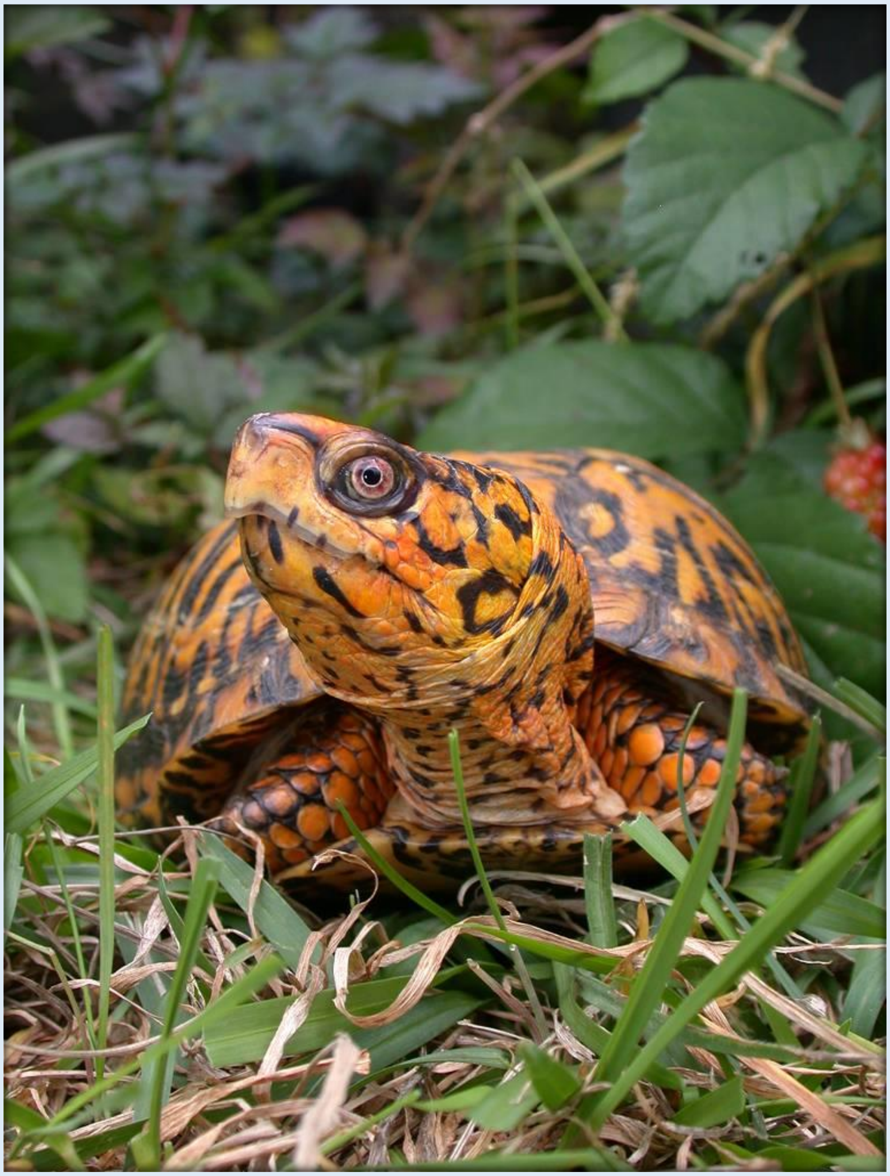
THE BOX TURTLE CONNECTION

Building a Legacy



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and Ashley A. LaVere

Published 2017

Cover image by J.D. Willson, male *Terrapene carolina carolina* from Aiken County, South Carolina. 2006.

Our work on this second edition of the book has been partially funded by an informal science education National Science Foundation grant (DRL-1114558), Herpetology Education in Rural Places & Spaces (The HERP Project) Any opinions, findings, conclusions or recommendations expressed do not necessarily reflect the views of the National Science Foundation.

The Box Turtle Connection

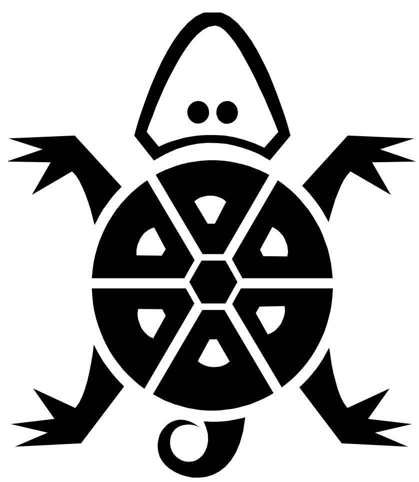
Building a Legacy

We dedicate this book to The Box Turtle Connection Project Leaders. They are the foundation on which this project is built. Their hard work and passion act as the frame that shapes and supports this long-term study. With their help, we will continue to further our knowledge about box turtles and strive to protect them and their habitats.

https://boxturtle.uncg.edu/

"To the amateur, I say learn about nature, but do it carefully and with commitment . . . Amateur naturalists have much to offer the scientific community in understanding the ways of box turtles. To the professional, I say get outdoors and observe nature . . . Natural history should be celebrated. After all, we are dealing with life in all its complexity. A study of box turtles is the perfect place to begin."

Ken Dodd (2001)



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The Turtle Connection

There, on the path was a box turtle. She paused and looked at my 7-year-old self curiously. I squatted down, fascinated by the subtle colors that moments earlier had so easily concealed this splendid creature in the leaves. The joy of the unexpected discovery and the warm feeling I experienced when I picked her up has not been forgotten. We made eye contact, each checking out the other through the window to the soul. It was as if the turtle and I shared a private experience, some intimacy, some connection. For me, it was like getting a present. I now recognize that others feel it too and that it never goes away no matter how many box turtles you might meet…or bog turtles…or sea turtles for that matter. I knew about looking turtles in the eye before my friend Jean Beasley told me to connect with sea turtles that way. I learned that from a box turtle as a child.

I appreciated that turtle immensely for allowing me to hold her. No flight or fight here. Some box turtles simply clam up and hope for the best when confronted by humans. Others take their situation into account and boldly ask to be left alone by means of urinating or walking on air as you hold them in your hand. But they are docile, gentle beasts for the most part. Only once did a box turtle really bite me. It was a feisty youngster that did not appreciate my fingers dangling before its face as I spoke to a small group of middle school students. It answered my insult by chomping down decisively on the fleshy part of my finger and holding on and on and on. It was all I could do to resist the urge to curse and throw the turtle off. This was not exactly the human-turtle connection I meant to demonstrate. Running water over the turtle finally solved the problem, as the students laughed hilariously at my predicament. Those students are older now and have forgotten many of the turtle facts I shared with them, but they always remember the day the turtle bit my finger in front of the class, and never fail to mention it when we meet, and we get to laugh again.

Children and adults alike respond to the gentle nature of the turtles and come to see life through their eyes. The turtle connection can be a key that unlocks the door to a new relationship with the natural world, one of wonder, beauty, and intimacy.

Ann Berry Somers

Preface

In 2006, we wrote *The Box Turtle Connection: A Passageway into the Natural World*, a guide for resource managers, herpetologists, nature center directors, and citizen scientists that would help direct their work on this (once) common organism. The book was resoundingly successful. Scientists and agency personnel working with box turtles and other species of turtles have adopted and adapted our practices. The book has been reproduced hundreds of times and put directly into the hands of teachers and environmental educators who are working to keep box turtles common across their native ranges.

Ten years later, we offer a revised version: *The Box Turtle Connection: Building a Legacy*. This edition modifies and standardizes our research protocols and portrays how the Box Turtle Connection project in North Carolina is building a long-term research study that will exceed 100 years and leave a legacy for others to follow, be inspired by, and build upon. We have not surrendered our mission to connect others to the natural world through box turtles, but now turn our focus towards the quality of the research that informs us about box turtle populations' present and future status. By reflecting upon our protocols and introducing new techniques, we hope curators, naturalists, educators, and students will engage in carefully designed box turtle research studies with a commitment to scientific validity.

New sections have been added to the book about gardening, mowing, and health concerns. Although our research and conservation work concerns populations and not individuals, we have new appendices on identifying wellness and disease in box turtles. Guest author Sandy Barnett wrote a clear and concise piece on box turtle health concerns. Ranavirus and other pathogens have ravaged some box turtle populations, making these appendices absolutely necessary. The lesson plans in the 2006 book are now included with our box turtle curriculum, *In Awe of Nature: Treasuring Terrestrial Turtles*, and is available for free download at https://theherpproject.uncg.edu/curricula/. Additional herpetology curriculum projects are also available on this website.

As you proceed through this book, building excitement for your own study, we urge you to plan and conduct your research carefully. Ken Dodd (2001) calls box turtles "homebodies" for good reason. They have a strong sense of place and for the most part stay home and seem satisfied to be left alone. Do not move them around casually or allow others in your study to do so. Do not allow your field study site to become a dumping ground for turtles that are displaced by well-meaning but misinformed participants. Take pride in your study and show your commitment to the safety of box turtles both on and off your site. Seek help from professionals who are working in the field of conservation biology. Box turtles have been an important part of our ecosystems for a very long time and we hope that with the aid of research like ours, they will be around for a long time to come.

We (Somers and Matthews) are faculty members at the University of North Carolina Greensboro and active members of the statewide research initiative to study box turtles in North Carolina—the Box Turtle Collaborative. We have added Ashley LaVere, a graduate from UNCG's Biology Department, as a co-author. She has worked with Somers and Matthews on various facets of The HERP Project, a NSF funded project, and assists Ann Somers and Gabrielle Graeter (NC Wildlife Resources Commission) in directing the Box Turtle Connection project.

Ann Berry Somers, Catherine E. Matthews, and Ashley LaVere

Acknowledgements

The Box Turtle Connection is built upon the connection between people and box turtles, but depends upon the connections among people. This book revision could not have happened without the support of those who work with the Box Turtle Connection project as well as those who work alongside it. We acknowledge and wholeheartedly thank:

Research Sites	Project Leaders
Camp Chestnut Ridge	*Christine Peckman*
Cliffs of the Neuse State Park	*Candace Rose*
Collie Farm	*Mike Vaughn*
Dismal Swamp State Park	*Katie Sanford*
Earthshine Lodge	*Steve O'Neil*
Elk Knob State Park	*Kelly Safley*
Eno River State Park	*Amy Duggins*
Falls Lake State Park	*Brian Bockhahn; Katie Scheip*
Fort Bragg	*Brian Ball*
Goose Creek State Park	*Nicole Crider; Candace Rose*
Gorges State Park	*Torry Nergart*
Greensboro Science Center	*Rick Bolling*
Hammocks Beach State Park	*Sarah Kendrick*
Hanging Rock State Park	*Sam Koch; Mary Griffin*
Haw River State Park	*Kathryn Royall; Heidi Dull*
Kerr Lake State Recreation Area	*David Treno*
Lake Crabtree County Park	*Carol Cunningham*
Lake James State Park	*Jamie Cameron*
Lake Raleigh Woods	*Kimberly Burge*
Lake Waccamaw State Park	*Amy Bernhardt*
Lumber River State Park	*Charles Gause; Neill Lee*
Mayo River State Park	*Keith Martin*
Medoc Mountain State Park	*Sandra Fambrough; Ryan Newsome*
Merchants Millpond State Park	*Jane Wyche*
Morrow Mountain State Park	*Ron Anundson*
N.C. Arboretum	*Trudie Henninger*
New River State Park	*Doug Blatny*
Piedmont Wildlife Center	*Sara Marschhauser Steffen*
Pilot Mountain State Park	*Nick Bowman*
Price Park	*Don Alleman*
Raven Rock State Park	*David Brown*
Reedy Creek Nature Preserve	*Laura Domingo*
Somers Berry Farm	*Ann Berry Somers*
South Mountains State Park	*Cheryl Waltz*
Summey Family Property	*Ocean Summey*

Special thanks to our ever-patient editors, Gia Coturri Sorenson and Sandy Barnett.

We also express deep gratitude to Haw River State Park in North Carolina which has long been considered the home of the Box Turtle Connection project. The park has hosted and sponsored many of the Project Leaders Workshops and is home to our time capsule, established in 2017 at the 10th anniversary Project Leaders Workshop. The time capsule will be opened in 2107 on the 100th anniversary of the Box Turtle Connection.

Supporting groups and organizations: The Box Turtle Collaborative, NC Wildlife Resources Commission, National Science Foundation (NSF) through The HERP Project (Herpetology Education in Rural Places and Spaces), UNCG Departments of Biology, Teacher Education and Higher Education, NC Herpetological Society (NCHS), NC State Parks, NC Partners in Amphibian and Reptile Conservation (NCPARC), NC Wildlife Federation, Clinch River Environmental Studies Organization (CRESCO), JBQ Charitable Foundation, and Davidson College Herpetology Lab.

Writers, editors, reviewers, and other contributors: Nancy Adamson, Matt Allender, Danelia Amortegui, Courtney Anderson, Andy Ash, Sue Bean, Jeff Beane, Aerin Benavides, Brian Bockhahn, John Byrd, Wendy Caldwell, José Castañeda Gamaliel Gaytán, Heidi Carlone, Ed Corey, Ken Dodd, Mike Dorcas, Andrew Durso, Mark Eastburn, Jim Eldrett, Lori Erb, Stan Faeth, Laura Fogo, Gabrielle Graeter, Jim Greenway, Marian Griffey, John Groves, Jeff Hall, Haley Hegedus, Paul Hildago, Jeff Humphries, Carol Buie-Jackson, Michael T. Jones, Karen Judge, Joe Kelleher, Kelley King, Douglas Lawton, Jeff Lovich, Jonathan Marchal, Sam McCoy, Mary Myers, Kelly Nail, Jodi Owen, Lance Paden, Steve Price, Mike Quinn, Omar Raya, Martha Regester, Anders Rhodin, Candace Robinson, John Roe, Ashley Rose, John Rucker, Lynn Sametz, Anna Smith, Sara Marschhauser Steffen, Dave Stephan, Brian Strong, Chris Swarth, Terry Tomasek, Emilie Travis, Tammie Vass, Mike Vaughan, Beth Walton, Alayna Ward, the stupendous Turtledogs, and The HERP Project's Herpetological Research Experience participants.

Photographs without attribution have been taken by the authors or are in the public domain. Other images have been contributed by: Dean Alessandrini, Matt Allender, Arrowhead Reptile Rescue, Steve Atkins, Colin Barnett, Sandy Barnett, Shane Boylan, Adam Charney, Noah Charney, Charlie Eichekberger, Gil Grant, Jeff Hall, Jennifer Mansfield-Jones, Sherry Kelly, Jenny Kimmel, John Lindsay, Maryland Zoo in Baltimore, Drew Mellon, Moses Michaels, Lynn Moseley, Mark Musselman, Steve O'Neil, Beate Pfau, Martha Regester, John Rucker, Sarah Seymour, Dan Smith, Sara M. Steffen, Tim Spruill, Sara Valenzuela, Mike Vaughn, Neil Wagner, Lisabeth Willey, and J.D. Willson.

Project Leader Sara M. Steffen of the Piedmont Wildlife Center.

Ancient Chelonians

Ancient chelonians of lineage primeval
Their survival now threatened by man's upheaval

We gather together to celebrate our perception
Of turtles and their need for preservation and protection

For turtles forever to play their part ecological
To prosper and maintain their diversity biological

For turtle and tortoise, terrapin and kin
Their kind to preserve, their future to win

We must work together, I tell you from the heart
Whether we work together, or apart.

Anders G. J. Rhodin

1. The Box Turtle Connection: A Hundred Year Study

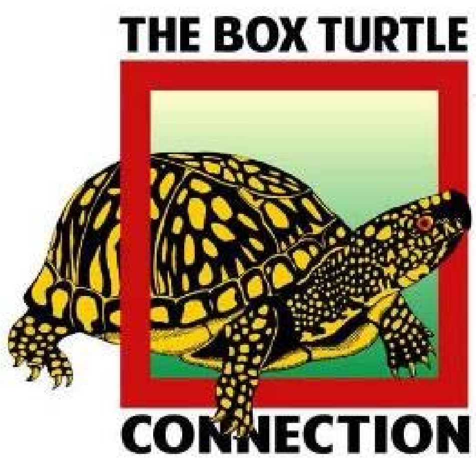
To create effective conservation plans, we need long-term studies that assess the population dynamics of long-lived species such as box turtles. The problem with long-term studies, as renowned turtle researcher Justin Congdon says, is that they take a long time and require resources. The Box Turtle Collaborative is a visionary group that bridges these difficulties by harnessing the dedication of enthusiastic, trained volunteers and by establishing partnerships among agencies, universities, and private citizens to collect high quality data on box turtles at a low cost.

The Box Turtle Collaborative

The Box Turtle Collaborative, first assembled in 2007, is a think tank for conservation and education focused on box turtles. The original group consisted of North Carolinian educators and biologists, representing four institutions of higher education (Davidson College, Elon University, University of North Carolina at Greensboro, University of North Carolina at Pembroke) and four state agencies (NC Parks and Recreation, NC State Museum of Natural Sciences, NC Wildlife Resources Commission, NC Zoo). Members have expertise in herpetology, conservation biology, wildlife management, science education, museum studies, and conservation education. The collaborative launched the Box Turtle Connection (BTC) in 2008 to learn more about Eastern Box Turtles (Figure 1) in North Carolina.

The Box Turtle Connection: A Hundred Year Study

The Box Turtle Connection (BTC) is a long-term study anticipating at least 100 years of data collection on box turtles. Our purpose is to learn more about the status and trends in box turtle populations, identify threats, and develop strategies for long-term conservation of the species. The Box Turtle Connection is underway across the state of North Carolina with more than 30 active research study sites. Each site is overseen by a volunteer citizen-scientist, called a Project Leader (PL), who makes a long-term commitment to the project and is trained in data collection. Each PL manages data collection at their site. Some sites are simply the place where a PL works, such as a state park, but other sites are on private property or municipal land (see Acknowledgements).



Craig Bannerman

Box turtle captures are mostly incidental captures, but sometimes trained dogs are used to find turtles; other times turtles may be located by methodically surveying sites (see Chapter 5). Turtles are weighed, measured, photographed, and permanently marked by the PLs. These data, along with voucher photos (photos that document sightings), are then entered into a password-protected, centralized database managed by the NC Wildlife Resources Commission. The database is available to researchers for data analysis upon request. Interested parties should visit our website (https://boxturtle.uncg.edu/) to learn how to join the Box Turtle Connection project or to access the database. We hope the project will outlive its youngest researcher so that 100 years from now our turtles and their offspring will be educating the next generation of scientists, citizen scientists, and others who care about the natural world.

Assuring Data Quality

To assure data quality, PLs undergo an initial two-day training and then return every other year to refresh their skills and get new information. Experienced PLs will often help the Box Turtle Connection staff run the meetings. Training includes presentations on sexing, measuring, and marking turtles according to the protocols outlined in this book. Additional presentations are offered on special topics like box turtle mating, behavior, and ecology. PLs are invited to share information about their project site or topic of choice. The trainees then rotate through a series of workstations, learning how to take voucher photographs, sex, measure, and mark turtles, count annuli, and manage a project site.

Now that we are ten years into the project, site reports have been prepared for each site and PL. Data are being assessed for possible errors. For example, a turtle that has a reported 35 mm carapace length and a mass of 348 grams probably does not exist because a turtle that small would not weigh so much. We forward notes likes this into a report and send to the PL asking that they review the original data sheet. We also look for negative growth reported for individual turtles. While negative growth does occur in some species (Wilson et al., 2003), we highlight entries that indicate negative growth of greater than 5%, an unacceptable margin for measuring error. Likewise, while positive growth is expected, extensive growth beyond a 5% error rate within an inappropriate amount of time, such as a single month, is flagged for review. Our preliminary results suggest that sites with the fewest errors are from projects overseen by PLs who have been with the project the longest and have undergone official training multiple times.

In addition to carefully monitoring reported data, we have now revised and established standards for caliper jaw length, scales, calibration of scales, and photo documentation that are described in the following chapters. These standards are important for reliable and valid data collection.

Strengths and Limitations of The Box Turtle Connection: Ready for the Next Decades?

The keys to BTC's success include the following 1) data are collected by volunteers who attend training sessions biennially, 2) data are entered by PLs into a centralized database that is managed and protected by a state agency, the NC Wildlife Resources Commission, 3) the vast majority of captures are incidental (discovered in the course of going about normal activities rather than specific searches), 4) demands on PLs are kept to a minimum, and 5) a shoestring budget is sufficient to run the project.

Due to the small number of long-term studies, much remains to be learned about box turtles. Studies of short duration are important, but may not provide sufficient data to inform conservation decision-making. The Box Turtle Connection is valuable because it seeks to support a long-term study inexpensively. Since most of the box turtles in the project are captured incidentally rather than through active searches or censuses, the time demand on the part of the Project Leaders is surprisingly low. Our meetings are held at a state park with no cost for the meeting space. Tools are donated by supporting groups, state wildlife agencies, or the personal funds of a project leader. Since our training sessions are two-day meetings, anyone who cannot afford lodging is offered free lodging with a local host family.

As with many aspects of life, our strengths can also be our weaknesses. The strength of the BTC model is that our Project Leaders do not have to conduct special searches for the turtles because most are incidental captures. However, we do not have a suitable way to measure the time spent looking for turtles, which means there is no way to measure "capture per unit effort" (CUPE). This means that statistical methods that depend on this measure cannot be used in our data analyses. Though limited in this aspect, our data provide valuable insight into the regional and temporal differences in the life histories of the turtles and the status of our box turtle populations over the lifespan of this project. Our data are available to researchers worldwide; to request access see contact information on our website (https://boxturtle.uncg.edu/).

Figure 1. A juvenile Eastern Box Turtle (*Terrapene carolina*)

2. Range and Habitat

North American box turtles, genus *Terrapene*, are found over a wide geographic range. Within that range, their variety of camouflaging colors and patterns, shell shape, and behavior allow box turtles to utilize many different macro and micro habitats. Turtles control their body temperature by occupying different macrohabitats like open meadows during cooler mornings or evening hours and withdrawing to woodlands during the hotter hours of the day to find areas with higher humidity and lower temperatures. Microhabitats are small areas that may be distinguished from other areas in the surrounding environment by humidity, temperature, cover, or other physical characteristics. Turtles can behaviorally control their body temperature in part by moving into and out of microhabitats with different thermal profiles, such as warm, sunlit spaces and cool brush piles. Thermoregulation is further fine-tuned by adjustment of body position relative to incident solar radiation, and by tucking in or extending the limbs and head.

Eastern Box Turtles (*T. c. carolina*) may spend cool days, nights, or periods of aestivation (dormancy) in shallow depressions called *forms*. They use their front legs to dig and their back legs to push out loose material, forming a depression that securely fits and helps to camouflage, thus protecting the turtle (Stickel, 1950). A form also importantly reduces water lost through evaporation across the skin. When settling in for the winter, the turtle gradually digs a chamber until the carapace is completely hidden, though during mild winters the carapace may remain visible. Some turtles may dig into root tunnels or old tree stumps, using the natural structure of the root system or stump for support. Other turtles bury themselves along slopes, under blackberry thickets, next to logs, or in briar patches. The same over-wintering sites may be used in subsequent years and box turtles may share the same chamber with other box turtles, though this is rare (Dodd, 2001). Although box turtles typically stay in these chambers for the entire winter, our radiotelemetry studies have allowed us to confirm what other researchers have found—turtles sometimes move short distances during warm spells.

The Desert Box Turtle (*Terrapene ornata luteola*) may be the exception among the terrestrial box turtles in that it does not make extensive use of forms. To avoid the harsh desert climate, these turtles usually live in the burrows of small mammals year-round, confining above-ground activity to early morning, late afternoon, and periods following summer rain showers (Nieuwalt 1996, Plummer 2003). Florida Box Turtles also are known to utilize mammal burrows.

Most, if not all, sexually mature box turtles have a home range where their daily activities occur, although not all parts of a home range may be visited in a given year. According to Dodd (2001), home ranges vary in size from less than 1 hectare (2.5 acres) to about 5 hectares (12.5 acres), although some are larger. Radiotelemetry studies are greatly increasing our understanding of turtle behavior (Chapter 5) and their home ranges. For instance, we have learned, through radiotelemetry, that females may travel outside of their normal home range for nesting, but will usually return to their original home range afterwards.

With ranges across much of the U.S. and into Mexico (Figure 2), the habitats box turtles occupy can vary significantly. Box turtles must have habitats that allow them to sunbathe, seek shelter from environmental pressures and predators, cool off, keep hydrated, and find food. Eastern Box Turtles (*T. c. carolina*), (Figures 3 and 4), occupy forested areas but also make use of meadows (for egg-laying and as transit zones), freshwater marshes and other riparian habitats. In contrast, the Ornate Box Turtle (*T. ornata*) and the Spotted Box Turtle (*T. nelsoni*), live primarily in treeless, sandy plains dominated by grasses and scattered low brush, while the Coahuilan Box Turtle (*T. coahuila*) spends most its time in shallow ponds.

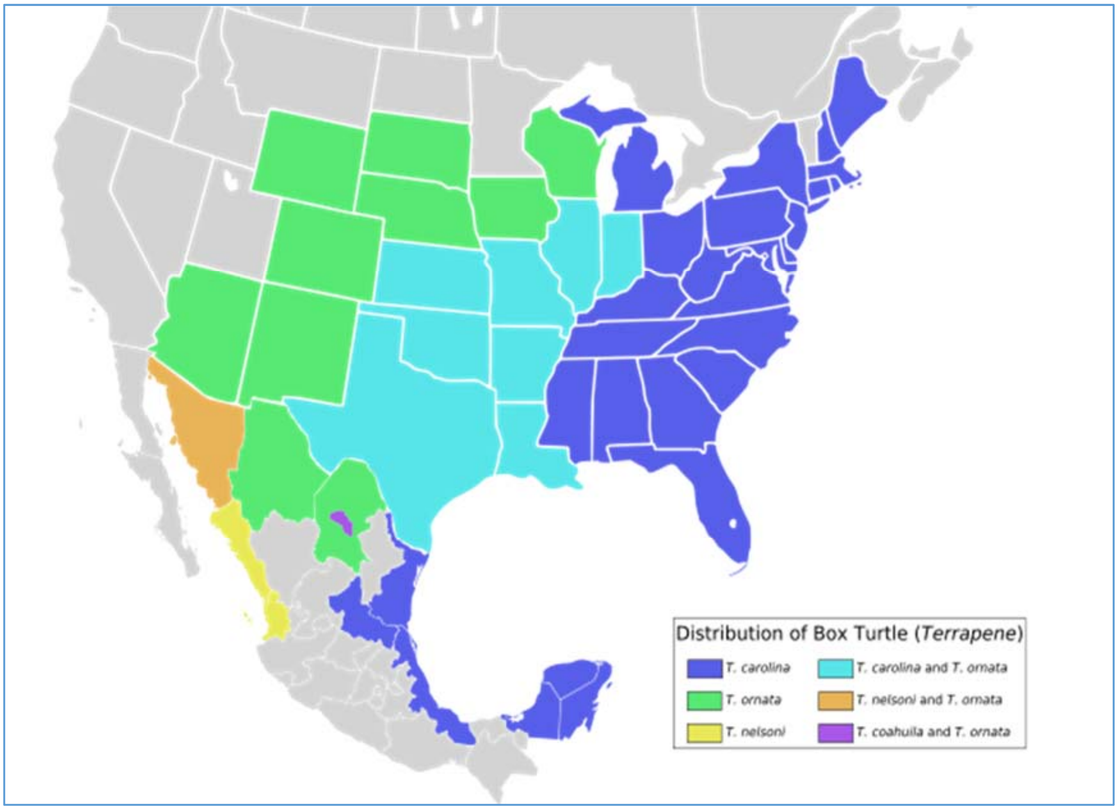


Figure 2. A generalized map of the ranges of box turtles in North America which does not distinguish the Florida Box Turtle (*T. baurii*) as a separate species, as the taxonomy below notes. Use local field guides for greater accuracy in distinguishing ranges of different species and subspecies. As we learn more, the designated species names may change again. Image https://en.wikipedia.org/wiki/Box_turtle.

The Committee On Standard English and Scientific Names (2012) established a standard for box turtle nomenclature and standards for capitalization (see list below). It was determined that the English name of a subspecies should not be identical to the English name of the species. Previously, the name Eastern Box Turtle referred to both *Terrapene carolina* and *T. c. carolina*. The English name for *T. c. carolina* is now Woodland Box Turtle to avoid conflating the two groups. Under the 2012 system, all Woodland Box Turtles and Three-toed Box Turtles (*T. carolina triunguis*) are considered Eastern Box Turtles, which is the more inclusive category. Likewise, all Desert Box Turtles and Plains Box Turtles fall under the more inclusive category of Ornate Box Turtles.

The recommendations of the Committee on Standard English and Scientific Names (2012) on use of common names have not yet moved into the vernacular (common use), hence the authors of this book have determined that we will use terms as they are most commonly and widely used at this time. In this book, “Eastern Box Turtle” refers to *T. c. carolina* unless stated otherwise; also, in this book, “Ornate Box Turtle” refers to *T. o. ornata* unless stated otherwise.

T. baurii (Taylor, 1894)—Florida Box Turtle

T. carolina (Linnaeus, 1758)—Eastern Box Turtle (Note: In this book, “Eastern Box Turtle” refers to *T. c. carolina* unless stated otherwise).
- *T. c. carolina* (Linnaeus, 1758)—Woodland Box Turtle
- *T. c. triunguis* (Agassiz, 1857)—Three-toed Box Turtle
- *T. c. mexicana* (Gray, 1849) —Mexican Box Turtle
- *T. c. yucatana* (Boulenger, 1895) —Yucatan Box Turtle

T. ornata (Agassiz, 1857)—Ornate Box Turtle (Note: In this book, “Ornate Box Turtle” refers only to *T. o. ornata* unless stated otherwise).
- *T. o. luteola* (Smith and Ramsey, 1952)—Desert Box Turtle
- *T. o. ornata* (Agassiz, 1857)—Plains Box Turtle

T. coahuila (Schmidt and Owens, 1944)—Coahuilan Box Turtle

T. nelsoni (Stejneger, 1925)—Spotted Box Turtle

Figure 3. An Eastern Box Turtle found in Gates County, NC.

Habitat Problems for Eastern Box Turtles

Jane Wyche

Landscapes throughout the range of the box turtle have changed drastically over the last few centuries. Habitats are fragmented and microclimates altered when roads, railroad tracks, or phone and power line right-of-ways transect them or when they are closely mowed, clear-cut, or burned. Such fragmentation allows more sunlight and wind to penetrate an area because of reduced canopy cover. The result can be an increase in daily and seasonal temperature fluctuation, and higher temperatures and drier conditions in warm weather, and lower temperatures in cold weather. On a geological and evolutionary scale, these habitat changes are swift with an unknown impact on turtle populations.

Because box turtles are generalists, they can benefit from early successional habitats, such as weedy fields (that attract insects) and blackberry thickets that grow under electrical and telephone lines. However, such habitats may be deadly when it puts turtles into contact with road traffic, tractors, and mowers. Additionally, mowed roadsides, lawns, and cell tower fields offer turtles (and many other species) very little in the way of food or shelter. In the case of Eastern Box Turtles, this kind of habitat alteration and fragmentation can also increase the chance of fire and allow non-native species, such as honeysuckle and Japanese stilt grass to invade. Although young Eastern Box Turtles take cover in the Japanese stilt grass, invasive species are not a part of the natural ecosystem and can have undesired effects on the community. Alteration in the plant community can negatively impact box turtles in ways that may not be immediately obvious. For example, Desert Box Turtles may be unable to survive in areas where the plant community can no longer support the seed-eating rodent population essential for digging the burrows used by turtles as year-round shelters. A loss of burrows would also mean a loss of the other burrow inhabitants—both vertebrates and invertebrates—that turtles eat.

Figure 4. These turtles illustrate the variety of colors and patterns in Eastern Box Turtles found at a single site.

3. Box Turtles in Decline

Turtles are important to the environment and their decline is of concern for many reasons. For indigenous people of most temperate and tropical regions, turtles are, or have been, important symbols in religion, mythology, art, writing, and medicine. For example, North American Indians used turtles for food and ritual and made practical objects from their shells. Turtles are members of natural ecological communities and perform important ecological services, such as seed dispersal (Braun and Brooks, 1987), and play roles in predator-prey interactions and energy flow systems.

The Mayans saw turtles as sacred beings and symbols of good health. In some records, their god Pauahtun was depicted as being housed in the shell of a turtle.

Box turtles are often characterized as the longest-lived vertebrates in North America. However, while they may be able to live more than 100 years, it is unlikely that many actually do. As is the case with all wild populations, more offspring are born than live to reproductive age due to natural causes of mortality, such as high levels of predation of eggs, hatchlings, and juveniles. But in the past, box turtles were much more abundant even with predation from native predators. Modern pressures on wild populations seemingly far exceed those of the past.

Figure 5. Turtles can die in fires but sometimes survive low intensity fires. This burned turtle was healthy and active, but may experience physiological challenges due to a damaged carapace.

Box turtles are gradually disappearing from landscapes across eastern North America (Swarth, 2005). Although they are not facing imminent global extinction, most box turtle researchers believe that populations are in serious decline and that mortality from human activity is significant and increasing (Swarth and Hagood, 2004). Local extinctions, called extirpations, appear to be rising. Extinction, at a low rate, is a natural and important aspect of evolution. However, the vast majority of extinctions today result from human activity and are occurring at an accelerated rate so great that it is comparable to the mass extinction that eliminated the dinosaurs and other plants and animals 66 million years ago. Species like box turtles which have few offspring, are slow moving and late maturing, are particularly susceptible to human-related extinction.

Figure 6. Shell fragments remaining after a box turtle was hit by a vehicle.

Habitat loss and overexploitation are the primary threats to reptile species at risk of extinction (Primack, 1998), and this appears to be the case for box turtles as well (Dodd, 2001), although long-term studies describing these trends are not available. Box turtles have little or no protection from loss of habitat, although collection, possession, and commercial sale of wild box turtles is controlled by law to some extent in nearly all the U.S. states where they are native. Also, *Terrapene* is listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), which strictly regulates box turtle trade to other member nations (Dodd, 2001).

Injury and mortality from roads, railroads, and other transportation infrastructures are evident throughout the range of box turtles. Although turtles are equipped to deal with some types of physical injuries (Figure 5), they cannot withstand most car strikes and mower injuries or being trapped between railroad tracks (Figure 6; Kornilev et al. 2006). Over-collection for the pet trade (Figure 7) also constitutes a serious threat. Trade in wild-caught turtles, both domestically and internationally, has escalated worldwide, as the demand for turtles for Asian food markets and pets grows. Data are required to document the removal and killing of animals taken from the wild and the impact on box turtle populations. Such pressures are likely causing wild populations and numbers of turtles to decline.

Turtles are susceptible to decline because they are late to mature and have low reproduction rates, making long life essential to ensure members of the population replace themselves in the next generation. Male Florida Box Turtles may not begin to reproduce until they are 5 to 6 years old, while females at the same latitudes do not mature until they are closer to 7 or 8 years old. This varies with latitude, with later maturation associated with higher latitudes and a shorter active season. Females on average lay from 1-7 eggs, with some populations laying more than one clutch per year, but not all wild box turtles reproduce every year due to inconsistent availability of food and fluctuating environmental conditions (Dodd, 2001). Small clutch sizes and inconsistency in annual nesting leaves box turtle populations unable to recover quickly from losses. A large hit to a single population can mean that it will take several years, if not decades, for their population to recover.

Figure 7. Turtles confiscated in Los Angeles on the way to Hong Kong. The shipment included 26 Eastern Box Turtles and 20 African Spurred Tortoises (*Los Angeles Times*, 2014).

Researcher Spotlight

Dr. José Castañeda Gamaliel Gaytán (Gama)

Dr. Gama Castañeda is on the faculty in the Department of Biological Sciences at Juarez University of the State of Durango, Mexico. His interests include conservation of endemic chelonians and lizards from Mexican deserts, particularly endangered species. Conservation in his region, like all others, requires accurate data regarding current distributions of species and local political collaboration.

The Coahuilan Box Turtle (*T. coahuila*), the only extant semi-aquatic box turtle, is endemic in Cuatrociénegas Valley and is one of the most endangered species in Mexico. They are listed as endangered by IUCN and are on the conservation priority list of the World Wildlife Fund and the Turtle Conservation Fund. This chelonian's vulnerability is due to their limited distribution, their dependence on wetlands, and their region's progressive habitat loss, which is the most challenging threat to conservation. There have been efforts to preserve the preferred aquatic habitats in the Valley, but, until recently, little information was available regarding the current distribution, abundance, and habitat use of this turtle. Gama and his team have collaborated closely with the National Commission of Protected Natural Areas (*Comisión Nacional de Áreas Naturales Protegidas*, or CONANP) to develop a sampling program to help understand the natural history of this species. Using niche modeling and known vegetation use of Coahuilan Box Turtles, Gama is learning about potential areas of distribution of the species.

Gama and his team are describing the ecology, home range, movements, and general spatial requirements for males, females, and gravid females. With this information, they intend to promote science-based decision-making in land and water management in the Cuatrociénegas Valley and help preserve the Coahuilan Box Turtle. This is the first population recovery program of *T. coahuila* in Mexico.

4. Starting a Box Turtle Study

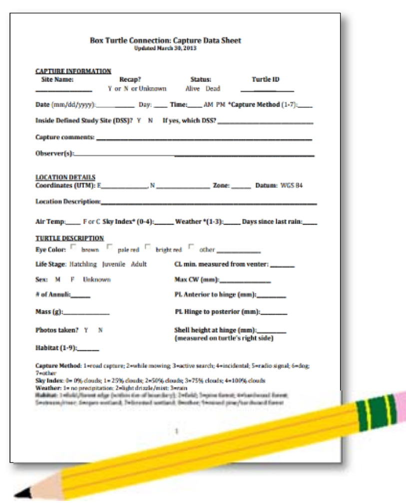
This section provides tips for creating effective field research methods for collecting quality data, information on equipment you will need, and suggestions for additional questions and materials you should consider before starting your study. Science centers, museums, schools, and even neighborhoods can conduct box turtle research that, if carefully planned, will generate information of conservation value. If box turtle numbers are declining, as many scientists suspect, then sound scientific data are needed to develop successful conservation strategies. The following information explains how to plan and conduct your study in a way that will allow you to compare your data with those data collected by other researchers.

Planning Field Research

1. Is a box turtle study right for my organization and me? Before you begin, consider the following: Am I really interested in activities that involve working outdoors? Am I dedicated to following the methods of sound science? How much time am I willing to commit to this study? If I plan to use radiotelemetry (Chapter 5), am I prepared to track turtles throughout the year, even during seasons of uncomfortable weather?

2. Know your goals and limitations. Ideally, research on any long-lived species, including turtles, would last years since animal activity and environmental conditions vary over time and trends are difficult to detect with short-term studies. However, even short-term studies have value, especially for educational purposes. Whether a short-term or a long-term study, commitment is an underlying factor for success. Any research study takes time, hard work, and patience and you must be prepared to give these with the knowledge that what you give, you will get back in reliable results and a meaningful contribution to conservation.

3. Before committing to a box turtle research study, you must ask yourself the following questions: What are your goals? Which surveying methods will be most valuable and efficient in meeting your goals? What are your research questions? What types of data will help you answer your research questions? How much time and effort can you devote to your project? Are you willing to see that turtles are returned to their point of capture as soon as possible? Can you provide safe, secure, clean accommodations for turtles that cannot be processed right away?



4. Consult your state wildlife agency *before* you begin planning your study for information regarding permits. Wildlife agents may know of other turtle researchers who can also help advise you. Collaborating with other researchers and supporters will help you determine the purpose and the scope of the study. Investigate forming

relationships with local institutions of higher learning or organizations such as local herpetological or natural history societies to learn about potential collaborations.

5. Develop data sheets and acquire your tools and other materials. Once you have determined what information you intend to collect, develop data sheets or modify the samples provided in Appendices A through C. Compile a list of the needed materials, supplies, and equipment. Develop a budget and identify potential sources of funding. If your institution receives federal funds, you must be aware of and follow the *Guidelines for the Use of Live Amphibian and Reptiles in Field Research.* Even if you do not have federal funding, these guidelines can serve as a good example for proper procedures for accommodating animals in your study.

6. Determine the geographic parameters of your study. You may work on one site or you may want to expand your study to different sites. If you choose to commit to multiple sites, be sure that you have sufficient time in your schedule to allocate to each project.

7. How will you analyze your data? How will the results from your study be used? Plan on analyzing your data and publishing your results. There are many possible venues, from peer-reviewed publications to a museum newsletter; just get your results in print.

Participant Safety

Before you allow participants to join your turtle study, be sure that they each complete a medical form so that you are aware of any potential health issues such as allergies, asthma, or seizures. Always be prepared for any such events. Even though the safety concerns encountered in box turtle research are normally few, incidents do occur.

Figure 8. Permission to access property can be important for participant safety.

Insect pests (mosquitos, bees, and wasps), arachnids (spiders, chiggers, and ticks), and snakes may be encountered as well as bothersome plants such as briars and poison ivy, oak, or sumac. Barbed wire, large farm animals such as horses and cows, and deer may also pose issues in some rural areas. Be aware of hunting seasons, particularly in the fall, and know when and if hunting is allowed on the land where your study is being conducted, or if it is allowed on surrounding properties. You may want participants to wear orange safety vests and hard hats (for falling branches in forests) and be noisy, or avoid days when hunting is allowed. In the summer, heat and humidity can cause problems for people in the field. Do not move too quickly – gauge your work based on your participants' abilities. Always have water and carry a first aid kit.

When in contact with a turtle, avoid having your fingers pinched when the turtle closes up by holding it tightly by the upper shell or cupping the turtle by the back end between the hind legs. Don't dangle your fingers in front of their heads as box turtles can bite. *Salmonella* refers to a group of bacteria that can cause diarrhea in humans. *Salmonella* live in the intestinal tracts of humans and other animals, including turtles and birds. Transmission of *Salmonella* between turtles and humans is rare but such infections can last 5-7 days or less and usually do not require medical treatment unless the patient becomes severely dehydrated or the infection spreads from the intestines. In rare cases, serious health problems may result. The most common means of infection is by mouth, but can also occur through open cuts or sores (Regional Centers of Excellence for Biodefence and Emerging Infectious Diseases, 2005). To avoid *Salmonella* when working with turtles:

- Use antibacterial soap and wash hands with warm water. Carry disinfectant hand wipes or sprays in your backpack and a plastic bag to hold the discards.
- Do not eat, drink, wipe your mouth, or rub your eyes until you have washed your hands.
- Some people use plastic gloves to avoid exposure through an open cut or sore. Use fresh gloves with each turtle encounter to prevent possible cross-contamination between turtles.

Guidelines for Use of Live Amphibians and Reptiles in Field Research

> *"The humane treatment of both captive and wild vertebrates is an ethical, legal, and scientific necessity. Traumatized or stressed animals may exhibit abnormal physiological, behavioral and ecological responses that defeat the purposes of the investigation (Raney and Lachner, 1947; Pritchard et al., 1982). Humane treatment of wild-captured animals requires minimal impairment of their abilities to resume normal activities when returned to the wild. Moreover, habitats that are essential for these activities should not be rendered unsuitable during the course of capture or study efforts."*
>
> ASIH, HL, and SSAR, 2004

There are expectations regarding use of live specimens in research. These are set forth by herpetological organizations and the federal government. The *Guidelines for Use of Live Amphibians and Reptiles in Field Research* (2004) will help you make good decisions about animal welfare. This joint publication of the American Society of Ichthyologists and Herpetologists (ASIH), the Herpetologists' League (HL), and the Society for the Study of Amphibians and Reptiles (SSAR) is available online (www.aish.org/pubs/herpcoll.html).

Federal regulations require that institutions receiving federal funding establish an Institutional Animal Care and Use Committee (IACUC) to assure that all animal-related activities comply with the Animal Welfare Act. Most research compliance officers at colleges and universities are familiar with the requirements of the Act and may be willing to advise you in establishing research and teaching protocols that adhere to the standards. Even if you are not required to abide by federal standards, set a good example by demonstrating concern for individual box turtles as well as their populations. Do not move them to new locations casually or allow others in your study to do so. Return turtles to the point of capture without delay.

Possession and collection of box turtles are regulated by some state agencies. Violation of these regulations is a serious offense. As mentioned in *Planning Field Research* above, you should contact your state wildlife agency to see which activities are allowed *before* you begin planning your study and to obtain all necessary permits.

Handling Turtles

Handling turtles can be tricky. Although turtles do not have teeth, they have a strong, powerful mouth that acts like a beak. Box turtles are docile creatures, but any turtle can bite or scratch you with their nails. Be prepared to not drop the turtle if bitten or scratched. Keep the turtle's head aimed away from you so it can't latch on to a nearby part of your body. Never place your hands in front of the turtle's face or even close to its head.

Pick up turtles by holding the whole shell between both hands slightly in front of the hind limbs. (Figure 9). Grip the carapace (top shell) on both sides above the hind legs (thumbs on the carapace and fingers on the plastron). Alternately, for children, using two hands to cup the turtle from the back end can be a safe way to handle turtles due to the decreased chance of the scratching, which can cause a child to drop a turtle,

Since examining the plastron is important, turn the turtle over slowly. Always turn the turtle with the head facing away from you. Slowly turn the turtle back in the same direction from which it was originally flipped over. This eliminates the possibility of twisting the intestines (see Appendix G).

Figure 9. Students use both hands to handle the turtle safely.

Field Equipment Checklist

Below is a list of recommended equipment for a field study of box turtles. Field equipment is usually carried in a backpack or a shoulder bag. In addition, carry a holding sack suitable for turtles or a 5-gallon (~ 110 liter) bucket to hold turtles if there are delays between the time you catch them and the time they undergo data collection. Never put two turtles in one sack/bucket. You may include plastic non-latex, disposable gloves, and antibacterial hand wipes to prevent transmission of pathogens to or from animals. For turtle transportation in a car, use a plastic or lidded cardboard box (turtles can climb cardboard!). A cooler is also useful for this purpose, but avoid Styrofoam. Consider laying down a towel in the bottom to provide more comfortable bedding and allow for hiding places.

Essential equipment for a turtle backpack:

- ✓ Appropriate data sheets and codes (see Appendices A, C or E)
- ✓ Smartphone app., e.g. Trimble Outdoors Navigator or GPS Essentials or a GPS handheld unit
- ✓ thermometer
- ✓ flagging tape and a fine tip permanent marker for writing on tape
- ✓ pencil or indelible ink pen (not standard ink pen) for filling out data sheets
- ✓ appropriate turtle containers, such as snake sacks, pillow cases or even plastic grocery bags for single use (if double bagged), since they are sanitary, lightweight and free

If you measure turtles in the field, also include your measuring equipment:

- ✓ calipers with jaws 2.5” (~ 6.5 cm) deep, minimum; shaft length 8” (~20 cm) or greater
- ✓ electronic digital platform scale or Pesola spring scale
- ✓ triangular file
- ✓ list of available identification codes (see Appendix E)
- ✓ small pieces of lightweight cardboard to write turtle ID, date and site, to include when photographing turtles
- ✓ smartphone or camera for dorsal and ventral photos of turtle
- ✓ cutting mat (clear) with metric scale for photographing turtles, 9" x 12" (~ 23 x 30 cm)
- ✓ spare batteries for all electronics and a bag to discard old batteries

Also, consider the following items:

- ✓ disinfectant hand wipes
- ✓ disposable, non-latex gloves
- ✓ first aid kit
- ✓ water for hydration
- ✓ sulfur powder for chiggers (dust around the opening of your pants, socks, and boots)
- ✓ insect repellent (DEET is not recommended for hands of animal handlers)
- ✓ zipper-type baggies to collect interesting things and look at later
- ✓ sunscreen
- ✓ hat
- ✓ rain gear

To Treat or Not to Treat Sick Turtles in Your Project *with John Groves*

Conservation projects aim to monitor and prevent declines in populations and in biological communities over time. Populations of box turtles are the target of our attention rather than the individual animal. This means that any pathology that might impact the long-term well-being of a population is of serious conservation concern. A sickness or an injury that impacts a single individual, but does not threaten the health of the population is not considered a conservation matter. Concern for the individual animal is an animal welfare issue not a conservation issue, but it is one that has an important place in the discussion of running a project such as The Box Turtle Connection. In this section, we offer some opinions on handling sick turtles in a research study that should be considered prior to starting your study. When encountering a sick turtle, also refer to Appendix G.

Without question, any animal that displays symptoms of highly contagious disease such as ranavirus should be taken to a vet immediately. Symptoms include extreme weakness, labored breathing, swollen eyelids, sunken eyelids from dehydration, diarrhea, discharge from eyes, nose, and/or mouth, skin sloughing on footpads, patchy red blotches on skin, and thick white or yellow plaques on the tongue, palate and/or cloaca. Animals suspected of having this serious disease should be taken to a veterinarian for examination. For a discussion of this topic see Appendix G. Ranavirus is a genus of pathogens that infects box turtles in the wild as well as in captivity and threatens populations. It spreads quickly and is lethal in most cases. Turtles surviving the disease may become carriers of the virus, potentially exposing other turtles in the population. Mass mortality events in fish, amphibians, and reptiles have resulted from ranavirus.

Figure 10. Blackberry developed a left eye infection (top). A few weeks later it had healed nicely without human intervention (bottom).

Certain non-contagious aliments of individual turtles, such as mild eye infections, may resolve themselves without treatment (Figure 10). Some ear infections may not self-resolve and can become life threatening (Appendix G) without treatment. Deciding whether to seek medical treatment for an individual sick or injured box turtle, such as the one in Figure10, is an animal welfare and ethical matter. Many factors drive the decision, including time, financial considerations, and accessibility of competent medical care. In the Box Turtle Connection project, the decision to seek treatment for individual turtles is left up to the Project Leader.

Different people have different views about the advisability of seeking treatment for turtles in research studies. One view suggests that getting treatment for turtles skews the results of the study underway because there has been interference with "natural" turtle survival rate. In this view, the results would not truly reflect the natural forces at work in the ecosystem, and survivorship from resulting human action is "unnatural" survivorship. (*It must be noted here that all studies within the range of human impact reflect mortality due to human causes along with other non-human related causes such as freezing, disease, or injury from wild canines and raccoons*.)

Another view holds that humans are part of the ecosystem, hence any benefit *or* harm to box turtles from interaction with humans is as natural as any other species benefiting from or being harmed by other species. For example, beavers' activity harms some individual trees and helps others. Some maple trees are killed by beaver gnawing but other maple trees benefit by the increased sunlight and the increased level of the water table as a result of the same beaver activity.

Figure 11. This box turtle was clipped by a riding lawn mower.

The same holds true with human activity and its impact on box turtle survivorship. There are risks and benefits for box turtles from sharing an ecosystem with humans. Human activity might harm box turtle survivorship when turtles are killed on roads or when their eggs are depredated by subsidized predators such as raccoons (raccoons are subsidized by human garbage, bird feeders, and pet food put out on porches). Other human associated risks include other paved surfaces, wildlife unfriendly lawns, monoculture agriculture, and, of course, mowers, mowers and more mowers.

Despite the risks, human activity may also benefit box turtles, either intentionally or unintentionally. One such way is unintentionally creating additional box turtle nesting areas with mulch piles and sand piles, allowing for increased survivorship of eggs. Another benefit which would increase survivorship of adults (those with the highest reproductive value) would include being carefully taken from the road and moved to the side where the animal was headed. Additionally, medical care may benefit the individual, the population, and the ecosystem if the turtles survive, are allowed to rejoin the population, and reproduce, thereby contributing to future generations. Hence, one could think of getting treatment for a sick box turtle as having no more influence in survivorship than helping a turtle cross the road safely or creating brush piles to improve habitat.

Getting treatment for an individual turtle has the potential of having unintended negative consequences. Taking a turtle into a medical facility may not always be beneficial for the individual or the population. If a turtle is taken to a rehabilitation facility for treatment, it may be exposed to other turtles with infectious diseases that may transfer to the wild population once the treated turtle is released. A box turtle in treatment for an eye infection may experience improvement in the condition, but, if held at the facility long enough, they may also see a decline in immune response due to the artificial conditions of the rehabilitation facility.

We have observed unsuitable housing in some rehabilitation and veterinary facilities. Just because a vet may know how to treat a turtle does not mean that the same vet knows how to house and care for captive turtles, and may not provide areas for privacy and hiding. Unfavorable housing conditions may result in stress-induced immunosuppression, enabling pathogens normally held in check to be expressed. Releasing an immunocompromised animal can allow illness to gain a foothold in the native population after it is released, possibly causing harm to the population. Although box turtles have great powers of healing, they are not able to withstand all illnesses and injuries, as some people think.

If convinced that a turtle should be treated, then decisions regarding care must be made. If one is skilled at reptile medicine, it is preferred to treat any injured turtle on site as best as possible then release it at the capture site. Another approach would be to treat the turtle in a turtle-friendly facility, and keep it isolated from other animals, especially other herptiles (reptiles and amphibians). In such cases, keep the time that the animal is held captive as short as possible. In the case of serious illness, it also is advisable to allow for a few weeks of quarantine prior to release. Always release turtles at the point of capture (not directly in the road of course), as box turtles generally are strongly tied to their home places.

Project Leaders in The Box Turtle Connection project may decide themselves whether to treat or not to treat seriously sick animals with one exception. If a turtle is suspected of having a ranavirus infection, it must be taken to the vet (see Appendix G for more information**)**. We, the overseers of the project, work on the assumption that by allowing this choice, the BTC study will truly reflect the forces at work, considering humans and their decisions as a part of the natural environment with beneficial and harmful impacts.

Researcher Spotlight

Dr. Matt Allender

Photos provided by Matt Allender

Matt Allender is a Veterinarian who directs the Wildlife Epidemiology Lab at the University of Illinois. Epidemiology is a branch of medicine that deals with the incidence, distribution, and possible control of diseases and other factors relating to health. For the past ten years, Matt and his students have been monitoring the biochemistry of and diseases in Eastern Box Turtles. Dr. Allender along with John Rucker and his famous turtle dogs have located over 3,000 turtles for health studies. His lab is in its ninth year of monitoring the health of a box turtle population in Oak Ridge, Tennessee, making it the largest long-term box turtle health study to date.

In addition to having blood samples and swabs of the mouth taken, the turtles get a thorough check-up. However, health assessment in free-living reptiles is challenging. Reptiles demonstrate a high variability in characteristics of their blood and plasma in response to different reproductive and physiologic states, and their responses to pathogens, trauma, and metabolic disturbance do not always follow predictable patterns. Dr. Allender's lab has found differences in these basic health parameters between season, years, sexes, and age classes. Characterizing these findings have increased knowledge of box turtle health and improved conservation strategies aimed at optimizing wellness. This veterinary work with wildlife is important because deteriorating wildlife health effects the sustainability and successfulness of conservation efforts. Thus, conserving the wellness of these populations is integral to conserving ecosystems and assessing recovery efforts.

In box turtles, upper respiratory pathogens are increasingly reported, including ranavirus, Terrapene herpesvirus 1 (TerHV1), Mycoplasma, and adenovirus. These pathogens have similar clinical signs, but vastly different disease outcomes from near 100% mortality to no observed clinical signs. Matt's Lab has addressed these pathogens individually and recently developed a novel technique to investigate all of these pathogens simultaneously. Interestingly, co-pathogens are common and not necessarily detrimental to box turtles.

Matt is an advocate for box turtles and *The Box Turtle Connection* is pleased to highlight his work. If you tweet, Matt keeps everyone updated on his work - just check out his twitter handle, @Turtle_Doc. Matt joins others in his quest to "Save the world, one box turtle at a time."

5. Finding Box Turtles

Wild box turtles are difficult to find on demand but, using the methods described here, your chances of finding box turtles should increase. When you find a box turtle, begin collecting data right away (see data sheets in Appendix A). Sometimes a person can encounter a box turtle when they are engaged in a non-turtle searching activity such as hiking or working outside. These are called incidental finds. Intentionally finding turtles can be accomplished by visually searching in likely places or conducting a formal census, radio-tracking turtles with previously attached radio transmitters, or by using dogs that may be untrained pets or trained turtle-finding dogs. These methods are described below. Before you begin, you need to know what to do when you find a turtle so you are prepared to gather as much useful information as possible.

Before You Pick Up a Turtle

It is always exciting when a turtle is encountered. Before you pick up the turtle, though, take note of its behavior. Was it closed in its shell? Walking? Alert and looking around? Eating? Mating? What direction was it traveling in? Was it nestled in a form (depression in ground)? Take a picture if you can. You can report these observations in the comments section on the data sheet.

The turtle should not be handled at this point (unless it tries to walk away), but should be left on the ground where it was discovered. When you are with a group, stop and call out so that others in your party can observe the turtle *in situ* (in its original place). Get a GPS location and record the time each turtle is found along with weather conditions.

Visual Surveys

It is not uncommon to encounter box turtles on roads, in the garden, or the woods, but finding a box turtle when you want to find one can be challenging. Hatchlings are especially rare (Figure 12). The search method we find most effective is to form a line and have all participants stand with outstretched arms touching, then move through the search area keeping the arm's length transect. Look around large tree trunks, fallen logs, in stumps, and in brush. Try not to disturb habitats any more than necessary.

Figure 12. A hatchling Eastern Box Turtle.

Box turtles are mostly diurnal (active during the day), although females often lay their eggs after dark. They are most active throughout the day during the spring and fall. A good time to search for turtles is just after a rain in late spring or early summer. Deep in the summer months, you may find box turtles are more active in the mornings or later in the afternoons; during the hottest hours, they may hunker down under leaves or vegetation or seek wet places during droughts, so be careful where you step!

When you can, collect all data while you are in the field so you do not have to remove the turtles from their habitat. Carefully pack your backpack so that you will have all the equipment necessary for data collection on site (Chapter 4). If you must remove a turtle from the wild, mark the location using flagging tape and return it to that spot as soon as possible so that it may pursue its own agenda. A good guideline is to return the turtle by the next day, if not immediately. Avoid subjecting the turtle to strong temperature swings after removing it for processing (e.g., don't transport it next to the air conditioner in a car or house it in a highly air conditioned building).

Sheets of tin or plywood, called coverboards, may be found lying on the ground particularly near old home sites. These provide excellent habitat for turtles, other reptiles (especially snakes), and amphibians. Some people place coverboards to deliberately attract herps. Be careful when you look under coverboards since what you find may surprise you. Copperheads are found over much of the same range as box turtles and may take refuge under tin or plywood. These snakes are venomous, but not deadly as many people believe (although a bite does require immediate medical care). If you find a copperhead, simply replace the coverboard and move quietly away from the area. As a safety precaution, lift the far side of the coverboard towards you, allowing the board to act as a barrier between you and what may be under it. Also, if able, use a snake hook or some sort of hooked tool to lift the coverboard. This will prevent you from having to place your hands under the edge of the board and possibly within striking distance of a startled snake.

How to Conduct a Box Turtle Census *by Mike Quinlan and Chris Swarth*

Many field ecologists conduct censuses of animals in order to monitor population size and status. A census is a standardized count. When censuses are conducted frequently or for several years, they can provide accurate information on the numbers of animals in a given area. A fairly accurate estimate of numbers and density (for example, the number of box turtles per hectare) can be determined if a census is conducted in a measured study plot.

Censuses are a good way to introduce students and adults to ecological monitoring, population ecology, and turtle behavior, and can be conducted by novices after they have been provided with some training. If censuses are conducted regularly, the resulting data can be used to track population trends and can even be used for comparative purposes by researchers elsewhere.

Setting-Up the Census Plot. First you must select an area or habitat that you would like to census. Be sure to seek permission from landowners before you begin. Conduct a preliminary reconnaissance survey to make certain that the area is safe and that the terrain is not too difficult to traverse on foot. A reasonably sized census plot is one or two hectares (a hectare is 10,000 m^2 or ~ 2.5 acres). Your census plot will need to be marked well on the ground. The easiest way to do this is to use a GPS unit and a 100-meter tape. Mark each corner with a white, 3-inch (7.6 cm) diameter, 8-foot (~ 2.5 m) tall PVC pole and paint the top of the pole a bright color. If your census area is heavily vegetated, you will need to place poles or colored plastic flags along the periphery and in the interior of the plot at 25 meter intervals. Interior flags or poles are useful for marking turtle locations within the plot and for helping searchers know where they are within the plot. Pipes or poles should be conspicuous enough that they can be seen from 10 to 15 meters away. If the plot has many deciduous trees, it will be easiest to mark the plot in late winter before trees and shrubs have fully leafed out. Since it may take a day and a half to mark the plot, so it well ahead of time.

Make a data sheet with a plot map on an 8.5- by 11-inch (215.9 by 279.4 mm) piece of paper (see Appendix C). Use a fresh map and data sheet for every census. Include space on the data sheet to record the date, time, weather, names of searchers, and include a census plot map so that the exact location of each turtle can be plotted on the map.

Figure 13. Make it a family affair! These families went searching for turtles at Earthshine Discovery Center in North Carolina.

Conducting the Census. Censuses should begin in the spring when turtles are emerging from hibernation. A weekly census is a useful frequency. Censuses should be done at the same time each day and should not be done before 10 am or after 4 pm. Strive for consistency. The census crew should consist of at least 4 or 5 competent searchers, but not more than 12. We recommend 45 minutes to one hour to conduct the census, depending on plot size and the number of searchers. Try to keep the duration of each census consistent.

Start the census by lining up the searchers, evenly spaced, along one edge of the plot. Walk slowly through the plot staying within sight of one another and everyone should walk in the same general direction (for example, from east to west). Each searcher should cover a swath of ground that is about 2 meters wide and runs the length of the plot. It is desirable to have some overlap of coverage between adjacent searchers to avoid overlooking turtles. Searchers should scan the entire plot looking for turtles that are on the surface or partially buried. Pay particular attention to fallen logs, bases of large trees, and shrubby tangles; these are places where turtles are more likely to be found. Occasionally scan back in the direction that you walked for turtles that might be partially covered by leaves or under the edge of a log or shrub. Do not turn over logs or dig through the leaf litter, as this will disturb the turtles and their habitat. Searchers should move deliberately and slowly. Don't be rushed!

Not all of the turtles in your census plot will be detected on a census. Box turtles can blend in very well and may simply be overlooked, even by seasoned box turtle experts. Other turtles will be hidden under leaves or logs. Based on experiments we conducted using old turtle shells placed in a small plot, we determined that experienced searchers could miss one third of the turtles in a plot. The fact that not every turtle will be spotted during a census is not a large problem and is partially offset if censuses are conducted the same way each time. The more censuses you conduct the better your estimate of density becomes.

Searchers should carry a map and compass to help the group stay oriented as they move through the plot. This also ensures more complete coverage and helps prevent searchers from wandering outside the plot. In dense vegetation, a map and compass may be crucial. The interior plot markers also help to keep searchers properly oriented.

With time, your censuses will provide an accurate estimate of the number of turtles using the plot, the fidelity of turtles to the plot, and even the numbers of turtles that pass through the plot but that may not actually live in the plot. If turtles are marked, you can begin to create individual home range maps. If you conduct censuses over several years, you may even be able to estimate population fluctuations.

Using Your Smartphone to Acquire GPS Data *by Jim Greenway*

A smartphone's Global Positioning System (GPS) app can be as accurate as many popular hand-held GPS receivers. The keys to good smartphone GPS data are a fully-charged phone along with correct technique and appropriate GPS app settings.

Always start your turtle monitoring day with a fully charged smartphone. Many project leaders use their smartphones as cameras, too. The combination of photography and GPS navigation can quickly drain the battery, leaving you unable to take photos or location data in the field.

Launch your GPS app as soon as you find the turtle, but wait to record or save the location data until you are about to leave the find site. Hold the phone level and at arm's length. The smartphone may take several minutes to get a "fix" with sufficient accuracy. Its accuracy is reduced when GPS signals are blocked by your body or other nearby obstacles.

Finally, choose an app that allows you to set the coordinate system. Ideally the app should display the accuracy of the fix. The BTC coordinate system is "Universal Transverse Mercator," or UTM. The datum is WGS 84. The coordinate system and datum can often be changed in the app's "Settings" menu. The accuracy is usually displayed with the coordinates. A smaller accuracy number is better. Try for a fix that is accurate to five meters (16 feet) or less. Most smartphones will only reach an accuracy of ten meters in a forest, though. Consider switching to a stand-alone receiver or adding an external GPS antenna to your smartphone if your smartphone's accuracy is routinely over ten meters.

Radiotelemetry

Radiotelemetry helps researchers understand the habits, movements, home range, and habitat preferences of box turtles. Radiotelemetry will require battery-powered transmitters and a hand-held receiver with an antenna (Figure 14). For public venues or schools, be sure to have a receiver that has a visual meter so that participants who are hearing impaired can participate in tracking turtles.

Miniature radio transmitters come with batteries encased in a coating of surgical wax and dental acrylic for waterproofing. The transmitter package varies in size depending on the battery used (long-lived batteries are larger and heavier). The supplier will advise you about battery life and size. It is important not to use a transmitter that is too large or too heavy for your box turtles.

Figure 14. Researcher Courtney Anderson smiles after finally locating her box turtle with a radio antenna and receiver.

When choosing a site for placing the transmitter, be sure to attach the transmitter to one of the pleural scutes (see Appendix F for scute names). Avoid the rear vertebrals as placement there may interfere with mating. We secure transmitters near the 4th pleural scute (Figure 15), with the antenna placed toward the posterior of the specimen but not everyone does it this way. Some researchers find that gluing a small piece of aquarium tubing over the site where the antenna attaches to the transmitter can minimize antenna breakage, but we have not had a problem with antenna breakage. Be sure to order the transmitters during the winter to receive them by spring.

Transmitters are fastened onto the shell with quick dry waterproof epoxy. First use aquarium sealant (Wilson et al. 2003) or quick-stick epoxy (Eckler et al. 1990) on the base of the transmitter to stabilize it while you prepare and apply the epoxy that will cover the transmitter completely. Transmitter and glue should not add more than 7% of body weight (Schubauer 1981; Eckler et al. 1990), though size, shape, and placement of the transmitter may be more important than its weight (M. Dorcas, pers. comm. 2006). This process takes less than thirty minutes and the animal can then be released immediately.

Not all researchers agree about equipment and materials. Researchers at Jug Bay Wetlands Sanctuary (Maryland) find PC-7 epoxy to be a superior product, but a long drying time necessitates the turtle being held overnight. In this case, the transmitter is temporarily covered with a strip of duct tape so the epoxy will harden adequately before the release.

Transmitters do not appear to impact turtle breeding or movement. In one study, individuals were successfully re-fitted with radio transmitters as many as six times during a four-year study period. Turtles carrying transmitters were observed carrying out normal activities such as foraging, mating and nesting, and migrating (Eckler et al., 1990). You must remove or replace the transmitter before the battery dies, or you may never see it again. It is helpful to plan the removal or replacement of a transmitter at least a month before the maximum lifespan allotted to that transmitter. Dislodge transmitters from the carapace by gently prying with a knife or flathead screw driver. If you choose to stop tracking a turtle it is important that you remove the transmitter from the turtle.

Figure 15. This transmitter is on the 4th pleural scute, but some researchers place it on the 2nd pleural scute.

Each transmitter emits a different frequency which can be picked up by the receiver once it is adjusted to that specific frequency. Only one signal is picked up by the receiver at a time. When receiving a signal, a "chirp" sound is produced which becomes louder as the receiver gets closer to the transmitter. Some trackers find earphones helpful. Allow time for team members to get acquainted with care and use of the equipment and have them practice detecting signals.

Turtle locations can be marked with surveyors flagging tape but be sure to remove it once the turtle has been returned and the data collected. Record the turtle code, date and time on the tape with a permanent marker.

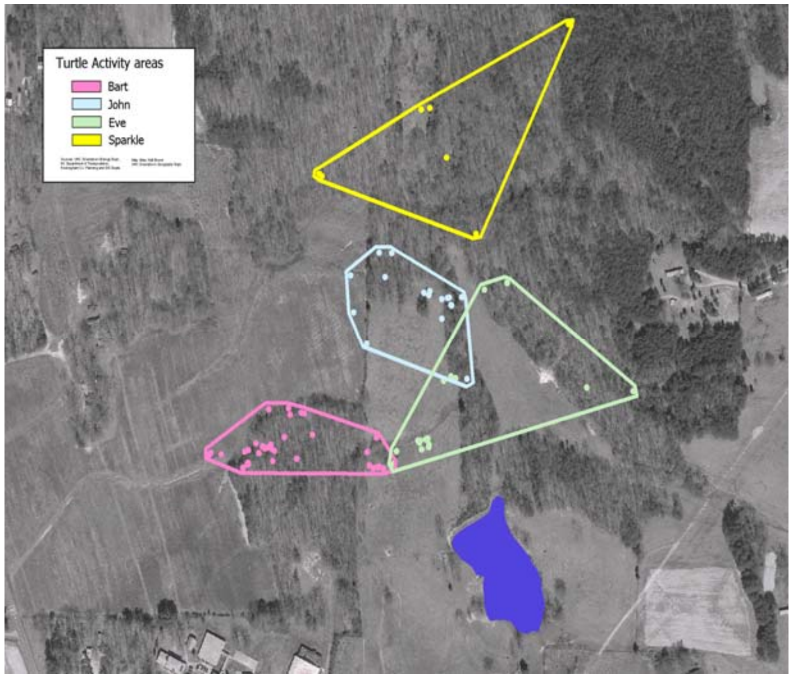


Figure 16. Area of activity of four Eastern Box Turtles over a one-year period. Source base map: NC Department of Transportation, Rockingham County Planning and GIS Departments. Overlay by Mary Hall-Brown.

DEVELOPMENTS IN TELEMETRY

by Andrew Durso

Conventional radiotelemetry can now be automated in a variety of ways, including using pre-programmed stationary radio antennas to monitor the behavior of Ornate Box Turtles (Tucker et al. 2014).

Ultra-light harmonic radar tags are starting to be used to track very small animals and insects. These are like PIT-tags (passive integrated transponders) but they are smaller and lighter and do not have unique IDs. They show some potential for herps, and you can make them yourself, but you have to buy a costly transceiver (Engelstoff et al. 1999; Gourret et al, 2011; Kissling et al. 2013; Rowley et al. 2007).

GPS coordinates can be sent like a text message in some urban/suburban areas using radio transmitters that use cell phone networks (McConnell et al. 2004). Additionally, stationary receivers with long flexible antennas (which could be placed in a circle on the ground around a wetland or hibernaculum) have also been used successfully for monitoring animals with PIT-tags (Charney et al. 2009; Rehage et al. 2014).

A good review of some new methodologies for tracking turtles is Plummer and Ferner (2012) but look for more recent reviews as technologies are always changing.

Aerial photos on Google Earth can be helpful, as can USGS topographic maps and hand drawn maps. Use measuring tape and a compass to establish exact locations if you don't have a GPS unit. Photocopy a map of the research site onto the back of data sheets so locations can be mapped while on site. Generate a comprehensive map by hand or electronically, using the locality data generated with each turtle capture. The maps illustrate each turtle's area of activity and its preferred habitat type, allowing you to calculate the size of the activity range (Figure 16).

Finding Turtles Using Specially Trained Dogs

We have all heard of hunting dogs, but what about turtle-hunting dogs? The use of dogs to find turtles is uncommon, but it is not a novel surveying technique. The Schwartzs of the Missouri Department of Conservation used Labrador retrievers in the 1960s-1980s in their almost two-decade study of Three-toed Box Turtles (*T. c. triunguis*). Since then there have been occasional reports of dogs of various species being trained to locate and retrieve box turtles as well as other reptiles (e.g., Cablk & Heaton, 2006; Nussear et al. 2008; Schwartz & Schwartz, 1991; Sammartano, 1994; and Stevenson et al. 2010). Smith (2015) recently published a book describing her hobby of tracking and monitoring over 80 Eastern Box Turtles on 65 acres of woods and fields in New York state using Australian cattle dogs.

In the early 2000s, we started our box turtle studies at Bethany Community Middle School in Rockingham County, North Carolina. We assumed that a school full of energetic students could surely find box turtles if given a few hours in the woods. On our initial outings, doing visual surveys with the middle schoolers, our high expectations were deflated when we only found one or two turtles. How could we run a box turtle project with only a handful of box turtles, and how could we make our searches more efficient and effective? We knew box turtles were on the school property as we had seen them incidentally, so then why was it so difficult to find them when actively searching?

Figure 17. John Rucker with two of his famous Boykin Spaniels.

Then we learned that John Rucker (Figure 17), a Greensboro native, had dogs that retrieved box turtles and was interested in putting his dogs to work to benefit science. Their road to fame started several years ago, when John was hiking with Buster and Sparky when Buster trotted up with a box turtle in his mouth. Instead of scolding his bird-hunter, John praised him and wondered if his dogs' unique ability to track and retrieve box turtles might be of use to the research community. Quickly, John began building upon these skills, relying on traditional methods used in training bird dogs and depending heavily on the positive reinforcement of praise and a good pat on the head.

When we first spoke with John, it was clear that he understood the value his dogs could have for box turtle research and conservation, and that he wanted to join the project. Soon after, the career of John Rucker's box turtle hunting dogs began in earnest, and Buster, Sparky, Greta, and their progeny became famous in the turtle world. Since then, much of our work in North Carolina through The Box Turtle Connection has revolved around our partnership with John Rucker and his Boykin Spaniels, more commonly referred to now as "the turtledogs."

There are some difficulties with using dogs for searches. The dogs must be well trained and soft mouthed. If not carefully trained, dogs can unintentionally injure turtles, especially young box turtles whose shells are soft. To avoid prolonged opportunity for injury, the turtle is quickly collected from the dog, minimizing the time the turtle spends in the dog's mouth. Another serious concern is that the dogs will sometimes encounter venomous reptiles. Copperheads and other snakes occupy the same habitats as box turtles and may be stumbled upon during a search. Lastly, dogs being dogs, they are often distracted by other wildlife, like deer, and may run off at times. John constantly worries about the safety of his dogs; they must be watered down frequently, have plenty of drinking water, and ideally conduct their searches a good way from roads. John and his dogs have worked with the Box Turtle Connection for many years now, since 2002, and they have searched various sites in the Piedmont, Coastal Plain, and the mountains of North Carolina for box turtles in addition to their work all over the Eastern and Midwestern United States. They have been instrumental in locating populations of the threatened Ornate Box Turtle, native to the prairie states, and have travelled as far west as South Dakota. Using dogs to find and retrieve box turtles has forever changed the face of box turtle research.

In many studies, when both humans and dogs search for box turtles, dogs are found to be more effective and more efficient than humans at finding box turtles. Dogs mostly find turtles by scent, not sight, and can get into places that humans can't or won't go (blackberry thickets for example). Also, dogs are much quicker and often more persistent and focused than humans in searching for turtles. But dogs also have their limits. When scent trails created by turtles are destroyed by heavy rainfall, or weakened under prolonged dry conditions, dogs may be no more successful than humans in finding turtles.

6. Data Collection

One of this book’s purposes is to describe some common methods of collecting morphometric and environmental data on box turtles and their surrounding habitat and to stress the importance of data quality. The value of any research effort is greater if the results can be compared with results from other studies. When similar research efforts in different areas result in data that are collected in a consistent manner, it is possible to compare results. If research findings are to be pooled or compared with other studies, consistency is key! Methods used in various studies can differ and still generate sound scientific conclusions; however, inconsistent methodology rules out the possibility of pooling data across sites, limiting sample size and the potential for generalization and transferability of conclusions and recommendations.

Each study should have any research questions described prior to initiation of field work, as the questions define the information to be collected on data sheets. Once data sheets are constructed, participants should undergo field training with the research director. This should include practice measuring and notching turtles, and filling out data sheets. Rain repellent paper can be used, but is not necessary. Data sheets must be filled out in dark pencil or black indelible ink, as standard ink will smear when it gets wet, and light pencil and ink do not copy well. Design an electronic spreadsheet that will accommodate your data and have a responsible person enter the data as it becomes available. With help, junior curators or students can learn to do this. As always, each entry should be double-checked. Hard copies of the data sheets should be reproduced and kept on file at a different location than the originals. This allows researchers to examine questionable entries or findings in the spreadsheet database. Having hard copies in different locations means that the information is protected against disasters like fire or water damage.

When it comes to statistical analysis, missing data on key variables can result in loss of important information. This is true regarding data from turtles or sites. Complete each blank on the data sheet, even if the information has been recorded elsewhere. If the solicited information is “not applicable” then enter “N/A”; if the information is not known, enter “UNK” in the space provided. Complete the environmental data on the sheets while in the field since trying to remember the information later leads to inaccurate data. If you do not have a data sheet on hand in the field, be sure to record the measurements and take detailed notes that can be transferred to the data sheet later. Information such as temperature, sky index, and location description are point specific, and should be recorded at the site where the turtle was found even if the turtle is brought to an alternate location for measuring.

Protocol for handling of the data sheets must be discussed with the participants. This includes the need for checking the forms for accuracy and legibility since legibility is *always* an issue with hand-written documents. Data collectors may use inappropriate writing instruments, such as ink pens that bleed, or fail to take the time to write words and numbers clearly. Make sure 4s, 7s, and 9s are distinguishable. Do not use ambiguous abbreviations because the person entering the data may not interpret them correctly or you may later forget what the abbreviation stood for at the time of use. If one person collects the data, and another writes it down, have the person *writing* repeat the measurements out loud as they write to avoid miscommunication. Project Leaders should take time to train assistant data collectors to use these important techniques.

Marking System for Box Turtles

A widely-accepted method of marking box turtles is described below. This system is used by the Box Turtle Connection project (Somers and Matthews 2006), Davidson College Herpetology Lab (Dorcas, 2006), researchers at the Savannah River Ecology Lab, and many others around the world.

Figure 18. Marginal scute notches are made with a triangular file.

Most box turtles have 12 marginal scutes on each side of the carapace. Turtles can be marked permanently by using a slim triangular file to make small v-shaped notches (Figures 18 & 19) in the marginal scutes. Dipping the file in ethanol, or wiping down with alcohol wipes, between uses may reduce the risk of infection for the turtle.

On each side of the turtle, there are four marginal scutes that form the bridge between the carapace and the plastron. These are **not** used for marking because the vascular connections between the plastron and carapace may be damaged. Use the remaining eight marginal scutes per side for notching. Identify the cervical scute in Figure 20. The cervical scute is sometimes called the nuchal scute in popular literature and by field biologists, though the term nuchal technically identifies the bony plate below the cervical scute. In the field, the terms cervical and nuchal are often used interchangeably. The top two (anterior most) marginal scutes on either side of the cervical scute will always be "A" (right of the cervical scute) and "X" (left of the cervical scute) respectively. The two marginal scutes at the posterior end of the carapace will always be "L" (to the right of the tail) and "M" (to the left of the tail) respectively. Turtles are marked with three notches representing a unique three-letter code (for codes see Appendix E). **Count scutes carefully because marginal scute numbers can vary, which may alter the intended code.** Some turtles have 10, 11, or 13 marginal scutes on a side rather than the expected 12. This need not cause confusion when determining where to mark turtles or read codes. Use the method below for the easiest way to determine where to mark a turtle, *regardless of the number of marginal scutes*.

Figure 19. This photo illustrates our preferred notch size. Notches too shallow can be mistaken for injuries.

Regardless of the number of marginal scutes, letters "A", "L", "M", and "X" always refer to the same marginal scutes with respect to the notches, as seen in Figure 20. We will refer to them as the compass scutes. “A” and “X” always border the cervical scute and “M” and “L” always border the posterior notch.

Once the turtle code has been selected, begin the lettering count with the compass scute code closest to the letter to be notched and count towards the bridge. For example, if the turtle code you are notching is “BKO,” “B” is closest to compass scute “A,” therefore the count to “B” begins with “A”. Marginal scute “K” is closest to compass scute “L,” therefore the count to “K” will begin at “L” and count up towards the bridge on the right side. Marginal scute “O” is closest to compass scute “M,” so the count will begin with “M” and count forward towards the bridge on the left side.

If there are 13 marginals on a side, then the extra marginal scute is considered an unnamed bridge scute. If this is the case, then the letter “K” may be the 12th marginal scute and the letter “L” is the 13th scute. Regardless, the “K” is one away from compass scute “L” which is always in the same position.

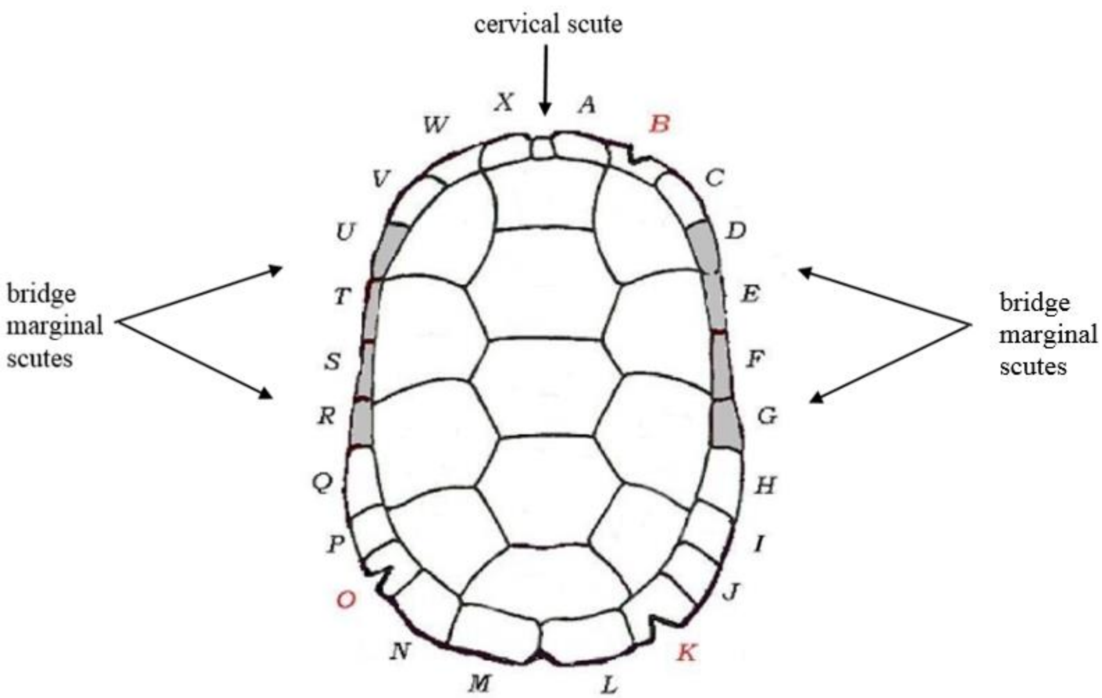


Figure 20. The edge of the carapace is lined with marginal scutes. These are notched using a three-letter code system. This turtle was marked “BKO.” Bridge marginal scutes are never notched.

If there are missing marginal scutes so that there are 10 or 11 marginals on a side, the missing scute is considered missing from the bridge scutes (either D, E, F, or G or R, S, T, or U). In this case, the letter “K” may be the 10th marginal scute. Regardless, it is one away from the compass scute “L” which is always in the same position.Again, to determine which marginal scute should be notched between the bridge and the posterior end of the carapace, always count from the closest compass scute towards the bridge. Photos of the carapace and plastron should always be taken as documentation of how the marginals were notched, since notching errors can and do occur. Each carapace and plastron is unique and the digital photos can be stored with the data sheet. Images will also provide useful documentation of any injuries.

Notch depth varies according to the preferences of the researcher. We use a 1/8” triangular file. Notching too deep can lead to infection, and notches too shallow can be mistaken for injuries. Most folks err on the side of notching too shallow rather than too deep and, therefore, previously marked turtles are sometimes not recognized. Make sure your notches will be recognizable by the next researcher who finds the turtle. Every recapture provides an opportunity to reevaluate the notch depth. If not deep enough, they can be deepened to avoid confusion the next time.

Researchers disagree about the advisability of marking hatchlings. We follow the advice of the late Bern Tryon, formerly of the Knoxville Zoo, who did not recommend it for most studies. He offered two compelling reasons: 1) the younger the age at marking, the less likely the markings will be retained as the turtle matures, and 2) considering the low rate of hatchling survival in any given population, to mark them and then count them as part of the population will likely give an unrealistic estimate of the population size. If marking hatchlings is deemed necessary, use small, but sharp, fingernail scissors rather than a triangular file, because the carapace of hatchlings is soft and flexible. Notches on the marginal scutes of hatchlings will migrate backward as the turtle grows. Do not attempt to mark a hatchling unless you have been adequately trained by a qualified individual since using improper technique may cause injury to the turtle.

For all possible letter combinations for marking, see Appendix E *Turtle Identification Codes.* Recall that the bridge marginal scutes are not used for notching. You may use the same system for marking other turtle species and the same codes can be used. Please note that all turtle species have bridge marginal scutes and the avoidance of these scutes for marking should be applied to all turtle species you may work with. Keep the next few available identification codes with you while in the field so you’re prepared to process the next new turtle. This will reduce the chances of designating the same code to two separate turtles which can cause confusion later during data entry and analysis. If you accidentally notch an identical code on a new turtle, it is possible to simply notch a fourth scute and assign this exception a 4-letter code. It is better to do this than have two turtles with the same code.

Sex Determination in Eastern Box Turtles

The turtle lives 'twixt plated decks
Which practically conceal its sex
I think it clever of the turtle
In such a fix to be so fertile.

Ogden Nash

Sex determination in turtles can be tricky business because unless you see male genitalia or a female laying eggs, you cannot be 100% certain of a turtle’s sex. Instead, a combination of features should be used to confidently assign a sex to a turtle. Some of the key physical traits that generally differ between male and female Eastern Box Turtles include tail length and placement of the vent, hind claws, flaring in marginal scutes, general shape of the carapace, degree of concavity on the plastron, eye color, and coloring on the head, neck, and forelegs (Appendix D).

The tail size and vent placement can be a fairly reliable sexually dimorphic characteristic in box turtles. Males have long, thick tails with the vent positioned more posteriorly than on the females, usually extending past the edge of the carapace. Females, with their shorter, thinner tails, have a vent that is positioned closer to the body, not extending past the edge of the carapace. As a defensive response, many box turtles will tuck their tails sideways and up against their body. Do not try to pull the tail out from this position to view vent placement as you may harm the turtle.

Figure 21. Male box turtle (bottom) has a flatter carapace than the female whose carapace is more highly domed (top).

Another sex characteristic is the curvature of the hind claws. Males tend to have thicker, sharper, and more curved hind claws. During mating, the male will use his hind claws as anchors by placing them just inside the back end of the female's plastron. She will close her shell, trapping the male's hind claws between her carapace and plastron. Thicker claws allow for strengthened support, and the curvature allows the claws to rest tightly against the inside of the plastron. In the Ornate Box Turtle (*Terrapene ornata*) and the Spotted Box Turtle (*Terrapene nelsoni*), males can rotate the first digit of the hind foot nearly sideways to hook their sharply recurved claw under the edge of a female's carapace during copulation. Occasionally scratches are visible on the inner edge of females' plastrons, suggesting that they have mated recently. Females' hind claws are used for digging nest chambers, hence are usually thinner and straighter. This varies significantly though, leading to difficulty in categorizing the thickness or curvature of the hind claws.

Figure 22. Adult male Eastern Box Turtles (left) tend to have a deeper concavity on their plastron, whereas females have a flattened or only slightly concave plastron (right).

Shell shape, both top and bottom, can be very useful in sex determination in Eastern Box Turtles, but sometimes is ambiguous. Shell features may be the only physical characteristics available to sex a turtle since the most common defensive position in box turtles involves enclosing their head, legs, and tail in their shell, making these features inaccessible. Notice the degree of flaring of the posterior marginal scutes. Males tend to display more flaring in this area than females. The carapace on females is usually more domed, producing a larger and higher curve (Figure 21). The taller dome provides females with space for egg development.

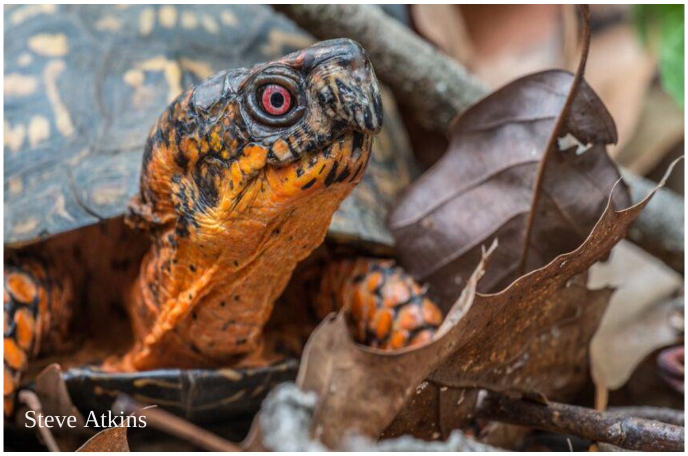


Figure 23. Male Eastern Box Turtles often have bright red eyes, though this can vary between individuals. Some have brown eyes.

If you gently turn the turtle over to view the plastron, you may find that it contains a slight concavity on the posterior portion of the plastron (Figure 22). Adult male Eastern Box Turtles plastrons have this depression to aid them during mating, providing them with more stability and a closer fit when mounted against the female's carapace. Females typically have flatter plastrons though some may have a slight depression. In contrast, the plastron on Three-toed Box Turtles (*Terrapene carolina triunguis*) often has little or no indentation despite the high dome shape of the carapace in both sexes. The Ornate Box Turtle (*Terrapene ornata*) shows no sexual dimorphism in shell shape – top or bottom. Both sexes have a flat plastron and compared to the other *Terrapene*, the Ornate has a rather flat, oval shaped carapace.

While eye and skin color in Eastern Box Turtles can show striking sexual dimorphism, there is enough overlap between the sexes to make these traits unreliable indicators. Males generally have bright red eyes (Figure 23) although some have brown eyes. Females typically have brown, yellow, or darker red eyes. In the Florida Box Turtle (*Terrapene bauri*), both males and females may have dull red or brownish eyes.

Much like their differing eye color, skin color in Eastern Box Turtles also varies between the sexes. Females typically have dull yellow or brown coloring on their heads and forelegs, contrasting with the bright orange, yellow, or red accenting the heads, necks, and forelegs of males. That said, some males are cryptically colored, like females.

Just like the intraspecific variation seen in Eastern Box Turtles, there is also interspecific variation between all box turtle species and subspecies. Although all box turtle species have the characteristic hinge and a similar shell structure, they can differ greatly in body coloring, shell pattern, shell shape and sexual dimorphisms. If sexing other species or subspecies of box turtles, please take the time to look at potential differences in sexual dimorphisms.

Figure 24. Sex determination of box turtle hatchlings is not reliable.

Sex characteristics in hatchlings (Figure 24) and young juveniles are vague, so determining the sex of a turtle at this stage is difficult. For instance, the longer tails and concave plastrons of males are not generally conspicuous until they reach a straight carapace length (SCL) of about 60 mm.

Due to the high variability of box turtle sex characteristics (Figure 25) as well as the late onset of some of the sex determining traits, if there is any uncertainty when sexing a turtle do not hesitate to mark "Unknown" on data sheets when asked for the sex of the turtle. If you mark unknown, be sure to describe any sexual characteristics you did see in the comment section on the data sheet even if you are still unsure. Uncertainty is never frowned upon, but recording a sex without the proper assurance can result in skewing of data sets in both short-term and long-term research. For more detail, refer to *Sexing Eastern Box Turtles* in Appendix D.

Determining the presence of eggs in any turtle can be one way to confirm a female sex determination and is often done by inserting the little finger into the cavity behind the bridge in front of the hind legs and feeling for the distinctive lumps. This is not recommended for female box turtles, however, because box turtles have a hinged shell, which permits them to close the plastron tight against the carapace putting the researcher at risk of getting a finger caught. If using this technique with box turtles or other turtles, be cautious! Probing incorrectly can cause pain or discomfort to the turtle as well as pose a risk to the developing ova if the female is indeed gravid. We recommend only doing so if you feel comfortable with the probing technique. X-rays of gravid (egg-bearing) females will clearly show eggs, but in-field radiography is normally reserved for advanced levels of research. In such cases, researchers should consult Hinton et al. (1997). Although little information is available on the long-term effects of radiographs on hatchling health, data suggest that radiation from standard shoulder x-ray doses (for humans) should not harm hatchlings or adults.

Figure 25. This colorful turtle has a relatively concave plastron, suggesting it is male. However, it laid 10 eggs while in rehab which obviously means it is female. Don't be afraid to record UNKNOWN for the sex of a turtle when you are not absolutely sure.

The Mystery of Aging Turtles: Don't Count on Annuli

Can you accurately determine the age of a turtle? Yes—if you know when it was born.

The plates (scutes) on the shells of turtles, such as box turtles, are said to record the age by adding a concentric growth band each year called an annulus. Recognizing that the Latin root of the word annulus is *annularis* (ring) rather than *annualis* (year), some researchers prefer the term *growth ring* rather than *growth annulus* to help dispel the notion that annuli are deposited annually.

Anyone who has attempted to count multiple growth rings on adult box turtles will understand why the Project Leaders in our Box Turtle Connection study are always seeking clarification on what is expected of them in counting annuli. *"Do you count every ring? If not, how do you decide which rings to count and which to ignore?" "Did I count the annuli correctly?"* Jane Wyche, Project Leader at Merchant's Mill Pond State Park, has been marking turtles on her own for decades and with the BTC since its beginning 10 years ago. She has attended almost every training session. She wrote

> *"I would love to either drop the counting of the annuli or go over how to do it for consistency's sake. I never think I do it right. There are some deep lines and some sallow lines. If the shallow lines are not counted, it does not seem enough for the age of the turtle."*

In training, we typically reference Germano and Bury (1998) who describe "false rings" as those forming shallower indentions than "true rings" and these "false rings" do not form completely around the scute like "true rings." This implies that "true rings" are accurate records of annual growth and "false rings" are intra-annual growth, and that these rings are distinct from one another.

But are there data to support this method as a valid means of estimating age? Box turtles such as the one in Figure 26 illustrate the inherent uncertainty in counting annuli. In the article "Estimating age of turtles from growth rings: A critical evaluation of the technique" Wilson et al. (2003) evaluated 145 papers and concluded that

> (a) there is no basis for aging turtles from counts of growth rings that can be generalized across species or populations, (b) relatively few studies have attempted to calibrate the relationship between counts of growth rings and age, and (c) the preponderance of literature relies on an assumption that ring counts are an accurate estimate of turtle age, without testing that relationship or citing studies that verify the relationship.

Given these findings, our own observations, and experience training dozens of citizen scientists in the Box Turtle Connection project over the last decade, we conclude that equating the number of annuli with turtle age should be used with caution. As Dodd (2001) mentions, some of the estimates of age using this method are undoubtedly in error, some are accurate, and others can be used only to gauge relative age. Factors that seem to impact annuli production are rainfall, energetics of nesting (in females), and resource availability, all of which may skew the annuli-to-age relationship. This emphasizes that 1) annuli counts cannot be trusted as accurate estimates of age and 2) photos of the carapace and plastron are important with each capture for comparison and re-evaluation of annuli counts.

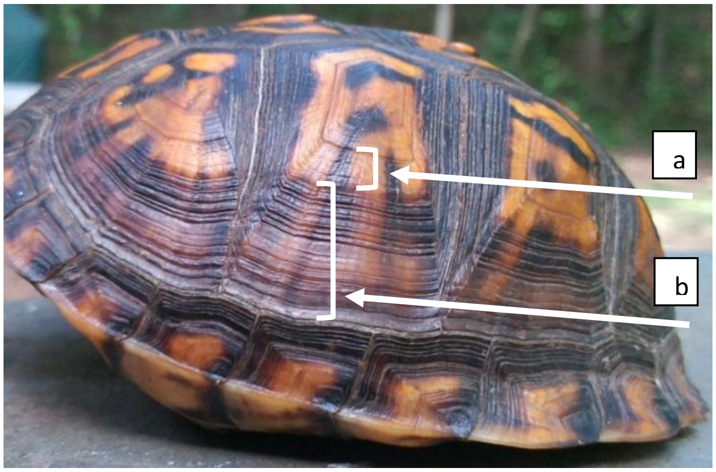


Figure 26. (a) Should this cluster of annuli be counted as one annulus or three annuli? Clearly some rings are much shallower than others. Should the shallow rings be considered "false rings?"

(b) Ring counts in this cluster range from 12 to 19 depending on what the observer calls "true rings" and what is determined to be "false rings." Use of a magnifying glass will increase the variation in the count even more.

Mature Turtles

Many turtle researchers recognize that turtles with over 20 annuli are difficult to age due to the tendency of annuli to become compact, and therefore record "20+" on data sheets. The unspoken expectation is that turtles with this many annuli are minimally 20 years of age, though this may or may not be the case. In examining adult turtles, scientists also take note of other clues, such as the amount of wear on the shell.

Turtles with worn or smooth areas on the shell (Figure 27) are thought to be older than other turtles of the same size with unworn scutes and clearly defined annuli, though this is also uncertain. A smooth shell may have been worn down by friction of the soil, sand, or forest debris in the same way sandpaper smooths rough surfaces. Alternately, this could be a function of habitat or micro-habitat choice.

Figure 27. Turtles with smooth shells are thought to be relatively older than turtles with well-defined annuli from the same site.

The Floyd Estates turtle JN 21-21 (Figure 28), a verified centenarian (Cook et al., 2010), shows some, but not excessive, smoothing of the top and bottom shell. This suggests that shell-wear may also be a function of soil types in preferred habitats rather than just age.

Other signs of age are well developed flanges on the posterior marginal scutes of adult males. Also, carapacial (top shell) scutes on box turtles may show some minor cracking and give the turtle an older appearance, although they could just be the results of an environmental hazard that could occur at any age.

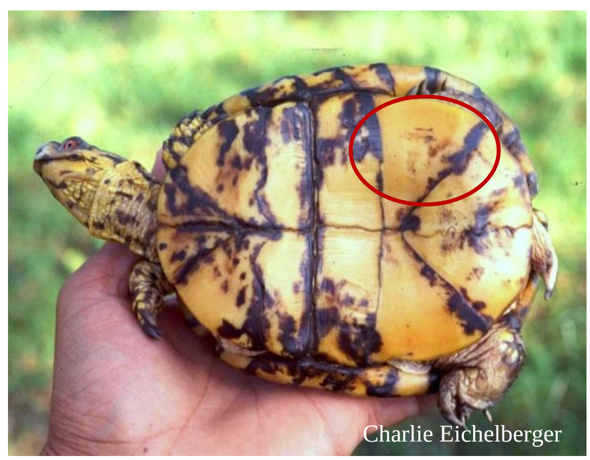


Figure 28. First captured in 1921 by naturalist J.T. Nichols at the William Floyd Estate at the Fire Island National Seashore, this turtle was determined to be a minimum age of 20 years. JN 21-21 (impressed into left abdominal scute, barely visible within the red circle) was declared a centenarian when recaptured in 2002 (Cook et al. 2010).

Young Turtles

Can annuli reliably estimate age in juveniles and sub-adult turtles? Some juvenile desert tortoises do not add annuli each year (Wilson et al., 2003) and some may add several growth rings annually (Berry, 2002). It is not known if this is true for *Terrapene*. Some young turtles show remarkably wide, clear rings around the natal scute and others will show a faint line (false rings in the parlance of Germano and Bury, 1998). It remains unknown what triggers growth of new scute layers.

Annuli Counts

Data sheets for box turtles almost always include a field for exact annuli counts. However, as explained above and as your fieldwork will certainly show, counting an exact number of annuli is tricky and often not nearly as exact as one would wish (see Figure 26). An "exact" annuli count is really an estimate of annuli numbers and is neither an exact count of annuli (although exact counts are possible in young turtles) nor an estimate of age.

Nevertheless, some box turtle researchers still advocate for an "exact" annuli count while other box turtle researchers advocate for creating categories (a range) for the annuli counts and reporting those categories. For individual researchers who are always measuring their own turtles, an exact count is likely a good strategy. Later, the researchers can confidently group the turtles any way they choose.

For projects that include citizen-scientist data collectors, reporting the range of counts versus an exact count may increase the confidence in the data collectors in making these counts and will help minimize the outdated expectation, held by some researchers and amateurs alike, that the annuli are an accurate source of age information. For example, instead of having a space on the data sheet for a single number of annuli, some projects may find it more valuable to record ranges of annuli counts such as: "Annuli count (circle one): 1-3 4-7 8-11 12-15 16-19 20+." This method recognizes that recording a single value of 19 is likely no more accurate than recording a range of 16-19 (also see Figure 26 for illustration).

As of the publication of this book, the BTC is still using "exact" annuli counts, which some scientists consider to be "richer" data. When analyzing the data, it is always easy to group (categorize) the annuli data according to the goals of the study being conducted.

How to Do an Annuli Count

To determine an "exact" annuli count we ask our Project Leaders 1) to count the rings on one scute three times and record the average number of annuli counted, and/or 2) to count the rings on three different scutes and record an average, to reinforce confidence in the data reported. When we have multiple researchers and time, we often ask several individuals to try these two methods and share their annuli counts. This exercise leads to interesting discussions about what rings should be counted and what rings should be ignored. We defer to Germano and Bury's (1998) work while counting annuli, distinguishing between complete rings (annuli) and incomplete rings (false rings, not annuli). The important thing to remember here is that this is tricky. Don't get too concerned about getting the annuli count perfect, recognizing the inherent difficulties involved.

When asked about why we count annuli if it is not a reliable indication of age, we respond, that we don't know if we can learn anything valuable about turtles from annuli counts since we are not sure what signals promote their growth, but one day we may know more. Because our project is to last over 100 years, should it turn out that there is important information to be learned by studying them, we would like our project to be able to provide an extensive, long-term database, which includes raw annuli counts, as imperfect as they may be.

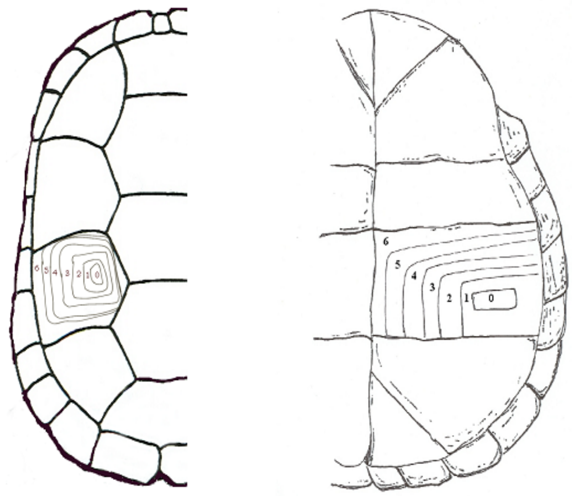


Figure 29. Within each scute the natal scute (labelled "0") can be identified as in the diagram. This image over simplifies the clarity of the rings and their distinctiveness. Although in small turtles the rings can be easy to distinguish.

Determining Life Stage, Not As Easy As It Seems!

Designating the life stage of a turtle is an inexact science at best. In box turtle research, this normally takes the form of including a field for life stage on the data sheet and asking the data collector to decide if they have a hatchling, juvenile, or an adult turtle. If one has a quarter-sized turtle with no growth rings (annuli), it is fairly safe to designate it as a hatchling. Likewise it is easy to say that a large, heavy turtle with many annuli, is an adult. But for many other turtles it is not easy to determine life stage, even for experienced researchers.

The term "adult" generally refers to a turtle that is reproductively mature. Normally this is taken to mean that their reproductive organs are capable of producing sperm or eggs and that the animal is taking opportunities to copulate when encountering a member of the opposite sex. Provided the animal has viable sperm or eggs, and that sperm transfer takes place during copulation, this would presumably result in offspring (eggs and hatchlings), allowing us to consider that animal an adult.

Sexual maturity and mating are complicated in turtles and asking data collectors to determine life stage is questionable (pers. comm. J. Lovich, M. Dorcas, J. Roe). The only way to confirm the maturity status of a box turtle is to detect the presence of eggs in females by radiograph (x-ray), to test for the presence of sperm (male), or to directly observe nesting. Even observations of mating can be unreliable indicators of reproductive status since males will mount males (we do not know if females mount other turtles). Also, juvenile turtles may show reproductive behavior (Cagle, 1955) and in one study on wood turtles (*Glyptemys insculpta*), Kaufmann (1992) observed that 85.4% of the mountings probably did not result in sperm transfer. Hence, mounting another turtle is not an absolute indicator of adult status in males.

When studying data sets of populations, researchers may use a particular carapace length (e.g., 115mm SCL min) as the *average* size of maturity to calculate how many adults are in a population. Some turtles in that population will likely mature at a smaller than average size and some will mature at a larger than average size. Determining the number of adults and juveniles is important for analyzing the structure of a population, for conducting population viability analyses, and modeling other population dynamics. The size designated as the average size at maturity is somewhat arbitrary. Age and size of mature individuals varies, particularly among populations. The criteria used when analyzing population data are not relevant when collecting data on an indivudual turtle.

In the *Box Turtle Connection*, we have found that PLs often leave the life stage field blank, presumably because they are being honest about not being able to determine the life stage. Alternately, when PLs make a declaration regarding the life stage on the data sheet, there sometimes is a reversal on the next data sheet when that turtle is recaptured, either by that same data collector or by another. Because of this we no longer ask PLs to determine life stages of box turtles and this category has been removed from our data sheet (see Appendix A).

Measuring Turtles

The following pages include diagrams and instructions for weighing and measuring box turtles. Beginner researchers are encouraged to limit the number of measurements taken on the turtles in their study. Taking too many measurements increases the chances for error, consumes more field time, and can take the fun out of the excursion. This book includes additional measurements to help standardize different measurements that are currently being used by researchers, but we advise most studies to limit data collection to the following: mass, straight carapace length (minimum or maximum, but state which one), total plastron length, shell height (depth) at hinge, and maximum width. Health and body condition should always be part of the data collection.

Mass Measurements

What we normally call “weight” is more accurately called “mass” by scientists. Mass measurements can be taken using either a spring or digital scale.

Some field researchers use spring scales (e.g. Pesola scale) to mass box turtles, but spring scales may present inconsistencies and other problems if not used carefully and correctly. Larger, heavier box turtles can fall from spring scales unless they are first placed in a cloth, paper, or plastic bag. If using a bag, the weight of the bag must then be subtracted from the total weight (bag and turtle) to get the accurate weight of just the turtle. Use a separate bag for each turtle since they become wet and turtles sometimes defecate in them. Larger turtles may also surpass the weight allowance of your spring scale, resulting in the need of an additional spring scale to compensate for the additional weight. Box turtles generally weigh between 50-650g, so when purchasing a spring scale, keep in mind what size animal you will be measuring. Having a 500g and a 1000g scale should allow you to measure any size box turtle with fair accuracy and prevent the necessity of hanging one turtle from two scales. Spring scales must be used with patience because they may bounce around if the turtle is very active or if environmental conditions cause the bag to sway.

Seek a spot out of the wind when using a hanging scale and wait out the movement so that you can obtain the most precise measurement.

Digital/electronic scale: Recently, researchers have been favoring the use of small digital scales to obtain mass measurements of turtles in the field. If you choose this route, use a digital scale with a platform to weigh box turtles. When using a platform scale, be sure to place it on a level spot when in the field (e.g. flat stump). Lightweight and compact digital scales are available and, if handled carefully, will survive being carried in a backpack. Much like with spring scales, an uncooperative turtle can be difficult to keep on the scale. By turning the turtle upside down and gently tapping it on a solid surface, it will temporarily close up in its shell, allowing you to obtain its mass. You may also use an upside-down cup, with a surface area smaller than the width of the turtle's plastron and place the turtle on top, creating a sort of podium. Be sure to stabilize the cup before placing the turtle on top and subtract the mass of the cup from total weight.

Quality Control of Box Turtle Mass Measurements *by Mike Vaughan*

The integrity of any study depends in large part on the quality of the data. The Box Turtle Connection involves over thirty projects, so we are always aware of assuring our measurement's accuracy. You can purchase calibration weights online or, if you have the means to scientifically weigh fishing weights, you can use the simple and inexpensive means of quality control for measuring mass described below.

Four-ounce lead fishing weights can be used as calibration weights (Figure 30). Their exact mass in grams is calibrated on an official laboratory scale and the number is engraved on the weight. Each Project Leader is provided a weight to keep in their measuring tool box as a standard to use to calibrate their scale. The instructions are as follows:

> *In this packet is a standard weight for you to calibrate your own scale. The accurate mass of <u>your</u> weight was scratched onto it when it was weighed on an officially calibrated laboratory balance. That mass is written on the laminated tab attached to the weight. Also on the tab is the acceptable range for scale measurements (+/- 5% of mass of the calibration weight). <u>The calibration weight is an ordinary metallic lead fishing sinker, safe to handle but please don't put it in your mouth.</u> Store it in its plastic bag, in your turtle measuring kit, and be sure to keep this sheet and the calibration tab with the weight.*
>
> INSTRUCTIONS FOR USE:
>
> STEP 1: First measurement of the standard weight
>
> - Remove the tab from the standard weight
> - Using your turtle scale, take a reading of the calibration mass (Note: the string is for attaching it to spring scales but you won't need it if you have a platform scale).
> - If the reading falls within the acceptance range for scale measurements, then your scale has passed the calibration test. <u>This means your scale is accurate enough for the BTC project.</u>
> - Repeat this **at least once a month** or, if you can, every time you measure turtles

STEP 2: If the first reading is not within acceptable range, a second measurement is needed

- If the result is not in the +/- 5% acceptance range, first look at the scale carefully to see if it is broken or if a bit of debris might be interfering with its function.
- Then, re-zero the scale and re-measure the calibration standard.
- If the result is now within the acceptance range, then you are ready to measure turtles.

STEP 3: If second measurement fails, scale must be replaced immediately

- Use scale until it can be replaced (hopefully immediately) and adjust the turtle weights by the amount your scale is off and record that adjustment value in the Comments on the data sheet.
- Replace your scale **immediately**. Be sure to check the replacement scale before using it.

Figure 30. Accurate calibration weights are provided to each Project Leader. Right: This fishing weight was accurately weighed on a triple beam balance.

Left: Our project also uses manufactured calibration weights like the one shown here, purchased online.

Length, Width, & Height Measurements

For length, width, and height measurements, some researchers use 150-mm calipers, but the jaws are not long enough for adult box turtles. We suggest using calipers with jaw lengths of *at least* 2.5 inches (or > 6 cm) to compensate for the higher dome on adult box turtles, especially females, and therefore allow for a more precise measurement. Also, we prefer dial calipers when we can find them with the longer jaws. In the case of the occasional extra-large box turtle, calipers with the jaw length of 8-12 inches (20-30 cm) may be necessary. Many box turtles show evidence of damage to marginal scutes from deformities in shell development or injury resulting from encounters with predators. This may produce a bias in your measurements, such as straight carapace length, if the deformity occurs at the measuring locations. Any deformity interfering with a measurement should be noted on the data sheet so that it can be accounted for during data analysis.

Carapace Length. The literature is full of turtle studies that reference carapace length (CL) without any specifics as to what was measured. We distinguish between minimum straight carapace length (SCL min) and maximum straight carapace length (SCL max) and suggest that this become standard when establishing written protocols and standard when reporting methodology in the literature.

Minimum Straight Carapace Length (SCL min). This is sometimes called the notch-to-notch measurement. This measurement is obtained by placing calipers on the cervical scute on the anterior end and in the posterior notch of the carapace just above the tail. Some researchers will refer to this measurement as straight carapace length (SCL), carapace length (CL), or midline carapace length. SCL min can be taken with the calipers below the turtle (ventral aspect) or with the calipers above the turtle (dorsal aspect).

We prefer to measure SCL min from the venter, although measuring from the dorsal side is also acceptable if the jaws of the caliper are long enough (2” jaw length or greater). To measure from the venter, hold the calipers underneath the turtle with the jaws pointing upwards. To correctly place the caliper in the anterior notch created by the cervical scute, the turtle must be fully enclosed within the shell. Calipers should be positioned so that the one jaw is placed within the notch on the anterior part of the carapace (closest to the head) while the other rests within the notch on the posterior end of the carapace (closest to the tail) created by the marginal scutes. Once the calipers are resting in this position, adjust the turtle so that the portion of the jaws sticking out above the carapace are even (Figure 31). This helps ensure that the calipers are measuring on the straightest line possible.

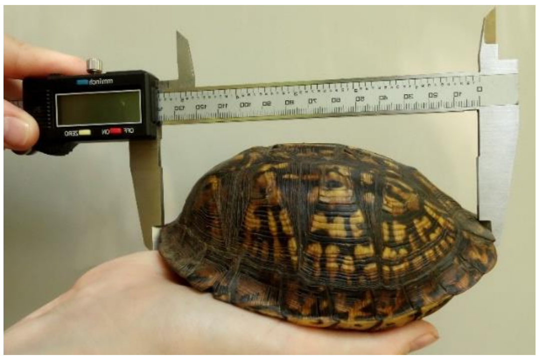


Figure 31. Both images above show “SCL min” measuring technique. It can be taken accurately with the shaft of the calipers either on the dorsal side of the turtle (left) or on the ventral side (right). Notice that in both cases, the turtle is touching the right and left jaws at about the same place. The shaft of the calipers is not held against the shell of the turtle in either case. The longer jaw lengths allow for this measurement to be taken without the carapace impeding the positioning of the calipers.

Measuring from the dorsal side mimics the same technique as measuring SCL from venter, but will be measured by holding the calipers above the turtle with the jaws facing down. To obtain the most accurate measurement, we strongly suggest using long-jawed calipers when measuring from the dorsal due to the natural curvature of box turtle shells. Short-jawed calipers may not be able to sufficiently reach the edge of the carapace if the shell is too highly domed. As when measuring from the venter, each jaw should be securely placed in the anterior most notch, resting behind the head, and the posterior notch, located above the tail area. The turtle should then be adjusted so that the excess jaw length on both ends is equal (Figure 31). Be extra cautious when taking this measurement if the turtle refuses to stay in its shell. The anterior placement of the calipers will place the jaw of the caliper very close to the neck and head of the turtle. SCL min is the only carapace length measurement that we take in our project.

Maximum Straight Carapace Length (SCL max). Obtain this measurement by placing caliper jaws on the carapace so that the scale on the calipers is visible and parallel to the ground (Figure 32). Carapace length (CL) is a common term for this measurement, but we suggest that "SCL max" would be more descriptive and would comply with standard terminology used in other fields of turtle research (Wyneken, 2001). Many researchers do not specify which type of carapace length they take, but it would be helpful if they did. SLC max is not a measurement taken in our project.

Figure 32. Maximum straight carapace length (SCL max) is the longest possible measurement of the carapace and is best taken holding the calipers as you see them here. Long jawed calipers are a necessity.

Curved Carapace Length (CCL). Curved Carapace Length minimum (CCL min) and Curved Carapace Length maximum (CCL max) use the same landmarks as SCL min and SCL max but are taken over the curve of the *carapace* with a flexible tape measure. Sea turtle projects often use this measurement, but CCL measurements are not often taken in box turtle studies and is not taken in our project.

Plastron Length (PL). This measurement refers to obtaining the complete length of the plastron. Due to the characteristic hinge on box turtles, when they close up the edges of the plastron rest tightly against the interior edge of the carapace, making it impossible to place the caliper jaws directly on the edge of the plastron. Therefore, this measurement will be broken down into two parts: anterior to hinge and hinge to posterior (Figure 33). These measurements can then be added to get total plastron length.

PL Anterior to hinge. With this measurement, you will be obtaining the length of the top, anterior-most, portion of the plastron. Calipers should be positioned so that they extend from the top edge (closest to the head) of the plastron down to the center point of the hinge (Figure 33). The line created by your calipers should be perpendicular to the hinge.

PL Hinge to posterior. To obtain this measurement, you will be measuring the length of the bottom, posterior, portion of the plastron. Position your calipers so that the jaws extend from the hinge of the turtle, down to the bottom edge of the plastron. Be sure that you are not extending down to the bottom edge of the carapace (Figure 33). Make sure that you are beginning in the center of the hinge and ending at the center-most portion of the posterior end of the plastron.

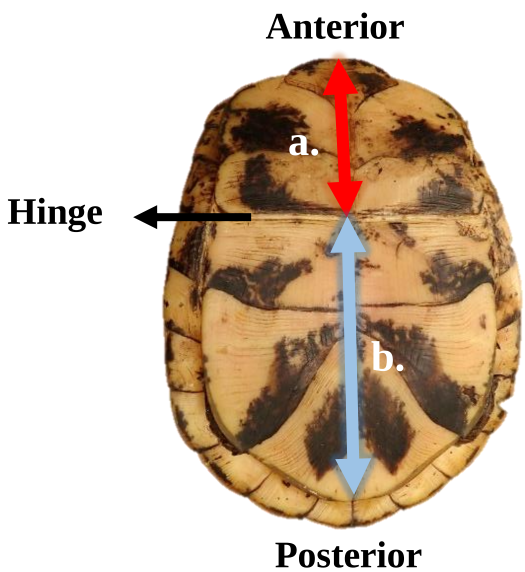


Figure 33. The plastron is separated by the hinge which allows the anterior portion to close. Plastron shell length measurements are taken in two separate measurements that are then added together.

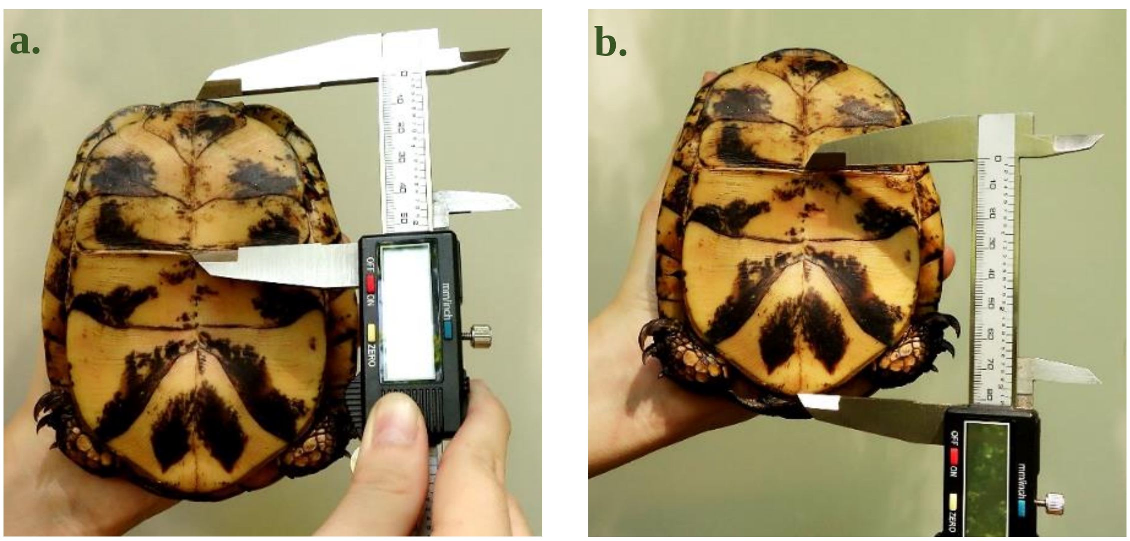


Figure 34. These two measurements are involved in obtaining the plastron length: a. anterior to hinge and b. posterior to hinge.

Shell Width & Height. Height and width measurements are used to gather information on 3-D aspects of the shell. Much like our own heights and widths (waistline measures), the shell height and width of a turtle can give insight into the health and development of that turtle.

Shell Width = Maximum Carapace Width (CW max). This measurement may take a little practice before you feel comfortable with obtaining an accurate shell width. Looking at the turtle, from above or below, decide where the widest part of the turtle resides (Figure 35). This can be done by placing your caliper jaws on either side of what you believe to be the widest part of the shell followed by moving them along the sides of the shell, front and back, until you have reached a point of maximum width. Due to the shape of the box turtle shell, the widest point will be near the rear of the turtle where the marginal scutes flare out. Once the widest point has been determined, the calipers should be kept parallel to this point so that the calipers extend from one side of the turtle to the other. Because of the dome of the shell, it may be easier to take this measurement from the ventral side of the turtle, meaning that the calipers should be under the turtle with the jaws facing upward (Fig. 35)

Figure 35. A demonstration of the maximum carapace width (CW max)

Shell height (SH at hinge). The hinge is a characteristic feature in box turtles, allowing them to fully enclose themselves in their shell. It is located on the plastron and usually correlates with the tallest point on the shell, except in the Three-toed Box Turtle. For consistency, we take the shell height measurement at the hinge. This measurement requires that you essentially sandwich the turtle between the jaws of the caliper with the bottom jaw aligned on top of the hinge and the top jaw adjusted so that the calipers and turtle are perpendicular (Figure 36). For further consistency, we ask our PLs to take the measurement from the right side of the turtle (with the turtle facing away from you).

Figure 36. Caliper placement to measure shell height at hinge.

Photo Documentation

The value of good photo documentation cannot be overestimated and should be considered as important as any other type of data collection in your research. This section describes how to take good images and suggests a system for filing them on your computer. Software is now being developed that will recognize individual turtles from photos, increasing the future value of the images you take now.

What You Need

1. Camera or smartphone with the ability to take close-up images, with settings for deep depth-of-field. This normally means the ability to adjust the f-stop; smartphones often have this setting.

2. A background surface with a neutral color. We use an inexpensive 12" x 9" (30 x 23 cm) cutting mat, as shown in Figure 37, with something of solid, neutral color behind it.

3. If you do not have a background surface with a metric ruler, include a metric ruler and place it next to turtle (Figure 38).

4. A small piece of cardboard with turtle code, date, and site information written on it, like the ones in Figures 37 and 38.

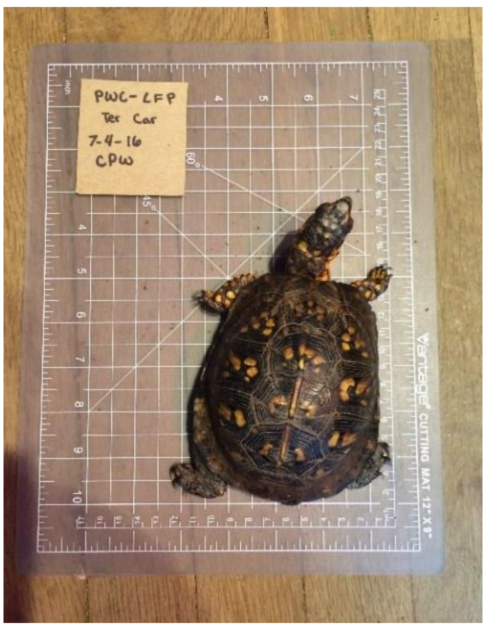


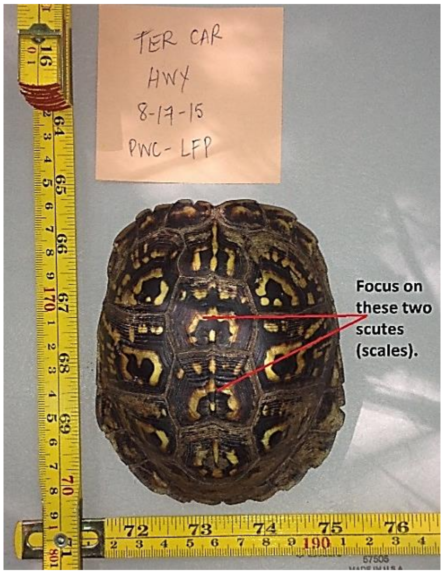
Figure 37. A clear cutting mat like the one shown here is a convenient way to include scale. Scales in the images are not meant to replace measurements taken with calipers.

Taking the Image. Test the settings on your camera by taking several images of turtles using the directions below and adjust as needed. The most common faults are lighting errors and blurring due to shallow depth-of-field.

- Make sure the data sheet is filled out completely and the turtle is marked before taking photos.

- Don’t shoot in direct sunlight. Images become harsh and glare may distort details or coloring.

- Take photo from directly above so that the ruler and the turtle information are clearly visible. If the photo is taken outside, make sure that there is uniform light so all parts of turtle are visible. Shield the photography surface from direct sunlight so the turtle is in full shade and use the camera’s flash.



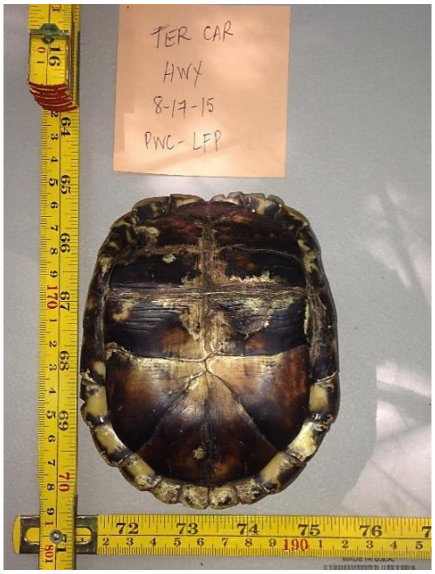


Figure 38. The neutral background color in this image allows the markings of the turtle’s carapace (left) and plastron (right) to show up nicely. White backgrounds alter the camera’s exposure index and cause the shell to be under illuminated. The ruler in this image is added for scale, not as a means of measuring the turtle.

- If you have a fill-in flash option, use it to assure full and even lighting. Take photos with and without flash. You can determine which photos are the best quality after uploading the photos to the computer.

- Many smart phones and smart cameras adjust automatically, but you will need to test them to be sure you are getting the entire shell in focus.

- Size images at medium unless you have large amounts of storage space. If you don’t know how to size your images when organizing them, there are instructions below.

- Minimally one photo should be taken each for the carapace and plastron. Additional photo(s), e.g., of rare behaviors, anomalies and/or injuries, or side (lateral) view, can provide valuable information. We suggest a minimum of three carapace photographs, which may aid in the use of individual turtle recognition software now in development.

Figure 39. This defensive posture in box turtles is rarely observed. When possible, photograph any special behaviors, if you are lucky enough to observe them when you have a camera.

Organizing Photos on the Computer *by Gabrielle Graeter*

Below is a suggested filing system for box turtle photos on your computer. Each turtle should have a separate folder as shown below.

- Folder: Box Turtle Images
    - Folder: Turtle ABC
        - Folder: ABC_1May2013
            - Carapace photo
            - Plastron photo
            - Additional Photo(s)/Injury Photo(s)
        - Folder: ABC_1June2014
        - Folder: ABC_1June2015
    - Folder: Turtle BCD
    - Folder: Turtle KLO

Resizing Photos. If digital storage space is not limited, we recommend keeping both the full-size and medium-sized photos for personal records. The medium-sized photo will allow for easier uploading, but the full-size photo may serve as a better reference photo because it is more detailed and clear. One very easy way to resize images is using the Paint program that is on most computers.

For Windows, if you don't have the Paint program, you can download the image resizer from the internet. Once Image Resizer is downloaded, you can resize images to "Medium" size.

For MAC computers, iPhoto will allow you to resize, but make sure to duplicate the photos, as the program will not automatically save the original; alternatively, you can resize in Preview.

7. Box Turtles in Your Community

Field Etiquette and Landowner Relations

Public land is generally owned by a county, city, state, or federal agency and access is regulated by that agency. Citizens or corporations have ownership of private land and access is generally restricted. Before you begin to conduct fieldwork with wildlife on public or private property, you must obtain permission from the owners. In most cases, you will need a wildlife permit from the state to do your study, so contact your wildlife agency before you begin.

Developing a good relationship with the landowner, public or private, is essential for the success of the study. Neighboring landowners will discuss your study with one another and attitudes tend to be contagious. If some key landowners support your study, others may follow. The following guidelines may prove useful with any type of field research on private property. *Do not underestimate the importance of good landowner relations*.

Good field etiquette means treating landowners, land, and property with respect. Minimize any human impact on the environment. Recall the saying that goes: "Take only pictures; leave only footprints." Remove plastic flagging marking significant locations once your data have been recorded. Once you have checked for critters under coverboards or logs put them back in place carefully, without harming any animals or habitat. Remind the participants that all organisms deserve respect, including insects, plants, and snakes.

Figure 40. Involving children is a good way to interest parents and grandparents in wildlife conservation.

Be respectful of the landowner's privacy. Remember that you are a visitor and dependent on them for permission to use that property for research. Share some time with the landowner over a glass of tea or snack if asked. Many landowners enjoy the social aspects of your visits, so do not cut this short. If possible, get written permission to study turtles, though some landowners are fearful of any document that looks like a contract. Not all family members may be knowledgeable about an agreement you have with one family member, so try to determine who is considered the head of household.

Discuss the issue of liability. It may be prudent to use liability release forms. Discuss whether the landowners want to be called before each visit, or if you may come and go as you please. Be sure to park in the spot designated by the landowner. Make sure you have notes for each site that includes phone numbers and names of family members and pets. Do not assume that junior curators, students, or volunteers are knowledgeable about the importance of this aspect of the study. Make it a priority during training.

Involve Landowners

Landowner sightings and observations can be valuable. Provide interested landowners with data sheets to record their observations. Allow them to submit them in any format, such as email, hard copy, or phone.

Share the results of your study with interested landowners and be sure to acknowledge their assistance in your reports or presentations, especially when talking to the media.

Consider the following as priorities:

- Allocating time for “chewing the fat” with landowners. Give them pictures of the students or their children or grandchildren working with the turtles (Figure 40). Many people love the idea of making contributions to education, even if they are not interested in wildlife conservation. Involve children whenever possible.
- Explaining the value of the research.
- Knowing the boundaries of the property. Remember to close every gate you open as soon as you pass through.
- Writing letters of thanks and sending greeting cards. Art or computer classes can help create an official *Certificate of Thanks*.

Avoid the following:

- Climbing over barbed wire fences or gates, as this can necessitate repairs and you might get hurt. Use gates or crawl under, not over, fences.
- Wearing T-shirts with political messages.

Surprise Encounters with Box Turtles: How to Guide the Public Response

We all know that wonderful time of year…SPRINGTIME! As the weather warms, box turtles begin popping their heads out from under the leaves, eager for sunlight and food. Driven by hunger, thirst, and the desire to bask, they begin to venture out. As they move across the landscape, they cross paths with well-meaning people, on trails, roadways, or even in backyards. Because of your interest in turtles, you may be in the position to educate people on the dos and don'ts of such encounters.

Figure 41. Turtles will take advantage of puddles to rehydrate on hot days.

Box turtle encounters can be a wonderful experience, as most people find them charismatic and engaging. Many people enjoy watching box turtles cautiously navigate the world. Unfortunately, there is a tendency for people to move turtles to new places or to take them home. Displacing a box turtle, even just a few miles down the road, can cause the turtle to become confused and stressed. Many people who escort box turtles across roads already know that they must move turtles to the side of the road in the direction they were heading. There are other, well-intentioned individuals who move turtles to distant areas they consider to be safer or more suitable, such as removing a turtle from the side of the highway to a neighborhood park. Turtles cross roads for many reasons. The road may transect their home range, or they may be moving to or from a specific place where they lay eggs or over-winter. Box turtles often maintain small home ranges, only a few acres, and if placed outside of that home range, may wander in search of familiar surroundings. Within their home ranges they know of good feeding spots, sources of water, and safe shelters. By moving them outside their home, you may directly or indirectly cause the death of that individual or drastically reduce its lifespan.

So, what is a responsible action when encountering a turtle in the road? Simply place turtles on the side of the road in the direction in which they were heading. Box turtles can and do survive in some urban environments, even those surrounding roadways, so do not take turtles to a park as most parks prohibit the unauthorized release of wild or domestic animals.

Box turtles have a certain gentleness about them that wins you over in a matter of seconds. It can be hard to resist the urge to bring them into your home or to allow your children to do so, but removing them from the population can do harm to both that individual and the wild box turtle population. By removing an individual from a population, you decrease current population numbers as well as future ones by inhibiting the removed individual's reproductive contribution to future generations. In addition, when held in captivity, a box turtle has an increased chance of displaying a variety of maladies or diseases. If this turtle is later released, it can introduce those illnesses into the wild population, creating a threat for the entire box turtle community.

Box turtles need to stay wild. Give them a helping hand across the road or off a bike trail but let them stay home. Since box turtles are such homebodies, you can always be reassured that your creature-friend is not too far away, tromping through the leaves, fields, and gardens in search of a tasty blackberry and a mate!

Box Turtles Are in Trouble

Eastern Box Turtles (*Terrapene carolina carolina)* are North Carolina's state reptile. Their numbers are dwindling, in part because people move them to a new place or take them home as pets. It may be just one here or there, but the result is thousands of box turtles disappearing from their forest and field homes, forever.

They Need to Stay Wild

As far as nature is concerned, a turtle taken from the wild is "dead." It can no longer help maintain the population. "Saving" or "helping" a turtle by bringing it home or moving it to a new location in fact hurts fragile turtle populations. Moved from its home in the wild, a box turtle may sicken and die and pose a health threat to recipient populations. Turtles released into unfamiliar surroundings (relocated) are often killed by predators or crushed by cars as they attempt to return to their original wild homes.

THE HERP PROJECT
theherpproject.uncg.edu

THE BOX TURTLE CONNECTION
boxturtle.uncg.edu

NSF Grant #DRL-1114558 Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of NSF

Turtles on the Road

If you see a turtle crossing the road, move it to the side that it is headed towards. Resist the urge to drive it to a "safer" place. Remember - that turtle may have been living there for decades, already knows where to find food and mates, and has a special place to hibernate or lay eggs. Watch out for vehicles when helping turtles. Don't take risks with your own life!

Help Wild Box Turtles

Adults and children can help wild box turtles. Report your turtle observations and other reptiles and amphibians to HerpMapper:

www.HerpMapper.org

Above: Female Eastern Box Turtle by *J.C. Beane*
Cover Photo: Male Eastern Box Turtle by *J.D. Willson*

Figure 42. Example of a box turtle information card that can be distributed widely. Top image: front of card; bottom image: back of card. A free, downloadable pdf of this card is available at http://boxturtle.uncg.edu.

Researcher Spotlight

Dr. Aceng Ruyani

A good example of *The Box Turtle Connection*'s contribution to research, conservation, and education about turtles outside North America is Dr. Aceng Ruyani's work. Dr. Ruyani, a science educator at the University of Bengkulu (UNIB) in Bengkulu, Indonesia, teaches K-12 teachers and students about turtle biology and conservation and founded the program "UNIB Campus, A Safe Home for Turtles," which protects endangered Sumatran turtles in on-campus ponds and outdoor housing areas. His research study, *Developing Science and Learning Research Capacity of Bengkulu University in Ex Situ Conservation of Sumatran Freshwater and Terrestrial Turtles*, is funded by the United States Agency for International Development, with the HERP Project as his U.S. partner.

Dr. Ruyani came to the U.S. in 2013 to work with the authors on their projects in herpetology education and to share his ideas for similar work at UNIB. He now utilizes *The Box Turtle Connection*'s scientific protocols, methods, and techniques in his work on the UNIB campus and in the natural areas surrounding Bengkulu. The turtles housed on the UNIB campus include *Cyclemys oldhamii*, *Cuora amboinensis*, and *Siebenrockiella crassicollis. Cuora amboinensis*, the Southeast Asian Box Turtle, is a semi-aquatic box turtle that inhabits various natural and human-constructed wetlands with soft bottoms and slow to no current. Though semi-aquatic box turtles are in a different family than U.S. terrestrial box turtles, our recommendations remain applicable and Dr. Ruyani's work has much to teach us in return. Southeast Asian box turtles are considered vulnerable and the population is decreasing primarily due to unregulated illegal trade. Indonesia is the main supplier of *Cuora amboinensis* for the international meat, traditional Chinese medicine, and pet markets. While Indonesia has a substantive legislative framework in place to govern the management of wildlife harvest and trade, these regulations are inadequately enforced (Schoppe, 2008). Dr. Ruyani's long-term focus is on conservation of the turtles' natural habitats. He and his students have contributed to the scientific research literature as well as science education literature.

photos by Deni Parlindungan

8. Eastern Box Turtle Habitat Management and Creation

Managing and creating habitat for box turtles can mean a few changes in gardening and mowing practices but it can also inspire landscape-level changes. For example, Mike and Tucky Vaughan, inspired by box turtles, books, and art, converted 15 acres of their farm into a fire-dependent piedmont prairie community that supports native vegetation and box turtles. In this chapter, we offer suggestions for anyone interested in restoring native habitats in backyards, farms, hunting preserves, summer camps, and industry-owned properties for wildlife conservation, since box turtle habitat management also benefits other wildlife.

In some instances, such as when altering very large tracks of land or disturbing soil near streams and creeks, you will need special permits to change the landscape. Contact your state Natural Heritage Program or your state's Department of Natural Resources or Department of the Environment for information to determine what, if any, permits are required.

A Backyard for Box Turtles

A backyard can be both a playground for us and a sanctuary for wildlife. Our backyards are thresholds between the nature we have claimed and the nature that remains unclaimed by humans. This threshold can become a strict barrier, keeping human life in and wildlife out, but it can also be a blending of home and nature, fostering coexistence. By welcoming wildlife, nature is brought a little closer to home.

Figure 43. Box turtles benefit from having a place to enjoy an occasional good soaking.

Many box turtle habitats are currently threatened by habitat fragmentation and deforestation, so why not share your backyard by providing for some turtle needs? Box turtles are charismatic creatures that not only add to the aesthetics of any habitat, but can also be beneficial to the health of your small backyard ecosystem.

The National Gardening Association reports that 31% of U.S. residents (36 million households) have and maintain gardens. To many gardeners, wildlife is often the enemy. Snails nibble on the greenery and squirrels dig up vegetables, but box turtles, as omnivores, mainly consume wild fruits, insects, slugs, and snails. Because of this, they not only act as pest managers, but can also act as gardeners themselves, distributing the seeds they consume. Kenneth Dodd, author of *North American Box Turtles: A Natural History* (2001) and avid conservationist, has found that turtles act as seed dispersal agents for many plant species. The passage of seeds through the box turtle digestive system increases seed germination rate. Eastern Box Turtles have also been found to play an important role in fungal spore (mushroom) dispersal (Jones et al., 2007). Beyond providing extermination of several pests and lending a helping hand (or stomach) in the garden, box turtles are also beautiful creatures that are a joy to watch.

Just A Little Encouragement

Box turtles can be easily encouraged into a space with the invitation of food and shelter. Blackberries, mulberries, blueberries, figs, and strawberries are among a box turtle’s favorite fruits. The presence of these fruits is sure to attract some hungry visitors. Consider adding a few extra tomato plants just for the turtles——they love them! Turtles will sometimes congregate where ripe paw-paws drop.

Leave natural litter under trees, create brush piles that may be used for shelter (see next section), and provide open areas for basking. Box turtles will return to feeding areas, so even though your yard may not meet all their habitat needs, they may return several times over the growing season or even daily.

Creating a Safe Haven

Box turtles can be colorful, but still hard to spot, so be sure to check your yard for box turtles before mowing or burning leaf piles. A good alternative to burning leaf or stick piles is to use them to create a brush pile that can serve as shelter for box turtles and other wildlife (see next section, “Build It and They Will Come: Miracle Brush Piles”).

Most houses are located on or near a street, so remain attentive for box turtles that may be crossing the road. If you should come across a box turtle on the road, safely move it to the side of the road in the direction it was headed; if you don’t, the turtle may attempt to cross the street again. In the late summer or early spring, you may witness a box turtle digging a hole with its hind legs. This is most likely a female turtle preparing her nest. If you have a female box turtle nest in your yard, do not disturb the nest. The formation and placement of the nest was constructed and chosen by the mother for a reason. If the nest is constructed in an area that is clearly unsuitable, such as in your gravel driveway, you may try and relocate the eggs if you do so within their first 24-48 hours. If so, try to find a spot that will mimic the thermal and moisture properties of the original nest (see “Creating Nesting Habitat on Managed Properties” later in this chapter).

Most importantly, do not remove any box turtles from the wild. By providing a suitable habitat for them in your backyard, you are already inviting them into your home and therefore there is no need to remove them from that habitat. Also, do not release any pet turtles, or box turtles from a different location, into your backyard, even if you have an appropriate habitat for them. Box turtles form home ranges and a turtle taken outside of its home range may become lost and confused. Released turtles may also spread sickness or disease among the healthy population in the surrounding area.

Figure 44. Box turtles emanate a gentle demeanor.

Box turtles are magnificent and gentle creatures (Figure 44). Their presence is one to share with family and friends. Protection of these animals can and should extend beyond your own property lines. Some neighborhoods have listserves where residents share community news. Why not use these for sharing box turtle news and stories? This will bring your neighborhood community together for a common cause. By protecting wild areas and habitats in your neighborhood and community you can further help to conserve this beautiful species.

Yard Mowing

Turtle mortality due to mowing is not uncommon in suburban backyards. A Rockingham County, NC landowner reported that she and her husband had inadvertently killed six box turtles while mowing their yard in one weekend. However, suburban lawns can be mowed with both turtles and healthy lawns in mind and that means mowing the lawn high. Setting the blades high means the grass has more blade surface, therefore photosynthesizing more, which creates healthy root systems. Furthermore, higher grass means more shade on the soil and less moisture loss and greater drought resistance.

Recruit family members to help scout the lawn for wayward turtles *before* trimming gets underway. When possible, mow in the heat of the day when box turtles are less likely to be out in the lawn.

Build It and They Will Come: Miracle Brush Piles *with Mike Vaughan*

stop mowing today
create a brush pile chalet
safe haven! hurray!
forget what the neighbors say
Ann Somers

It is almost too good to be true. It is amazing how easy it is to make even a small piece of property wildlife friendly. Here is a start: give up mowing at least half of what you are mowing now and build some brush piles. In a year or less, you will notice more birds, reptiles and amphibians. Just set it up and nature will provide the necessities.

All living organisms require food and water, but animals also need adequate shelter for protection against predators and weather extremes. Box turtles of all ages need cover. Dogs and coyotes chew on box turtles and may crush juveniles in their jaws. Some raccoons learn to pull adult box turtles' limbs out of the shell to eat them. Turtles with partial limbs have more difficulty mating, digging forms, and, for females, digging and covering nest chambers. Shelter can be especially valuable for box turtles that spend significant amounts of time in open fields. Even a turtle that ordinarily spends most of its time in the field-forest edges will likely utilize available shelter in grassy fields and forests. Our observations indicate that some box turtles spend a great deal of time in tall grassy meadows where well developed shelters may not exist, so these are great places for brush piles either in mid-field or along the edge.

A brush pile can be haphazardly created or deliberately built. Some deliberate methods may be more creative architecturally, but following the few simple steps below will ensure a safe and stable shelter for wildlife. A brush pile requires a chainsaw, some pieces of tree trunk, and some woody brush. A good size for this type of pile is five square feet, though smaller ones can be useful too.

Build A Magnificent Five Foot Square Brush Pile

A. Cut several logs five feet long, about six inches in diameter, to provide the foundation layer. Freshly cut logs will make a longer lasting pile, but wood that has been dead for some years can still be used.
B. Space logs on the ground parallel to each other, separated by six to seven inches, to allow space for turtles to crawl between them (Figure 45[1]).
C. Place a layer of smaller logs, three to five inches in diameter and five feet long, across the first layer. These logs should touch each other, providing a roof for the spaces you've created with the first layer (Figure 45[2])

Lay a third layer across the second one. This time the logs can be smaller, consisting of whatever is available. These will add weight and stabilize the lower two layers (Figure 45[3]).

Figure 45. Steps to create a wildlife brush pile. Images by Mike Vaughan.

D. Finally, the pile needs to be made wildlife friendly and attractive. This can be done by loosely heaping on top any pieces of brush, weeds, and debris available (Figure 45[4]). Birds, particularly wrens and sparrows, welcome such shelters.

Methodically building a shelter is not necessary; haphazardly throwing fallen or trimmed branches into a pile can effectively create a wildlife shelter, either in fields or forests (Figure 46). It is fun to build onto the original structure as the seasons pass, creating different wildlife rooms. It is anyone's guess what the wildlife dynamics are in such piles, but creating additional rooms theoretically allows prey refuge from outside predators as well as other inhabitants. For example, black racer snakes (*Coluber constrictor*) are regular inhabitants of our piles, but also other inhabitants are regularly found there, such as frogs and other snakes which may be prey for racers. These piles may last for many years. We know that box turtles use them because we frequently locate them in and around brush piles. No moving parts and no up-keep! Hard to beat.

Figure 46. This brush pile was made by loosely piling the prunings from nearby blueberry bushes. It serves as excellent habitat for reptiles and amphibians, insects, birds, and mammals. The sheet of tin was added to enhance thermal options for wildlife.

Don't Forget Coverboards

Many animals utilize shelters such as on-the-ground coverboards made from untreated plywood and tin. If you situate these around the brush pile, you are in for some fantastic wildlife viewing when you gently lift them. Another good coverboard strategy is to lay scrap boards such as 1x6s (or any other dimension) close together around a brush pile or along a field-forest edge where they get some sun and some shade. This will provide shelter for all sorts of wildlife including insects, amphibians, reptiles, and small mammals. These are great fun because you can check them whenever you wish and often get fun surprises (Figure 47). Use a rake or gloves when gently lifting one side of the board since a surprised animal underneath may be frightened into biting defensively.

Figure 47. Cohabitants under a tin coverboard.

Burning Brush Piles or Not

There are lots of different opinions about burning or not burning brush piles. Sooner or later, your brush pile will have trees or aggressive non-native vines growing in the sheltered spaces. To deal with the undesirable vegetation, the pile may be moved, burned, or spot-sprayed with organic herbicides. Spot-spraying means applying the herbicide to the offending plant, which may do less harm than burning. Consult with experts if you are unsure how to safely burn a brush pile or do not know proper application methods for applying chemical herbicides. If done incorrectly or without the necessary safety precautions, any method of controlling unwanted vegetation can be dangerous to both yourself and the surrounding wildlife.

Burning a brush pile should be done carefully since there is no time of year when the pile will not be occupied by some form of wildlife. Below are some suggestions and options.

- Think twice before burning in mid-winter. Animals such as reptiles and amphibians will overwinter in the piles. If they are near the surface, they will not be able to escape due to the temperature and may be burned alive.
- Consider partially burning the pile to allow inhabitants the opportunity to move to other parts or rooms within the shelter. Early fall might be considered a good time for this since animals sheltered in the pile will be able to move to safety or find other shelter for the winter months.
- Move the brush and other materials and use them to create a new pile nearby so you can mow down the invasive plants.

Mowing Guidelines for Conservation of Box Turtles and Other Wildlife

Modified with permission, from Erb (2009) *Mowing Advisory Guidelines in Rare Turtle Habitat: Pastures, Successional Fields, and Hayfields*

Grasslands, meadows, prairies, pastures and hayfields are important habitats for Eastern Box Turtles. Many turtles prefer these areas for feeding during the late spring, summer, and early fall months. For nesting in summer, turtles require sparsely vegetated areas with some bare soil. To maintain these nesting habitats, periodic mowing, light grazing, or prescribed burning is recommended to keep trees and other types of woody vegetation from taking over. However, mowing during the spring and summer months can cause significant turtle mortality. In fact, researchers in rural areas are finding that the rate of mortality due to mowing and agricultural machinery is much higher than the rate of mortality due to roads.

Most people do not realize that wildlife can be saved if mowing is done thoughtfully. Most farmers have had the experience of mowing over wildlife unintentionally and are saddened by the experience. We receive reports of mowing-related fawn and rabbit deaths and destroyed turkey nests. The results of poorly timed mowing often go undetected until the next day when vultures are seen working the fields, picking up the pieces.

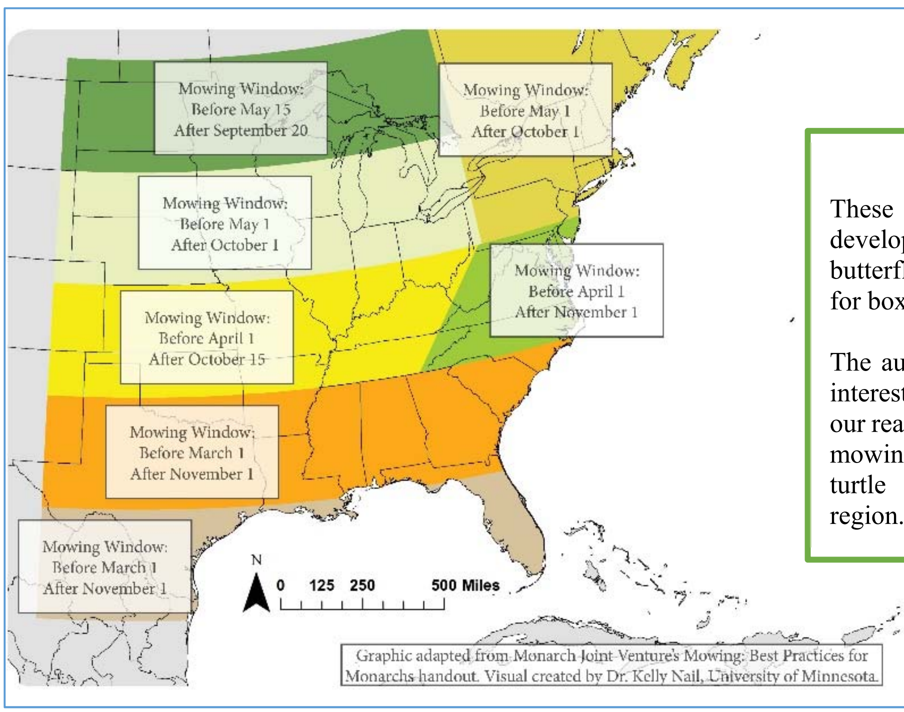


Figure 48.

These mowing windows, developed for monarch butterflies, might also work for box turtles.

The authors of this book are interested in feedback from our readers on how well these mowing dates work for box turtle conservation in your region.

The following guidelines are intended to avoid or minimize the detrimental effects of mowing on box turtle populations. These measures will likely benefit native plant communities and other desirable wildlife species, such as butterflies and songbirds. It is always best to avoid mowing when turtles are using the fields (in the southeast, this is normally May through October). However, if you must mow when turtles are in the field then follow the suggestions below, which should minimize the detrimental impacts of mowing during times turtles utilize fields and meadows.

1) Time of day—Mow in the heat of the day when turtles are less likely to be in open fields.

2) Mowing Rotation—Mowing to maintain field habitat for conservation reasons should only require mowing once every 2-3 years. If mowing is combined with other maintenance methods such as chemical control of invading woody plants, mowing during the turtle active season may not be necessary.

3) Percent Mowed—For sites with more than 10 acres of grassland/fields, do not mow more than 25%-50% of the acreage in any given year. For example, when possible, mowing that occurs during the active season should be limited to approximately 25% and areas mowed during the inactive season should be limited to approximately 50%.

4) Mower Blades and Blade Height—Tractor-mounted bush hogs are generally used to mow fields. The cutting height of the blades should allow 7-12 inches of stubble to remain in the field. This will reduce wildlife mortality, reduce blade wear, and will leave important cover for animals. The lower portions of the plant stems have relatively low nutritional value. Also, mowing higher reduces blade wear and makes good economic sense, increases soil moisture retention which can increase yield of the second harvest, and reduces soil erosion (Saumure, 2006). Mowing should be done slowly, ensuring that the tractor-mower is not bouncing and the blade height remains somewhat constant.

5) Pattern of Mowing—Start mowing from the center of the field and use a back-and-forth approach, or mow in a large circular pattern, so that fleeing animals can escape. In addition, leave an unmowed 30 ft. strip around the perimeter of the field and mow this area last if it must be mowed. Turtles are found in these areas and this provides time for them to react to the mowing activity and move out of the area (Figure 49). There are exceptions to this general rule:

   - When a stream is near the field, start mowing at the side furthest away from the stream and work your way towards the stream.
   - When the field is bordered by woodland, start mowing from one side of the woods and mow towards the other side of the woods.
   - When the field is bordered by a road, start mowing next to the road and work your way across the field.

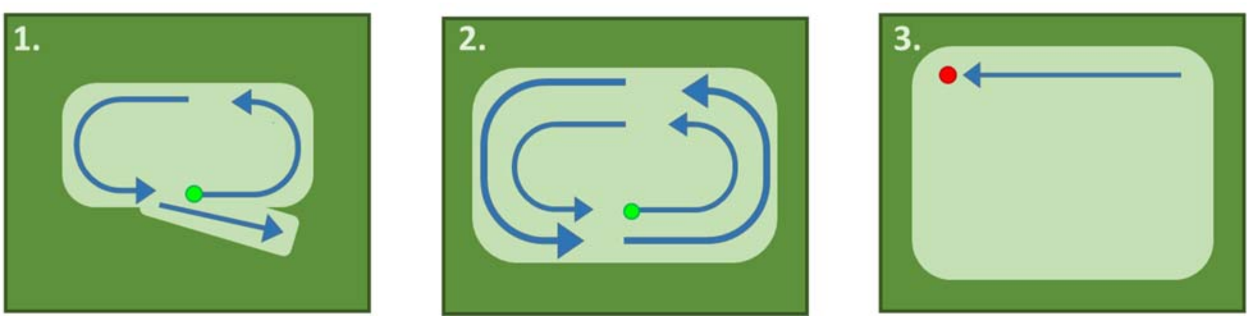


Figure 49. 1) Mow in a circular pattern, beginning near the center of the field (indicated by the light green dot). If the field is boarded by a road, start close to the road, since turtles are more likely to be near the edges bordered by habitat. 2) Continue the circular pattern, moving outwards towards the perimeter of your field. 3) Stop within 30' of the edge of the field to provide a safe zone for animals. If the edge must be mowed, mow it last or mow it during wintertime.

6) Mower Speed—Mowing in low gear or at slow speeds sometimes allows turtles time to react to the vibrations and move out of the field.

7) Unmowed Edges and Patches—If mowing is required to harvest hay or for other reasons, leave the edge of the field unmowed until late fall. Eastern Box Turtles will use the field edges adjacent to forest and nearby streams, as well as unmowed patches in the meadows. Gravid female box turtles commonly use the patches as cool daytime retreats between their nocturnal excursions to select a nest site. Such nighttime excursions to find "the perfect spot" can continue for days. Edges and patches are important habitat for other species also such as bobwhite quail, bluebirds, and turkey (Figure 50).

Figure 50. Leaving tree patches in mowed meadows increases habitat diversity.

Good guidelines for habitat management depends on good research. Although there are many outstanding research needs, below are a few recommendations:

- Behavior data
    a. the behavioral responses of turtles in reaction to mowers
    b. use of secondary successional habitats by type (native vs. non-native vegetation, etc.)
    c. use of agricultural fields (monoculture vs. polyculture, etc.)
- Blade height tests fields are being mowed during regular maintenance at various sites
- The optimum mowing rotation for turtle habitat management

Unwanted Vegetation Control

Most gardeners and farmers desire some means of vegetation control. Most conservation management sites need some type of vegetation control also. Mowing and burning are important methods and can be used in conjunction with other means, such as boiling water or organic or non-organic herbicides.
Avoid plowing if possible. Little is harder on the land than plowing, and poor plowing practices have long been understood to be wasteful (Madison, 1819). Mowing and burning may be good choices but, in some cases, are too harsh for the task. In such cases, spot herbicide applications may be the best alternative to control woody plants and avoid impacts to turtles and native vegetation.

There are many types of herbicides available, including organic herbicides, and the best policy is to consult your local NRCS (Natural Resources Conservation Service) technician for advice when choosing one. Spot-spraying using a back-pack sprayer, rather than area-wide spraying, is strongly recommended. Roundup and other herbicides using glyphosate affect virtually all plants and should only be used for careful spot-spraying. Consider alternatives before choosing a glyphosate-containing herbicide. Other herbicides, such as those containing trichlopyr, are selective regarding the plant species affected. Regardless of herbicide used, the spot-spraying method of application is recommended. In all cases, use the lowest effective concentration of herbicide.

Creating Nesting Habitat on Managed Properties

Modified with permission from Erb (2009) Advisory Guidelines for Creating Turtle Nesting Habitat

Open canopy areas with well-drained soils are ideal turtle nesting habitats. One of the major threats to our native turtles is habitat fragmentation and associated adult mortality due to road traffic. Female turtles often travel substantial distances from feeding and overwintering areas to the nearest appropriate nesting habitat to lay their eggs. One way to reduce nesting-related mortalities is to facilitate access to nesting habitat near feeding and overwintering wetlands, with roadless corridors in between.

Figure 51. A box turtle lays eggs in western Pennsylvania. See omendrifter’s video for more.

Site Selection. Nesting habitat should be created away from roads and in areas that box turtles are known to frequent. Nesting sites should have full southern exposure and get sun throughout most of the day. Nesting habitat should be above the flood plain. The site may need to be larger to get sun exposure throughout the day, depending on the proximity and height of adjacent forested areas. Larger nesting areas or multiple small ones will likely dilute nest predation. To minimize predation and human related mortality and collection, nesting sites should be as isolated as possible from housing developments and human activity areas, such as trail bicycle paths, ATV/motorcycle trails, playgrounds, picnic areas, walking paths and other recreational activities. Even though public parks include human activity, many of them could be excellent sites for building nest habitat, which will help us maintain a box turtle population.

The original substrate should consist of well-drained soil, sand or small-sized gravel. If the substrate does not appear adequate for nesting, the deposition of sandy soil on top of existing vegetation may be all that is necessary. If soil is brought to the site, it should be washed sand or small-sized gravel. Washed substrate will minimize translocation of weeds or invasive plant species and impede rapid growth of native vegetation. In most cases, even non-forested areas, the surface material will need to be disturbed through scarification. Removal of the surface material, to expose the underlying strata, may also be necessary if the area is infested with invasive and/or weedy species.

Where necessary, forest cover and tall vegetation should be removed. Contact your state's wildlife agency for guidelines and best practices to prevent damage to other species that may be impacted. Ground vegetation should be sparse and include native sedges, grasses, and a few low growing shrubs (less than 1%-5% cover of the site, with less at smaller sites). Shrubs will provide cover for the gravid females and hatchlings once they emerge from the nest.

If the exposed native mineral soil is heavy clay, a fine sand should be deposited (25% of the intended nesting area). Herbaceous and woody species should never occupy > 50% of the area. In addition, shrubs should be no taller than 24" in height. If shrubs grow taller than 24", most of these materials should be removed or trimmed. The removal areas should then be raked and lightly tilled.

Providing some topographic variation (slightly raised areas) is advised because doing so provides options in microtopography conditions.

Our Futures: Inextricably Linked

Despite problems, there appear to be success stories. These have been long, arduous affairs. And for the most part, they have been the work of extraordinarily dedicated individuals, not legions of bureaucrats. I suspect that the turtle wars will be fought and won and lost by individual "turtle men" and "turtle women" who are on divine missions from their chelonian gods to save their species.

John Behler, 1993

Appendix A. Sample Turtle Data Sheet and Completed Sample

Sample Turtle Data Sheet

Fill out a separate sheet for each turtle. Use only pencil or indelible ink.

CAPTURE INFORMATION

Site Name: _______________ **Recapture?** Y or N or Unknown **Turtle ID:** ___________

Status: Alive or Dead **Date** (mm/dd/yyyy): ________ **Day:** _____ **Time:** ______ AM PM

Capture Method* (1-7): ____ **Capture comments:** ____

Observer(s): ____

Processed By: ____

LOCATION DETAILS

Coordinates (UTM): E____________________, N ______________________ Zone: ___________

Datum: WGS 84 **Location Description:**____

____

Air Temp: ____ ˚F or ˚C **Sky Index* (0-4):** ____ **Weather *(1-3):** _____ **Days since last rain:** _____

TURTLE DESCRIPTION

Eye Color: ____ brown ____ pale red ____ bright red ____ other: ________________________________

Sex: M F Unknown

SCL min. (mm): ___________

Mass (g):____________________

Max CW (mm):______________________

Annuli Count: ______

PL Anterior to hinge (mm):____________

Habitat (1-9): ______

PL Hinge to posterior (mm): ___________

Photos taken? Y N

Shell height at hinge (mm): ____________
(measured on turtle's right side)

Capture Method: 1=road capture; 2=while mowing; 3=active search; 4=incidental; 5=radio signal; 6=dog; 7=other
Sky Index: 0= 0% clouds; 1= 25% clouds; 2=50% clouds; 3=75% clouds; 4=100% clouds
Weather: 1= no precipitation; 2=light drizzle/mist; 3=rain
Habitat: 1=field/forest edge (within 6m of boundary); 2=field; 3=pine forest; 4=hardwood forest; 5=stream/river; 6=open wetland; 7=forested wetland; 8=other; 9=mixed pine/hardwood forest

Sample Turtle Data Sheet
Page 2

TURTLE CONDITION & NOTES

Injuries/Defects: None seen ____ Crushed or damaged carapace ____ Crushed or damaged plastron __________

Damaged eye or eyes ____ Missing digits, and/or limbs ____ Skin/soft tissue scars or injuries ________________

Tooth marks on shell ____ Other ____

Injuries/Defects Notes: ____

Illness/Health Issues: None detected ____ Discharge from ____eyes, _____ mouth, ______ nose. What color is discharge? ____

Discharge from vent _______ If there is a discharge from vent, what color? ______________________________

Swollen ear ____ left ____right. Swollen eye ____ left ____ right.

Other ____

____

Illness/Health Issues Notes: ____

Parasites: None detected ____ Leech(es) ____ Tick(s) ____ Other ______________________________________

Parasites Notes: ____

Indicate ID file markings in Figure 1. Show any Injuries, Unusual Scute Patterns, or Defects in Figures 2 and 3:

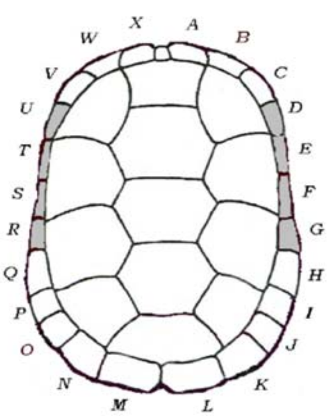


Figure 1

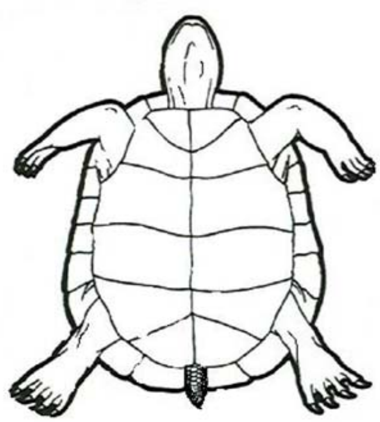


Figure 2

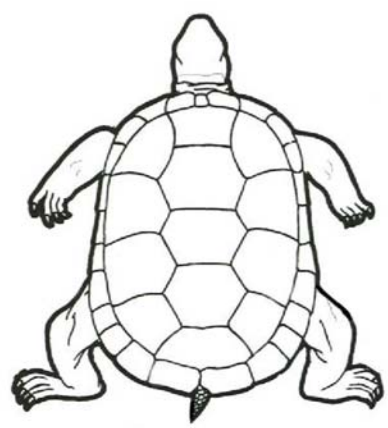


Figure 3

Comments:

____

____

____

____

Initial when each of the following actions is performed: ________ Entered ________ Proofed _______ Scanned

Completed Sample Turtle Data Sheet

CAPTURE INFORMATION

Site Name: *Two Pines Farm* **Recapture?** Y or N or Unknown **Turtle ID:** *ABI*

Status: Alive or Dead **Date** (mm/dd/yyyy): 04/11/2030 **Day:** *Wed.* **Time:** *1:00* AM PM

Capture Method* (1-7): 3 **Capture comments:** ______

Observer(s): *Ashley Rose, Lynn Rose, Leanne Murray, Kim O'Neill, Benjamin Cole*

Processed By: *Ashley Rose*

LOCATION DETAILS

Coordinates (UTM): E *692232*, N *3971205* **Zone:** 17

Datum: WGS 84 **Location Description:** *sunning near long leaf pine, near south side of barn*

Air Temp: *70* ˚F or ˚C **Sky Index* (0-4):** *2* **Weather *(1-3):** *1* **Days since last rain:** *2*

TURTLE DESCRIPTION

Eye Color: *X* brown ____ pale red ____ bright red ____ other: ______

Sex: M F Unknown

SCL min. (mm): *134.5*

Mass (g): *435*

Max CW (mm): *98.6*

Annuli Count: *15+*

PL Anterior to hinge (mm): *50.8*

Habitat (1-9): *1*

PL Hinge to posterior (mm): *75.8*

Photos taken? Y N

Shell height at hinge (mm): *55.8*
(measured on turtle's right side)

Capture Method: 1=road capture; 2=while mowing; 3=active search; 4=incidental; 5=radio signal; 6=dog; 7=other
Sky Index: 0= 0% clouds; 1= 25% clouds; 2=50% clouds; 3=75% clouds; 4=100% clouds
Weather: 1= no precipitation; 2=light drizzle/mist; 3=rain
Habitat: 1=field/forest edge (within 6m of boundary); 2=field; 3=pine forest; 4=hardwood forest; 5=stream/river; 6=open wetland; 7=forested wetland; 8=other; 9=mixed pine/hardwood forest

Completed Sample Turtle Data Sheet
Page 2

TURTLE CONDITION & NOTES

Injuries/Defects: None seen ___*X*___ Crushed or damaged carapace ____ Crushed or damaged plastron ________
Damaged eye or eyes ____ Missing digits, and/or limbs ____ Skin/soft tissue scars or injuries ________________
Tooth marks on shell ____ Other ____
Injuries/Defects Notes: ____

Illness/Health Issues: None detected ___*X*___Discharge from ____eyes, _____ mouth, ______ nose. What color is discharge? ____
Discharge from vent _______ If there is a discharge from vent, what color? ______________________________
Swollen ear ___*X*___ left ____right.   Swollen eye ____ left ____ right.
Other ______*none*____

____

Illness/Health Issues Notes:____

Parasites: None detected ___*X*___ Leech(es) ____ Tick(s) ____ Other ______________________________
Parasites Notes: ____

Indicate ID file markings in Figure 1. Show any Injuries, Unusual Scute Patterns, or Defects in Figures 2 and 3:

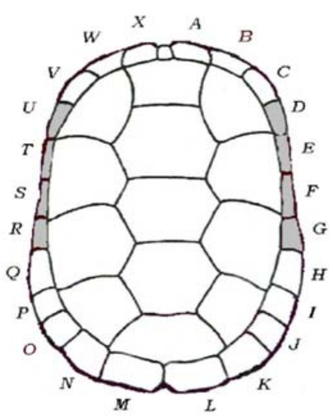


Figure 1

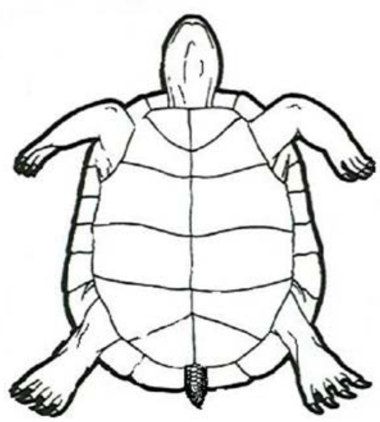


Figure 2

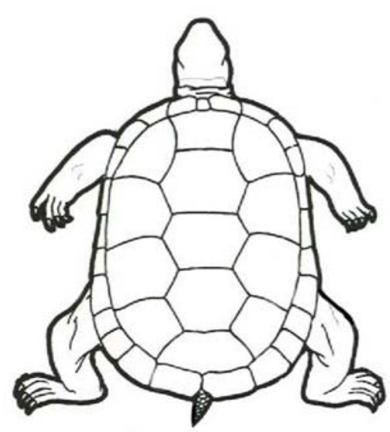


Figure 3

Comments:

____
____
____
____

Initial when each of the following actions is performed: ___*ALR*___ Entered ___*ALR*___ Proofed ___*ALR*___ Scanned

Appendix B. Sample Turtle Data Sheet Instructions

CAPTURE INFORMATION

Site name – If a name does not already exist for the property where the turtle was found, invent one. Examples: The Matthews Home Place, Somers Berry Farm, or Camp Chestnut.

Recaptured? – Circle "Y" for yes or "N" for no. Don't be too hasty. Carefully inspect the turtle for previous marks. Filed notches often fill in with dirt, so run the tip of your fingernail along the edge of the marginals to feel for previously filed marks.

Turtle ID – For newly captured turtles, refer to *Marking System for Box Turtles* in Chapter 6 or, if previously marked, enter the code.

Status – Record if the turtle is alive or dead. (Note: collecting data on dead turtles is important too.)

Date – Enter the date you are collecting data (mm/dd/yyyy).

Day of week – Enter the day of the week you are collecting data for this turtle.

Time – Record the time this turtle was discovered and indicate whether it was found in the A.M. or P.M.

Capture method – Enter the number that represents the way this turtle was observed: 1= road capture; 2= observed while mowing; 3= active search (you found the turtle by actively looking); 4= incidental; 5= radio signal (turtle found by radiotracking); 6= dog (a dog located the turtle); 7= other (give a complete explanation of any method that does not fit into the previous categories).

Capture comments – Provide any additional details related to the capture of the turtle.

Observer(s) – List the complete name of the leader and the name of the group. You need not include all people present.

Processer – The processor does the measuring and fills out the data sheet themselves or is responsible for supervising the recorder. This should be a trained person adhering to the protocol for measurements.

LOCATION DETAILS

Coordinates (UTM) – Geographic coordinates should be recorded in the Universal Transverse Mercator (UTM) grid system using datum WGS 84. Easting (E) and Northing (N) are the coordinates to be recorded. If you do not have a personal GPS, you may use UTM finder available free on smartphones from Tremble Navigation (does not need internet connection).

Zone – Band of longitude (there are 60, 6 degrees each). Find your UTM zone using one of many internet sites that cover this material.

Datum – World Geodetic System of 1984 (WGS84) is the default datum for the UTM finder on Tremble Navigation.

Location description – Use semi-permanent landscape features to record location (nothing is permanent, but if you think something is long-lasting, use that feature). This is not a habitat description. Example: turtle found in group campground, approx. 200 meters northwest of bath house, crossing paved road.

Air temperature – Record air temperature in the shade near where the turtle was found. Use either Fahrenheit or Celsius, but do not forget to circle which one.

Sky index – Use the following numerical codes for sky conditions: 0= 0% clouds; 1= 25% clouds; 2=50% clouds; 3=75% clouds; 4=100% clouds

Weather – Use the following numerical codes for weather conditions: 1= no precipitation; 2= light drizzle/mist; 3= rain. Unusual weather can be entered in Comments section.

Days since last rain – Record every time it rains on a calendar so you can enter this accurately. It is hard to remember when it last rained, especially during dry spells.

TURTLE DESCRIPTION

Eye color – Turtle's eyes can be many different colors, so consider the following as categories: brown, pale red, bright red, yellow, or other. Describe *other* carefully if you choose this category.

Sex – Refer to *Sexing Eastern Box Turtles* handout by LaVere & Somers available online at boxturtles.uncg.edu, as well as in Appendix D of this book. You must identify a minimum of 3 of the sex characteristics described in the handout before you declare that a turtle is a male or a female. Note that using the category of UNKNOWN is strongly encouraged when there is doubt.

Mass – Use a reliable scale to weight turtles. Each project should have received a calibration weight. A scale is considered reliable if it correctly measures accurately to +/- 5% of the calibration weight. Scales should be calibrated at least once a month. If your scale is not measuring accurately, then you will know how far it is off when you calibrate it. Continue to measure turtles and adjust for the weighting error until the scale can be replaced. For example, if your scale is over the allowed acceptance range (provided with the weight) by 6.3 grams, then subtract 6.3 grams from the turtle's weight. Note this in the Comments section of the data sheet. Carefully read the section of this volume on using calibration weights to assure the accuracy of your scale.

Annuli count – Counting annuli should be done with care and repetition. Count 3 scutes, on carapace or plastron, before you decide what number to write down.

Habitat – Enter the code for the type of habitat in which the turtle was found: 1= field/forest edge (within 6m of boundary); 2= field; 3= pine forest; 4= hardwood forest; 5= stream/river; 6= open wetland; 7= forested wetland; 8= other; 9= mixed pine/hardwood forest

Were digital photographs taken of the carapace and plastron? – Circle yes or no. Refer to the section on *Photo Documentation* for best practices.

SCL min. – This measurement refers to obtaining a straight carapace length in millimeters using calipers, with jaws placed on notches on the anterior and posterior parts of the carapace. Because the carapace overlaps the plastron when the turtle is closed up, it is easy to measure the carapace by placing the calipers under the turtle (ventral side) with jaws facing up. IMPORTANT: Use calipers with jaw lengths of at least 2.5 inches (~ 6.5cm).

Max CW – Carapace width. Use calipers to measure the widest part of the turtle's carapace to obtain a maximum width in millimeters. This measurement is typically taken from the ventral side of the turtle. Once again, use of long jawed calipers (2.5 inches or greater) is expected.

PL anterior to hinge – Due to the unique hinge characteristic of box turtles, the total plastron length will need to be determined through two separate measurements. With your calipers, using the anterior edge of the plastron (or the edge closest to the head of the turtle) as your starting point, you will measure down to the hinge, recording your measurement in millimeters.

PL hinge to posterior – For the second plastron measurement, you will be using the hinge as your starting point and extending your caliper to the posterior edge of the plastron (or the edge closest to the tail), recording your measurement in millimeters.

Shell height at hinge –To measure the height of the shell, sandwich the turtle in the jaws of your calipers at the hinge. Take this measurement from the right side of the turtle for consistency.

Turtle condition and notes – The data sheet is clear on these items so we will only include specific directions for the unusual notes.

Injuries/Defects/Parasites – Briefly describe any abnormalities observed. This could include any healed injuries noted on the carapace or plastron, missing appendages (legs, tail), or discharge from eyes, nares, or vent (other than normal feces or clear urine). For parasites, this could include leeches, ticks, mites, turtle fly larvae, and/or flesh fly eggs and maggots.

Indicate ID file marking in the figure – Be sure and mark on the diagram the file marks you make as well as any others.

Indicate below where injuries, fire scars, or unusual scute patterns or defects occur – Indicate the location of the injury, anomaly, or defect on the drawing(s) provided. Describe and illustrate these if possible.

Comments – List anything that seems noteworthy, such as unusual scute patterns (see Figure 51), color, or markings, damaged shell (be specific), or bite marks.

Indicate whether data was entered, proofed, and scanned – Be sure to check off or initial when data is entered, proofed, and scanned. These can be done by different individuals, but needs to be recorded when action is completed. It is a good idea to indicate by initials who performed the action indicated.

Figure 51. Box turtles normally have four lateral (pleural) scutes (left photo), but some turtles have more or less. The turtle in the photo on the right has three lateral scutes on the left side and five on the right (not shown). This should be noted in the "Comments" section of the data sheet.

Appendix C. Turtle Census Data Sheet

Instructions for Completing the Turtle Census Data Sheet

Details of how to conduct a census are included in a section of Chapter 5 titled How to Conduct a Box Turtle Census. A separate Box Turtle Census Data sheet should be used for each census. Each turtle discovered will be recorded on that census' sheet. A blank sample and a completed sample of the Box Turtle Census Data Sheet are included on the following pages. Design your own data sheet to fit your study. All turtles should be released at the point of capture after data are collected.

Turtle Plot # – Enter the number assigned to the plot where you are conducting the census.

Date – Enter the date you are conducting the census.

Searchers – Enter the names of all persons participating in the census, if possible. If not, enter the number of participants.

Start – Enter the time you begin the census.

Finish – Enter the time you finish the census.

Temp – Enter the temperature (note Fahrenheit or Celsius) when you begin the census.

Wind – Enter the wind speed at the time you begin the census, using the appropriate code from the table below.

0 - Calm (smoke rises vertically, <1 mph)

1 - Light air (smoke drifts, 1-3 mph)

2 - Light breeze (feel wind on face, leaves rustle, 4-7 mph)

3 - Gentle breeze (leaves and small twigs in constant motion, 8-12 mph)

4 - Moderate breeze (blows dust and loose paper, 13-18 mph)

5 - Fresh breeze (trees swaying, >18 mph)

Sky/Weather – Enter the prevailing sky cover and weather conditions at the time you begin the census, using the appropriate code from the table below.

0 - Clear or few clouds

1 - Partly cloudy (scattered or variable)

2 - Cloudy (broken) or overcast

3- Fog or smoke

4 - Dry

5 - Drizzle or light rain

6 - Rain

Turtles Found – Enter the appropriate data on each turtle found during the census. Record the notches on the marginals and look up the identification code later, or just use the code. A number, corresponding to the line number for each turtle's entry, should be placed on the map, in the location where the turtle was found.

Search Technique

The four corners of your census plot should be marked in some way; three-foot-tall PVC or metal pipes or wooden stakes, in combination with plastic flagging work well. It is helpful to mark intermediate points around the perimeter and inside the plot at 25m or 50m intervals. This aids searchers in staying on line and making sure the whole plot is thoroughly covered. It may be useful to provide searchers with maps of the plot and magnetic compasses. Binoculars might also come in handy.

Searchers spread out along one side of the plot. At the signal to start, they move into and slowly through the plot, staying roughly abreast and heading toward the opposite side; e.g. east to west, north to south.

Searchers follow a generally straight course through the plot, but wander back and forth of the center line of their direction of travel. Each searcher should overlap slightly with the person on the right and left. In this manner, the group is more likely to cover the whole plot.

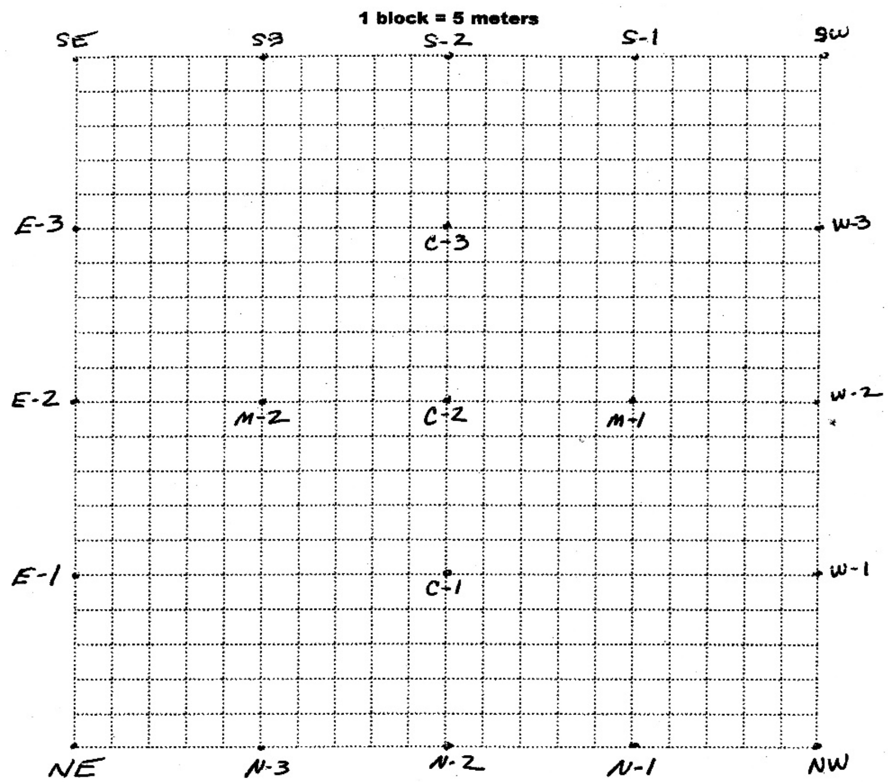
Searchers should stop periodically and scan the ground all around them, including to the rear. Carefully check in thickets, under shrubs, around the base of larger trees, inside tree hollows at ground level, in vernal pools, and alongside fallen logs and branches.

One person should be designated as the recorder. It helps if this person is very familiar with the census plot, as he or she will be the one plotting the location of each turtle found on the map. This person can also be searching for turtles, but is best positioned in the center of the line of searchers.

When a turtle is discovered, the person finding it shouts out “turtle” and remains in place, waiting for the recorder. After desired data is collected and the location plotted, the turtle is released at the site of capture.

Usually, a thorough census conducted by four to six people, in moderate terrain and vegetation, will take 45 minutes to one hour.

TURTLE CENSUS



TURTLE PLOT # ____

DATE_____________________________ **SEARCHERS_______________________**

START____________ FINISH____________ **____________________________________**

TEMP____________ WIND_______________ **____________________________________**

SKY INDEX ___________ WEATHER ____________

TURTLES FOUND (notches on marginals, sex)

1. ____________________________________ **5.__________________________________**

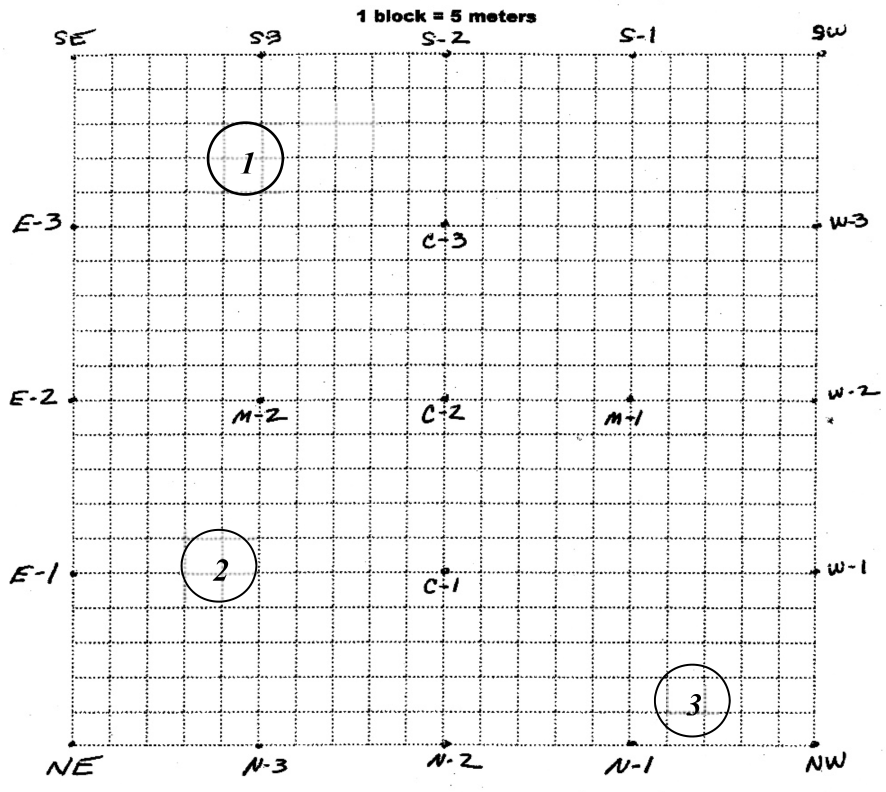
2. ____________________________________ **6.__________________________________**

3. ____________________________________ **7.__________________________________**

4. ____________________________________ **8.__________________________________**

TURTLE CENSUS

Completed Sample



TURTLE PLOT # *2 — Forest Trail*

DATE *24 July 2018* **SEARCHERS** *Chris Swarth,*

START *1:00 p* **FINISH** *1:50 p* *Mike Quinlan, Joe Sage,*

TEMP *25° C* **WIND** *0 = calm* *Crista Kapps, Elaine Friehele*

SKY INDEX *0 = 0% clouds* **WEATHER** *1= no precipitation*

TURTLE (notches on marginals / sex)

1. *BKO (R 2, R 11, L 10) / ♀*
2. *New / ♂*
3. *JNV (R 10, L 11, L 3) / ♂*
4.
5.
6.
7.
8.

Appendix D. Sexing Eastern Box Turtles

By Ashley LaVere and Ann Somers

Sex determination in turtles can be tricky because unless you see a male's genitalia or see a female laying eggs, you cannot be 100% sure about the sex. Instead, a combination of features should be used to confidently assign a sex to a turtle. We suggest examining the following seven key features of box turtles before any sex determination is made: 1) coloring on the face and forelegs, 2) eye color, 3) hind claws, 4) general shape of the carapace, 5) depression or lack thereof on the plastron, 6) tail length and placement of the anus, and 7) extent of flaring of marginal scutes. We suggest that you identify at least three sex characteristics before determining and recording the sex.

CAUTION: Due to variability in sex characteristics in box turtles, these traits are not always reliable for sex determination. For research purposes, if ever unsure about the sex of a turtle, do not hesitate to mark it as "Unknown" for sex on the data sheet.

1. **Coloring on the face and forelegs**
   Body coloring can differ greatly between the two sexes. Females typically have a dull yellow or brown coloring on their heads and forelegs, contrasting greatly with the bright orange, red, or yellow accenting of the heads and forelegs of males. Some males, however, have dull yellow and brown skin coloration similar to that typical of females.

2. **Eye color**
   Similar to their body coloring, males usually have bright red eyes, whereas females are normally seen with a brownish or auburn eye coloring.

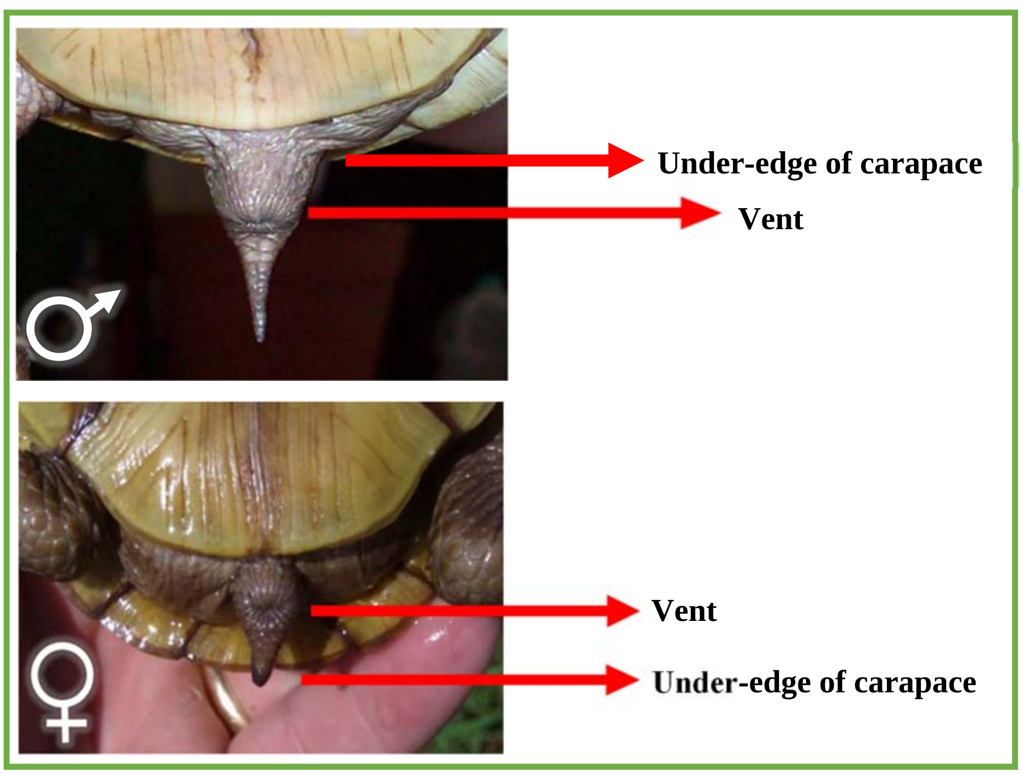
3. **Hind Claws**
   The hind claws are located on the back feet of the turtle. Male hind claws are thicker and more curved than those on females.

4. **Shape of Carapace**
   The term carapace refers to the upper, or top, of a turtle's shell. Males usually have a flatter carapace, giving them an overall thinner appearance (dorsal-ventrally). The carapaces on females are more highly domed than males.

5. **Depression on Plastron**
   The plastron is the bottom of a turtle's shell. Box turtles have a hinge on their plastron allowing them to completely close up their shells. Males have an indentation on the plastron, posterior to the hinge. This depression allows the male to gain stability when mounted on a female during copulation. Females, which do not mount, exhibit little or no depression or indentation on their plastron.

6. **Flaring of Marginal Scutes**
Marginal scutes are the scutes located on the outer perimeter of the carapace. In males, the marginal scutes over the back half of the carapace flare out more than those on females. It is important to remember that overly flared scutes may be a sign of previous captivity rather than sex.

7. **Tail length and Placement of Vent**
The tail length and placement of the vent (in respect to the posterior edge of the carapace) can provide clues about whether you are looking at a male or female. In males, the tail is usually longer and the vent is located outside the edge of the carapace. In contrast, female box turtles commonly have a shorter tail with the vent located inside the edge of the carapace.



Appendix E. Turtle Identification Codes

Compiled by Davidson College Herpetology Students

Cross off codes once they are used to avoid duplications. Put date used in space beside code.

ABC	AHN	AKO	AOW	BHL
ABH	AHO	AKP	AOX	BHM
ABI	AHP	AKQ		BHN
ABJ	AHQ	AKV	APQ	BHO
ABK	AHV	AKW	APV	BHP
ABL	AHW	AKX	APW	BHQ
ABM	AHX		APX	BHV
ABN		ALM		BHW
ABO	AIJ	ALN	AQV	BHX
ABP	AIK	ALO	AQW	
ABQ	AIL	ALP	AQX	BIJ
ABV	AIM	ALQ		BIK
ABW	AIN	ALV	AVW	BIL
ABX	AIO	ALW	AVX	BIM
	AIP	ALX		BIN
ACH	AIQ		AWX	BIO
ACI	AIV	AMN		BIP
ACJ	AIW	AMO	BCH	BIQ
ACK	AIX	AMP	BCI	BIV
ACL		AMQ	BCJ	BIW
ACM	AJK	AMV	BCK	BIX
ACN	AJL	AMW	BCL	
ACO	AJM	AMX	BCM	BJK
ACP	AJN		BCN	BJL
ACQ	AJO	ANO	BCO	BJM
ACV	AJP	ANP	BCP	BJN
ACW	AJQ	ANQ	BCQ	BJO
ACX	AJV	ANV	BCV	BJP
	AJW	ANW	BCW	BJQ
AHI	AJX	ANX	BCX	BJV
AHJ				BJW
AHK	AKL	AOP	BHI	BJX
AHL	AKM	AOQ	BHJ	
AHM	AKN	AOV	BHK	

Turtle Identification Codes Continued

Cross off codes once they are used to avoid duplications. Put date used in space beside code.

BKL	BOP	CIJ	CLM	CQV
BKM	BOQ	CIK	CLN	CQW
BKN	BOV	CIL	CLO	CQX
BKO	BOW	CIM	CLP	
BKP	BOX	CIN	CLQ	CVW
BKQ		CIO	CLV	CVX
BKV	BPQ	CIP	CLW	
BKW	BPV	CIQ	CLX	CWX
BKX	BPW	CIV		
	BPX	CIW	CMN	HIJ
BLM		CIX	CMO	HIK
BLN	BQV		CMP	HIL
BLO	BQW	CJK	CMQ	HIM
BLP	BQX	CJL	CMV	HIN
BLQ		CJM	CMW	HIO
BLV	BVW	CJN	CMX	HIP
BLW	BVX	CJO		HIQ
BLX		CJP	CNO	HIV
	BWX	CJQ	CNP	HIW
BMN		CJV	CNQ	HIX
BMO	CHI	CJW	CNV	
BMP	CHJ	CJX	CNW	HJK
BMQ	CHK		CNX	HJL
BMV	CHL	CKL		HJM
BMW	CHM	CKM	COP	HJN
BMX	CHN	CKN	COQ	HJO
	CHO	CKO	COV	HJP
BNO	CHP	CKP	COW	HJQ
BNP	CHQ	CKQ	COX	HJV
BNQ	CHV	CKV		HJW
BNV	CHW	CKW	CPQ	HJX
BNW	CHX	CKX	CPV	
BNX			CPW	HKL
			CPX	HKM

Turtle Identification Codes Continued

Cross off codes once they are used to avoid duplications. Put date used in space beside code.

HKN	HOV	IKV	IPQ	JMO
HKO	HOW	IKW	IPV	JMP
HKP	HOX	IKX	IPW	JMQ
HKQ			IPX	JMV
HKV	HPQ	ILM		JMW
HKW	HPV	ILN	IQV	JMX
HKX	HPW	ILO	IQW	
	HPX	ILP	IQX	JNO
HLM		ILQ		JNP
HLN	HQV	ILV	IVW	JNQ
HLO	HQW	ILW	IVX	JNV
HLP	HQX	ILX		JNW
HLQ			IWX	JNX
HLV	HVW	IMN		
HLW	HVX	IMO	JKL	JOP
HLX		IMP	JKM	JOQ
	HWX	IMQ	JKN	JOV
HMN		IMV	JKO	JOW
HMO	IJK	IMW	JKP	JOX
HMP	IJL	IMX	JKQ	
HMQ	IJM		JKV	JPQ
HMV	IJO	INO	JKW	JPV
HMW	IJP	INP	JKX	JPW
HMX	IJQ	INQ		JPX
	IJV	INV	JLM	
HNO	IJW	INW	JLN	JQV
HNP	IJX	INX	JLO	JQW
HNQ			JLP	JQX
HNV	IKL	IOP	JLQ	
HNW	IKM	IOQ	JLV	JVW
HNX	IKN	IOV	JLW	JVX
	IKO	IOW	JLX	
HOP	IKP	IOX		JWX
HOQ	IKQ		JMN	

Turtle Identification Codes Continued

Cross off codes once they are used to avoid duplications. Put date used in space beside code.

KLM		LPX	MWX	PQV
KLN	KQV	LQV		
KLO	KQW	LQW	NOP	PQW
KLP	KQX	LQX	NOQ	PQX
KLQ			NOV	
KLV	KVW	LVW	NOW	PVW
KLW	KVX	LVX	NOX	PVX
KLX				
	KWX	LWX	NPQ	PWX
KMN			NPV	
KMO	LMN	MNO	NPW	QVW
KMP	LMO	MNP	NPX	QVX
KMQ	LMP	MNQ		
KMV	LMQ	MNV	NQV	QWX
KMW	LMV	MNW	NQW	
KMX	LMW	MNX	NQX	VWX
	LMX			
KNO		MOP	NVW	
KNP	LNO	MOQ	NVX	
KNQ	LNP	MOV		
KNV	LNQ	MOW	NWX	
KNW	LNV	MOX		
KNX	LNW		OPQ	
	LNX	MPQ	OPV	
KOP		MPV	OPW	
KOQ	LOP	MPW	OPX	
KOV	LOQ	MPX		
KOW	LOV		OQV	
	LOW	MQV	OQW	
KOX		MQW	OQX	
	LOX	MQX		
KPQ			OVW	
KPV	LPQ	MVW	OVX	
KPW	LPV	MVX		
KPX	LPW		OWX	

Appendix F. Diagrams, Handouts, and Infographics

Turtle from Dorsal Aspect

Turtle from Ventral Aspect

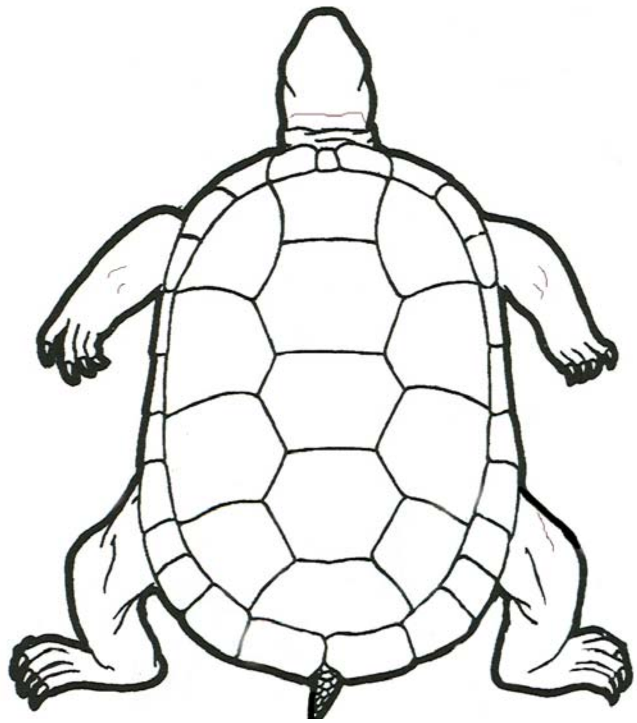
Names of Carapace Scutes

Names of Plastron Scutes

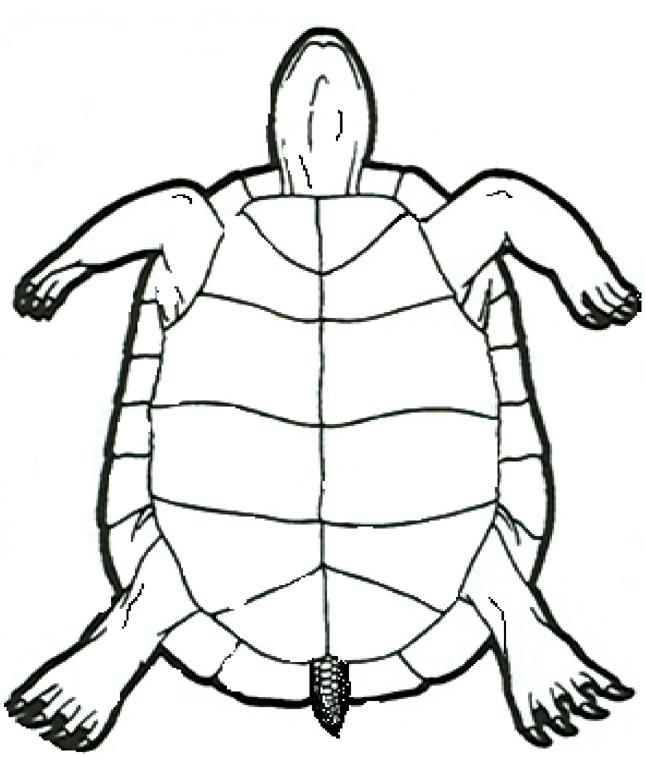
Carapace Labeled for Identification Codes

Box Turtle Infographics

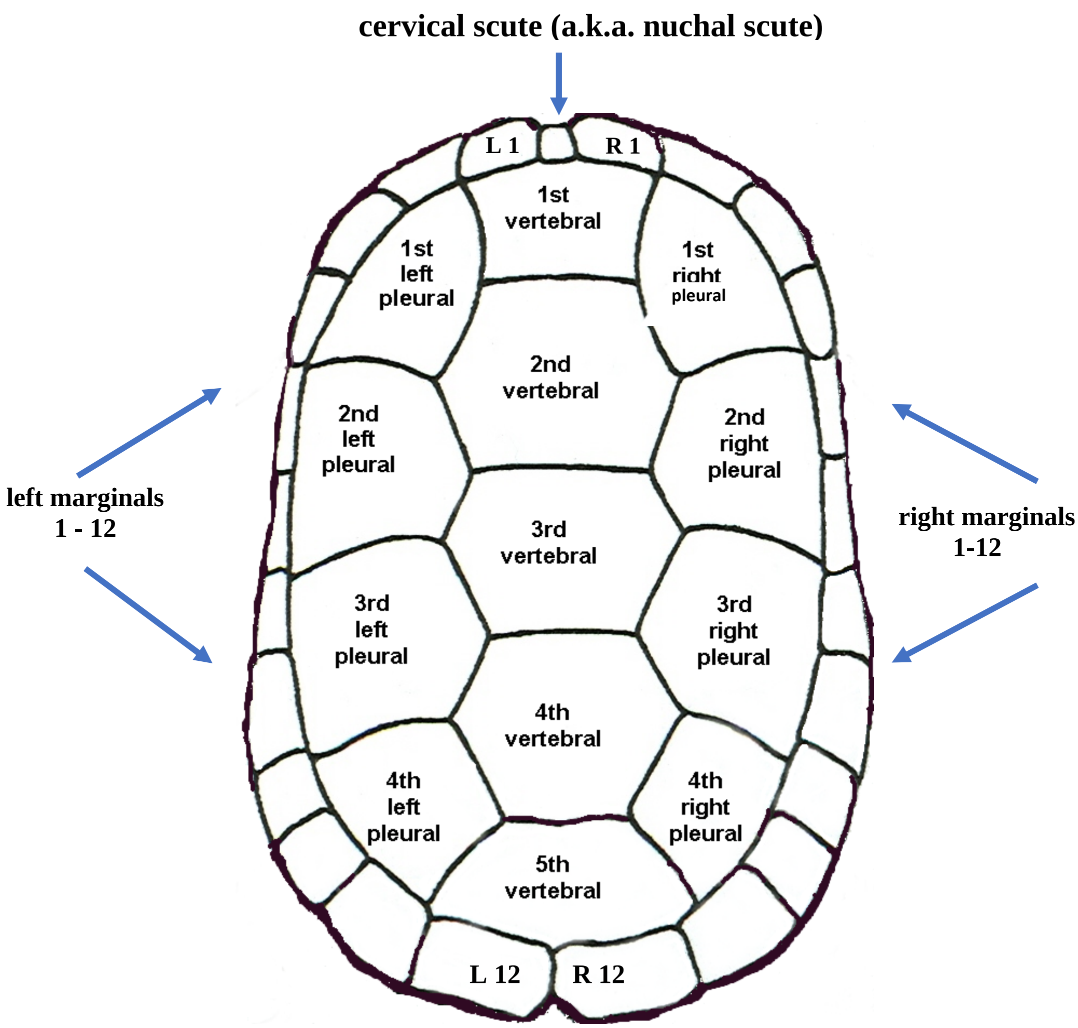
Turtle from Dorsal Aspect



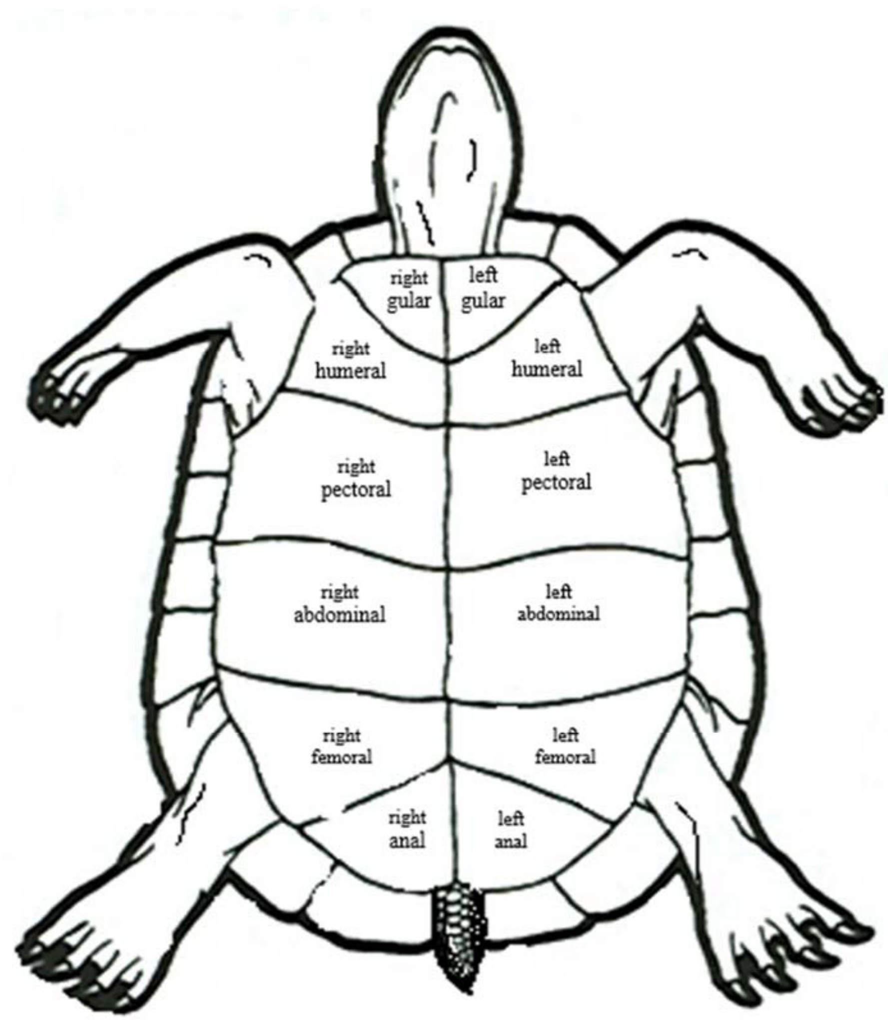
Turtle from Ventral Aspect



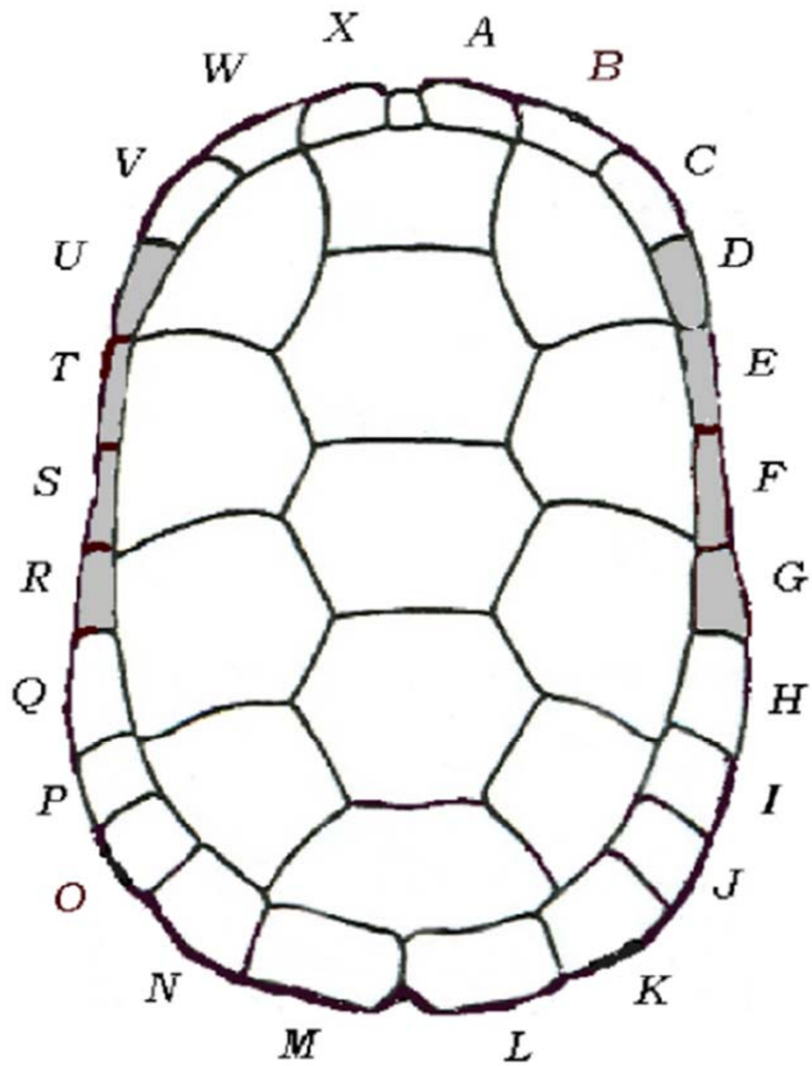
Names of Carapace Scutes



Names of Plastron Scutes

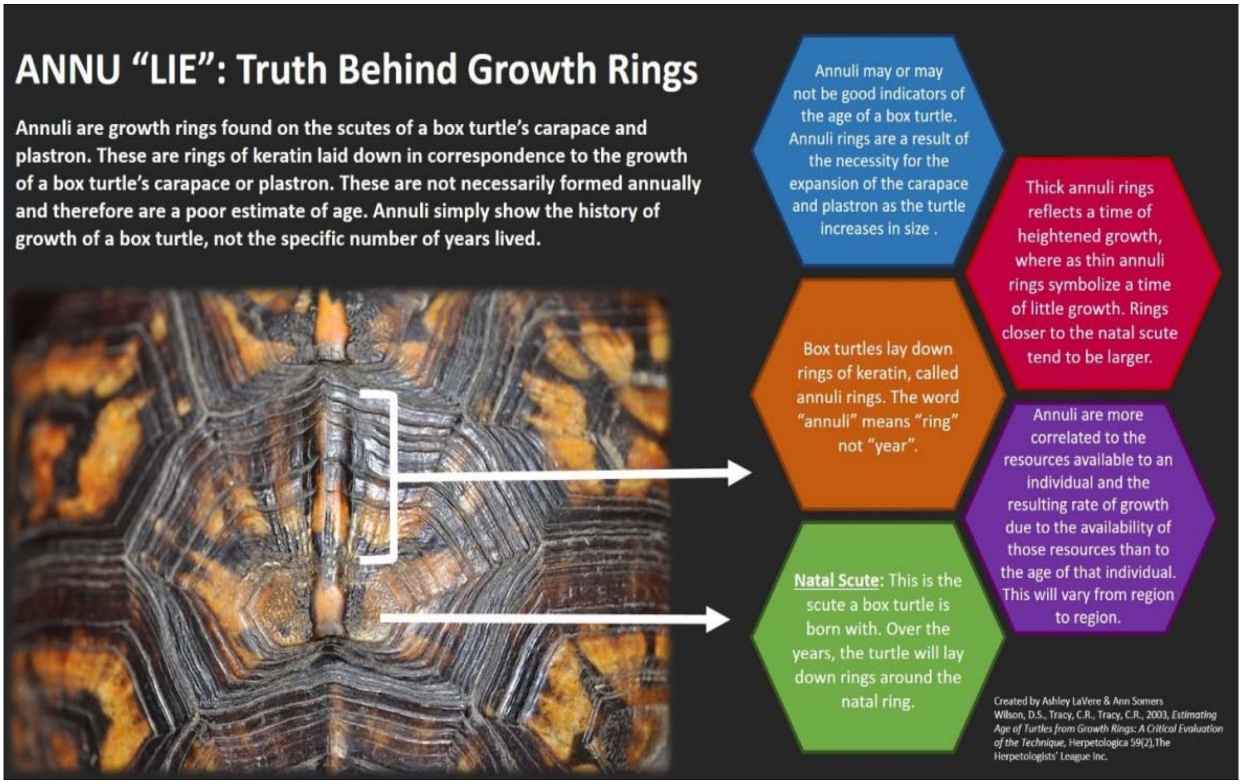


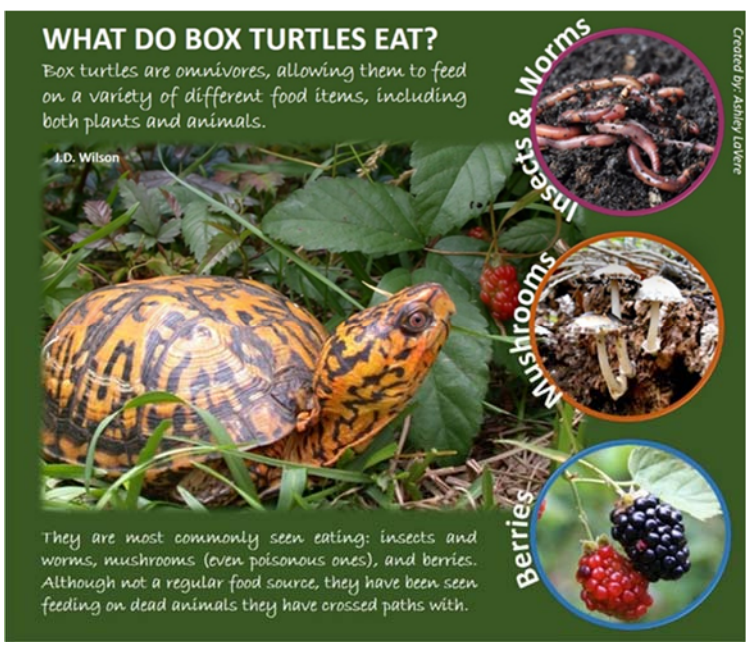
Carapace Labeled for Identification Codes



Box Turtle Infographics

Available for free download at: https://boxturtle.uncg.edu/





Appendix G. Identifying Wellness and Disease in Box Turtles

By Sandy Barnett

Disease outbreaks in box turtles can have serious implications for population health and survival, so a little care and observation on your part can make a difference in both an individual turtle's life and, potentially, the entire local population. (Haley Hedegus, 2016)

You may occasionally encounter a wild turtle that shows signs of illness or injury. While some illnesses are non-infectious, you may not be able to tell without specialized laboratory testing, so treat every sick animal as if it has a contagious disease; wear separate gloves or sanitize your hands after handling each animal and do not mix turtles or re-use the containers used for holding them (discard or wash and disinfect). We recommend that you follow the same protocol for handling injured turtles. An injured turtle may actually have an underlying illness that put it in harm's way. For example, sick turtles may seek out a warm place, such as a road edge or forest clearing, where they can elevate their body temperature to fight their infection. This can expose the turtle to possible danger, such as a vehicular strike or predator attack.

How can you tell if the turtle you have found is sick or injured? A complete physical exam, complemented by a host of laboratory tests—oral and cloacal swabs, fecal and blood samples, and radiographs—is ideal for such a determination but is neither practical nor affordable in many cases. Much can be learned from just a careful visual inspection of the animal as well as from observing the animal's behavior (normal or abnormal or seasonally inappropriate) at the time it was found.

Figure 1. This Eastern Box Turtle was found along a roadside, probably attempting to raise its body temperature (referred to as a "behavioral fever") to fight a respiratory infection. Note the swollen, closed eyes, bubbly nasal discharge, and overall depressed and dull demeanor of the turtle.

Appendix A provides a form for collecting morphometrics and information on a turtle's physical condition based on visual inspection. You may not be able to determine the exact medical problem, but you can often tell if a turtle is injured or unwell. To start your examination, collect whatever information you can without handling the animal; this reduces the likelihood that it will "box up" and limit your observations.

Start with observing the animal's breathing and overall alertness, posture, and locomotion.

- Does the turtle look alert? Healthy box turtles generally rest or sit still in the daytime with their eyes open and alert (at least when you draw near), even if the head is somewhat tucked in. The legs may be tucked in or be planted firmly on the ground.

- Is the turtle breathing comfortably with a closed mouth? Breathing is normally through the nares (nostrils) with the mouth closed and a rhythmic expansion and contraction of the throat; open mouth breathing/gaping, which may be accompanied by an outstretched neck and rhythmic pumping/heaving of the front legs, suggests the turtle is in serious respiratory distress. That said, turtles are remarkably tolerant of low levels of oxygenation and may nose breathe even with significant respiratory impairment.

Figure 2. This Eastern Box Turtle was found basking in the woods on a cold but sunny December day. Its abnormal behavior (basking when it should have been in brummation) suggested it was ill. On close inspection, the animal's crusty sealed eyelids, raspy breathing, and nasal discharge confirmed it had a respiratory infection. It was successfully treated with systemic antibiotics and supportive care and returned to its point of capture the following spring.

- Is the head held level? Head tilting (not the normal tilting that occurs as a turtle retracts its head/neck into its shell) could indicate that there is infection or trauma on the side of the head to which it is tilted. A head tilt, prolonged backward arching of the head and neck ("star-gazing"), erratic walking, or walking in circles might reflect neurological damage due to illness or physical trauma.

Figure 3. Box turtles resting/sitting above ground during the daytime usually have bright, open eyes (at least when you draw near) even if the head is tucked in slightly. The legs may be tucked in or firmly planted on the ground.

- Does the turtle locomote normally? Limping or dragging one or more legs could be due to traumatic injury (directly to the limb or spinal cord) or disease. A heavy infestation of fly larva (maggots) in the soft tissue around or on the legs can impair movement.

Keep in mind that a turtle may be seriously injured or diseased yet appear alert and responsive. It is natural predator avoidance behavior, so always handle a turtle carefully.

Handling

As you begin to process the turtle, a few precautions should be followed:

- Be careful about putting your fingers between the carapace and the plastron. If the turtle closes up, you could be painfully squeezed and have trouble extracting your fingers!

Figure 4. If it is necessary for data collection to keep an already open shell from closing, place a large syringe case, ½-inch I.D. PVC pipe, or plastic wine cork between the head and a foreleg. Try not to re-use items you can't sanitize, especially if the animal shows signs of illness.

- Box turtles normally don't bite when handled gently, but as a precaution, keep your fingers away from the front of the head.

- If a turtle closes its shell, just put it down and wait for it to re-open; do not force (or rather "relax") it open unless trained by an expert. *You can cause serious damage if it is done incorrectly*. *Never* try to open or keep a turtle from closing its shell if there is an unhealed break/crack in the carapace, plastron, or bridges (the point at which the upper and lower shells connect on each side of the body).

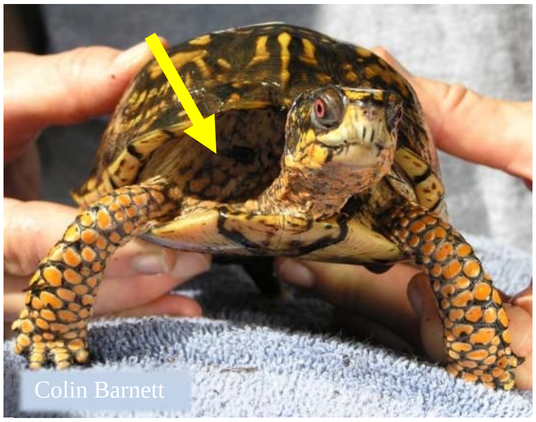


Figure 5. Eastern Box Turtle showing normal weight (left) and underweight conditions (right). Note the deep concavity in the underweight individual.

- Do not pull a turtle's head out to examine it unless trained by an expert on how to gently and slowly do so. You can cause serious injury. For most studies, it is adequate to simply examine the animal's head, neck, and forequarters without restraining the head.

- When you need to turn a turtle over to look at its underside, do it slowly. Turn the animal 180 degrees, side over side, inspect the underside, and then turn it back the same way. (This eliminates the possibility of twisting the intestines – a rare but potentially fatal condition.)

The Head

The head should be free of any lumps or irregularities. Viewed from top and straight in front, it should look symmetrical and flat on the sides. The eyes should be bright, alert, and of equal size, the nares (nostrils) open, and mouth clean and pink (or pale grey in some Ornate Box Turtles).

Figure 6. This Eastern Box Turtle quickly improved with drug therapy and supportive care and was returned to its point of capture the following spring.

The Eastern Box Turtle in Figure 6 was found sitting on top of the leaf litter in a Maryland forest on a cold November day. When first brought into rehab (left), it was lethargic and clearly suffering from a respiratory infection. Note the thick, white nasal discharge and bilateral inflammation of the eyelids (worse in the left eye). The turtle quickly improved was returned to its point of capture. There should be no discharge from the eyes, nostrils, or mouth. Eyes that are puffy, have discharge (often combined with a nasal discharge) are generally signs of a respiratory infection although there may be other complicating health issues as well.

The Eastern Box Turtle on the left in Figure 7 was extremely weak when found on a fall day. It's sunken, closed eyes indicated that it was severely dehydrated. A radiograph confirmed it was suffering from a lower respiratory infection (pneumonia). Frostbite was responsible for the loss of the right eye of the turtle on the right as well as the damage to the tissue on the tip of its snout. It was found with fresh damage after a cold front with snow hit the Mid-Atlantic following a week of unseasonably warm weather.

Figure 7. Sunken eyes in the two turtles shown here were from different causes.

Listen to the breathing. In a healthy box turtle, the only sound they emit is a "hissing" when air is expelled as the head is retracted into the shell. In turtles with respiratory infections, breathing is often accompanied by wheezing, crackling, and popping sounds.

Ears

The tympanic membrane, or external eardrum, is a large disk-shaped scale located just behind the jaw on each side of the head. It should appear flat in its normal, healthy state (Figure 8, on right). When the ear is infected, pus (usually cheesy in consistency) accumulates in the middle ear, eventually forcing the tympanum membrane to bulge (Figure 8, on left). There may also be pus draining down into the oral cavity (mouth) via the connecting Eustachian tubes. Aural (ear) abscesses can affect one or both ears, often do not self-resolve, and can become life threatening. Veterinary attention is recommended.

Figure 8. The right tympanum on the juvenile Eastern Box Turtle on the right is normal. The left tympanum on the same animal (left) is swollen and infected.

Figure 9. The large aural abscess on this box turtle prevented it from closing its shell. The infection had spread systemically by the time the animal was found and it died despite medical intervention.

Figure 10. The swelling in the throat of this Eastern Box Turtle contained a large abscess that tracked internally to an infection originating in the left ear. The tympanum over the affected ear appeared normal. The blood on the neck is from the incision made to remove the pus.

Oral Cavity

An oral examination is recommended; it is often the most revealing component of an examination. The mouth should be pink (sometimes pigmented grey in the Ornate Box Turtle), moist, and clean-looking. In dehydrated turtles, the mouth may be tacky. Other unhealthy conditions may be expressed by an unusually pale or bright red/inflamed oral cavity, one coated in a cheesy film, or one containing raised yellow or whitish plaques. Also look for discharge (bubbles/foam, blood) that could suggest that the animal is ill or possibly suffering from a head/mouth or internal injury.

Figure 11. The oral cavity and tongue of a healthy *Terrapene carolina* is normally a medium pink (left). In *Terrapene ornata*, the oral cavity may be pale pink with a pale grey tongue (right).

Figure 12. The turtle on the left has advanced infectious stomatitis (a mouth infection) of undetermined origin. The turtle on the right has ranavirus, a highly contagious disease among susceptible cold-blooded vertebrates. The yellowish raised plaques on the palate and tongue are indicative of this disease. Extra caution should be taken in handling such turtles and anything they encounter, such as cage bedding.

Neck

The presence of any swelling, lumps, skin flaking, discoloration, fresh or healed wounds, and discharge should be recorded. In addition, the skin should be checked for the presence of any parasites (ticks, mites, leeches, fly eggs, or larvae). Flesh flies, as seen in Figure 13, have larvae that enter through small existing openings or weak spots, such as thin scar tissue from old tick bits, creating an open-ended large swelling with a black discharge (arrow). A heavy infestation can kill a turtle. The larvae (upper right) can be carefully removed with tweezers and the wound(s) flushed with sterile saline. (This is best left to an experienced rehabber or veterinarian.) Severe infestations may require topical and systemic antibiotic therapy.

Noah Charney

Figure 13. *Cistudinomyia cistudinis* is one of several species of flesh flies that parasitize reptiles, this one specializes in turtles and tortoises.

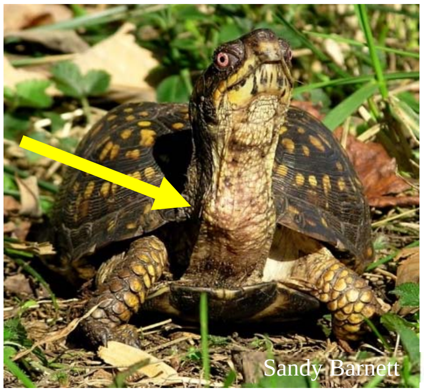


Figure 14. The lump on this box turtle's neck contains a small confined abscess, which a veterinarian removed under anesthesia. The cause of the abscess is uncertain but may have been caused by a puncture wound from thorny vegetation or an insect bite that became infected.

Limbs / Surrounding Soft Tissue

Check the limbs and feet for injuries, missing or malformed digits, sores, swellings, and parasitic infestations. Don't forget to check the skin where the fore and hind limbs join the body and the "seam" where soft tissue meets the shell. Injuries and parasitic infestations in these areas can easily be overlooked.

Figure 15. All four feet on this Eastern Box turtle are malformed. The cause is unknown. The turtle seemed otherwise fine and was left on site.

Parasites should be removed with tweezers, or in the case of a coating of fly eggs and maggots, gently flushed away with plain water. Do not allow water to enter infested wounds that extend into the body cavity, including through a fractured shell. Take the turtle to a qualified reptile rehabilitator or veterinarian for appropriate treatment. Treatments are discussed at www.boxturtlefacts.org/tools.

Cloaca

A healthy cloaca should be clean and free of any fecal staining or bloody or other abnormal discharge. It should also be free of swelling, lumps, or prolapsed tissue. (For more information on prolapses, see www.boxturtlefacts.org). If a turtle has a soiled cloaca, or inflammation around the cloaca, flies may opportunistically strike and lay their eggs there.

Figure 16. Left—A box turtle's vent should be clean and free of any lumps, swelling, or inflammation. Right—This box turtle has a tail abscess of unknown source.

Shell

Examine the shell for any soft spots, pitting, erosions, fractures, scute or bone loss, bruising, or discharge.

When checking the shell for defects, remember to carefully examine the bridge where the upper and lower shell join between the front and hind legs. Such breaks are easily overlooked and, like any fracture, provide a pathway for contaminants, pathogens, and flesh-eating fly larvae to enter.

Figure 17. Carapace pits have been reported in Three-toed Box Turtles from Oklahoma and Missouri (Carpenter 1956; Schwartz and Schwartz 1974). These pits are mostly found in the suture between the second and third pleural scutes on the carapace in the central half of the suture line between the marginal and the vertebral scutes. These pits are not considered to be a health problem; their cause is unknown.

Figure 18. Left—When this box turtle was struck by a vehicle, the right bridge was broken. Right—This box turtle was hit by an agricultural mower when it was a small juvenile, breaking the right bridge. It was not stabilized properly, causing the plastron to grow at an angle (since it was only firmly attached by bone on the left side to the carapace), eventually impairing the ability of the turtle to close its shell completely.

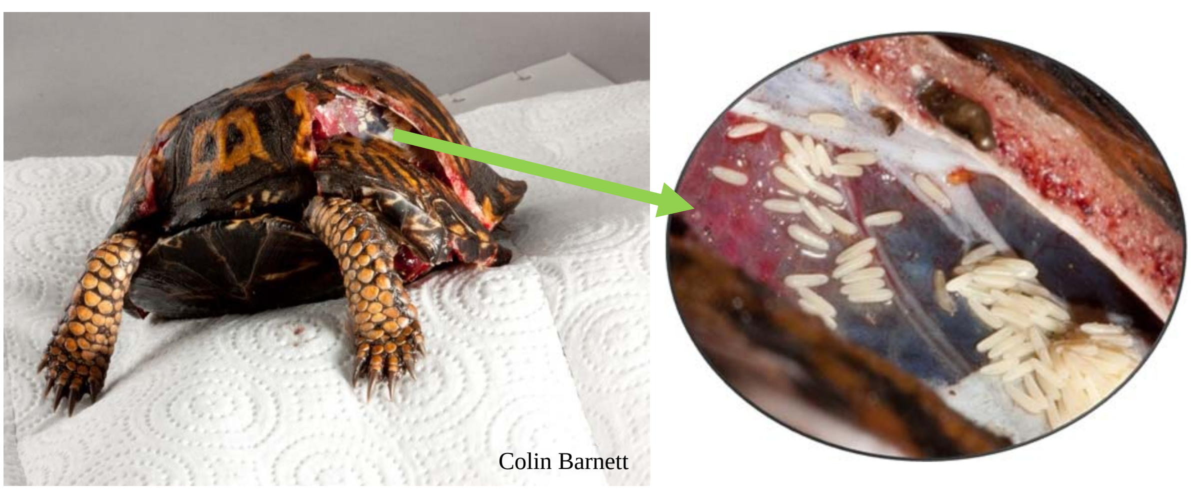


Figure 19. “Myiasis” is the infestation of fly larvae in a vertebrate. Blow flies and flesh flies are attracted to open wounds or even intact skin where moist conditions (such as the area where the limbs join the trunk in turtles) can support hatching larvae (maggots) as they burrow through the skin and into the body. Larvae can gain entry through fresh narrow shell cracks too. In warm weather, fly eggs may hatch in less than a day. Large infestations can be life threatening.

Figure 20. Scute loss in wild turtles can be due to many causes—nutritional deficiencies, disease, metabolic imbalances, or traumatic injury.

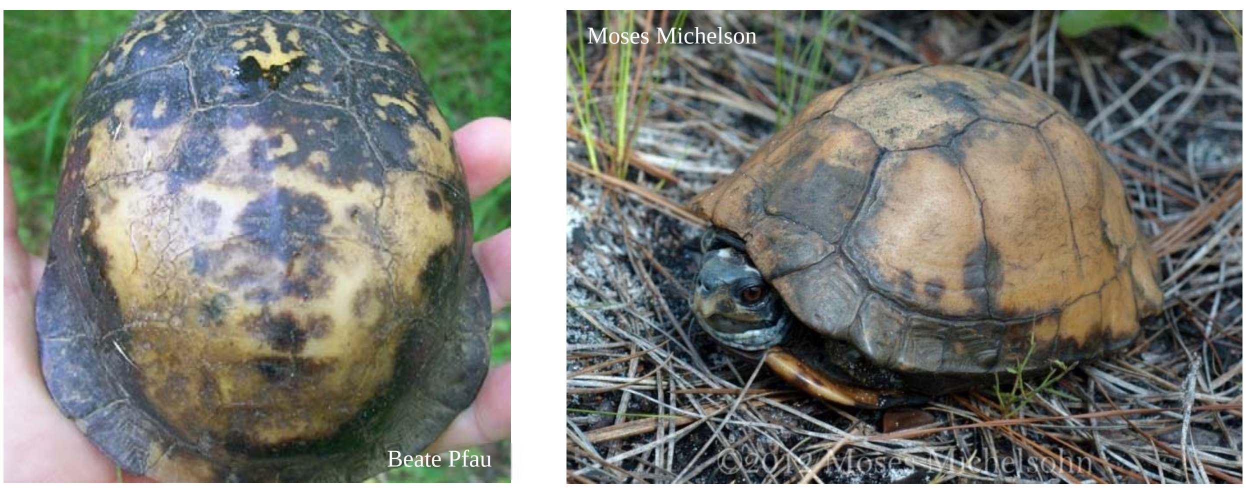


Figure 21. These turtles (left—Eastern Box Turtle; right—Florida Box Turtle) have fire damage to their shells. Such damage can leave a turtle more vulnerable to internal infections as well as negatively affect their ability to thermoregulate and control their water balance

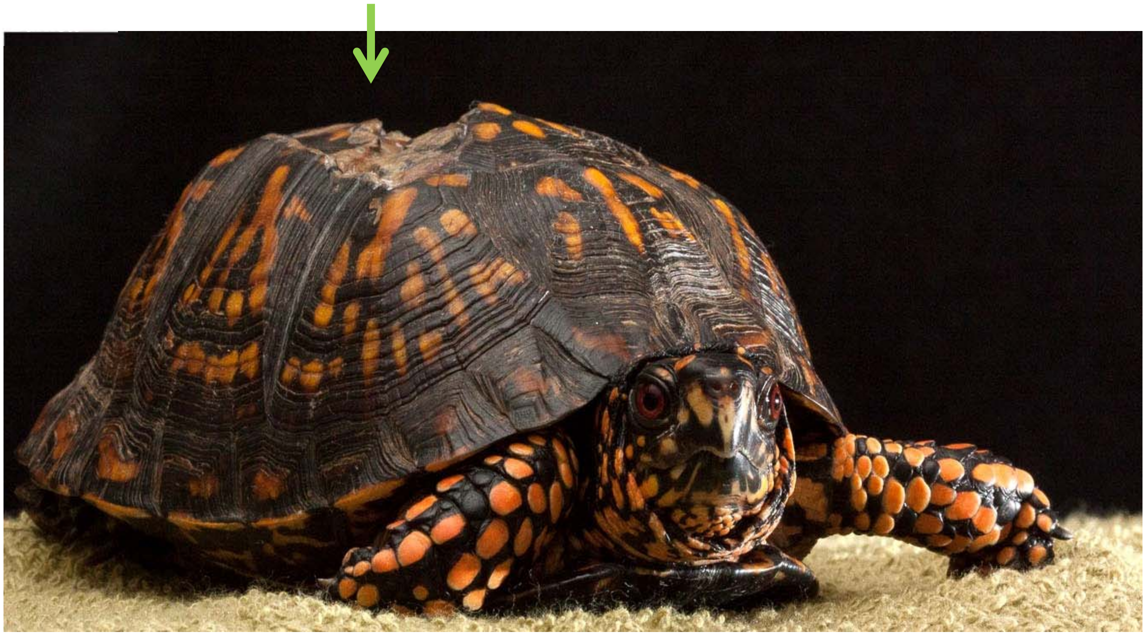


Figure 22. Turtles can make remarkable recoveries from injuries that would appear to be fatal or seriously life-altering. This Eastern Box Turtle was struck by a vehicle and sustained a large compression fracture over its back, including breaking the backbone. The spinal cord did not break. The animal recovered full use of its limbs and was re-released into forested land the following summer several hundred yards from the road where it was found.

Mark Musselman, Audubon South Carolina

Figure 23. Box turtles are remarkably resilient and often recover from their injuries. This Eastern Box Turtle from South Carolina had significant old trauma to its shell, possibly from a predator attack. The turtle appeared to otherwise be fine.

Ranavirus

Ranavirus is a genus of pathogens that affect both captive and wild Eastern Box Turtles. Ranaviruses have been implicated in several mass mortalities in fish, amphibians, and reptiles (Hausmann et al. 2015).

There is no way to tell if a turtle has an active ranaviral infection without confirmation from specialized laboratory testing. There are many symptoms associated with ranavirus, some shared with other, treatable diseases. A ranavirus-infected animal may have all, a few, or none of the following symptoms:

- Extreme weakness
- Labored breathing
- Swollen eyelids
- Sunken eyelids if very dehydrated
- Diarrhea
- Discharge from the eyes, nose, and/or mouth
- Skin sloughing on the footpads
- Patchy red blotches on the skin
- Thick white or yellow plaques on the tongue and palate (Figure 12 above) and/or cloaca

Figure 24. This box turtle is infected with ranavirus. The disease is usually fatal; animals that recover may carry the infection for life, passing the virus on to other susceptible animals.

Research to date indicates the disease is infectious between animals, with multiple modes of transmission (e.g., direct contact between animals, contact with contaminated surfaces/water, etc). Infected box turtles that undergo intensive treatment and recover from an active infection may still be carriers for life, intermittently shedding the virus and possibly infecting other susceptible animals (Hausmann et al., 2015). It is recommended that animals diagnosed or highly suspected of being infected with ranavirus (as determined by a veterinarian) be humanely euthanized. Your veterinarian can contact your State Veterinarian for guidance.

What should you do if you have determined a turtle is sick or injured?

As stated in Chapter 4, Project Leaders in the Box Turtle Connection can decide if it is appropriate, in the context of your study, to remove a sick or injured turtle for treatment. If an animal is removed, record the following information:

- date and time of removal
- exact location
- description of injury or signs of illness
- treatment given (you can obtain this from the rehabber or veterinarian)
- date, time, and location of release (it should be at the same location as where it was collected, but of course away from any nearby road)

We cannot overemphasize that during convalescence, a wild turtle should be held in strict quarantine (no contact between animals or anything they contact—including unwashed human hands) to minimize the spread of potential pathogens. Practice this in your handling of the animal and impress this upon whomever will be treating it.

If a sick or injured turtle is to be in your care for only a matter of hours, it is least stressful for the animal to be housed in a small, dark container (e.g., disposable cardboard box with closeable top) with several pencil size ventilation holes. The animal should be able to extend its appendages comfortably, but not move around or have enough space to climb the walls and end up on its carapace.

Fill the box with clean newspaper (torn into strips and crumpled), paper towels, or hand towels; the animal will feel safer and be less stressed in a dark, confined space. Spray the packing material with a little water if available; it isn't essential except in the case of hatchlings and very young

Figure 25. A disposable cardboard box filled with shredded newspaper makes a good transport container for a sick turtle. A small plastic food container with moist moss or moist field clippings works well for hatchlings and small juvenile box turtles that can dehydrate quickly. Note air holes in the side of the left box and the lid of the right box.

juveniles which can easily desiccate. Do NOT use tissue paper as packing medium; it can cling to wounds and smother an animal if it sticks to their nostrils and mouth. For animals that are sick but not injured, wet leaf litter or soft plant material from the field will do for packing it up. NEVER transport a turtle in standing water. The turtle can develop aspiration pneumonia if it inhales water, and possibly even drown.

If the animal is injured, remember that internal tissue—everything that was never meant to see the light of day—must be kept moist. Tissue that dries out is dead tissue. That includes exposed raw edges of shell. In the field, limb injuries can be rinsed off gently with plain water to remove debris, but never wash or attempt to remove impaled debris from deep wounds that enter the body cavity or shell cracks that extend beyond the marginal scutes. You can make matters worse by forcing contaminates into the wound or removing foreign bodies that are entangled with body tissue. For limb injuries, make the packing material moist to keep the injured limb(s) moist. For shell injuries, other than damage to the marginal scutes, cover the wound with gauze (or even clean paper towels, if that is all you have) that you have pre-moistened with clean water, and secure them lightly with paper tape. Alternatively, secure the gauze lightly with sports wrap. Avoid duct tape, or at least avoid applying it directly to shell or skin, since it may be hard for the rehabilitator or veterinarian to remove without causing further damage.

Additional instructions:

- Do not give an injured turtle anything to eat or drink. You do not know what type of internal injuries it may have and you do not want to contaminate any open wounds.

- The animal should be maintained at ambient temperature (assuming it is summertime) out of direct sunshine. Animals collected in cold weather should be brought indoors and kept at room temperature. Do not offer extra heating.

- If the animal has an open wound, it is vital that no flies can enter the container. A reliable way to do this is to seal the box in a cloth bag (e.g., shopping bag, pillow case).

- Put the container in a quiet spot, away from activity, and, ideally, in the dark.

- When transporting the turtle by car, be mindful of the temperature of the vehicle. The turtle's container should be placed in the cab of the car, never the trunk. In summer, do not blast the turtle with the air conditioner, and in the colder months, do not place it on the front floor of the passenger side and direct hot air at the animal. You can thermally shock the animal. Place the container on the floor of the backseat or buckled in place on the car seat. Place a newspaper or cloth lightly over the box to shade it from the sun.

Finding Help

- To find a licensed wildlife rehabilitator in your area:
    - http://www.nwrawildlife.org/?page=Find_A_Rehabilitator
    - http://wildliferehabinfo.org/Contact_A-M.htm
- To find a veterinarian who treats turtles in your area:
    - http://www.nytts.org/nytts/helpnet.htm
- Contact your local reptile or turtle club or nature center that keeps herptiles to find out which veterinary service they recommend

- Contact the closest veterinary college; some have clinics that provide care for wild turtles (e.g. the vet student-run Turtle Rescue Team at North Carolina State University, https://ncturtlerescueteam.org/)

- Be sure to share all the information you have observed with the turtle's new caregivers, including the exact location where you found the turtle. Request that you are contacted when the turtle is released back into the wild if you yourself do not do it. (Some rehabilitators do not allow the public to do releases.)

Short-term Housing

Figure 26. An inexpensive, simple set-up can work well to house an injured or sick turtle. While a set-up for full rehabilitation should include a basking light and full-spectrum lighting (not shown), it is not essential nor necessarily desirable for very short-term care, especially before wounds have been properly cleaned and dressed by qualified personnel and any drug therapy begun. Under warming lights, bacteria can proliferate quickly in contaminated wounds.

For short-term care of a sick or injured turtle (no more than a couple of days), a simple set-up will work. A large plastic tote (approximately 1 ft x 2.5 - 3 ft x 12-15 inches high) is adequate for short-term care (Fig 27). A plastic flowerpot cut in half is an inexpensive hide but can make it difficult to check on the animal without stressing it unduly. A better choice is to create artificial plants (newspaper “pom-poms”) clipped to the sidewalls. Turtles feel safe and relaxed when hiding beneath this easily made, disposable enrichment. Adding in some piles of clean, moistened washcloths that the turtle can rest against or burrow into also helps to minimize stress (Fig. 28).

Figure 27. Minimizing stress plays an integral role in successful rehabilitation. Resting beneath newspaper “foliage,” we can tell this turtle feels safe and comfortable because of its relaxed posture (outstretched legs and general bright demeanor). The turtle had been found entangled in a wire planter basket disposed of carelessly in the woods. Although it lost part of its right front foot, the turtle was ambulatory and upon recovery was released back near its capture site.

For flooring, use clean moist cloth towels or several layers of moist newspaper (avoid use of shiny colored advertisement pages which may contain heavy metals). If the tote is clear or translucent, cover the outside with newspaper so the turtle cannot see out.

Figure 28. For turtles that must not get their bandages or open wounds wet/soiled, make a small drinking station.

Provide a shallow water dish (A Frisbee works well) for soaking and drinking if there are no open wounds (shell or soft tissue) that can come in contact with the water. Otherwise provide a small drinking station (Figure 28) made from a jar lid or mini Frisbee secured to a flat plastic food container lid (for stability). The two can be joined by glue or a simple loop of duct tape (sticky side out). Keep the turtle in the upper 70’s to around 80 F. For longer term housing of sick and injured turtles, see www.boxturtlefacts.org.

As when handling any wild turtle, always practice good hygiene to protect yourself from any pathogens that could be transmitted to you from the animal, or from animal to animal. Also, if you are temporarily housing more than one sick turtle, make sure to always sanitize your hands and equipment between turtles to ensure that you do not transmit pathogens between turtles in your care. Following these simple guidelines will help you to be a steward of wildlife health.

Glossary

abiotic – Non-living factors in an environment such as soil type and temperature.

annuli – Growth rings found on scutes located on the plastron and carapace of many species of turtles, including box turtles.

anthropogenic – Of or caused by humankind.

AOR – Alive on the road.

Appendix II – A list generated by Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) of species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. International trade in specimens of Appendix II species may be authorized by the granting of an export permit or re-export certificate; no import permit is necessary. (See Article IV of the Convention). *From CITES webpage* <http://www.cites.org/eng/append/index.shtml>.

biosphere – All the areas on the planet combined that contain living forms. This extends from the deepest parts of the oceans to the upper parts of the atmosphere where insects, birds, or bacteria can be found.

bridge – The bony connection between the carapace and the plastron.

caliper – An instrument with two adjustable arms (jaws) used to measure diameter or thickness.

canopy – The "roof" or top layer of the forest formed by the highest reaching branches.

carapace – The upper shell of a turtle or tortoise.

cartography – The art or technique of making maps or charts.

cervical – Of the neck. The scute overlying the nuchal bone is called the cervical scute.

chelonian – A collective term pertaining to turtles. Refers to the classification of turtle in the Order Chelonia.

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) **–**An international agreement between sovereign governments. Its purpose is to ensure that international trade in wild animals and plants does not threaten their survival.

cold-blooded – Outdated term used to describe species with body temperatures that reflect temperatures of the environment. Since the environment is not always "cold", neither is the body temperature of such creatures. Today we understand there are a variety of mechanisms for an animal to control its body temperature. The term "cold-blooded" has fallen out of favor with scientists, and the term ectotherm is preferred.

costal – Refers to the bones of a turtle's carapace that cover the ribs.

cloaca –A chamber into which an animal's digestive, urinary and reproductive systems empty. The anus is the external opening of the cloaca.

clutch – The group of eggs produced at one time by a single female.

DOR – Dead on the road.

dorsal – Of, near, on, or toward the back of an organism.

drainage – The specific region of land drained into a river or other body of water. A watershed.

ectotherm – A "cold-blooded" animal, having a body temperature that is largely determined by the temperature of the environment. Most reptiles are ectotherms. Also see "cold-blooded" above.

endangered species – A species of animal or plant in danger of becoming extinct.

estivation *also* **aestivation –** A period of inactivity, usually during the summer, in response to very hot or dry conditions.

extinct – No longer in existence; having no living descendant.

extirpated – Extinct within a region.

fecundity – The total number of eggs produced by a female.

form – A depression in the ground that a turtle makes for rest and camouflage.

GPS – Global positioning system.

gravid – A female animal carrying eggs or embryos.

hatchling – A recently hatched turtle.

herps – Reptiles and amphibians; the animals studied by herpetologists.

hibernacula – An overwintering place used by hibernating animals.

hibernation – A type of cold-weather dormancy when normal rates of metabolic activity are depressed and need for food and water decreased. Also called overwintering.

homologous – Similarity resulting from common ancestry. Body parts are homologous if they have the same basic structure, the same relationship to other body parts, and develop in a similar manner in the embryo.

human encroachment – The expansion of human activity which intrudes into the natural habitats and communities of other species.

hydrology – The study and/or the behavior of water including precipitation, evaporation, and volume.

indigenous – A species that naturally occurs within a region; native.

morphology – The size and shape of a structure.

morphometric – Measurable structural characters.

neonate – A newborn in the first few months.

non-indigenous – A non-native species. A species in an area that it does not naturally inhabit.

nuchal – Of the neck. In turtles, it refers to the bone of the carapace overlying the neck.

overexploitation – Includes non-sustainable commercial, sport, and subsistence hunting as well as live animal capture for any purpose.

palpate – To examine by touching or feeling.

plastron – The bottom part of the shell on the underside of a turtle.

pleural scute – Scute overlying costal bone on the carapace of a turtle.

posterior – Pertaining to the rear or back part.

salmonella – Rod-shaped bacteria of the genus *Salmonella* that may be pathogenic (can cause food poisoning and other diseases in humans) and can be transmitted by reptiles.

scutes – The plates or scales that cover the bones of the turtle's shell.

sedges – Grass-like plants with edges on the blades, usually found on wet ground or in water.

topography –Surface features, relative positions and elevations of land areas.

transpiration – The evaporative loss of water from a plant.

UTM – Universal Transverse Mercator Geographic Coordinate System used in mapping. Many topographic maps published in recent years use UTM coordinate system as the primary grids on the map. For more information see the USGS webpage <http://erg.usgs.gov/isb/pubs/factsheets/fs07701.html>.

vascular – Containing blood vessels or ducts for carrying lymph.

ventral – The underside or the lower surface; the belly not the back.

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