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Abundance of Juvenile Eastern Box Turtles Relative to Canopy Cover in Managed Forest Stands in Alabama

ZACHARY FELIX[1], YONG WANG[1], HELEN CZECH[2], AND CALLIE J. SCHWEITZER[3]

[1]*Center for Forestry and Ecology, Alabama A&M University, Normal, Alabama 35762 USA [zachfelix@hotmail.com; yong.wang@aamu.edu];*
[2]*SUNY Environmental Science and Forestry, Syracuse, New York 13210 USA [czechha@hotmail.com];*
[3]*USDA Forest Service, Southern Research Station, Alabama A&M University, Alabama 35762 USA [cschweitzer@fs.fed.us]*

ABSTRACT. – **Between 2002 and 2005, we used drift fences and artificial pools to sample juvenile eastern box turtles (*Terrapene carolina*) in northeastern Alabama in forest stands experimentally treated to retain various amounts of overstory trees—clear-cuts and those with 25%–50% and 75%–100% of trees retained. We captured juvenile turtles only in clear-cut and 25%–50% retention plots; microhabitats in these plots are characterized by a combination of abundant vegetative ground cover and leaf litter.**

Knowledge of habitat use by each life history stage and sex within animal populations is necessary to understand a species' habitat requirements. Because they are rarely observed, little is known about the habits of juvenile eastern box turtles, *Terrapene carolina carolina* (Ernst et al. 1994), especially in landscapes modified by humans. Lack of detailed knowledge of habitat requirements, especially of juveniles, is a common hindrance in an understanding of species of terrestrial turtles in North America (Morafka 1994), including box turtles (Legler 1960; Jennings 2007). The objectives of this study were to examine the impact of forest canopy removal and the associated changes in understory habitat on the use of these areas by juvenile box turtles. Because juvenile box turtles prefer habitats with open canopy and abundant vegetative ground cover (Forsythe, et al. 2004; Jennings 2007), we predicted that juvenile box turtles would be more abundant in early successional habitat created by canopy removal.

Methods. — Study Site. — The study took place on the Cumberland Plateau of Jackson County, northern Alabama. Sites were located on the escarpment of the Plateau with slopes between 12% and 20% and stony to gravelly loam soils. These slopes were covered by second-growth forests (80–100 years old) and contained mostly oaks (*Quercus* spp.) and hickories (*Carya* spp.) with a strong component of yellow poplar (*Liriodendron tulipifera*), sugar maple (*Acer saccharum*), and American beech (*Fagus grandifolia*).

The results presented here are part of a larger study concerning the potential of several shelterwood cuts for regenerating oak forests and the impacts these silvicultural techniques have on wildlife. Treatments involved 3 levels of basal area retention including clear-cuts (0% retention), 25%–50% retention, and 75%–100% retention of subcanopy and canopy trees. Trees were felled with a chainsaw and grapple skidded in the clear-cut and 25%–50% retention treatments. The midstory was killed with an herbicide (Imazypr), thus creating small gaps in the subcanopy on half of 75%–100% retention treatment plots. Treatments were applied in the fall of 2001 and followed a randomized complete block design, with 1 block at Miller Mountain (lat 34°58′11″N, long 86°12′21″W) on south and southwest facing slopes and 2 blocks at Jack Gap (lat 34°56′30″N, long 86°04′00″W) on north-facing slopes. Each experimental block had 5 4-ha plots that were adjacent to one another: 2 each of 25%–50% and 75%–100% basal area retention treatments and 1 of clear-cut treatment. Basal area was uniform across plots prior to treatment (Schweitzer 2003).

Data Collection. — Turtles were captured in drift fences and small artificial pools. Drift fences were 15 m long with terminal 19-L buckets and 2-sided funnel traps at their midpoint. Three fences were installed in each of the 15 plots. Fences were opened intermittently for periods of 5 continuous days and checked daily between July and August 2002 and March and September 2003–2005. Drift fences were opened for a total of 1455 trap nights on blocks 1 and 3 and 1575 trap nights on block 2. A trap night was 1 drift fence opened for 24 hours. Plastic pools were 91 × 61 × 46 cm and held 60 L of water. A group of 3 pools was buried flush with the ground near the center of each plot and filled with rainwater. Several juvenile box turtles were found floating in the pools. Turtles were measured for carapace length and width to the nearest tenth of a millimeter using calipers and mass to the nearest

Table 1. Relative abundance and size (average ± standard error) of juvenile eastern box turtles captured in Jackson County Alabama, 2003–2005. None were captured in the 75%–100% canopy retention treatment.

Treatment	Relative abundance (turtles/trap night)	Carapace length (mm)	Carapace width (mm)	Mass (g)
Clear-cut	0.002 ± 0.0008	48.2 ± 5.0	42.2 ± 4.1	24.4 ± 9.8
25%–50% retention	0.001 ± 0.0004	57.7 ± 6.8	43.9 ± 2.5	55.1 ± 25.5

tenth of a gram using Pesola spring scales, given a unique notch on marginal scutes (Cagle 1939), and immediately released at the site of capture.

The microhabitat features measured along 20-m line transects at each drift fence location during late summer in 2002–2005 included percent cover of leaf litter, vegetative ground cover, slash, and coarse woody debris and percent canopy cover above 3 m. Microhabitat features were averaged across sampling locations within each of the 15 plots and across years. We used analysis of variance (ANOVA) to compare number of juvenile turtles captured per trap night across treatment levels and Tukey tests to separate means, with $\alpha < 0.10$ accepted for significance. We chose this relaxed α because of the low replication and high levels of variation usually found in large-scale ecological studies such as this one (deMaynadier and Hunter 1995). Turtle captures were square-root transformed to better meet assumptions of ANOVA (Zar 1999).

Results. — A total of 20 juvenile box turtles were captured. Five of these were found in pools and 15 in drift fences. No juvenile turtles were recaptured. Turtles ranged between 31.5- and 112.9-mm carapace length and were captured between April and September (Table 1). The largest turtle included in these analyses approached the carapace length of sexually mature males (Dodd 2004) but showed no secondary sexual characteristics.

Relative abundance of juvenile box turtles differed among treatments ($F_{2,10} = 14.08$, $p = 0.001$) and was highest in clear-cut and 25%–50% retention treatments (Fig. 1). No turtles were captured in the high-retention treatment (75%–100% retention). Tree removal treatments created a gradient from closed-canopy stands with low coverage of vegetation, coarse woody debris, and slash to open-canopy stands with dense understory vegetation, slash, and woody debris at the ground level (Fig. 1). All juvenile turtles were captured in open-canopy stands.

Discussion. — It appears that the relative abundance of juvenile eastern box turtles is affected by canopy tree removal. Juveniles were never captured or observed in closed-canopy stands. The removal of more than 75% overhead canopy resulted in the growth of a dense ground covering (> 80%) of herbaceous and woody vegetation and an increase in slash and coarse woody debris associated with the cutting operations. At our sites, the stand was thinned to at least 16 m^2/ha (70 $feet^2$/acre) of basal area to achieve this level of canopy cover.

The relative abundance of juvenile turtles was related to the increase in the habitat features described previously. Although possibly a correlation, we hypothesize that the treatments created suitable habitat for juvenile box turtles by opening the forest canopy. Presence of juvenile box turtles could be related to food resources: increased production of vegetative growth is likely accompanied by increased biomass of dietary items such as fruits and leaves (Greenberg et al. 2007). In 2002, air temperatures were on average 1.5°C higher on clear-cuts than controls, soil temperatures were 3°C higher, and both showed a positive gradient associated with increasing tree removal (Felix et al. 2003). Increased heat and food availability may be required to meet metabolic demands during the rapid growth of early life stages (Dodd 2004). Alternatively, increased numbers of juvenile turtles could be related to cover requirements. Although juvenile box turtles could find cover in the plentiful, deep leaf litter in closed canopy, they may prefer a combination of litter and the abundant vegetative ground cover, slash, and coarse woody debris in cut plots. Juvenile Florida box turtles (*T. c. bauri*) used areas with thick understory vegetation and leaf litter during movements (Jennings 2003) and were found most frequently beneath dense understory vegetation under leaf litter or other organic debris (Jennings 2007). Hatchling eastern box turtles in Illinois were found in an open-canopy grassy field with abundant herbaceous and woody vegetation. Within these habitats, turtles preferred microhabitats with less canopy closure and herbaceous vegetation and more leaf litter than random locations (Forsythe et al. 2004). Based on these observations, it appears that important features of juvenile box turtle habitat include open canopy, abundant vegetative ground cover, and leaf litter.

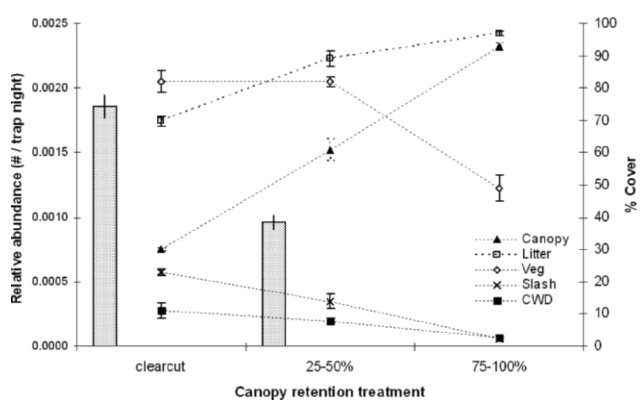

Figure 1. Relative abundance of juvenile box turtles captured and percent cover of 5 microhabitat categories in each of 3 basal area retention treatments 2002–2005, Jackson County, Alabama. Bars represent average number of juvenile turtles captured per trap night, and lines show 4-year averages for percent cover of microhabitat features. Error bars are ± 1 standard error.

This information is only 1 small puzzle piece in determining habitat requirements of eastern box turtles. For example, *T. c. bauri* show ontogenetic shifts in habitat use (Hamilton 2000), and adult turtles use different habitat than that of juveniles. Flitz and Mullin (2006) showed that adult females use different habitat types while nesting than in other seasons. At our study sites, canopy tree removal increased the relative abundance of juveniles. Increased relative abundance could be the result of differential habitat use by nesting females or juveniles. Flitz and Mullin (2006) showed that adult females tend to select relatively open habitats while nesting than at other times. If nesting habitat is limited in closed-canopy forests, tree removal might increase recruitment by increasing availability of suitable nest sites. The amount of benefit gained would depend, in part, on the balance of the amount of open- and closed-canopy habitat required by juveniles and adults and the interactions of these habitat types with other demographic features of the population. For example, edges created by forest openings support higher predator populations such as raccoons (Dijak et al. 2000), leading to greater predation on box turtle nests, juveniles, and adults (Temple 1987) than in nonecotonal areas. Optimal size and number of forest openings can be determined only with additional information on habitat requirements and home range size of adult and juvenile turtles as well as impacts of openings on survival of all life stages.

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