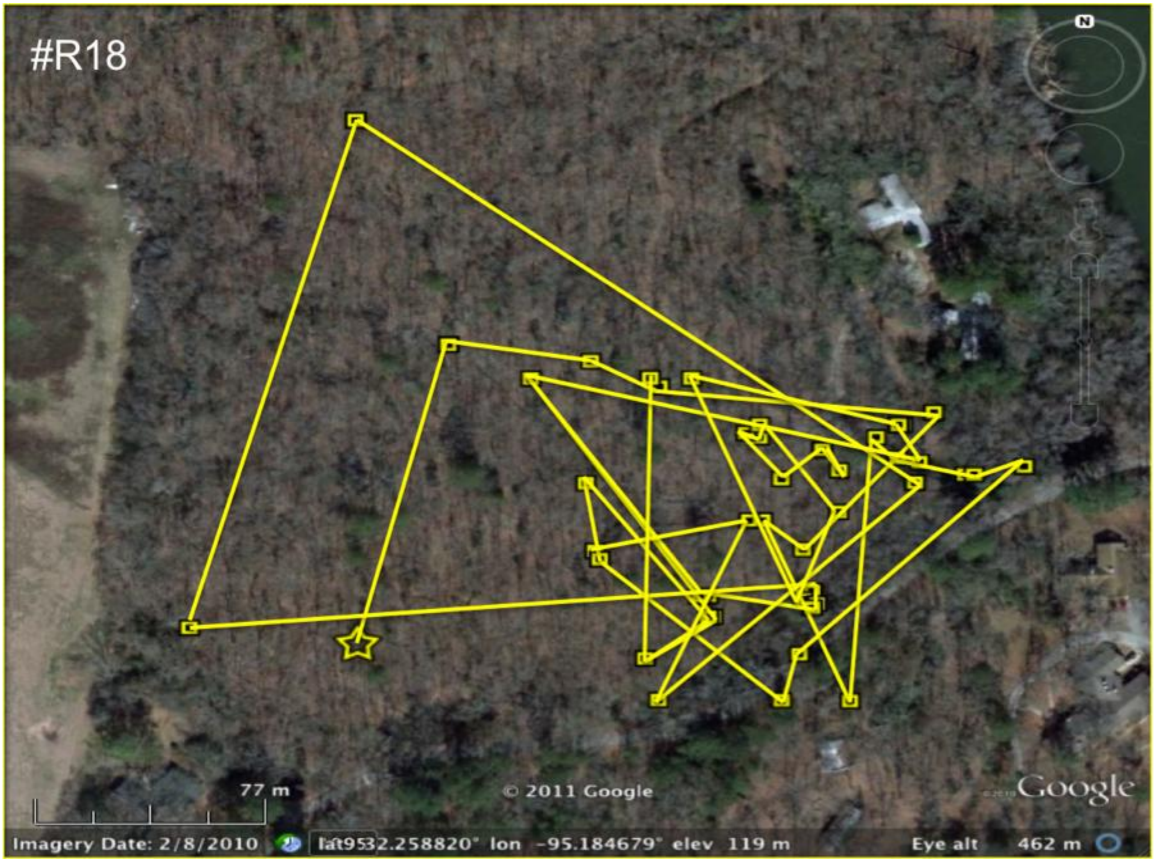

Figure 8. Movement pattern (m) (May 2009 - November 2011) of resident (#R18) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star represents indicates release point.

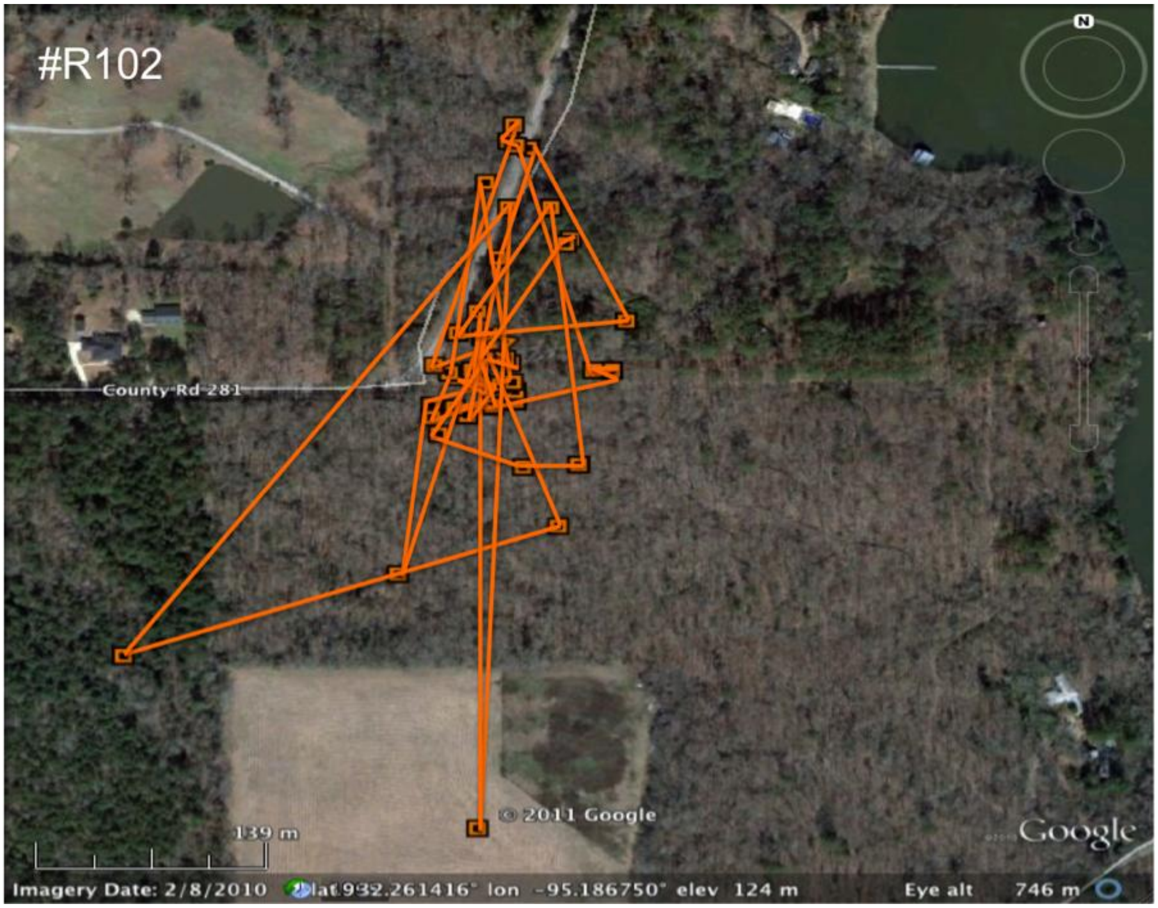

Figure 9. Movement pattern (m) (May 2009- November 2011) of resident (#102) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

Figure 10. Movement pattern (m) (May 2009- November 2011) of resident (#103) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

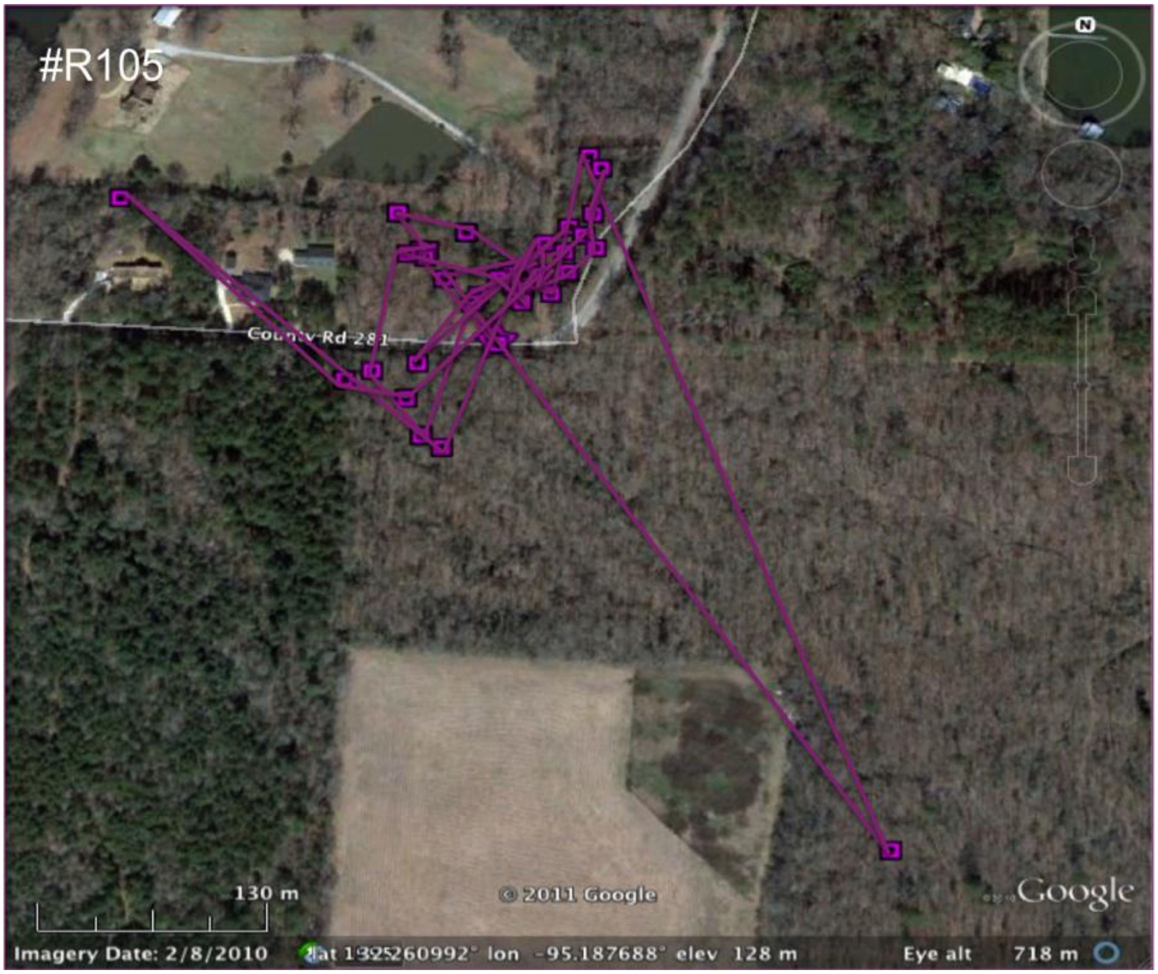

Figure 11. Movement pattern (m) (May 2009- November 2011) of resident (#105) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

Figure 12. Movement pattern (m) (May 2009- November 2011) of resident (#111) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

Figure 13. Movement pattern (m) (May 2009- November 2011) of translocated (#101) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

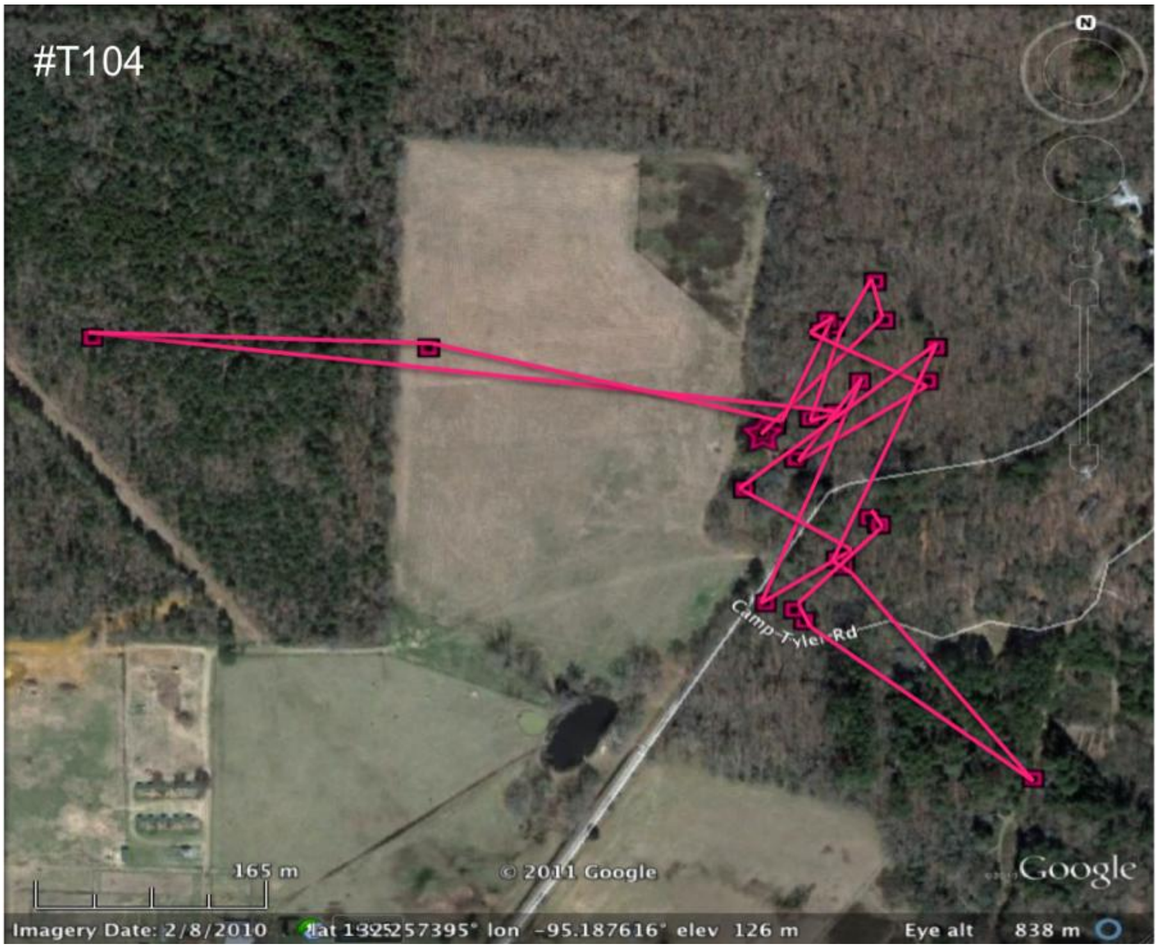

Figure 14. Movement pattern (m) (May 2009- November 2011) of translocated (#104) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

Figure 15. Movement pattern (m) (May 2009- November 2011) of translocated (#106) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

Figure 16. Movement pattern (m) (May 2009- November 2011) of translocated (#107) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

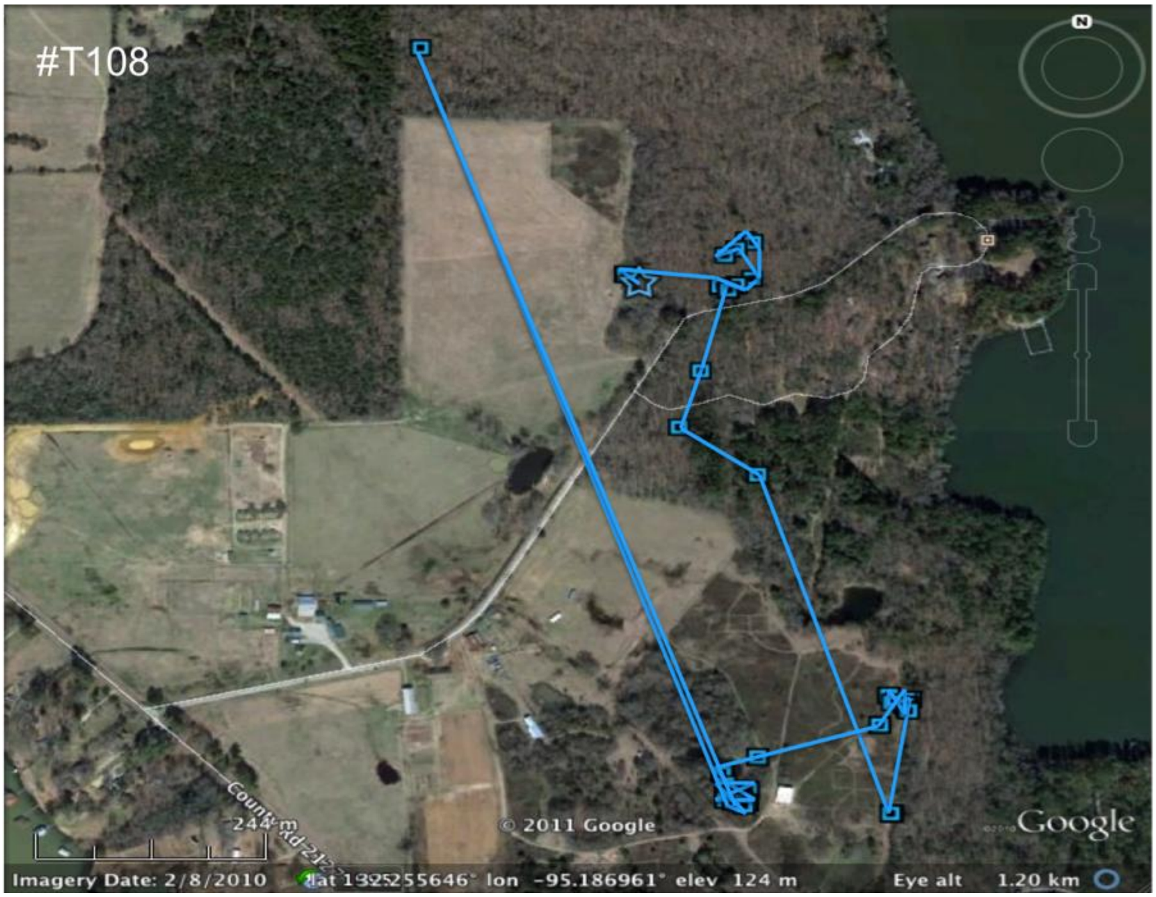

Figure 17. Movement pattern (m) (May 2009- November 2011) of translocated (#108) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

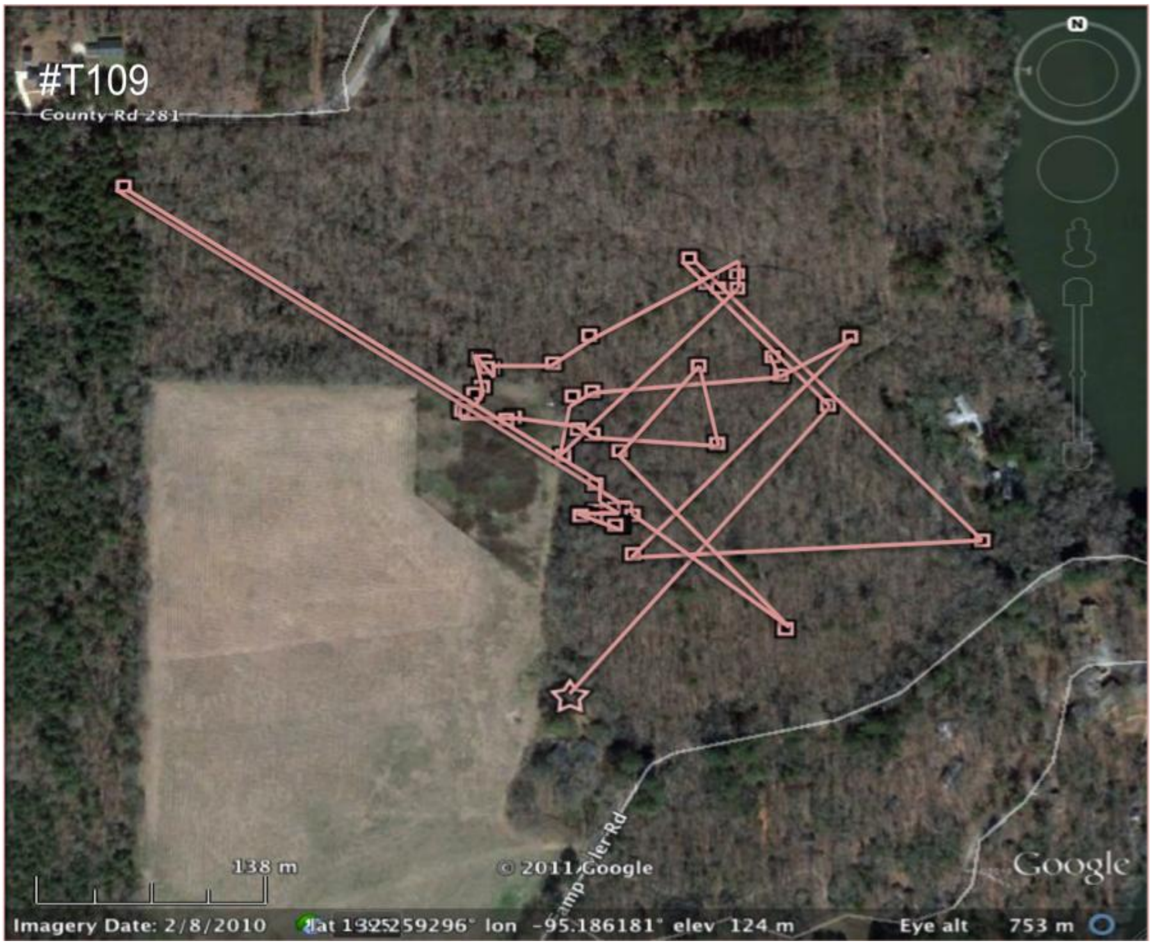

Figure 18. Movement pattern (m) (May 2009- November 2011) of translocated (#109) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.

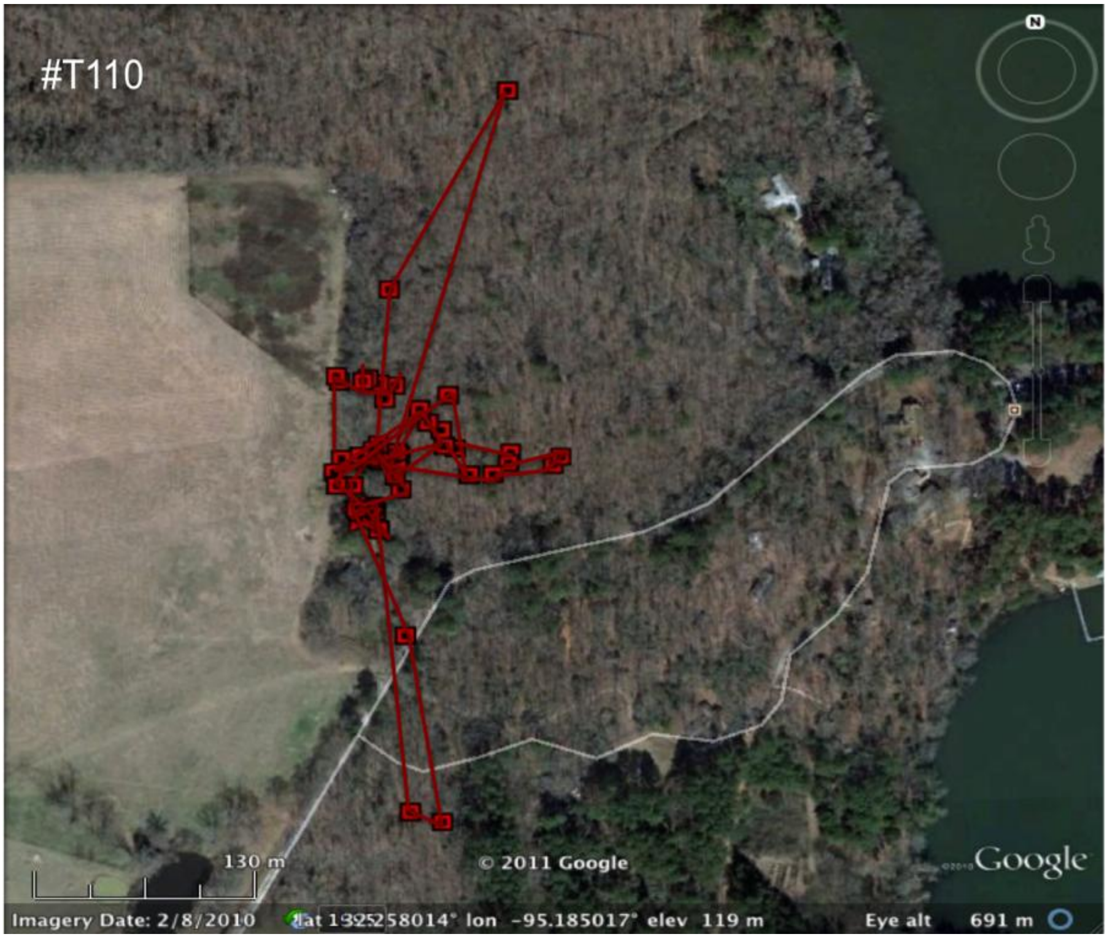

Figure 19. Movement pattern (m) (May 2009- November 2011) of translocated (#110) Three-toed box turtle *(Terrapene carolina triunguis)* at Camp Tyler, Whitehouse, TX. Star indicates release point.