Factors Affecting the Home Range of Eastern Box Turtles at Brookhaven National Laboratory

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August 12, 2011

Prepared in partial fulfillment of the requirements of the Office of Science, Department of Energy's Science Undergraduate Laboratory Internship under the direction of Timothy Green in the Natural Resources and Waste Management Division at Brookhaven National Laboratory.

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Abstract

Widespread among the many acres of Brookhaven National Laboratory (BNL), the Eastern Box turtle (*Terrapene carolina Carolina*) finds its niche in the dense understory of the Pine Barrens ecosystem. Box turtles move within a central home range, which varies among individual turtles and amount of habitat present. Disturbances, such as roadways, buildings, removal of forest, and change in ground cover impact turtle movement and behavior. Specifically, with the recent addition of a 200 acre solar farm on the property, it is being questioned whether the turtles will be disturbed and change their home range. Understanding the home range of each turtle gives better insight as to whether they will move nearer to or away from the solar farm. Twenty-eight turtles were found as part of the study. Each turtle was weighed, measured, and notched on three scutes around the rim of the carapace. After collecting the initial data, radio transmitters were attached to the lower portion of the carapace. Six turtles were chosen to be part of the radio telemetry study. Each transmitter has a unique frequency, which helps to identify the turtles in their specific home ranges. The turtles were tracked once daily to observe the distance traveled and vegetation they prefer to burrow or forage in. Their locations were recorded using a Global Positioning System and represented visually using Geospatial Information Systems mapping technology. Each turtle had a unique movement pattern, but they all stayed within a 1.0 – 2.0 hectare area. The turtles with frequencies 149.843 MHz, 149.802 MHz, 149.852MHz remained in a close home range and preferred the pitch pine/white oak habitat with a huckleberry/blueberry dominated understory. Transmitters with frequencies 149.833 MHz, 149.813 MHz, 149.822 MHz, all female, had greater movement going deep in the forest or walking across the dirt roads. These turtles moved from areas of no vegetation to dense barberry and blueberry thickets. Females typically have a greater range of movement than males, which explains their varied habitat preference. The more significant changes in movement indicate the possibility of disturbances caused by roads fragmenting the forest or by human activity. Turtles 802 and 822 are closest to the solar farm and are slowly moving away from the site. Future studies will investigate whether the Eastern Box turtles with transmitters, as well as others, will travel into the solar array area using the wildlife friendly fencing.

Introduction

Threatened by natural occurrences in the environment and anthropogenic effects, the Eastern Box turtle (*Terrapene carolina carolina*) population on Long Island remains stable. To its disadvantage, the box turtle has a slow maturity rate, which means that it reproduces later in life (Marsack, 2011). This poses a problem because if turtles are impacted by disturbances at a young age they may never reproduce and maintain the species population. Threats to the species include vehicular traffic, fragmentation, habitat loss, degradation due to development, and natural disturbances (Erb, 2011). Dirt and paved roads pose one of the greatest threats to box turtles at Brookhaven National Laboratory since they frequently cross roads in search of food, nesting sites, or areas of moisture. A road within a turtle's home range puts them at risk of getting run over by a car or construction vehicle. Specifically at BNL box turtles face the task of surviving in their natural habitat while encountering disturbances created by humans. For example, the 200 acre solar farm being constructed on site represents two major impacts to turtles. In order to build the solar farm, 167 acres of forest had to be cleared, with the exception of some shrubs in the understory. Clearing the forest removed viable box turtle habitat. Also, the placement of fencing around the solar arrays potentially acts as a barrier, even with the animal friendly fencing. It is being questioned whether the placement of the solar farm will impact the turtles behavior and act as a future obstruction to nesting, foraging, and natural home range movement.

The Eastern Box Turtle is common in the woodlands of the Northeast. Their preference of habitat includes densely forested areas with sources of moisture close by and a large enough space to extend their desired home range. As habitat generalists, this species prefers a variety of habitats and food. Prime turtle habitat includes deciduous or mixed forest, early successional habitat, fields, and shallow wetlands (Erb, 2011). Within their habitat they typically forage on both flora and fauna. Turtles prefer fruits, seeds, and all parts of the plant (roots, stems, and leaves). Foraging for plants is a seasonal activity for turtles. Telemetry of box turtles in one study in Bourne Massachusetts indicated a preference for low bush blueberry and huckleberry (Erb, 2011). Blueberry and huckleberry flourish in the early summer months giving turtles the opportunity to have variety in their diet. Invertebrate foods include slugs, snails, earthworms, spiders, crayfish, millipedes, grasshoppers, flies, beetles, ants, termites, cicadas, caterpillars, insect grubs, and maggots (Todd, 2000). Foraging for seasonal plants and insects typically takes place when the turtle is most active from April to November. The time in between is spent in hibernation.

Box turtles are characterized by their yellow and black carapace and yellow legs. Female and male turtles are differentiated by a few characteristics. The most obvious trait can be found by examining the shell of the turtle. Females and males differ in the shape of their plastron (bottom shell). Males have a concave plastron and flatter carapace, while females have a flat plastron and more rounded carapace. A less reliable technique of telling the difference between genders is looking at the eye color. Females typically have yellow eyes and males have red eyes.

Besides foraging, characteristic behavior of the box turtle in its habitat includes moving to areas of moisture, burrowing and nesting. Since Box turtles are ectothermic, their behavior, movements, and habitat selection are dictated largely by ambient temperature and moisture (Todd, 2000). The seasonal changes in climate influence turtle activity. Burrowing is a technique frequently used by box turtles during the warm, dry summer months. The turtles dig shallow burrows that function to regulate body temperature and hydration when the temperatures are high. According to studies, Eastern Box Turtles have generally been found to be most active on warm and sunny days, especially following showers, and they are least active in cold or dry weather (Donaldson, 2005). However, the climate in the Pine Barrens ecosystem on Long Island may prove to vary more in temperature and humidity, which may directly influence turtle behavior.

The Pine Barrens ecosystem at Brookhaven National Laboratory is prime habitat for turtles. The native vegetation is well adapted to the unique sandy Pine Barrens soil and provides the perfect habitat for turtles to forage, nest and burrow. In the forest, turtles use both the dense understory and areas where there are openings in the overstory. Forms of overstory plant life able to grow in the Pine Barrens include trees from the Pine family, Maple family, and Beech family. Typical trees include pitch pine, white oak, scarlet oak and red maple. Understory plants are mainly from the heath family and include huckleberry, blueberry, and cranberry.

Furthermore, various factors including height of understory vegetation can affect their microhabitat selection. For example, studies in Maryland illustrate the box turtle moving more frequently in areas of dense ground cover. The turtles' preferences for certain plants are based on the density of the cover provided by the species (McKnight, 2011). As the amount of ground cover increased, so did turtle movement. The Pine Barrens common ground cover, blueberry and huckleberry, allow to turtles to travel as well as be protected and forage. However, other studies showed observations of turtles preferring less dense ground cover. Researchers discovered that turtles preferred less dense areas because there was more air flow, which aided in thermoregulation (McKnight, 2011). The Pine Barrens at BNL provide both dense and sparse ground cover, giving turtles the option to select habitat based on need for regulating body temperature or foraging.

Box Turtles also prefer to be near areas of moisture. Within the Pine Barrens are areas of aquatic communities, such as streams, ponds, and swamps. While moving within their home range, box turtles will travel from areas of pine trees and dense blueberry understory to ponds or streams in order to rest and hydrate. Turtles have been found swimming in shallow ponds or resting on the banks. Periods of low rainfall coupled with high temperatures are associated with migration to the temporary ponds (Donaldson, 2005). As temperatures increase turtles will move toward areas of water. Conversely, after a day of high precipitation turtles are more active and have been observed crossing roads within their home range. Box turtles will travel to locations with moisture availability within their home range, but some have been documented to travel longer distances seeking relief from warm, dry climates.

Box Turtles move to obtain food and water, locate mates or nesting sites, thermoregulate body temperature, hibernate, and explore new habitat (Dodd, 2001). Movements may be direct paths to specific resources, such as blueberry or huckleberry. Others depending on resources available may travel through the home range in search of more viable habitat or even nesting sites. Turtles have even been observed to remain in one location for extended periods of time due to climate or moisture availability. Their home ranges greatly vary due to the individual and amount of habitat present. A turtle at BNL had limited habitat to move in around the central urbanized lab area. Studies exhibit box turtles move greater distances in heavily forested areas compared with more open or fragmented areas (Erb, 2011). Habitat quality, structure, diversity, and individual preference are all variables that account for variation in size and spatial distribution of home ranges (Dodd, 2001). Also, males and females exhibit different movement behavior within their home range. Females typically have a larger home range than males because of nesting. During nesting season, females move to locations that provide viable habitat to build a nest. They may move from areas of dense understory to roadsides or embankments with sandy soil in order to easily dig their shallow nests.

Radio telemetry is a preferred method when observing the movements of box turtles within their home ranges. Telemetry estimates distance traveled by measuring straight-line distance between consecutive locations (Iglay, 2006). Unfortunately, telemetry does not account for exact movement. It is difficult to predict exactly where the turtle moved each day. Attaching a string to the back of turtles is another common method used to determine more accurate movement. However, studying turtles with telemetry is beneficial since turtles do not move fast or far in their habitat. It is feasible to track the turtles and identify them directly in the field by logging their location in a Global Positioning System. Movement is estimated and can be represented visually using Geospatial Information Systems technology.

Building solar farms or creating a more urban setting, like the one at the Lab, greatly influences turtle growth, mortality, and behavior. Studies conducted on Box turtles in North Carolina obtained data showing that areas with forest cover greater than 90% accounted for the largest fraction of turtles present (Budischak, 2006). More mature turtles over the age of twenty were found in areas with extensive forest cover than in areas that were developed. With the removal of forest for the solar farm or increased human presence in the forests, it is likely that turtles will move away. One study indicated that although box turtles may persist in urbanized landscapes and may grow more quickly there, they suffer higher mortality in these habitats compared to forested landscapes (Budischak, 2006). This may be true, however, the solar farm area is a controlled environment near an urbanized lab landscape. The turtles most likely left the area immediately during the period of clearing the forest. Any left within the construction site were removed or perished due to an inability to find resources. Once construction is complete and the wildlife friendly fencing is in place, turtles have the option to move into the solar farm area. Grasses will be planted to grow at a low height under the panels, which may provide good habitat. The habitat must contain food, moisture, and areas to burrow in order to be worth moving in through the wildlife friendly fencing.

Methods and Materials

Six turtles were captured to use in this study. Method of capture included walking the dirt roads near the solar farm and running transects through the forest. Most captures took place along the dirt roads. Considerations needed in order to have a complete study included when the turtles were found, how far they moved each day, and their proximity to the solar farm. The goal was to capture the six turtles in the first few weeks in order to be able to monitor their movements for a full four to five weeks.

After each capture it was necessary to identify the turtles by examining various common morphological characteristics. The turtles were weighed using a Pesola spring scale. Turtles were placed in an open plastic bag and the Pesola scale was clipped to the top of the bag to aide in obtaining an accurate mass. Length and width of the carapace and plastron were measured using a manual caliper. In order to determine the sex of a box turtle, the plastron was examined to see if it was concave or flat.. The age was determined by counting the rings on the top scale of the carapace. The last step involved marking the turtles using a triangular file to file three notches into the scutes around the carapace. There are twelve scutes on each side of a box turtle. Using a master notch list provided, a unique notch ID was given. If the turtle was already notched from a previous capture, it was necessary to find the entry in the BNL turtle database to confirm the notch ID. Each measurement and notch ID was recorded on data sheets to be entered into the Master Database for BNL.

Once the six turtles were identified, a radio telemetry transmitter was glued to the back scales. Using Epoxy glue, the transmitters were carefully adhered to the lower scale as to not interfere with the shell growth process. Each of the six transmitters had a different frequency, which would be the determining factor in telling each turtle apart in their specific locations. The frequencies, given by the Advanced Telemetry Systems, were within the 149.8xx MHz range and ended in the digits: 813, 833, 802, 843, 842, 822. The frequencies were distributed randomly and each transmitter was tested to confirm proper functioning.

The six turtles were released after being assigned a frequency and tracking began immediately. Tracking took place once or twice daily. If the turtle showed little movement day to day, then it was only necessary to track them once a day. However, if great movement was observed it was best to observe twice a day to obtain a more accurate assessment of their home range. In the field, radio telemetry equipment was used to pick up the specific frequencies. The antennae, a three element yagi, picked up the frequency, which became louder when in close proximity to the turtles and was held horizontally to obtain the clearest signal. The gain was adjusted to a lower setting once close to the turtle. At each point of capture, a GPS point was logged to be used for GIS analysis.

GIS analysis included creating the path of movement for each turtle and a minimum convex polygon to show estimated home range. Using ArcGIS 9.2, each turtles points were loaded into the vegetation base map layer. Using an added program, Hawth's Tools, lines were drawn to connect each point based on date. Arrows were added to show the direction the turtles moved in. In order to find the estimated home range, Hawth's tool was used to create a minimum convex polygon around the paths. The area, represented in hectares, gave a conclusive visual of the different types of habitat each turtle entered. Statistics were also completed using the ArcGIS 9.2 Statistics tool and X-Tools program. Using the path line shapefile, a length field was created using X-Tools. By opening the attribute table for that shapefile and choosing the statistics option, minimum and maximum distance, mean, and standard deviation were calculated. In order to obtain the area, the minimum convex polygon shapefile was selected and using X-Tools, area was calculated in hectares.

Results

Movement varied for each individual turtle. Points recorded in the GPS and mapped out into paths using GIS showed movement in similar habitat or movement throughout a few different habitat types. Factors observed to play a role in movement were dirt and paved roads, fencing, the solar farm construction site, buildings, and vegetation density and type. Due to the factors effecting movement, the home ranges were also impacted. Turtles with frequencies 833, 802, 813 remained in a close home range. On the other hand, Transmitters 822, 843, 852 had greater movement going deep in the forest or walking across the dirt roads. Their home ranges had a larger area. Based on GIS calculation, all of the turtles stayed between a 0.3- 1.7 hectare area.

The larges home ranges were observed in areas where habitat extended for many hectares. This made it possible for turtles to make extreme movements. Areas with fragmentation, road barriers, and buildings forced turtles to have fewer options for movement. Turtle 843 experienced fragmentation due to the intersection of roads that divided the forest into four quarters. This turtle frequently crossed into each of the four sections every week. Roads also acted as a barrier to turtles with frequencies 822, 802, and 833. These specific turtles, during the two month study, never crossed the roads near their selected forest habitat. Turtle 833, that was treated for an ear infection and released two weeks later, moved to the very edge of a grassy area, but never went across First Path or the dirt road behind Building 528. Turtle 802 moved along the embankment along the south edge of Princeton Path, but did not venture to forested or grassy areas across the road. These areas led to the construction sites for the National Synchrotron Light Source II and Long Island Solar Farm. Turtle 822 was also moving away from the solar farm construction site.

Vegetation preferences were evident for the six box turtles. Turtles with frequencies 802, 833, 852 were frequently found in a Pitch Pine/White Oak forest. The understory in this type of forest consisted of low bush blueberry and huckleberry bushes. There was enough shade given by the canopy, but portions of the canopy were open to provide turtles with basking areas. Ground cover blueberry/huckleberry provided food for the turtles, especially turtle 852, who was always found near blueberry bushes. Turtle 833 made frequent long movements from the dense barberry thicket and blueberry/huckleberry understory to the grass edge, which was exposed to the sun. Turtle 843 preferred a similar habitat, but constantly moved from the forest to the successional edge habitat near the dirt/paved road. The successional habitat consisted of pitch pine seedlings, low bush blueberry, and ferns.

Turtles 822 and 813 had more of a variety of habitat types within their home range. 813 preferred the Scarlet Oak-Heath forest on either side of First Path near the Ecology Fields. It constantly moved from areas of dense barberry to the edge, which was dominated by various types of grass. Different from the other turtles, 813 walked across the road numerous times to an area that had little to no ground cover. Similarly, 822 moved in four different forest vegetation types. It preferred the Red Maple/Scarlet Oak-Mesic Heath forest, but moved great distances to be near moisture. Areas of moisture were represented by darker colored fallen leaves, indicating there once was a stream present. It moved north to these areas of moisture and dense fern ground cover. Turtle 822 was often found buried in the leaf litter or moving through the fern. It was rarely found near blueberry/huckleberry shrubs.

In regards to movement near the solar farm, turtles 822, 802, and 852 were observed closely. Each turtle exhibited some movement in the direction of the solar farm, but not significant enough to suggest if they were being affected by the placement of the farm. Turtle 822 was in closest proximity to the construction site, but moved north and south instead of east to move closer to the fencing. See Table 2 for each turtle's minimum distance from the Long Island Solar Farm.

Discussion/Conclusion

The study focused on determining a home range for six box turtles and how the home range space was used. Radio telemetry was successfully used in determining the location of each turtle every day. However, it did not show their exact movement day to day. For example, turtle 802 seemed to move in a straight line across the embankment. It is unlikely that this turtle remained on a completely straight path each day. Its home range was located near a pond, stream, and road. It is more likely that turtle 802 moved along the embankment and travelled closer to the pond to seek moisture or move from the sandy edge to the blueberry in order to forage. Telemetry was beneficial in that it has given an approximate home range area that can be used to predict future movements and turtle behavior. Each turtle's path illustrated that movement largely depends on the type of habitat present and the individual turtle's behavior.

Vegetation proved to be a major factor affecting turtle home range. The overstory, ground cover, and leaf litter are all useful to turtles. The overstory provides shade and openings give turtles a chance to bask in the sun. Ground cover is used for foraging, shelter, and daily movement. Leaf litter provides a place for turtles to burrow to rest or regulate their body temperature. Documenting the microhabitat for amount of plant cover and specific vegetation type was completed during each daily tracking session.

Turtle 843 showed similar edge movements to turtle 802, but displayed varying preference for different types of vegetation and height of groundcover. Located near the west firebreak, turtle 843 was frequently found near the successional edge habitat. The forest in that section of the Lab is separated into four quarters by dirt roads and a well building. Over the six week study, greater movement was observed in the area of forest to the northeast of the well building. After four weeks, the turtle began to move to the other quarters and its paths were longer day to day since it crossed dirt roads. This change in movement illustrates how turtle behavior can determine home range. During the last two weeks of tracking temperature fluctuated greatly and there was little precipitation. On days of high temperatures and low moisture, 843 burrowed. However, once the temperature decreased and precipitation increased, the turtle moved from quarter to quarter, but mainly stayed near the edge. After moving to areas of less dense understory, 843 always returned to more dense areas to spend a few days. It is evident that the building and roads were no obstacle to its daily movement.

Although found less frequently near the edge of grassy habitat type, turtle 833 exhibited definite vegetation preferences. This turtle was found in either dense barberry bushes or in less dense huckleberry/blueberry and grass. The barberry provided shade during the day and was located down a slope where moisture was likely to collect. It is likely that turtle 833 sought relief from the heat in the barberry and was able to retain more moisture by burrowing into the leaf litter in that area. Following previous research, turtles have been documented to seek relief from high temperatures by moving towards more dense, shady areas. Also, turtle 833 tracking began later into the six week period because it was in rehabilitation for an ear infection. Recovery was monitored closely by photographing its head to check a decrease in swelling and to ensure proper healing. As the tracking period drew to a close, the turtle looked completely healed. Taking into account its ear infection, it is possible that the turtle's behavior was impacted. In the beginning of recovery, 833 did not show large movements. Once it readjusted to its habitat, it began to behave like the other turtles, moving from habitat to habitat in search of food and shelter.

In addition to type of vegetation, density of understory proved to be a significant factor in the turtle's daily movement. Box turtles rely on their microhabitat for thermoregulation and controlling water loss (McKnight, 2011). During observation, trends were seen in the areas that turtles chose to regulate their temperatures and retain moisture. For example, during high temperatures, turtle 813 was frequently found in a dense grass that still retained moisture from the morning dew. It often rested under barberry bushes located near the dense grass. Both areas were indicative of resting behavior to regulate body temperature and forage. The barberry bushes provided shade and the leaf litter underneath was loose enough to burrow. During days of larger movements, this turtle was seen moving south along First Path. Again, it chose to stay in the grass or move into the barberry bushes. Foraging opportunities were high in this area because of the low ground cover and decomposing material near the soil surface. Turtle 833 illustrated patterns suggesting that box turtles prefer to move through both dense and sparse ground cover depending on their needs. Foraging mostly took place in dense ground cover and movement occurred in higher, less dense vegetation.

Furthermore, during the six week study, evidence of nesting was observed. Along the West Fires Break, seven nests were found with remnants of egg shells. After observing the behavior of the male turtle with 843 frequency, it is possible to infer that this area may be a breeding site. Both male and female box turtles change their range of movement in order to look for a mating partner or find a suitable nesting site. In the case of turtle 843, there was not enough evidence to show that he was looking for a mate. His extreme changes of movements can be attributed to foraging and looking for a mate is a definite possibility. A few female turtles were caught in the area, which increases chances of the area being a breeding site.

Roads were also assessed during the study to determine whether they act as barriers to turtle movement. Most roads at the Lab were established around 1934 and have not been changed much since. Each turtle's home range included at least one road. Frequencies 813, 822, and 802 had one road as a possible barrier. Frequencies 843, 852, and 833 had two roads. The amount of roads in the habitat did not prove to be a major factor in turtle movement. In urban/forested areas, wildlife often adapts to the changes and is forced to travel farther to forage. In the case of turtle 802, the habitat south to Princeton Avenue was suitable to foraging, retaining, moisture, burrowing, and regulating temperature. It did not need to move across the road. Similarly, turtle 852 did not move across the roads because it had a sufficient combination of groundcover plants with varied heights, a large amount of blueberry and huckleberry bushes, and a wetlands area to the south. On the other hand, turtle 843 frequently moved across the roads. Foraging opportunities were slightly different across the roads, as well as amount of ground cover, so it was more beneficial to move across the roads. Box turtles move to find what they need to survive and by studying their movements it is apparent that if they found a suitable habitat, they do not need to travel far.

Another potential obstruction to box turtles at Brookhaven National Laboratory is the solar farm being built in the south east portion of the lab. The closest turtle to the construction site is 822. This turtle displayed varied movement between four different forest types. Its preference to remain in the Red Maple/Scarlet Oak Mesic-Heath forest for long period of time was indicative of foraging and burrowing opportunities in the area. However, it moved from areas of dense ground cover by moving far north from Brookhaven Avenue. In the north area are ferns and dense blueberry/huckleberry. 822's pattern of movement illustrates movement due to foraging opportunities. The forest near the road had sparse ground cover, which the turtle simply used as traveling space. Areas near the edge of the road were rarely used, except during the end of the study when the temperatures were extremely high. Barberry bushes near the edge provided shelter and large amounts of leaf litter to burrow in. Since the turtle rarely moved near the road or in the direction of the solar farm, it is possible that it was disturbed. Brookhaven Avenue was frequently used for large trucks to transport materials to and from the construction site. It seemed to be avoiding the area completely. However, after observing the other turtle's behavior, it is also possible that turtle 822 had suitable habitat and had no need to move closer to the solar farm.

Eastern Box turtle's home range at Brookhaven National Laboratory is dependent on individual movement and resources needed that may force them to expand their home range. In order to thrive in their niche, turtles need proper groundcover to burrow, close proximity to areas of moisture, and good foraging habitat. The six locations chosen for this study had suitable habitat for each turtle. However, they varied in extent of anthropogenic effects. Roads, which usually act as a barrier, did not pose a huge threat to the box turtle movement. Looking at the data, it seemed that the turtles only crossed the road to forage or look for areas of moisture. If their habitat was suitable for all needs of survival, then there was no reason to cross the roads. In addition to the already established roads, the solar farm construction site was taken into consideration as a factor for impacting turtle movement. Mainly focusing on turtles 822 and 802, it was evident that the solar farm did not pose any immediate threats. There were few visible signs that the turtles were avoiding the area. It is possible that the solar farm area is simply not in their home ranges. Future studies will indicate whether box turtles travel into the solar farm using the animal proof fencing. Using the solar farm as a possible barrier, it will be interesting to continue studying factors that impact turtle movement, in addition to ones found in this study.

Acknowledgments

I would like to thank Brookhaven National Laboratory and the Environmental Protection Division for supporting this research and encouraging awareness for our environment. I would like to specially thank my mentor Tim Green and Jen Higbie for their expertise, enthusiasm, and input in my project. A huge thanks to my partner, Jasmin, for always being supportive and sharing in my passion for the outdoors. Also, thanks to the field team in 528 for always being available for guidance.

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Appendix

	833	813	852	822	802	843
sex	F	F	M	F	F	M
min dist (m)	3.01	1.12	1.65	3.67	2.36	1.12
max dist (m)	103.47	76.62	195.79	79.40	78.52	140.43
mean	33.09	28.65	43.08	32.54	30.53	45.34
SD	28.28	20.73	43.13	24.18	22.52	34.40
Area (ha)	0.568	0.721	0.925	1.67	0.364	1.42

Table 1: Length of movement for each box turtle and home range area

	833	813	852	822	802	843
Distance from solar farm (m)	871	728	646	290	420	2,260

Table 2: Distance turtle is from the Long Island Solar Farm

	Pitch/ white oak	Pitch/mixed oak/heath	Scarlet Oak/ Heath	Red Maple/ Scarlet Oak/ Heath	Red Maple/ Heath	Planted White Pine	Grass	Successional	Road
813									
822									
833									
852									
802									
843									

Table 3: Habitat preferences

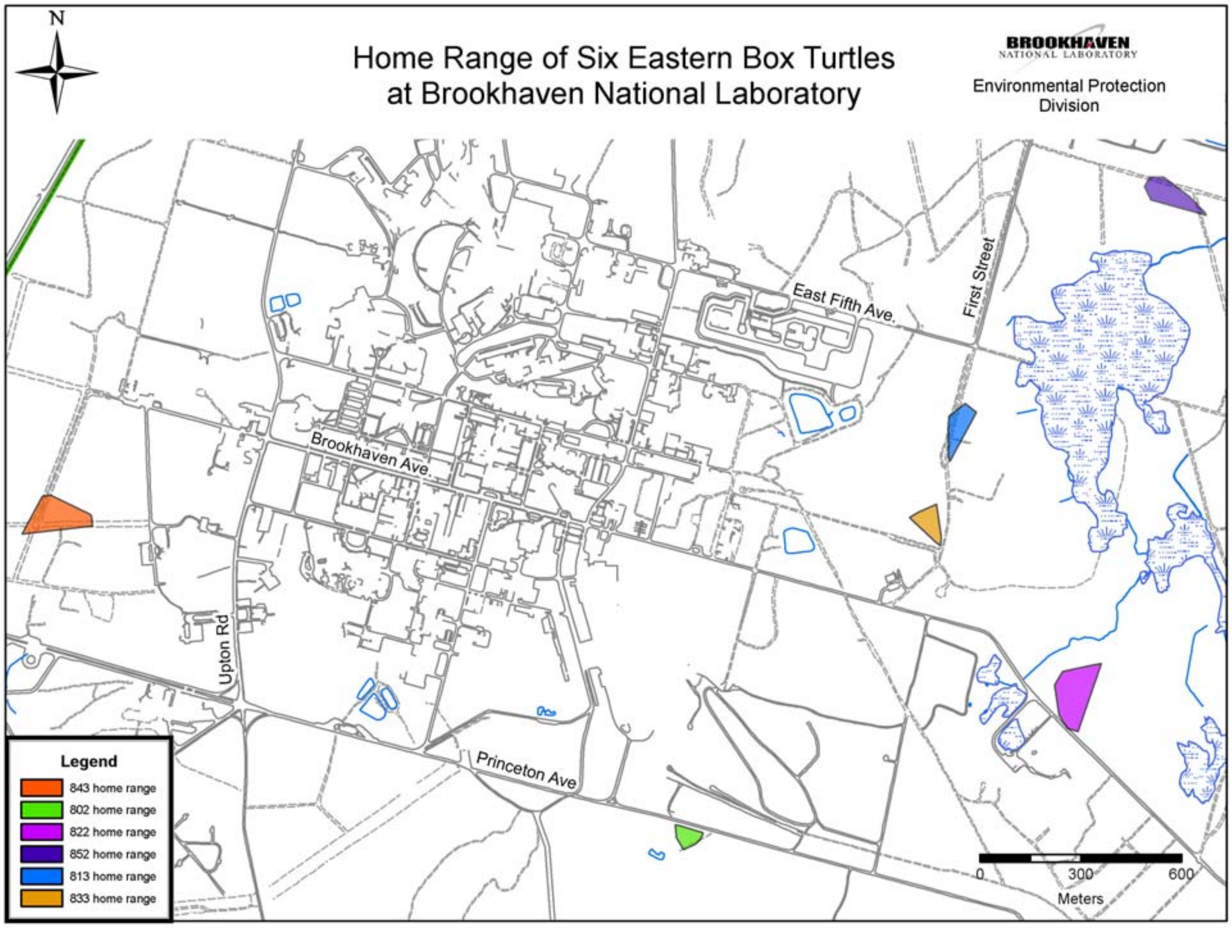

Figure 1: GIS generated map illustrating six eastern box turtle home ranges.

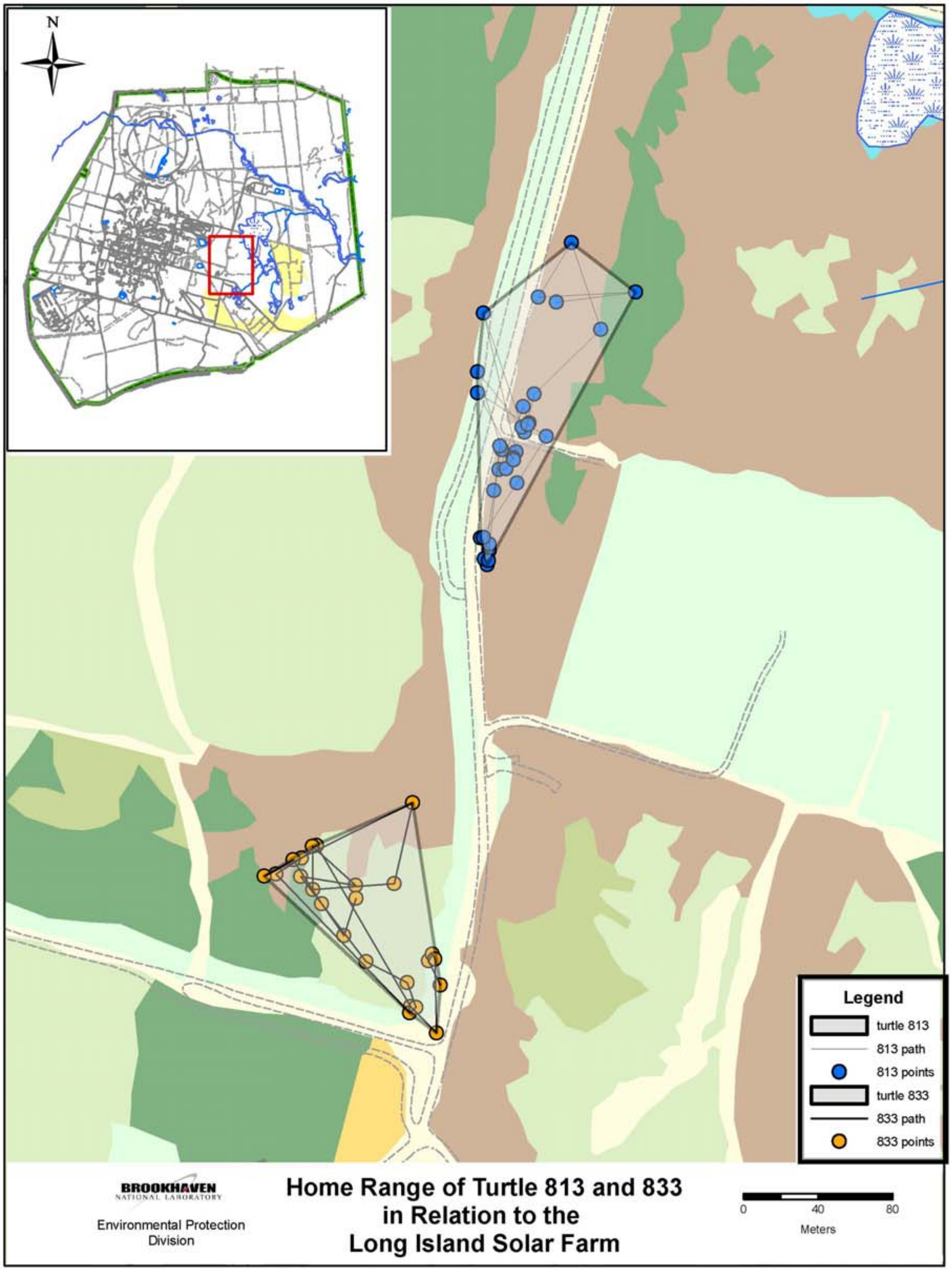

Figure 2: Home range of turtles 813 and 833. Solar farm is highlighted in yellow on smaller map.

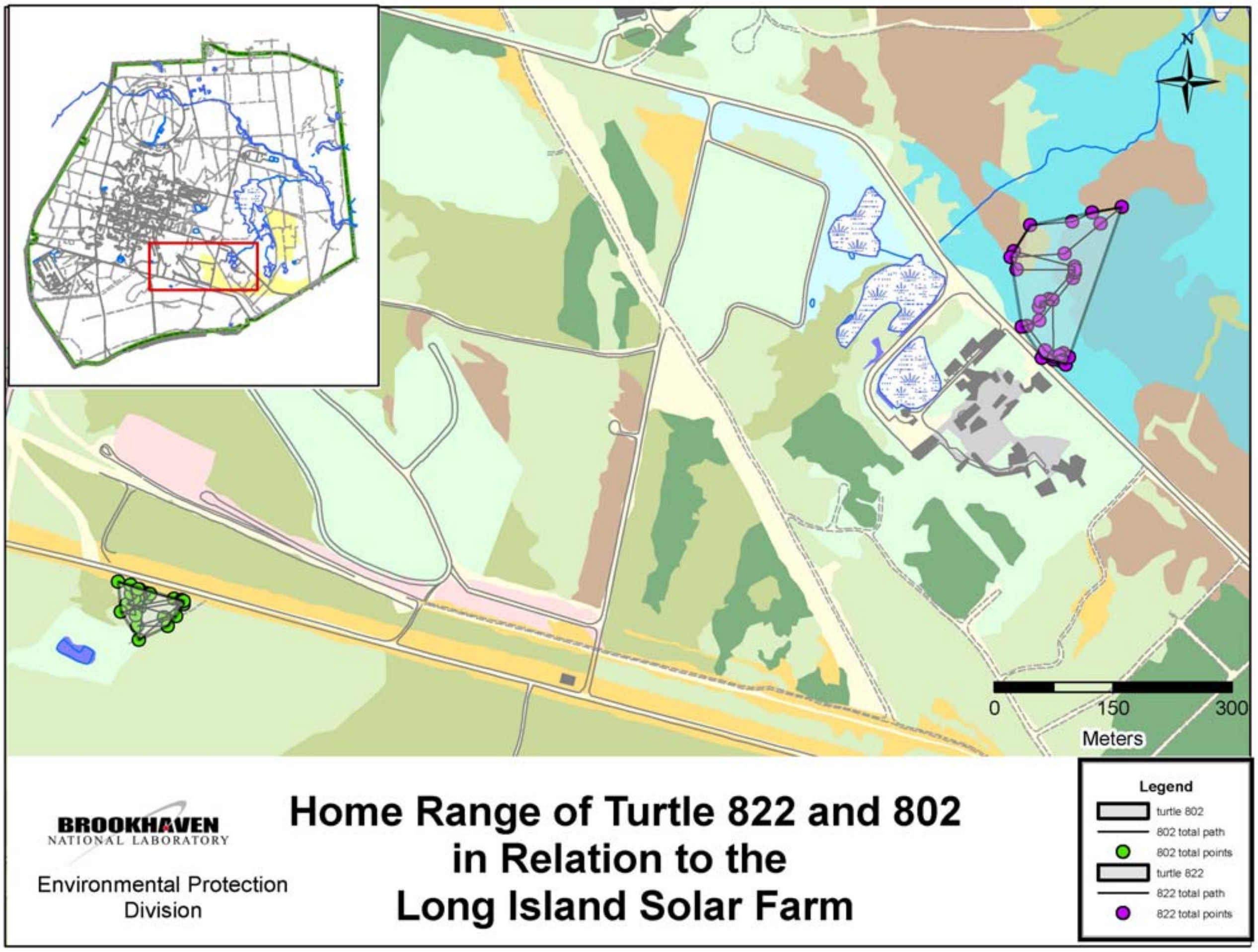

Figure3: Home range of turtles 822 and 802. Solar farm is highlighted in yellow on smaller map.

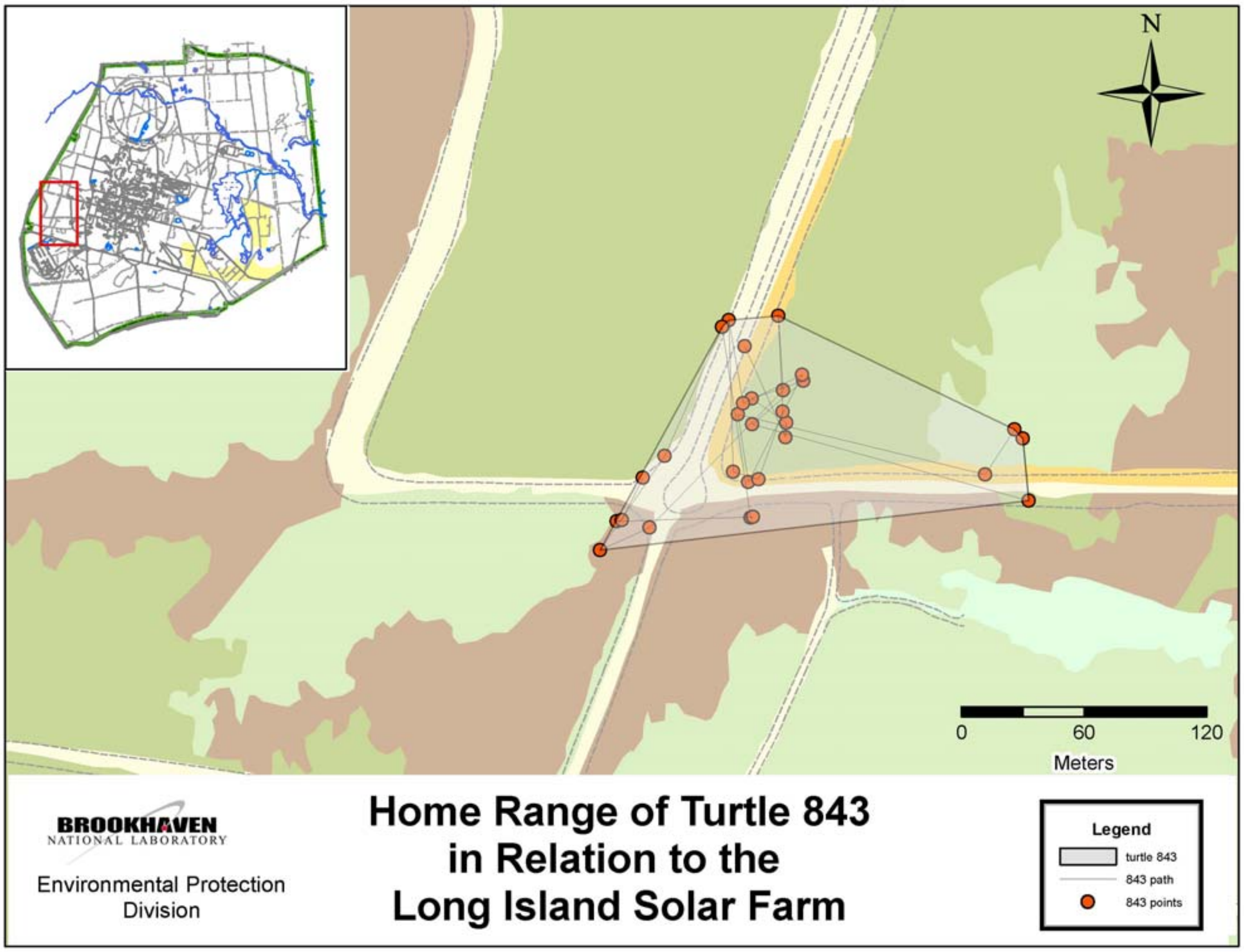

Figure 4: Home range of turtle 843. Solar farm is highlighted in yellow on smaller map.

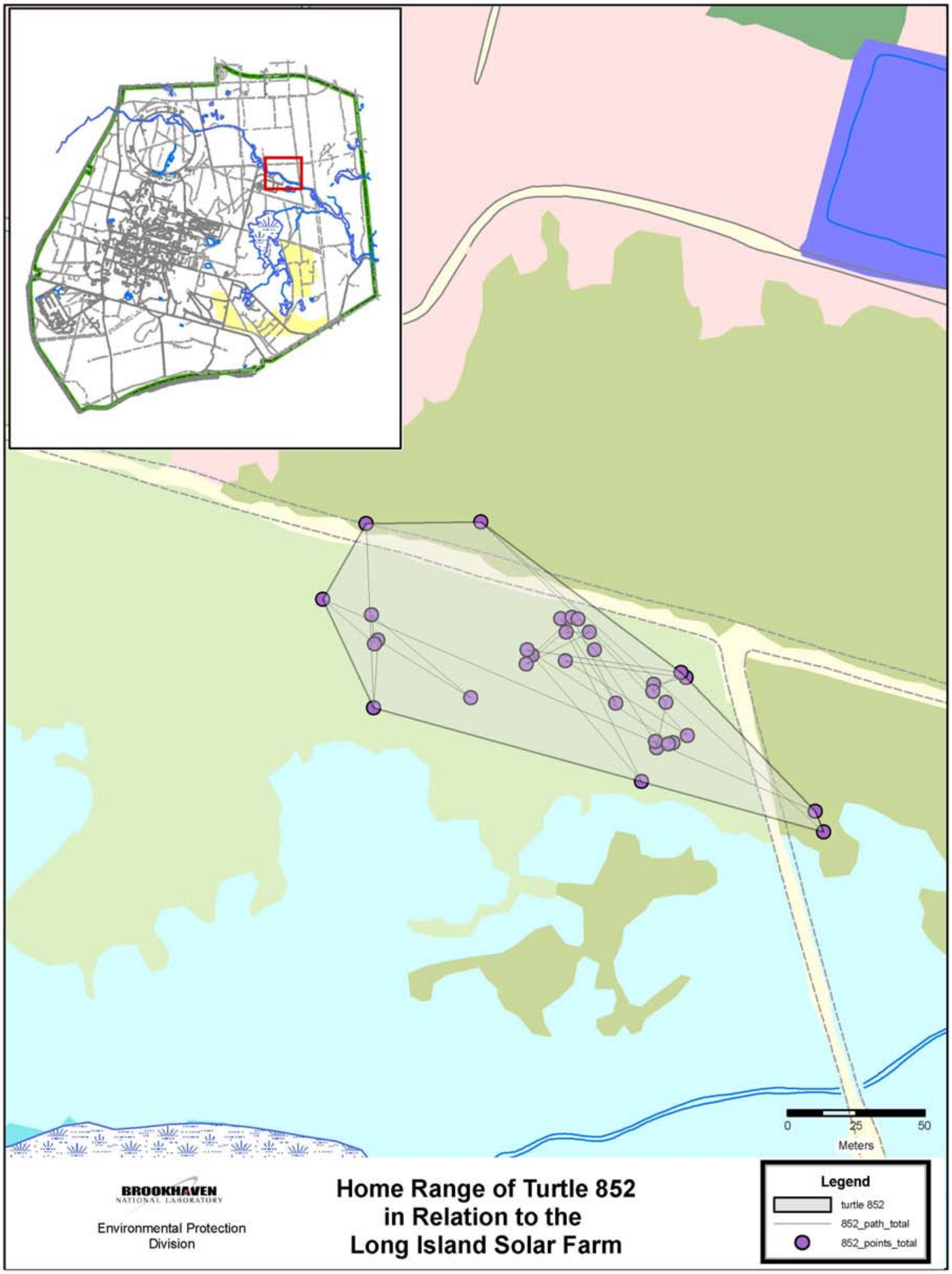

Figure 5: Home range of turtle 852. Solar farm is highlighted in yellow on smaller map.