



# Sustaining America's Aquatic Biodiversity

## Turtle Biodiversity and Conservation



*Authored by Joseph C. Mitchell, Department of Biology, University of Richmond, Richmond, Va., and Kurt A. Buhlmann, Conservation International, Center for Applied Biodiversity Science, Washington, D.C.*

**T**urtles are freshwater, marine, and terrestrial vertebrates with a shell. There are approximately 350 living species worldwide in 13 families and more than 90 genera. Of these, more than 75% live in freshwater.

The inexact numbers reflect changing taxonomy and descriptions of new species. Fifty-eight species of turtles live in the United States and Canada, with the highest diversity in the Southeastern United States. Most of these are freshwater species, including the well-known box turtles that are primarily terrestrial. Of the remaining species, three are tortoises and six are marine (sea) turtles.

Turtles are found worldwide except in the coldest regions. Their diversity is greatest in the tropical and lower temperate regions. They have colonized many habitats from deserts (several tortoises), forests, wetlands, ponds, and rivers (freshwater species) to the oceans (sea turtles).

Many species of turtles worldwide and in the United States are in need of conservation and some are close to extinction, particularly in Asia. The primary threats to turtles are habitat loss, alteration, and fragmentation; mortality from road traffic, urban predators such as raccoons and introduced species; and the collection of wild turtles for the commercial pet trade and oriental food markets. Throughout the world, many people eat turtles and/or their eggs. The demand for turtles of all kinds in the oriental food markets, especially in China, is driving many species to the brink of extinction. Environmental and landscape changes

in North America threaten many populations. Pollution (e.g., contamination by pesticides) is known to disrupt endocrine function and cause sex reversal in some species.

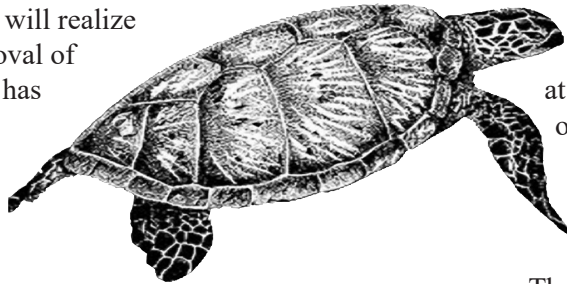
Turtles are some of the longest-lived vertebrates. In studies of North American freshwater turtles, Blanding's turtle appears to be one of the longer lived turtle species, as individuals older than 55 years are known to be reproductive. The oldest known age for painted turtles in a Michigan population was 34 years old. Yellow-bellied slider turtles and eastern mud turtles in South Carolina were both estimated to live for about 35 years. The fact that most turtles are long-lived, with most living for several decades and some known to live as long as a century, makes it difficult for these unique animals to sustain losses of individuals from populations.

A primary reason why many tortoise and freshwater turtles are endangered is their life history strategy. They take a long time to reach sexual maturity (i.e., some species require 20 years). This is in sharp contrast to traditionally-hunted North American wildlife species such as rabbits or white-tailed deer that can reproduce at six months to one year of age; these animals may only live to be 2 or 3 years old. Conversely, turtles spend their juvenile years building hard shells that will enable them to survive for many years; perhaps a century for a few species, such as the giant tortoises of the Galapagos Islands.

Eastern box turtles, for example, possess a life history much like humans; they reach maturity in their teens,

produce few offspring, and live for decades. The significant differences are that in turtles there is no known curtailment of the ability to reproduce and egg and juvenile mortality is high. Thus, loss of the older individuals in a population causes major negative effects. Many box turtles are killed on roads annually and many are collected for the pet trade. Consider that this and other turtle species cannot withstand losses of adults and one will realize that the killing and removal of even one old individual has serious consequences.

Conservation efforts on behalf of turtles include protecting habitat, controlling or preventing collecting, and reducing mortality through management of habitats and predators. Efforts are local, national, and international. The list of resources at the end of this publication provides a window into these activities.



## What Is a Turtle?

No one mistakes a turtle for anything else. One sees them basking on logs in lakes and ponds, walking in the forest or other terrestrial habitats, or nesting on beaches along the shoreline. Some species are secretive and seldom seen. Turtles are incredibly diverse. They come in all shapes and sizes, and each species is unique. The massive sea turtles have limbs that are modified to resemble paddles. They can, and do, travel across an entire ocean, but have great difficulty hauling themselves up on an ocean beach to dig a nest. At the opposite end of the spectrum are the land tortoises which have club-like feet that resemble those possessed by elephants. Tortoises may drown if they fall into water over their heads.

Most freshwater turtles, including the ubiquitous box turtle, have limbs modified to allow for both swimming and walking. However, variation within freshwater turtles is still great. The soft-shell turtles are fast and powerful swimmers, the snapping and musk turtles, often called “stinkpots,” are underwater “bottom walkers,” while the colorful spotted turtle is confined to shallow wetlands.

All turtles are included in the Order Testudines. Modifications of the unique shell and other body parts characterize each of the 12 families worldwide. Of these, seven families occur in North America. They include sea turtles, tortoises, soft-shell turtles, snap-

ping turtles, box turtles, map turtles, mud turtles, cooters, sliders, and painted turtles, among others.

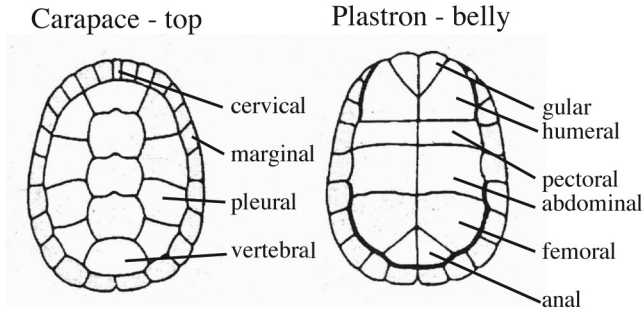
All turtles lay shelled eggs. Most deposit them in nests constructed in the ground by the female parent and a few lay eggs in leaf litter and on stumps in wetlands. Most turtle species (and all crocodylians) possess temperature-dependent sex determination (TSD); the sex of the baby turtle is determined by nest temperatures at a sensitive time during embryonic development. There are no sex chromosomes as in most other vertebrates.

## Structure and appearance

The distinctive shell is the most unique feature of turtles. The leatherback sea turtle has the largest known shell with a length of over six feet. Turtle body armor is made up of 59 to 61 dermal bones organized into an upper part (carapace) and lower part (plastron) of the shell that are connected together by extensions (bridges) of the plastron. Many bones (ribs, vertebrae, and sternum) are modified and expanded to form the shell. Another unique aspect of turtles is that the pectoral and pelvic girdles are positioned inside the rib cage (shell); they are outside in all other vertebrates. This body plan has been in existence for over 200 million years. Other features include a sharp-edged beak without teeth, hard, keratinized (fingernail-like) plates that overlap the bony shell, and the ability of some species to pull their heads and necks inside the protective shell.

Sea turtles are the largest of the North American turtles. Their forelimbs are modified into flippers and rear limbs are formed as paddles. Freshwater turtles in the Family Emydidae all have hard shells and are highly variable in color and pattern. They include the largest freshwater turtles, the snapping turtles that have large heads, massive jaws, sharp claws on powerful limbs, and flexible shells. Mud and musk turtles in the Family Kinosternidae are small, relatively drab species with dark shells and skin and scent glands that produce foul-smelling odors in some species. Soft-shell turtles lack the hard shell and instead have a flexible, leathery skin covering a reduced bony structure. These highly aquatic species have long necks and powerful limbs with expanded feet for swimming fast. Tortoises have hard, relatively high-domed shells, rear feet modified like elephant's feet for walking, and wide forelimbs and toes designed for digging burrows.

## Morphology: The Turtle Shell



Hatchlings and juveniles of all species have soft shells compared to adults because the bones take months to years to harden. The young of some Asian species have spines along the margins of their shells at hatching that may serve to protect the turtles until the shells harden.

### What do they eat?

Turtle diets vary widely. Some are strict herbivores, others are herbivorous as adults but carnivorous as juveniles, some are entirely carnivorous, and others are strictly omnivorous. Strict herbivores include tortoises and the green sea turtle. Those that switch from animal prey as juveniles to plants as adults include river cooters, red-bellied turtles, and red-eared sliders. Strict carnivores include leatherback sea turtles (they prefer jellyfish), loggerhead sea turtles (crabs), chicken turtles (crayfish, other invertebrates, insect larvae), map turtles (mussels), mud and musk turtles (snails, mussels), soft-shell turtles (invertebrates, fish), and juvenile alligator snapping turtles (small fish caught by “luring” them with a worm-like tongue). Surprisingly, the adult alligator snapping turtle is an omnivore, scavenging dead fish but also consuming acorns that float on the water surface in the fall. Turtles that eat both animal prey and plants as adults and juveniles include common snapping turtles, box turtles, painted turtles, and spotted turtles. Box turtles eat slugs, carrion, fruits, berries, and leafy plants. The estuarine diamondback terrapin specializes on snails and clams.

### How do they reproduce (life cycle)?

Adults of most species (e.g., painted turtles, cooters, sliders) engage in elaborate courtship rituals, although some, such as mud and musk turtles, have relatively simple mating rituals. Fertilization is internal. Females of small species lay one to ten eggs, medium-sized females lay ten to 30 eggs, snapping turtles can lay 75 eggs, and sea turtles can lay up to 200 eggs

in each nest. Sea turtle females may deposit several clutches in a single season but most turtles will lay only one clutch in a year. Many will skip years between reproduction depending on food resources in previous years.

Most species in North America lay eggs in late spring and embryos develop within the eggs for about 60 to 90 days. Hatchlings of some species emerge immediately from the nest once they hatch from the egg. However, hatchlings of other species (often painted turtles, chicken turtles, and red-bellied cooters) remain in the nest after hatching, sometimes over an entire winter, to emerge the following spring at a presumably more favorable time. Hatchlings of painted turtles in the north are able to tolerate subzero temperatures and being partially frozen. Hatchlings of sea turtles are well known for their synchronous hatching and mad dash for the sea, usually in August or September of the same year the eggs were laid. Other species that do not overwinter in the nest include snapping turtles, musk turtles, and bog turtles.

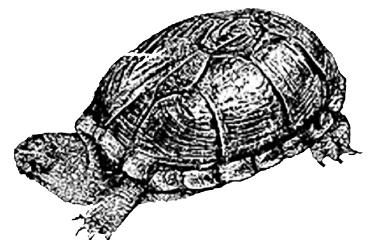
### How long do they live?

Turtles live long lives. The oldest documented is an Aldabra tortoise caught as an adult and held in captivity for 152 years until its accidental death. Documented ages for eastern box turtles are over 100 years in the wild, and up to 75 years for Blanding’s turtles and 60 years for alligator snapping turtles and wood turtles. Most species of freshwater turtles live for at least several decades.

Turtles grow rapidly as juveniles until they reach reproductive maturity. Growth then slows down, although individuals are capable of growing each year until they die. One can often determine the age of a juvenile turtle by counting the growth rings (annuli) on the shell, similar to looking at rings on a tree trunk. Turtles of all species, however, exhibit years of no or limited growth, especially once they reach maturity. The growth rings on older individuals are too close together to count, thus this method is accurate only for the first four to five years of growth, generally.

### Distribution and Diversity

Turtles occur in temperate and tropical regions on all continents except Antarc-



tica and in all the major oceans. Tortoises and freshwater turtles are found in seven major regions of the world. Centers of biodiversity for turtles are in South-eastern Asia, the Southeastern United States, Central America, the Amazon Basin, and Eastern Australia.

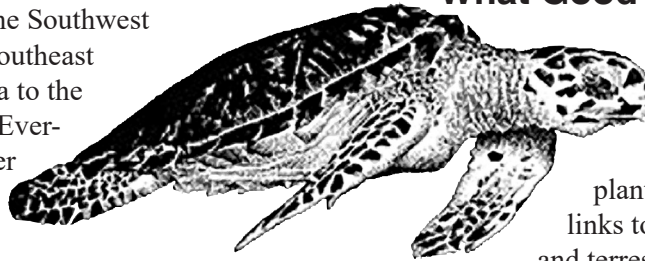
Most species in North America occur in the Southeastern states from east-central Texas eastward to the Atlantic states, with several species extending their ranges well into New England and southern Canada. Tortoises inhabit deserts of the Southwest and dry, sandy areas of the Southeast from southern South Carolina to the northern edge of the Florida Everglades. Most of the freshwater pond and river turtles occur in the eastern and midwestern portions of the continent with two species reaching the West Coast. Mud and musk turtles occur primarily in the Southeast and extend into Central America. Soft-shell turtles are primarily found in the Southeast and Midwest, but occur up the Rio Grande into New Mexico and have been introduced into the lower Colorado River. The diamondback terrapin occurs only in salt marshes along the Gulf and Atlantic coasts from near Corpus Christi, Texas, to Cape Cod, Massachusetts. Sea turtles occur along the Atlantic Coast as far north as New England, although the leatherback has been seen as far north as Nova Scotia. Sea turtles seldom occur along the rocky Pacific Coast except in Baja California.

### Where do they live?

Different habitats support different species of turtles. Sea turtles are exclusively marine and estuarine except when females come ashore to lay eggs. Juveniles of three species along the Atlantic Coast spend summers in the Chesapeake Bay and one makes it up to Long Island. Diamondback terrapins occur only in estuaries and coastal bays with brackish water. Large lakes and ponds support cooters, sliders, snapping turtles, painted turtles, and musk turtles. Large rivers support river cooters, softshells, map turtles, musk turtles, and the alligator snapping turtle. Smaller streams in the Northeast support wood turtles. Mud, spotted, bog, and wood turtles occupy shallow freshwater marshes and marsh-like systems along streams. Few species occur in mountainous areas, although the eastern box turtle occurs at over 5,000 feet elevation, and the bog turtle is found in mountain seeps at

mid-elevations in the Blue Ridge Mountains. Large vernal pools and most Carolina bays support populations of painted, chicken, and mud turtles, sliders, and snapping turtles. Box turtles occupy hardwood forests, open grasslands, and agricultural areas. Gopher tortoises occur in the Southeastern United States pinelands where the soil is dry and sandy, and desert tortoises inhabit in the Mojave and Sonoran deserts.

### What Good Are They?



Turtles, tortoises, and sea turtles play many important roles on the ecological stage. As consumers of plants and other animals they are links to the energetic webs in aquatic and terrestrial ecosystems. As prey of other animals (as eggs, juveniles, and adults), they are sources of energy to other links in the food web. Movements of turtles among wetlands and between wetlands and terrestrial habitats, especially to lay eggs in terrestrial nests, results in a major energy transfer link between these two ecological systems. The loss of any turtle species, each of which represents over 200 million years of evolution, persistence, and genetic information, would create a void that can never be filled by other species.

As long-lived vertebrates, they are studied to learn how animals have evolved to cope with uncertainty in a wide variety of environments. Turtles are models for the study of longevity, and may show us how to reduce senility and prolong human life. In some developing countries, turtles provide important sources of protein and economic stability, although hunting wild turtles has created a major conservation crisis in Southeastern Asia.

Turtles have been included in the mythologies of many ancient cultures. In a Hindu myth, the earth is a hemisphere resting flat side down on the backs of four elephants standing on the back of a giant tortoise. North American Indians included turtles in their myths and in their daily lives, mostly as food, implements, and ritual objects. Various forms of art have used turtles as their subjects. Not only do turtles have ecological values in their natural systems, they provide cultural, artistic, and spiritual inspiration values.

Like all species with which we inhabit the earth, we sometimes have a difficult time justifying why turtles are unequivocally important to humans. However, if we consider turtles as rivets on the wing of an airplane, we might pop out a few rivets with no ill effects, but if we pop out enough rivets, eventually a wing will fall off. If too many animal species become extinct, the natural ecosystem that supports life on Earth will crash, perhaps bringing humans down with it. Protecting turtle habitat will undoubtedly help to protect ecosystems and other forms of life, animals, and plants.

## Threats to Turtles

Habitat loss and exploitation for food markets are the most important threats to turtles worldwide. Loss of freshwater wetlands, hardwood forests, longleaf pine forests, and nesting beaches along coastlines and rivers have caused population losses worldwide. Conversion of desert or scrub lands to agricultural fields and monocultures reduces habitat for tortoises. Channelization of streams and rivers causes loss of critical basking and nesting habitat.

Several species spend parts of their annual life cycles in freshwater and the rest of the time on land usually buried in the substrate. Mud and chicken turtles, for instance, spend months, including winters, buried on land. Forested uplands connected to wetlands are very important habitats for turtles and other animals that need and use both land and water habitats. Individuals of most species occasionally wander away from their home wetland and move long distances to other wetlands. The habitats that connect these distant wetlands are corridors for migrating turtles. Highways, housing developments, and forest clear cuts are roadblocks and deathtraps for turtles and other wildlife trying to migrate to other wetlands. Female turtles of some species, like the Blanding's turtle, move over a mile to find suitable nest sites.

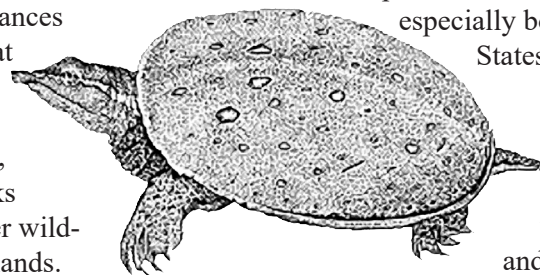
Hunting and collecting wild turtles for food markets in Southeast Asia and the pet trade worldwide threaten most species with extinction. Laws in the United States and Canada prevent the commercialization of turtles, and yet turtles are still being shipped to Asia for food. Pressure on turtle populations in the United States are expected to grow as demand in Southeast Asia increases.

Commercial fisheries, including long-line and drift gill nets in the open ocean and fish traps and shrimp trawl nets in shallow seas have severely reduced sea turtle populations. By-catch (accidental catch of non-target species) in fish nets, trawls, and traps is the most significant reason for the decline of leatherback sea turtles.

Respiratory diseases in desert and gopher tortoises in North America have caused population die-offs and declines. Such an infection resulted in the addition of the Mojave Desert tortoise population to the federal list of threatened species. Swollen neck abscesses in the eastern box turtle has been correlated with pesticide pollution. Severe malformations of the turtle shell have been related to industrial pollution.

The introduction of exotic wetland plants, such as phragmites and purple loosestrife, that have out-competed native aquatic plants, has reduced natural turtle habitat nationwide. The bog turtle has lost much of its native habitat because of foreign invasive wetland plants and is now on the federal list of endangered species.

Urbanization and suburbanization have reduced natural turtle habitat and created good environments for turtle predators. The most notorious turtle predator is the raccoon, which eats both turtle eggs and adults. Raccoon populations in urban areas have increased because of garbage and artificial feeding and the elimination of raccoon predators. Highway traffic is responsible for the loss of thousands of turtles, especially box turtles, annually in the United States.



## What Can You Do?

Everyone should be aware of the plight of turtles worldwide, and learn of conservation activities, including local and state laws regulating turtle trade. Make sure that the turtles in your pet store are legally caught and sold. Report any suspicious activities to the proper authorities.

Help prevent the loss of habitat, especially wetlands and the adjacent uplands. Participate in local land-use planning, and help to ensure that wetlands and riparian areas are set aside and protected. Remember that the adjacent uplands are equally as important for some turtles as the wetlands they inhabit. Participate in habitat restoration projects. Learn more about turtle

conservation and always take the opportunity to educate others about the plight of these unique animals.

Turtles are one of the most ancient and unique of all aquatic animals that have survived through evolutionary time. Because they are still with us, we sometimes take them for granted. However, if they only existed as fossils in museums, we might view their unusual protective bony shell with wonder. Turtles stimulate appreciation for nature in young people. Future human generations would be impoverished without them.

## Turtle Web Links

Partners in Amphibian and Reptile Conservation (PARC): <http://parcplace.org>

Virginia Herpetological Society: <https://www.virginiaherpetologicalsociety.com>

Northeast Turtle Conservation Plans: <http://www.northeastturtles.org>

Turtles of South Carolina and Georgia: <https://srelherp.uga.edu/turtles/>

New Jersey Bog Turtle Slide Show: <http://www.state.nj.us/dep/fgw/slideshows/bogturtle/bogtrintro.htm>

Ohio Reptiles: <http://wildlife.ohiodnr.gov/species-and-habitats/species-guide-index/reptiles>

Turtle Conservation Fund, A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: <https://turtleconservationfund.org/global-action-plan/>

Distribution of World Turtles: <http://emys.geo.orst.edu>

Habitat Management Guidelines for Amphibians and Reptiles: <http://parcplace.org/habitat/habitat-management-guidelines/>

Turtle Conservancy: <https://www.turtleconservancy.org>

## Selected Books and Publications

Buhlmann, K.A., Hudson, R., and Rhodin, A.G.J. 2002. A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: Strategy and Funding Prospectus 2002-2007. The Turtle Conservation Fund. Washington D.C. Conservation International and Chelonian Research Foundation, 30 pp.

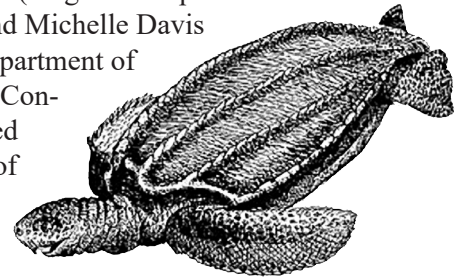
Dodd, C.K., Jr. 2001. *North American Box Turtles, A Natural History*. University of Oklahoma Press, Norman, Okla.

Ernst, C.H., Lovich, J.E., and Barbour R.W. 1994. *Turtles of the United States and Canada*. Smithsonian Institution Press, Washington, D.C.

Klemens, M.W. 2000. *Turtle Conservation*. Smithsonian Institution Press, Washington, D.C.

## Acknowledgements

Nancy Templeman (Virginia Cooperative Extension) and Michelle Davis (Virginia Tech Department of Fish and Wildlife Conservation) provided editorial reviews of previous versions of this publication. Additional support was provided by Randy Rutan and Hilary Chapman (National Conservation Training Center, U.S. Fish and Wildlife Service.) Virginia Master Naturalist volunteers Rod Allen, Lisa Klein, Tammie Lowry, Susan Sims, and Darol Wood reviewed and edited the current version.



Art illustrations by Sally Bensusen, Mark Chorba, and Mike Pinder.