

MICROHABITAT SELECTION AND USE BY THE EASTERN BOX TURTLE (*TERRAPENE C. CAROLINA*) AT PURCHASE KNOB, GREAT SMOKY MOUNTAINS NATIONAL PARK

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Abstract. Turtle longevity, development, and population growth may be compromised by human development. The purpose of this study was to contribute to current knowledge regarding habitat use and population dynamics of the eastern box turtle (*Terrapene carolina carolina*). Tracking data were collected for five individual turtles from June 2006 through October 2006 to assess habitat preference regarding vegetation cover type and soil type. Two turtles appeared to exhibit preferences in cover type. One was considerably associated with successional field habitat, while the other preferred understory forest habitat. Four out of five turtles were found associated with a subset of Wayah Sandy Loam soil. Results are based on one year of data collection; more precise conclusions can be drawn about eastern box turtle habitat selection with data collected over multiple years.

INTRODUCTION

Purpose

Recent evidence suggests that turtle longevity, development, and population density may be compromised by urbanization (Budischak et al. 2006). The eastern box turtle once had a fairly ubiquitous distribution throughout the eastern United States, but populations are declining because of human development (Thorbjarnarson et al. 2000). Because habitat loss is often directly followed by increased human activity and, subsequently, further habitat fragmentation, box turtles face secondary threats to population density such as highway mortality and overcollection by the pet trade (Klemens 2000). Temple (1987) found that habitat fragmentation also causes increased ecological edge and, therefore, a higher incidence of predation on turtle nests. Turtles in deforested areas may also experience retarded developmental rates that prevent them from reaching the safety of adult size early in life. Slow maturation could also delay mating ability (Dodd 2001, Budischak et al. 2006). These factors further diminish population densities.

Declining turtle populations are an immediate biological concern, as is evident in a 1990 study by Doroff and Keith, who found that the current ornate box turtle (*Terrapene ornata*) population in south-central Wisconsin cannot endure losing one adult per year. Eastern box turtles are a popular pet species in eastern North America, and they are exposed to significant urbanization throughout their range. Therefore, this species is of particular interest regarding the way it uses its habitat when relatively undisturbed by human activity. This study aims to contribute to a better understanding of the habitat use of eastern box turtles located in a high-elevation, protected area that includes several habitat types. Improved awareness of turtle movements may aid in better protection and management of this species both within and outside such protected areas as national parks.

MATERIALS AND METHODS

Study Area

This study was conducted in 2006 at the Appalachian Highlands Science Learning Center, located at Purchase Knob on the eastern edge of the Great Smoky Mountains National Park (GSMNP; Appendix A). Purchase Knob is mixed forest and managed open field site. The study site is characterized by four distinct vegetation cover types, the most disturbed of which is an open herbaceous field. This area is mowed every three years, once during the study period in Mid-August of 2006. Vegetation is predominantly timothy and fescue grass (*Festuca* spp.), with woody saplings and blackberry (*Rubus* spp.) in small abundance.

Old growth forest cover dominates the area directly below Purchase Knob. It is characterized by a relatively open understory and by typical northern hardwood canopy cover, the most dominant species being red oak (*Quercus rubra*) and red maple (*Acer rubrum*). Some open canopy areas are present due to loss of the American chestnut (*Castanea dentata*). There is limited and selective cutting in this area. Disturbance in forested areas is limited to removal of individual forest emergent tree species, while still saplings. The last removal was in winter of 2005/2006. Subcanopy species include eastern hemlock (*Tsuga canadensis*), mountain laurel (*Kalmia latifolia*), and *Rhododendron* spp. The forest edge is characterized by a significant amount of early successional species such as goldenrod (*Solidago* spp.), blackberry (*Rubus* spp.), and grasses.

On the east and west sides of the road leading up to the Learning Center at Purchase Knob, Fraser fir (*Abies fraseri*) has been planted for genetic conservation. These trees are sprayed and kept as two separate monocultures. For the purpose of this study, these areas were identified as managed field habitats. Several areas of commercial firs are also located within the study area, the largest of which is situated at the southernmost edge of the protected property. The commercial tree areas harbor a significant amount of undergrowth and are referred to in this study as successional fields.

Data Collection

Interns and groups led by GSMNP rangers Paul Super and Shelly Buranek located five eastern box turtles within the Purchase Knob area and tracked their movements for various durations from June 2006 until hibernation in late October 2006. After capture, each turtle was marked by attaching a transmitter with Devon 5-minute Epoxy on the front end of its shell, then released in the same area it was collected.



FIG. 1. *Terrapene c. carolina* showing attached radio transmitters; Christina, left; Rufus, right.

A radio frequency unique to each receiver allowed for individual identification of turtles after capture. National Park employees and interns tracked individuals twice weekly when possible, using a TRX-485 receiver. Six-digit codes unique to each transmitter were used to confirm the identification of turtles. Researchers limited interactions with the animals as much as possible, approaching them momentarily for identification.

Measurements

Descriptive data were recorded upon recovery of turtles, including activity (if turtle was stationary, moving, copulating, eating), relative humidity (measured with a sling psychrometer), soil temperature, ground temperature, and cover type. Turtle location was marked on a Garmin Etrex 12-channel GPS unit. Either directly before or directly after recovery, weather was documented from the National Weather Service's Climate Station at Purchase Knob. Barometric pressure and dew point were recorded from the NOAA National Weather Service site at Asheville Regional Airport, as this was the closest location from which to record this information.

Analysis

As soil type and vegetation cover type describe microhabitat, these factors were chosen for analysis. Four cover types were identified within turtles' ranges: managed field, understory forest, forest with sparse understory, and successional field. Nine soil types were classified by the USDA Natural Resources Conservation Service within turtle home ranges (Table 1).

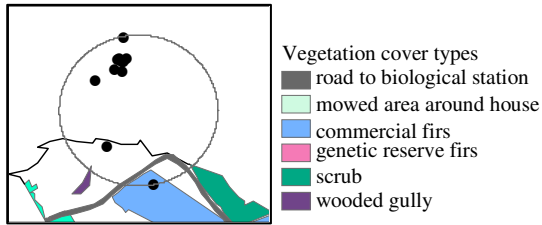
Soil classification	Soil composition	Slope (%)
AwB	Wesser complex	0 - 8
WaC	Wayah sandy loam	5 - 15
WaD	Wayah sandy loam	15 - 30
WaF	Wayah sandy loam	30 - 95
WeF	Wayah sandy loam	30 - 95
OwF	Oconaluftee-Guyot-Cataloochee complex	50 - 95
PwE	Leatherwood clay	30 - 50
TaC	Tanasee-Balsam complex	5 - 15
TaD	Tanasee-Balsam complex	15 - 30

TABLE 1. Soil types found in the study site at Purchase Knob, Great Smoky Mountains National Park.

In order to make predictions regarding what types of soil and vegetation turtles might prefer, position, soil type, and vegetation cover type maps were made using ArcMap software (Appendix B). Based on these maps, home ranges were identified. Stickel (1989) predicted average home range size of box turtles in Maryland, but the results were inapplicable to this study, as average home range size calculated was significantly smaller than the area utilized by turtles at Purchase Knob. In the present study, operational home ranges were determined by first identifying the two furthest location points for each turtle. This distance was used as the diameter of a circular area centered on the midpoint. This circular area was identified as the operational home range

for each turtle. Fig. 2 and Appendices C and D provide vegetation cover and soil maps, respectively, with operational home ranges indicated.

2a. Charlie – cover type



2b. Charlie – soil type

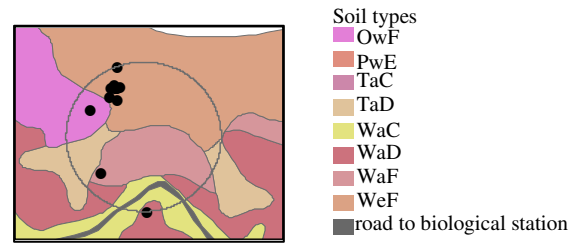


FIG. 2. Examples of operational home range maps

Using these circles, estimated areas of operational home ranges were calculated, as shown in Table 2.

Name	Operational home range area (m ²)
Charlie	126,901
Christina	420,978
Lucy	25,415
Peggy Sue	128,871
Rufus	182,657

TABLE 2. Operational home range sizes for five eastern box turtles studied at Purchase Knob, Great Smoky Mountains National Park.

Soil types and cover types within home ranges were then recorded. Cover types or soil types that measured less than 10 by 10 m were not counted. This value was chosen by researchers as an arbitrary area for which soil and cover types were too insignificant to expect turtle discovery and selection. Chi square tests were then used to test association with vegetation cover types and soil types available to each turtle within its home range (Zar 1999). In using this approach, the assumption was made that turtles had equal access to soil and vegetation types located in their operational home ranges (i. e. turtles had the ability to select for any habitat in the time interval between successive observations).

RESULTS

Location data are summarized for the five study turtles in Table 3. Complete data and a sample data sheet are located in Appendices E and F, respectively.

Turtle	Sex	Dates tracked (2006)	No. of observations*
Charlie	M	8/25 – 10/27	12
Christina	F	6/16 – 10/27	21
Lucy	F	6/23 – 7/11	4
Peggy Sue	F	6/27 – 8/30	8
Rufus	M	6/10 – 9/8	6

*Observations were only included if precise location of turtle was recorded.

TABLE 3. Summary data for *Terrapene c. carolina* studied at Purchase Knob, Great Smoky Mountains National Park.

Percent association with vegetation cover for each turtle is summarized in Fig. 3.

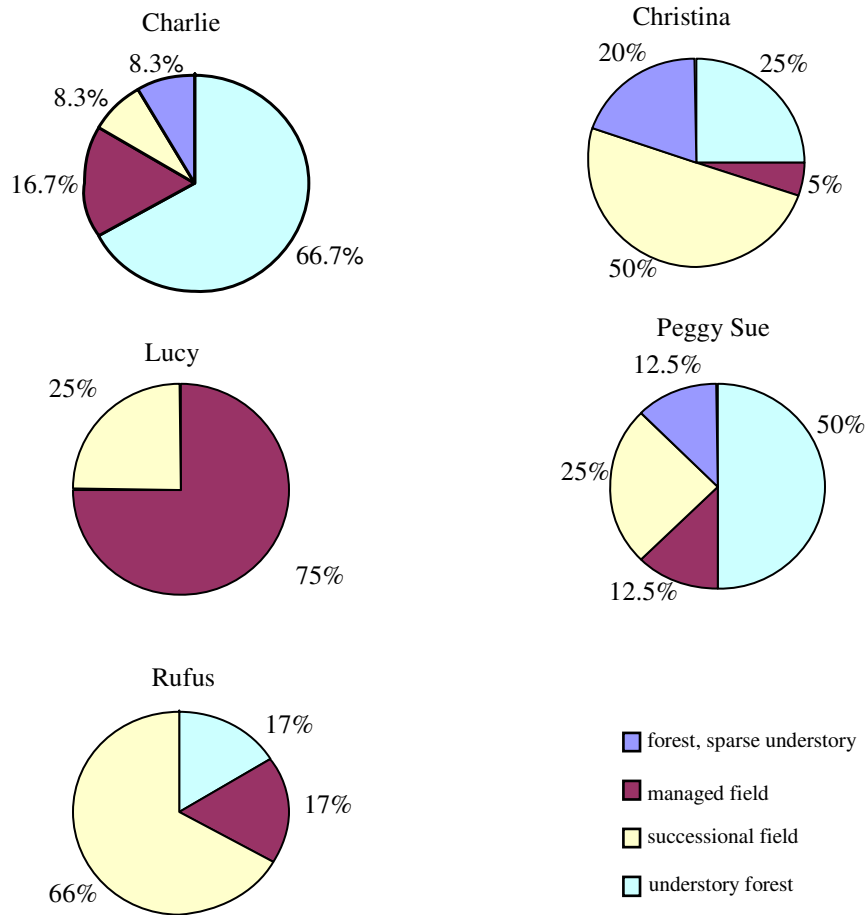


FIG. 3. Turtle incidence among vegetation cover types within operational home ranges.

Turtle home ranges included all cover types, except in the case of Lucy, who had only two cover types in range. Two turtles exhibited significant cover preferences. Statistical values associated with chi square analysis are listed in Table 4.

Turtle Name	Vegetation Cover				χ^2	P
	UF	SF	FSU	MF		
Charlie	8	1	1	2	11.3	0.01
Christina	7	10	*	4	18.16	0.05 > P > 0.025
Lucy	—	1	-	3	1.00	0.50 > P > 0.25
Peggy Sue	4	2	1	1	3.00	0.50 > P > 0.25
Rufus	1	4	0	1	5.98	0.25 > P > 0.10

*One data point under SF was not used in soil analysis or in Table 2, because there was no visual conformation of turtle. However, the turtle was triangulated in a successional field area, so the data point was counted as cover information.

TABLE 4. Association of turtles with vegetation cover at Purchase Knob, Great Smoky Mountains National Park; Vegetation cover types are abbreviated as follows: UF – understory forest; SF – successional field; FSU – forest, sparse understory; MF – managed field. A dash indicates that the habitat type is not present within a turtle’s operational home range.

Percent association with soil type for each turtle is presented below in Fig. 4.

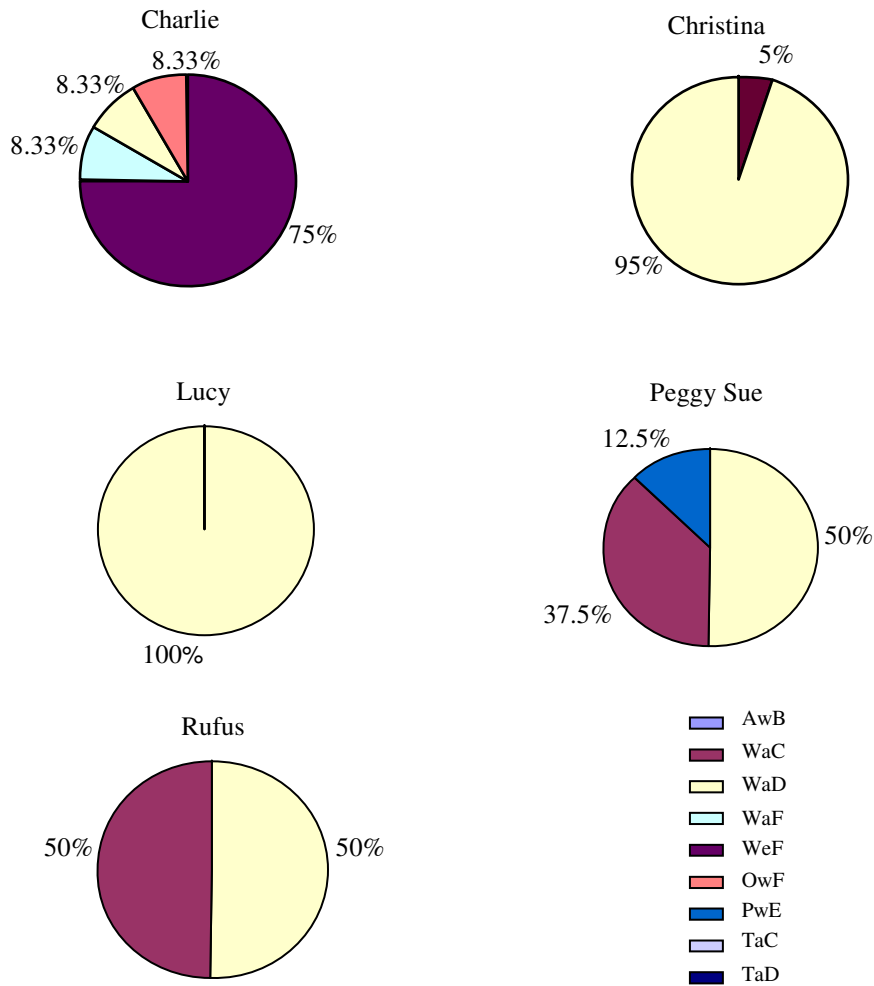


FIG. 4. Turtle incidence among soil types within operational home ranges.

The combination of soil types was different in each operational home range. Table 5 indicates significance values for chi square analysis based on turtle association with home range soil types.

Turtle	Soil types*									χ^2	P
	AwB	WaC	WaD	WaF	WeF	OwF	PwE	TaC	TaD		
Charlie	0	0	1	1	9	1	-	-	0	29.5	$P < 0.001$
Christina	0	1	20	0	0	0	-	-	-	8.16	$P < 0.001$
Lucy	-	0	4	-	-	-	-	0	-	8.20	$0.025 < P < 0.01$
Peggy Sue	0	3	4	0	-	-	1	0	-	11.7	0.05
Rufus	-	3	3	-	-	-	-	0	0	6.00	$0.25 < P < 0.10$

* See Table 1 for explanation of soil classifications.

TABLE 5. Association of turtles with soil types at Purchase Knob, Great Smoky Mountains National Park; A dash indicates that the soil type is not present within a turtle's operational home range.

Summary vegetation cover and soil data for all turtles are presented in Fig. 5. Overall, turtles were predominantly associated with understory forest and successional field habitats and Wayah sandy loam (WaD) soil, although chi square analysis was not performed for compiled turtle data.

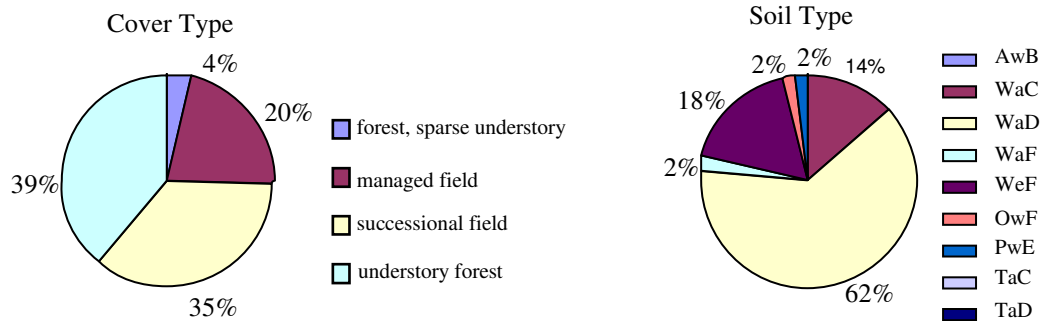


FIG. 5. Compiled data of turtle association with vegetation cover types and soil types.

DISCUSSION

Of the five turtles tracked during the 2006 season at Purchase Knob, only two yielded enough data for robust analysis. During the study period, Lucy and Peggy Sue lost their transmitters, and researchers lost signal from Rufus. Perhaps another type of epoxy, for example PC-7 epoxy cited in Morrow's 2001 study of the bog turtle (*Clemmys muhlenbergii*), would aid in reducing the effects of lost transmitters. Additionally, Charlie was not found and fitted with a transmitter until late August. Therefore, the amount of data available for each turtle was limited by early cessation or late onset of data collection. Researchers were occasionally unable to visualize turtles, finally, because of brambles or dense vegetation. This further limited the amount of data available for statistical analysis.

No notable difference was found between male and female habitat selection. Additionally, no significant correlation was found between the habitat selection of male and female turtles. Christina was the only turtle for which data was collected throughout the entire study period, and she had the largest operational home range. It is probable that other turtles would have had larger home ranges had data been available over a larger time frame. Therefore, no conclusions can be drawn about possible differences in home range size between males and females.

However, groups, interns, or National Park employees involved in subsequent years of data collection should consider some trends found within this first year study. It is noteworthy that Charlie and Christina, the turtles for which the most data points were collected, were those with identifiable cover preferences, understory forest and successional field, respectively. With further data, other individuals may have also shown patterns for incidence in certain vegetation cover. Furthermore, as Christina was found in the understory forest area in the fall, it is reasonable to consider that Charlie was associated with forest habitat because he was collected later, i.e., Charlie might have been associated with successional field habitat earlier in the study period.

Both Christina and Charlie, the only turtles for which data on hibernation site was available, chose hibernation areas within understory forests. This is especially significant in Christina's case, because before this point she was found mostly in successional field

habitat. This is consistent with other studies that have indicated that box turtles often hibernate in forested areas, perhaps for protection and moderated climate (Claussen et al. 1991).

All turtles exhibiting a soil type preference – Lucy, Charlie, Christina, and Peggy Sue – were found associated with some subset of Wayah sandy loam soil (Table 1). This is not surprising, as these are the predominant soils in the Purchase Knob area. It is possible, however, that physical attributes of this soil or the vegetation it supports are attractive to the turtles. Wayah sandy loam soils are often associated with high-elevation areas and, therefore, high-elevation vegetation, such as Fraser firs (National Cooperative Soil Survey). Data indicates that turtles are selecting areas in which fir and, more importantly, associated cover is prevalent. Analysis from this study indicates that turtles were found in managed field and successional field habitats for 74% of the turtle recovery observations made over the course of this study. Qualitative data regarding cover directly surrounding turtles upon location showed that turtles appear to be associated with herbaceous cover within the Fraser fir dominated areas, such as blackberry and goldenrod.

Rossell et al. (2006) found that turtles prevent desiccation by selecting for soil types that retain moisture and allow for high humidity. No soil humidity data was collected in this study. However, turtles were mostly associated with the WaD subset soil, which is of relatively gentle slope. Therefore, it may be reasonable to assume that turtles remained in areas with minimal runoff and maximal soil moisture. Additionally, turtle association with blackberry and goldenrod may indicate that turtles prevent desiccation by remaining in microhabitat areas in which vegetation cover allows for humid microclimates.

As mobility constraints are a factor in turtle habitat selection, a more thorough future approach may involve using ArcMap software to create polygons around each vegetation and soil type, in order to estimate the area of each polygon and assign a relative importance value to each vegetation and soil type based on area. As this is a preliminary study, the polygon-based approach may be implemented when further data are collected.

Supplemented with further data, this study will supply a better understanding of how eastern box turtles utilize habitat when relatively undisturbed. Identification of trends in selection of certain soil and cover areas may significantly contribute to better management and protection of this species.

LITERATURE CITED

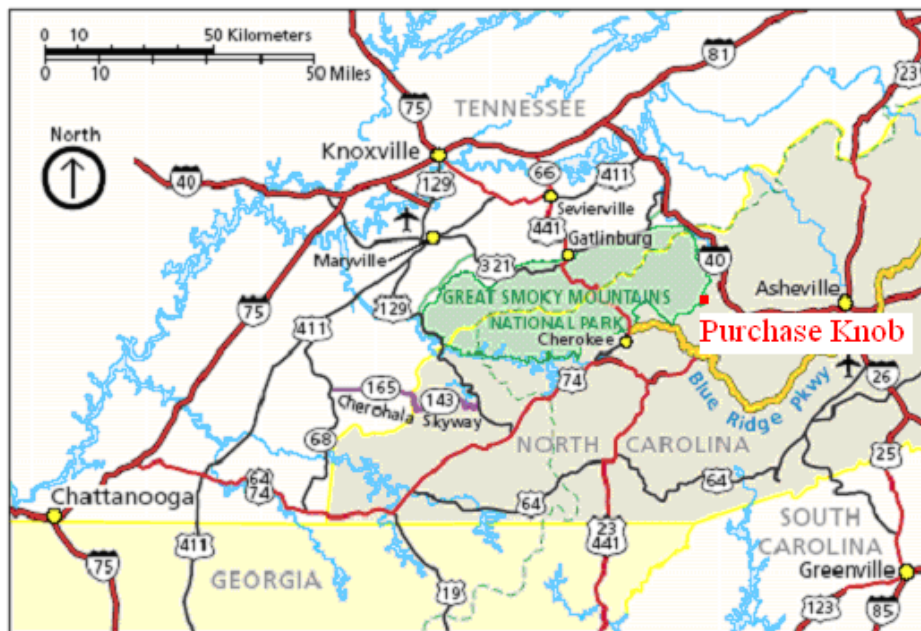
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REFERENCES FOR FURTHER STUDY

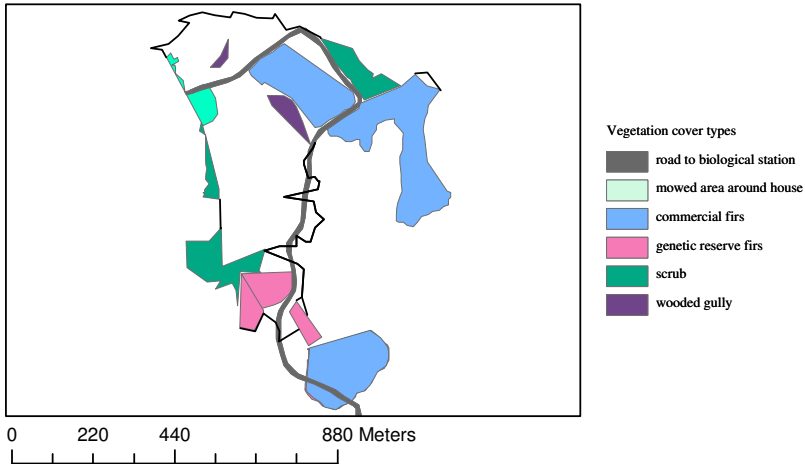
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APPENDIX A. Map of Great Smoky Mountains National Park with Purchase Knob indicated.

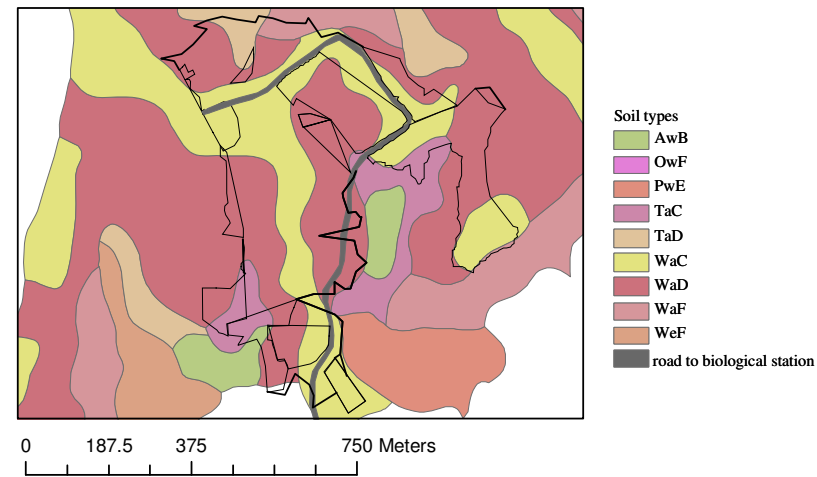


APPENDIX B. Vegetation cover type and soil type maps of Purchase Knob, Great Smoky Mountains National Park.

B1. Cover Type

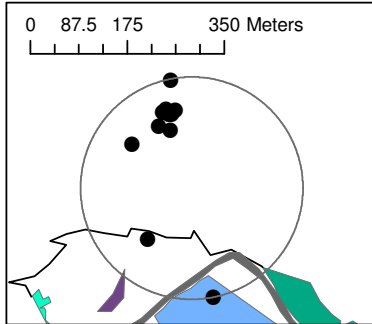


B2. Soil Type

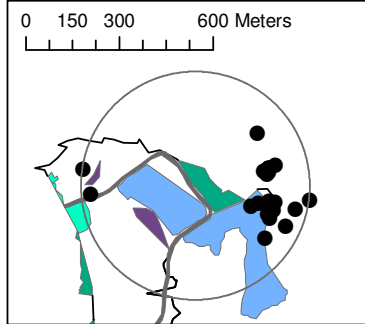


APPENDIX C. Vegetation cover types within operational home ranges of five eastern box turtles studied at Purchase Knob, Great Smoky Mountains National Park.

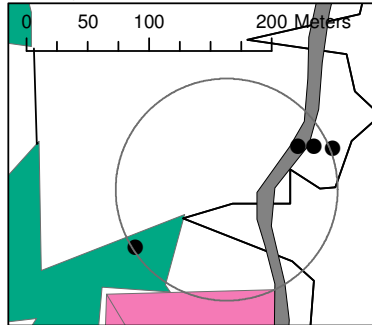
B1. Charlie



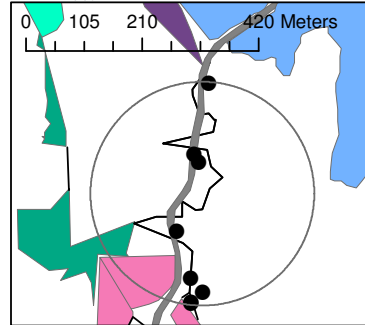
B2. Christina



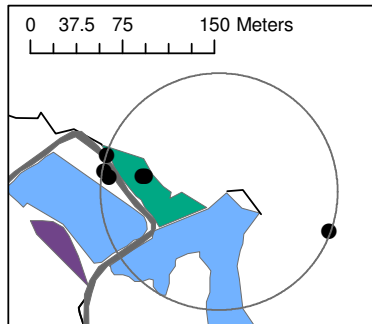
B3. Lucy



B4. Peggy Sue



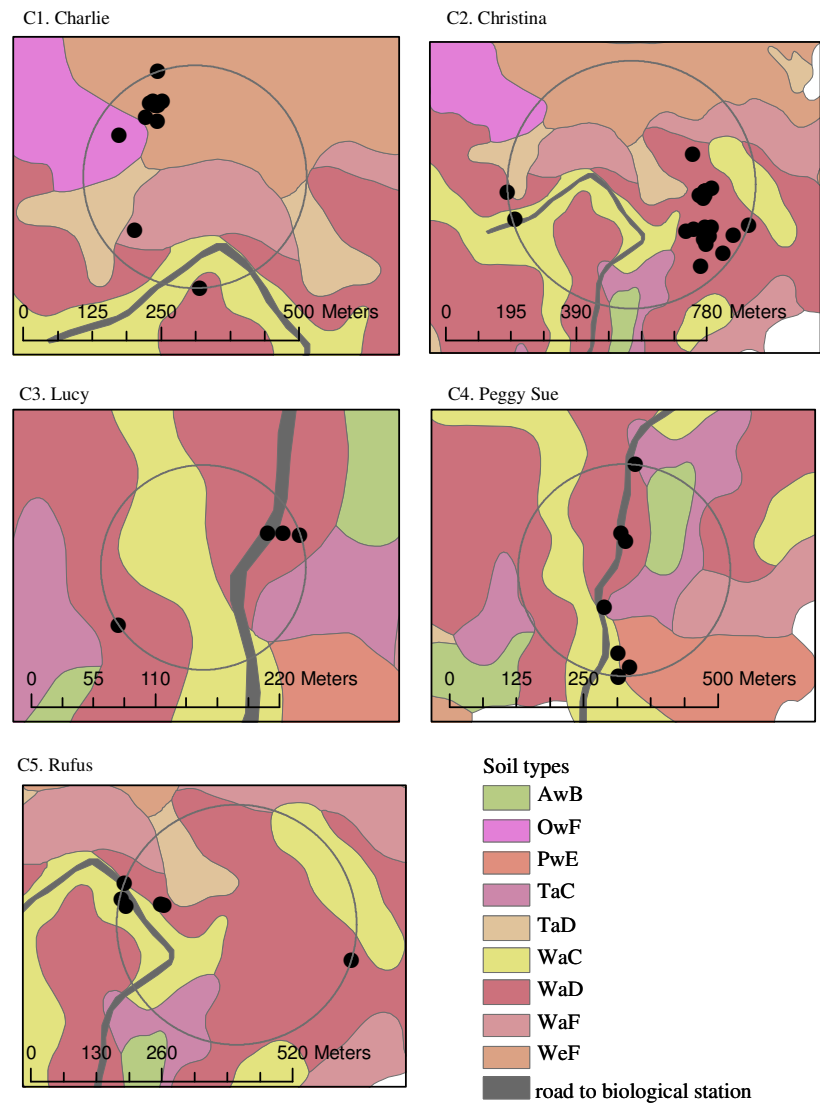
B5. Rufus



Vegetation cover types

- road to biological station
- mowed area around house
- commercial firs
- genetic reserve firs
- scrub
- wooded gully

APPENDIX D. Soil types within operational home ranges of five eastern box turtles studied at Purchase Knob, Great Smoky Mountains National Park.



APPENDIX E. Compiled data for five eastern box turtles studied at Purchase Knob, Great Smoky Mountains National Park during the 2006 field season.

Name	Date	Time found	Air temp. (°C)	Rain (mm)	Wind direction	Wind speed (mph)	Barometric pressure (Hg)	Dew point (°C)	Humidity (%)	Cloud cover	Easting
Charlie	8/25/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	312282
	8/30/2006	n/a	20.5	6	N	2	29.91	19.4	87	partly cloudy	312234
	9/8/2006	1:30	18	4.9	n/a	n/a	30.19	14.4	58	overcast	312262
	9/20/2006	n/a	13.5	0	NE	3	n/a	n/a	71	Clear	312303
	9/22/2006	3:30	166	0.254	NW	3	30.1	13.8	92	overcast	312295
	9/27/2006	2:40	n/a	0	N	2	29.99	10.5	49	partly cloudy	312312
	9/29/2006	10:46	12.2	0	N	2	30.04	5.5	68	partly cloudy	312289
	9/30/2006	11:25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	clear	312380
	10/6/2006	10:35	10	0.254	N	7	30.14	12.7	81	overcast/foggy	312304
	10/11/2006	10:00	15.5	0.254	NE	4	29.83	13.3	63	overcast	312305
	10/13/2006	12:13	16.1	0	NW	13	29.98	-6.1	63	clear	312301
	10/27/2006	9:36	6.6	0.254	SW	5	30.03	-6.1	86	overcast	312301
Christina	6/16/2006	7:55	15	0	SW	1	30.27	10.5	63	clear	312190
	6/27/2006	9:40	18.5	6	NE	2	30.05	16.6	90	overcast	312781
	6/28/2006	10:03	18.3	0	NE	2	30.21	15.5	78	partly cloudy	312764
	6/30/2006	n/a	20	0	N	4	30.21	15.5	78	clear	n/a
	7/5/2006	n/a	20	0	N	9	30.21	15.5	78	n/a	n/a
	7/11/2006	12:10	19.4	0	NW	2	30.27	18.8	81	vercast	312770
	7/18/2006	11:07	22.7	2	N	3	30.17	16.1	82	clear	312816
	7/20/2006	9:10	26.5	0	n/a	n/a	30.24	18.8	74	overcast	312758
	7/22/2006	n/a	n/a	n/a	n/a	n/a	29.93	19	n/a	overcast	312893
	8/1/2006	9:35	22.7	0	NW	3	30.12	20	72	clear	312847
	8/5/2006	11:20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	312775
	8/15/2006	2:20	21.1	trace	NE	4	30.07	18.8	87	overcast / rainy	312704
	8/17/2006	n/a	19.4	trace	NE	5	30.25	17.7	71	n/a	312725
	9/8/2006	12:06	18	4.9	n/a	n/a	30.19	14.4	n/a	overcast	312727
	9/13/2006	7:42	17.7	0	N	6	29.93	11.1	69	partly cloudy	312762
	9/22/2006	6:19	12.7	0.254	SW	3	30.17	13.8	92	overcast	312749
	9/26/2006	12:45	14.4	0.4	SE	3	n/a	n/a	88	partly cloudy	312745
	9/29/2006	2:00	12.2	0	N	2	30.04	5.5	68	partly cloudy	312756
	9/30/2006	1:40	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	312761
	10/3/2006	3:30	n/a	n/a	n/a	n/a	n/a	n/a	n/a	clear	312167
	10/6/2006	11:35	10	0.254	N	7	30.14	12.7	81	overcast and foggy	312782
	10/11/2006	10:20	15.5	0.254	NE	4	29.83	13.3	63	overcast	312761

Name	Date	Time found	Air temp. (°C)	Rain (mm)	Wind direction	Wind speed (mph)	Barometric pressure (Hg)	Dew point (°C)	Humidity (%)	Cloud cover	Easting
Lucy	10/13/2006	11:28	16.1	0	NW	13	29.98	-6.1	63	clear	312761
	10/27/2006	9:56	6.6	0.254	SW	5	30.03	-6.1	86	overcast	312761
	6/23/2006	n/a	20.5	3	NE	5	30.2	18.3	81	overcast	312279
	6/27/2006	10:20	18.5	6	NE	2	30.05	16.6	90	overcast	312411
	6/28/2006	8:40	18.3	0	NE	2	30.21	15.5	78	partly cloudy	312424
	7/5/2006	n/a	18.3	0	NE	2	30.4	15.5	78	n/a	n/a
Peggy Sue	7/11/2006	13:20	19.4	0	NW	2	30.27	18.8	81	overcast	312439
	6/27/2006	n/a	27	0	NW	2	29.99	16	86	partly cloudy	312426
	6/28/2006	8:50	18.3	0	NE	2	30.21	15.5	78	partly cloudy	312435
	7/5/2006	n/a	18.3	0	NE	2	30.21	15.5	78	overcast	312421
	7/11/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	7/14/2006	8:40	17.7	1.016	SE	2	30.16	18.8	95	overcast	312420
	7/18/2006	10:23	22.7	2	N	3	30.17	16.1	82	clear	312421
	7/20/2006	9:50	26.5	0	n/a	n/a	30.24	18.8	74	partly cloudy	312442
	7/22/2006	n/a	n/a	n/a	n/a	n/a	29.93	19	n/a	overcast	312395
	8/1/2006	n/a	22.7	0	NW	3	30.12	20	72	clear	n/a
Rufus	8/30/2006	n/a	20.5	6	NE	na	29.91	19.4	87	partly cloudy	312453
	6/10/2006	n/a	17.2	0	NW	3	n/a	13.3	81	partly cloudy	312480
	6/13/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	6/15/2006	n/a	18.5	0	NE	7	n/a	n/a	75	partly cloudy	312484
	6/21/2006	3:20	22.2	0	NE	5	30.18	13.3	57	partly cloudy	312474
	6/27/2006	11:25	18.5	6	NE	2	30.05	16.6	90	overcast	312559
	6/28/2006	9:30	18.3	0	NE	2	30.21	15.5	78	partly cloudy	312552
	6/30/2006	n/a	20	0	N	4	30.21	15.5	78	clear	n/a
	7/5/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	7/18/2006	11:35	22.7	2	N	3	30.17	16.1	82	clear	312932
	8/1/2006	n/a	22.7	0	NW	3	30.12	20	72	clear	n/a
	8/12/2006	n/a	14.5	16.002	E	9	n/a	16	100	overcast	312427

APPENDIX E (CONT.). Compiled data for five eastern box turtles studied at Purchase Knob, Great Smoky Mountains National Park during the 2006 field season.

Name	Date	Northing	Elevation (m)	GPS Precision (m)	Activity	Ground temp. (°C)	Soil temp. (°C)	Relative humidity (%)	Vegetation/Habitat
Charlie	8/25/2006	3940231	1463.3	n/a	moving	n/a	n/a	n/a	managed field
	8/30/2006	3940198	1468.5	6	stationary	n/a	18	n/a	managed field
	9/8/2006	3940027	1468.2	6	stationary	23.5	12.5	81	successional field
	9/20/2006	3940224	1467.3	5	burrowing	n/a	n/a	n/a	u-story forest
	9/22/2006	3940261	1467.9	6	burrowing	13	19.5	95	forest, sparse u-story
	9/27/2006	3940260	1467.6	6	burrowing	18	13.5	n/a	u-story forest
	9/29/2006	3940256	1467	15	burrowing	11	11	n/a	u-story forest
	9/30/2006	3939922	1471.3	15	burrowing	19.5	11.5	n/a	u-story forest
	10/6/2006	3940314	1471.6	26	burrowing	14.4	14.9	n/a	u-story forest
	10/11/2006	3940253	1472.5	8	burrowing	14	12	n/a	u-story forest
	10/13/2006	3940253	1473.1	8	burrowing	7	11.1	n/a	u-story forest
	10/27/2006	3940253	1473.7	8	burrowing	9.5	9.8	n/a	u-story forest
Christina	6/16/2006	3939867	1496	n/a	moving	20.3	60.2	90	managed field
	6/27/2006	3939841	1436	6	stationary	16.85	13	90	u-story forest
	6/28/2006	3939789	1460	6	stationary	17.5	11	n/a	u-story forest
	6/30/2006	n/a	1463.9	n/a	n/a	n/a	n/a	n/a	n/a
	7/5/2006	n/a	1463.6	n/a	n/a	n/a	n/a	n/a	successional field
	7/11/2006	3939839	1463	5	stationary	24.5	14	n/a	successional field
	7/18/2006	3939763	1487	6	stationary	22	12	66	forest, sparse u-story
	7/20/2006	3939804	1459	21	stationary	18.5	12.5	82	successional field
	7/22/2006	3939847	n/a	28	feeding	19	12	91	forest, sparse u-story
	8/1/2006	3939817	1492	6	feeding	22	13	91	forest, sparse u-story
	8/5/2006	3939815	n/a	5	moving	n/a	n/a	n/a	n/a
	8/15/2006	3939830	1454	5	stationary	20.5	13.5	100	successional field
	8/17/2006	3940061	1470	7	stationary	23	15.5	75	successional field
	9/8/2006	3939836	1470.3	5	stationary	21.5	16	90	successional field
	9/13/2006	3939842	1469.4	6	stationary	11.5	16.5	n/a	successional field
	9/22/2006	3939725	1469.1	7	moving	13.9	12.1	n/a	u-story forest
	9/26/2006	3939939	1469.7	7	stationary	22	12	53	successional field
	9/29/2006	3939930	1468.8	7	burrowing	8.9	11	n/a	successional field
	9/30/2006	3939937	1470.7	n/a	moving/stationary	15	12	n/a	successional field
	10/3/2006	3939946	1471.9	12	stationary	14	14	57	u-story forest
	10/6/2006	3939960	1470.96	8	burrowing	10.2	12.1	n/a	u-story forest
	10/11/2006	3939948	1472.2	8	burrowing	13.5	13	n/a	forest, sparse u-story

Name	Date	Northing	Elevation (m)	GPS Precision (m)	Activity	Ground temp. (°C)	Soil temp. (°C)	Relative humidity (%)	Vegetation/Habitat
Lucy	10/13/2006	3939948	1472.8	8	burrowing	9.9	10.3	n/a	u-story forest
	10/27/2006	3939948	1473.4	8	burrowing	8.9	9.9	n/a	u-story forest
	6/23/2006	3939379	1413	10	stationary	23	20.5	83	managed field
	6/27/2006	3939461	1432	5	moving	22	14	n/a	managed field
	6/28/2006	3939461	1428	24	stationary	22	13	n/a	managed feild
	7/5/2006	n/a	1465.5	n/a	n/a	n/a	n/a	n/a	n/a
Peggy Sue	7/11/2006	3939459	1424	5	stationary	32.5	14	n/a	succession
	6/27/2006	3939527	n/a	n/a	stationary	18	n/a	n/a	managed field
	6/28/2006	3939512	1436	8	stationary	21.5	13.5	n/a	successional field
	7/5/2006	3939260	1417	5	stationary	25.2	16.1	60	successional field
	7/11/2006	n/a	1465.1	n/a	n/a	n/a	n/a	n/a	n/a
	7/14/2006	3939303	1427	15	stationary	21	12	n/a	u-story forest
Rufus	7/18/2006	3939258	1424	7	moving	19	12	66	u-story forest
	7/20/2006	3939277	1430	6	burrowing	19.5	12	83	forest, sparse u-story
	7/22/2006	3939389	n/a	11	stationary	22	12	100	u-story forest
	8/1/2006	n/a	1466.4	n/a	n/a	n/a	n/a	n/a	n/a
	8/30/2006	3939656	1415	5	stationary	n/a	20	n/a	u-story forest/successional field
	6/10/2006	3939954	1463	n/a	moving	22	26	n/a	managed field
	6/13/2006	n/a	1464.3	n/a	n/a	n/a	n/a	n/a	n/a
	6/15/2006	3939909	1460	n/a	stationary	21.5	n/a	85	successional field
	6/21/2006	3939922	1457	7	moving	21.2	16.5	76	successional field
	6/27/2006	3939911	1463	5	stationary	24.5	12.5	n/a	successional field
	6/28/2006	3939912	1442	6	stationary	21.5	12.5	n/a	successional field
	6/30/2006	n/a	1464.5	n/a	n/a	n/a	n/a	n/a	n/a
	7/5/2006	n/a	1464.9	n/a	n/a	n/a	n/a	n/a	n/a
	7/18/2006	3939801	1506	8	stationary	23.75	11	67	successional field/u-story forest
	8/1/2006	n/a	1465.8	n/a	n/a	n/a	n/a	n/a	n/a
	8/12/2006	3939364	1426	7	moving	15.5	12	100	forest, sparse u-story

APPENDIX F. Sample data sheet for tracking eastern box turtles in 2006 at Purchase Knob, Great Smoky Mountains National Park.

Turtle Tracking Data Sheet					
North Carolina, Haywood County, Great Smoky Mtn NP, Purchase Knob					
Date _____		Data recorder _____	Name _____		
Tracking team members _____			Scan # or Freq # _____		
Time found _____					
Weather Data from Purchase Knob & NOAA					
Waynesville, NC weather station					
Temperature (°F)	_____	Barometric Pressure (Hg)	_____		
Precipitation (since 12 a.m.)	_____	Dew Point (°F)	_____		
Wind Direction	_____	Humidity (%)	_____		
Wind Speed	_____	Cloud Cover	Clear	Partly Cloudy	Overcast
Current Location			Turtle Activity		
GPS waypoint #	_____		Moving	Copulating	
Lat & Long N _____ W _____			Stationary	Burrowing	
UTM coordinates 17S _____			Feeding (<i>if feeding note food items below</i>)		
			Food _____		
Data at Site			Vegetation (<i>circle one</i>)		
Physical Characteristics			Managed field	Successional Field	
Ground Temp. (°C)	_____		Riparian Area	Understory Forest	
Soil Temp (°C)	_____		Water	Forest, sparse u-story	
Relative Humidity (%)	_____				
Notes: Where found, typical plants in area, unusual behavior, or condition of transmitter. Anything that is recurring between specimens or in stark contrast; these are the observations that will lead to future projects					
Plant Species:					