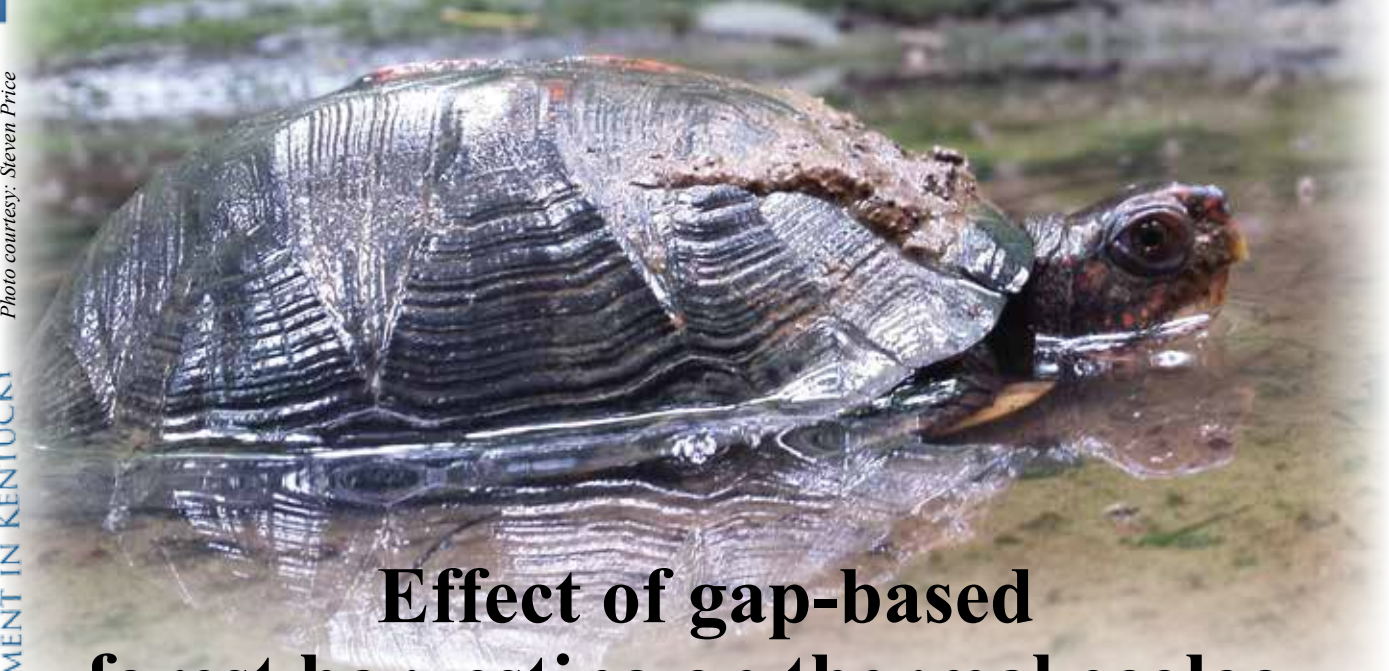


Photo courtesy: Steven Price

Effect of gap-based forest harvesting on thermal ecology of Eastern box turtles

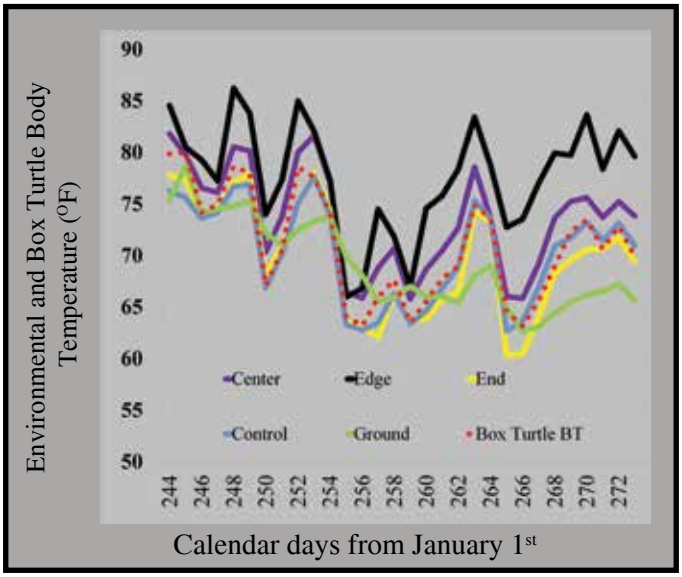
Eastern box turtle taking a swim at Berea College Forest.

by Mickey Agha, Benjamin Augustine, Steven J. Price

Introduction

The Eastern box turtle *(Terrapene carolina)* is one of the most commonly encountered reptiles in Kentucky forests. Box turtles, like all reptiles, are ectotherms (i.e., "cold-blooded"), meaning an external source of heat is required to warm their body temperatures. When air temperatures are cool, reptiles bask in areas with ample sunlight to reach their preferred body temperature. Conversely, reptiles seek refuge in a burrow or shift habitats when air temperatures are above their preferred body temperatures; this behavioral response is called thermoregulation. Box turtles prefer to keep body temperatures between 77°- 89.6°F, since they lose their ability to function at 102.2°- 107.6°F (i.e., critical thermal maximum). Although abundant in Kentucky, box turtle populations have declined in many areas in Eastern North America due to commercial collection, road mortality, and habitat fragmentation or loss. In 2011, the International Union for Conservation of Nature categorized the species as "vulnerable," or likely to become endangered unless conditions improve.

Silviculture techniques, such as canopy gap-based harvesting, promote ecological and ecosystem functionality by emulating natural disturbances to the forest canopy. Forest gaps change microclimatic conditions, such as light levels and temperature; this silvicultural technique offers potential for restoring native vegetation communities, maintaining forest biodiversity, and offering wildlife habitat. Reptiles, like box turtles, may utilize forest gaps for thermoregulation. Indeed, several studies have documented increases in abundances, diversity, or use by reptile species in forests thinned or altered through forest management. These studies hypothesize that increased temperatures in gaps lead to increased use by reptiles. Our objective was to test this hypothesis using box turtles as a model species.



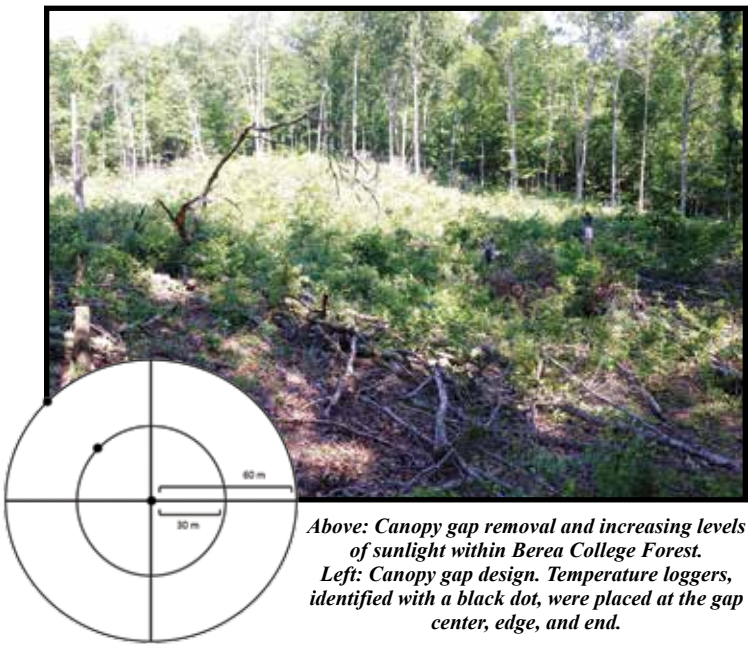
Daily average body temperature of a single box turtle during the month of September 2014.

Approach

This research took place within the 8,500 acre Berea College Forest in Madison County, Kentucky. The property is managed by Berea College and used for research, timber harvest, recreation and education. Since 2012, Berea College and UK have implemented gap-based harvesting to study the survival and growth of oak seedlings. Ten circular canopy gaps (including midstory and complete removal treatments) were created on east-facing slopes in fall 2012. Each of the canopy gaps were

harvested by removing all trees over 1.4 m within a 30 m radius of the gap center. All non-oak trees within a 60 m radius of the gap center were cut and treated with herbicide.

Box turtle surveys were conducted from early September 2013 to late April 2014. We used intensive time-area constrained searches to capture box turtles within and around canopy gaps. Twenty-four adult box turtles (13 male, 11 female) were fitted with radio transmitters, and temperature dataloggers were attached to the carapace. We used carapace temperatures as our measure for body temperature. Radio-transmitted turtles were relocated every 7-10 days from May to October, 2014. Temperature dataloggers recorded carapace temperatures (accurate to ± 1.8°F) every 30 minutes.



Above: Canopy gap removal and increasing levels of sunlight within Berea College Forest. Left: Canopy gap design. Temperature loggers, identified with a black dot, were placed at the gap center, edge, and end.

To investigate thermal characteristics of habitats within our study area, we measured ambient environmental temperatures using dataloggers placed at the center, edge, and end of canopy gaps. We also placed dataloggers in three undisturbed areas and one datalogger 15 cm under leaf litter and soil to mimic conditions when turtles were underground or within natural thermal shelters (i.e., rotting logs, mammal burrows, or mud). We then assessed differences in the thermal environment among habitats. To infer habitat use, we examined box turtle home range overlap with canopy gaps and modeled the relationship between box turtle carapace temperatures and environmental temperatures.

Group of eastern box turtles in a mud hole located within the research study area.

Results

Mean overall home range size for female turtles was 3.36 ± 0.62 acres and for male turtles, 4.27 ± 1.06 acres; these home range sizes equal about 2½ and 3 football fields, respectively. On average, 5%-25% of box turtle home range areas were calculated as occurring within canopy gaps. In our thermal assessment, we discovered that, in general, environmental temperatures of microhabitats were similar at sunrise and sunset, but by mid-day all habitats were significantly different. For instance, over the entire study, at midday, the gap center temperature average was 89.23°F (max: 100.85°F, one degree difference from critical thermal maximum temperature), while the control temperature average was 75.2°F. Mean box turtle temperatures changed throughout the day (sunrise: 65.48°F, midday: 75°F, sunset: 73.92°F), and tracked control temperatures or end of gap most closely in May-August. In September, when average ambient control air temperatures started to lower (mean 70.05°F), box turtle body temperatures resembled that of canopy gap center and gap edge environmental temperatures (mean 75.29°F), suggesting the turtles selected canopy gaps to effectively thermoregulate.

Management Implications

Results from this study suggest that box turtles select closed canopy forests throughout most of the summer, even when located in close proximity to warmer canopy gaps. However, when air temperatures began to decrease in September, box turtle body temperatures were most similar to the canopy gap centers. Therefore, our study supports the idea that increased temperatures in gaps lead to increased use by reptiles, especially during cooler months. During autumn (and perhaps spring), it is imperative to keep an eye open for turtles (and other reptiles) within canopy gaps because they offer preferable thermal environments.

Mickey Agha

This research was conducted as part of a research project by Mickey Agha (mickey.agha@uky.edu), who is a technician in Dr. Steven J. Price's lab at the University of Kentucky, Department of Forestry. Benjamin Augustine, a researcher at Virginia Polytechnic Institute, provided statistical computations for box turtle temperature assessments. This research project was overseen and directed by Dr. Steven J. Price (steven.price@uky.edu), assistant professor of stream and riparian ecology in the Department of Forestry.