Challenges of a changing environment: Urban development impacts a population of Eastern Box turtles

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Abstract

The Eastern box turtle (*Terrapene carolina carolina*) is a small terrestrial turtle, which lives primarily in open woodlands. Populations of these turtles can be threatened if drastic changes happen to their woodland environment, such as development projects. This is exactly what happened to a small population of eastern box turtles along the Blackwater Creek trail in downtown Lynchburg, VA. We have been researching this population since 1999 using a capture-mark-recapture method. The population was undisturbed until 2020 when a large portion of the study site was timbered for urban development, reducing the size of the forest habitat from 11 to 2.2 ha. **We hypothesize that if the population of box turtles in the post-development forest remnant is viable, then population characteristics, such as home range and density, should be similar to those from the pre-development population.**

Our study used the shell notch method to mark turtles, and several were monitored with radio telemetry to calculate population size, density, and home range size. There was a decrease in population size from 169 to 89 turtles, pre-development to post development, as well as a decrease in home range size from 8622 to 2449 m^2, while turtle density increased from 15 to 40 m^2. Even though there has been a decrease in the box turtle population living in the post-development forest remnant, some turtles successfully migrated from the timbered portion of the original study site to the forest remnant. This likely contributed to the increased turtle density and reduced home range sizes. Our research has brought understanding on how box turtles are affected by urban development, which typically reduces the amount of habitable space for the turtles. Further research needs to be done on how to mitigate the effects of urban development on this species.

Introduction

When sin was first committed in the Garden of Eden, relationships between man and creation and between species within creation shifted drastically. Where there was once harmony, peace, unity, and unlimited flourishing there was now death, decay, limitation of resources, and hardship. While many aspects in this current phase still hold goodness and beauty, the consequences of sin remain evident within our daily lives. Just as a construction project brings homes, community, and economic opportunity, there is also the destruction of natural habitat and removal or reduction of plant and animal species. Our question as creation scientists is how to mitigate the consequences seen in our fallen world to better reflect the Lord's original design. In the local area of Lynchburg, VA, a housing development was constructed and disturbed the habitat of the Eastern box turtle (*Terrapene carolina carolina*). By assessing the changes in this population pre-development and post-development, a better understanding of how anthropogenic factors impact this species can be developed, as well as a data-informed remediation plan.

Eastern box turtles are terrestrial turtles found from Maine to Florida. They prefer areas with forest cover, moderate temperatures, and humidity (Ernst, et.al., 1994). Home ranges between turtles often overlap; however, females will sometimes journey far outside their home range to nest in an open grassy field (Wilson and Ernst, 2008). As ground dwellers, box turtles can be opportunistic omnivores, feeding on insects, fungi, fruits, flowers, and sometimes carrion (Ernst, et.al., 1994). They have a steady growth rate until they near 20 years old, when growth almost halts until they typically die when 30-40 years old (Ernst, et.al, 1994). This long lifespan is linked to slow reproductive rates, resulting in slow recovery from adverse environmental changes (Dodd, 2001). Historically, most box turtles were threatened by conversion of woods to pasture lands, commercial pet trade, and industrialization. While these threats are still active today, many more are victims of automobile collisions, as well as mowing and construction equipment (Wilson and Ernst, 2008; Dodd, 2001).

Since 1999, this population of Eastern box turtle has been under routine monitoring of population size, carapace length, and home range sizes. The 11 hectare urban forest study site remained virtually untouched until 2020, when 80% of forest was cleared for residential housing, thus reducing the site to 2.2 hectares. From 2021-2023 we have been monitoring the impact of an urban development on the existing box turtle population. These post-development data were compared to pre-development data to assess impacts from the development as well as viability of the turtle population.

Methods & Materials

In 1999 a capture-mark-recapture study was initiated by Dr. Gordon Wilson within an 11 ha portion of the Odd Fellows Home property adjacent to the Blackwater Creek Nature area (Wilson and Ernst, 2005 & 2008). The turtle population was monitored annually with varying levels of sampling frequency. In 2019, the Odd Fellows Home property was sold and a housing development began which impacted the 11 ha study site. Much of the forested property was cleared of trees between 2019 and 2020 and by fall 2021 there was about 2 ha left of habitable forest from the original 11 ha site.

Turtles found throughout this study were found by the visual encounter method (Fig 1). When a turtle was found, it was hand collected and given a permanent, distinct marking for future identification by filing small notches into the marginal scutes on its shell (Figs. 2 & 3). This method allowed for the individual identification of hundreds of turtles by making use of a numbering system first described in "A new coding system for hard shelled turtles" (Ernst et al., 1974). In addition to using the shell notch method to mark turtles, the tradition of naming turtles, which Dr. Wilson initiated, was also maintained throughout the study.

All turtles collected had their sex, carapace length (Fig 2; which was used for estimating age), GPS coordinates, and date of capture recorded.

Figure 1. Box turtle on the forest floor found by the visual encounter survey method.

Figure 2. Students measuring carapace length and marking turtles with a file.

Figure 3. Box turtle displaying shell notch marking on outer scute.

Figure 4. Adhering a transmitter with epoxy to the carapace of a box turtle.

Figure 5. Pre and post-development study sites: left figure is from 2017. The right figure is from 2021, after tree clearing for housing development. The red outlines the 11 hectare pre-development study site, while the blue outlines the current, post-development, 2.2 hectare remnant forest study site.

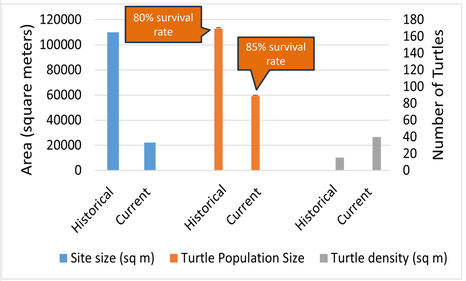

Figure 6. Since the development, the size of the study site decreased by ~80% and the turtle population size declined by ~52% while turtle density increased by ~63%.

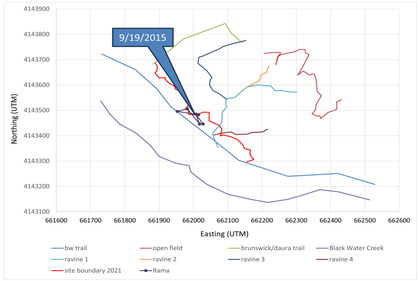

Figure 7. Rama, the box turtle, movements: red line represents the boundary of the post-development forest remnant which has been the home range for Rama since being first found in 2015 (prior to and after housing development).

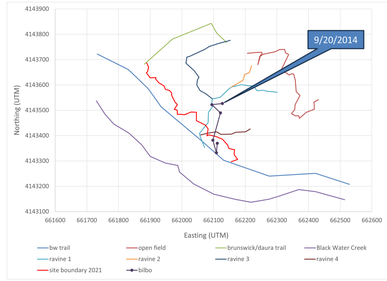

Figure 8. Bilbo, the box turtle, movements: red line represents the boundary of the post-development forest remnant. Bilbo was first initially found in 2014 in the pre-development site. Since the development, he has migrated to the post-development forest remnant.

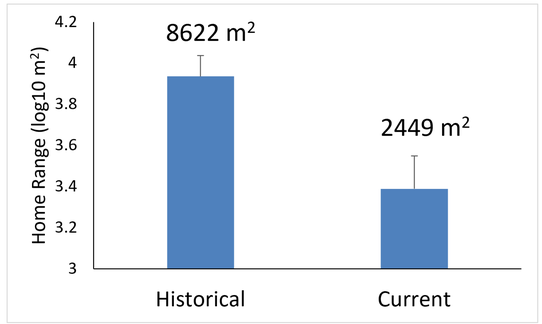

Figure 9. Mean home ranges (log_{10} m^2) for telemetered box turtle has significantly decreased from pre-development (8622 m^2) to post-development (2449 m^2).

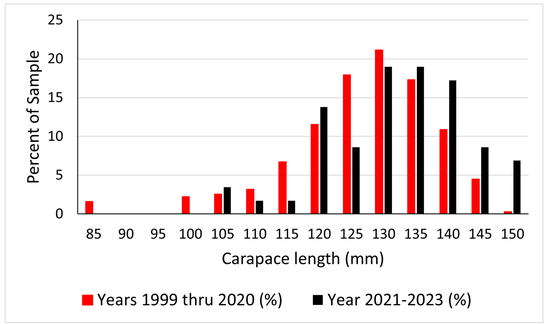

Figure 10. Box turtle carapace lengths pre-development to post-development. The post-development population had significantly fewer small (younger) turtles and more large (older) turtles compared to pre-development.

Figure 11. Nesting sites for box turtles pre-development and sites turtles will hopefully be using near the post-development forest remnant. Due to the loss of the original nesting site, an older population trend in the current turtle population is not surprising.

A small number of turtles were equipped with radio transmitters so that they could be regularly located for several months in the fall using telemetry equipment (Fig. 4). For telemetered turtles, prior to their release, a transmitter was epoxied onto the turtle's shell. A directional antenna and receiver were then used to locate each turtle several times a week. UTM coordinates using a GPS were recorded upon locating the turtle. The UTM coordinates were input into Biotas (Ecological Software solutions) to estimate home range size using the minimum convex polygon method.

Population size and survival rates were estimated using the Jolly-Seber method for pre-development years as well as for the three year, post-development time period (2021-2023). Home ranges were first log_{10} transformed to normalize them, before comparing pre- to post development data using a t-test. Carapace lengths of turtles found during pre- and post-development time periods were compared using the chi-square test. Alpha was set at 0.05 for all statistical tests.

Results and Conclusions

- The pre-development study site was partially cleared for housing development in 2020, reducing the study area from 11 ha to 2.2 ha (Fig. 5).
- As the total forested area decreased due to construction, there was a similar observed decrease in population size of the Eastern box turtle from 169 turtles to 89 turtles (Fig. 6).
- The survival rate of the box turtles has remained comparable between the sites, from 80% pre-development (1999-2020) to 85% post-development (2021-2023; Fig. 6).
- The average density of box turtles increased from 15 turtles per m^2 before the habitat loss (1999-2020) to 40 turtles per m^2 after the habitat loss (2021-2023) (Fig. 6). The increase in density may be due to turtles, from the development site, immigrating to the undeveloped forest remnant.
- Rama is a resident turtle of the undeveloped area. She was first found in 2015 and has continued to live in the undeveloped area to this day (Fig. 7).
- Bilbo was found frequently from 2014-2016 in the area that is now part of the housing development. He apparently successfully migrated to the undeveloped forest remnant since, in 2021, he was found in the post-development remnant forest far from his original capture location. Since then, Bilbo has remained in the remnant forest and he would have contributed to the increased turtle density in the undeveloped site (Fig. 8).
- Post-development, there was a statistically significant decline in the mean home range of telemetered turtles (mean = 2449 m^2) as compared to turtles tracked pre-development (mean = 8622 m^2) (t=2.06, d.f.=25, P=0.01; Fig. 9).
- This decrease in home range might be due to the increase in density, since the turtles have had to live in closer proximity to each other (Figs. 6 & 9).
- Carapace lengths of turtles found post-development (range = 105-150 mm) were significantly different from the pre-development range (range=85-150 mm) (x^2=26.70, d.f.=13, P=0.01; Fig. 10). Smaller, adult turtles were not found as frequently in the post-development forest remnant and since carapace length is an approximate indicator of box turtle age, these data suggest a trend of an aging population in the forest remnant population.
- An aging population is not shocking consequence of the development since the turtles lost their original nesting site (Fig. 11). The current population will have to find new nesting sites which may include the yards of people living along the perimeter of the post-development forest remnant (Fig. 11; see Future work).

Future Work

In an effort to decrease the anthropogenic impacts on the remnant box turtle population, involving the public can be a powerful next step. Since box turtles nest in open areas along the borders of the woodlands they inhabit, female turtles will likely migrate into the yards of the new urban development when nesting. Our plan is to educate the community about these turtles in general and in particular with regard to their nesting activities. This would include the residents in protecting this urban population of box turtles. By educating the homeowners, they may even notify us and send pictures of turtles they find thus giving us valuable information for monitoring this population. Our goal, as the research continues, is for the box turtle population to stabilize and persist and that the community will learn the value of caring for the environment.

Acknowledgements

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