

## Bog Turtle

*Glyptemys muhlenbergii*

Other Names: Muhlenberg's Turtle

Family: Emydidae

Order: Testudines

### Description

*Glyptemys* (formerly *Clemmys*) *muhlenbergii*, the bog turtle, is a secretive, semi-aquatic species, and likely the smallest turtle species in the world (Pritchard 1979). Conant and Collins (1991) give a maximum recorded carapace length of 114 mm. From 80 adult bog turtles captured from various locations in seven southeastern Pennsylvania counties, we found an average maximum carapace length of 94.8 mm, with a range of 81.0-107.9 mm. The brown or black carapace is slightly sculpted and may have light brown markings, sometimes resembling a starburst-like pattern radiating from the central portion of the scutes. The carapace is somewhat domed and has a slight mid-dorsal keel. As viewed from above, the sides of the carapace are straight-sided and somewhat parallel. Growth rings are typically visible on the scutes of young to middle-aged bog turtles (Ernst et al. 1994, Hulse et al. 2001). Due to their burrowing habit, many older individuals have worn their scutes such that growth rings are faint to non-existent. Some bog turtles have extremely worn shells that resemble smooth obsidian. The coloration of the plastron is predominantly dark brown to black, sometimes exhibiting tan or brownish markings originating along the centerline. A diagnostic trait of *G. muhlenbergii* is an orange-colored blotch located behind each eye on the neck and head. These markings may also be reddish or yellowish and look more like flecks than blotches. The background color of the skin is dark brown to black, and may contain brown, orange, or red (Ernst et al. 1994).

The species exhibits sexual dimorphism. Adult males have a more elongated and flatter carapace than the female. The male's plastron is concave. Males have much longer, thicker tails and the cloaca of the male extends beyond the rear edge of the marginal scutes, while the female's cloaca does not (Ernst et al. 1994, Lovitch et al. 1998). The head of the male appears slightly larger than that of the female (pers. obs.).

### Range

Two separate geographical populations of *G. muhlenbergii* are recognized (USFWS 2001). The northern population exists within NY, MA, CT, NJ, PA, DE, and MD. A disjunct southern population, separated by 250 miles from the northern population, exists in VA, NC, TN, SC, and GA, primarily in the Blue Ridge Province (Lee and Herman 1999). A significant portion of the northern population's range is found in PA. PA and NJ contain the highest number of extant bog turtle sites within the northern population (USFWS 2001).

### Distribution and Relative Abundance in Pennsylvania

Bog turtles are limited in distribution to portions of 15 southeastern and eastern counties and possibly other isolated areas in northwestern Pennsylvania. Fragmented populations are documented from Franklin and Cumberland Counties eastward to the Delaware River and northward to Monroe County. However, the occurrence of bog turtles in Franklin County is uncertain (C. Urban pers. comm.). A northwestern population existed in Crawford and Mercer Counties but is now considered historic or extirpated, with the last verified specimen captured in 1928 (C. Bier pers. comm.). Although significant acreage of habitat exists, limited surveying has failed to confirm the northwestern population in recent years. Due to increased interest in the species and survey requirements when land development impacts are proposed, new occurrences of bog turtles continue to be discovered in Pennsylvania. Most of the new occurrences are presumed to have a low number of individuals and are effectively isolated from other colonies (C. Urban pers. comm.).

### Community Type/Habitat Use

*G. muhlenbergii* is a habitat specialist that relies on early successional, groundwater-driven, emergent wetlands. The classic example of bog turtle habitat is a spring-fed emergent wetland meadow with dominant vegetation consisting of sedges and other low herbs, often containing a scrub-shrub wetland component, and with soft mud or mucky soils. Herbaceous species typically encountered in Pennsylvania's bog turtle wetlands include sedges (*Carex* spp.), skunk cabbage (*Symplocarpus foetidus*), cattail (*Typha latifolia*), jewelweed (*Impatiens* spp.), tearthumb (*Polygonum* spp.) and sensitive fern (*Onoclea sensibilis*). Common woody species include red maple (*Acer rubrum*), silky dogwood (*Cornus amomum*), arrowwood (*Viburnum dentatum*), alders (*Alnus* spp.), elderberry (*Sambucus canadensis*), and willows (*Salix* spp.). The preferred hydrologic characteristics typically encountered in Pennsylvania include persistent groundwater output and pockets of shallow surface water, creating saturated mucky conditions. During dry periods, the wet areas within and suitable bog turtle habitat may be restricted to springheads. Typically, wetlands that contain *G. muhlenbergii* are interspersed with a mosaic of wet and dry areas, often with subsurface flow. In addition, shallow rivulets (less than 10 cm

deep) or pseudo-rivulets are often present (USFWS 2001). Persistent groundwater discharge is critically important to maintaining hydrology and saturated soils, and may be linked to unique geological features. Bog turtle wetlands are usually situated above the floodplain. The third criteria of bog turtle habitat is suitable soils – saturated mud or mucky substrates a minimum of 7.5-10 cm deep to facilitate burrowing. In Pennsylvania, the typical soil in a bog turtle wetland consists of a saturated (“mucky”) mineral soil, e.g., loam, silt loam, etc. In some areas, a true organic muck or peat may occur or an organic surface layer may overlay a saturated mineral horizon. Portions of a wetland supporting bog turtles may lack one or more of these three required criteria. Recent radiotelemetry research has indicated that some individuals may spend considerable time during the active season within beaver ponds, stream systems, wooded swamps, and other habitats considered to be suboptimal (C. Urban pers. comm.). These findings may be due to seasonal shifts in habitat use, or in response to natural and anthropogenic habitat stresses.

### **Behavior and Ecology**

Bog turtles in Pennsylvania typically emerge from hibernation in late March through April. The specific timing is dependent upon local weather conditions. Ernst (1977) found that in Lancaster County, Pennsylvania, bog turtles became active at a water temperature of 7°C, but did not begin feeding until water temperatures rose to 13.5°C. Early research suggested that bog turtles exhibited a bimodal activity cycle and aestivated during the hot, dry summer months (Ernst 1985). Recent telemetry research has indicated that bog turtles remain active and may not be visible due to dense vegetation in the summer and fall. Bog turtles are often associated with tussock sedge (*Carex stricta*) and other tussock-forming vegetation (*Scirpus*, *Cyperinus*, and *Carex* spp.) that create a wide range of micro-atmospheric conditions allowing bog turtles to choose from a variety of temperature, solar, moisture, and humidity ranges. Bog turtles occasionally bask in the open; however, most individuals we have found are partly submerged in muck or shallow water with a portion of their carapace exposed, or partially or totally obscured by living or dead vegetative matter. When threatened, bog turtles withdraw into their shells or will quickly burrow headfirst into the soft substrate, disappearing within seconds. Bog turtles use surface runs and underground, water-filled tunnels. Many of these features are likely started by small mammals and then enlarged by bog turtles. Other tunnels used by bog turtles result from subsurface water flow and groundwater discharges.

Ernst (1977) studied the home range of bog turtles in Lancaster County, Pennsylvania and found the mean home ranges of males and females to be 1.33 ha and 1.26 ha, respectively. In Maryland, Morrow et al. (2001) found that although males expand their home range during the mating season, home range sizes between males and females were not significantly different. Individual turtle home ranges varied from 0.003 ha to 3.12 ha, with considerable variation between years and sites. They suggest that the species’ home range may increase with decreasing habitat quality. Bog turtles do not defend a defined territory, but adult males almost always attack or threaten smaller males (Ernst et al. 1994). The probable lifespan of bog turtles is 25-35 years or more. In Pennsylvania, one (currently) living, wild female was recently documented at 48 years of age (G. Gress pers. comm.). Bog turtles are omnivorous and will eat insects, slugs, worms, frogs, salamanders, *Carex* seeds, Japanese beetles, berries, cattails, skunk cabbage, snails, and carrion (Nemuras 1967, Holub and Bloomer 1977 as cited in Ernst et al. 1994, Ernst 1985, T. Amitrone pers. comm.). In Pennsylvania, bog turtles typically return to their hibernacula in October. They have been found hibernating in muskrat burrows, muddy rivulets, roots of vegetation, open marshes, and subterranean tunnels (Ernst et al. 1989, T. Amitrone pers. comm., G. Gress pers. comm., pers. obs.). Some bog turtles inhabit communal winter retreats and may exhibit site fidelity to their overwintering site (Ernst 1977, G. Gress pers. comm.).

### **Reproduction and Development**

Breeding occurs from late April through early June (Barton and Price 1955). During mating, males exhibit aggressive behavior, often biting and chasing females. Copulation can occur on both land and in water. In Pennsylvania, bog turtles generally nest from June through early July. An average of 3 (range 1-6) elliptical white eggs are deposited within a sedge hummock or sphagnum mat or in soft soil above the water line (Ernst et al. 1994, Somers et al. 2000, Whitlock 2002). The eggs average 30.1 mm by 15.7 mm (Arndt 1977) and may remain partially exposed. The female lays only one clutch of eggs per nesting season, and may only nest once every 2 or 3 years (Somers et al. 2000). Heat and humidity are required for proper incubation of the eggs. In laboratory studies, Pennsylvania hatchlings emerged after a mean incubation period of 55 days (Zappalorti et al. 1995). Hatchlings in the wild typically emerge from mid August through September and overwinter at or near the nest site. The carapace length of hatchlings varies from 21.1-28.5 mm (Arndt 1972, 1977; Ernst 1977). Ernst (1983) reported an occurrence of natural hybridization between a bog turtle and a spotted turtle (*Clemmys guttata*) in Baltimore County, Maryland. The growth rate of bog turtles is rapid for the first several years of growth. As the turtle matures, the rate of growth slows. Bog turtles are considered to be mature at a plastron length of 70 mm (Ernst 1977) (carapace length of approximately 75 mm) and an age of 6 to 10 years.

## **Management and Research**

### Current Protection

The bog turtle was given federal protection in November 1997 when the species was listed as a threatened species under the Endangered Species Act (USFWS 1997). The species has been listed as endangered by the Pennsylvania Fish & Boat Commission (PFBC) since 1974. The southern allopatric population of *G. muhlenbergii* is currently considered secure but is listed as Federally threatened because of similarity of appearance to the northern population.

### Primary Threats in Pennsylvania

In Pennsylvania there has been at least a 50% loss of historically known sites (Lee and Norden 1996) and the possible extirpation of the northwest population. Primary factors in the species' decline in Pennsylvania are (1) loss of suitable habitat and (2) illegal collection. Significant secondary factors are (1) predation and (2) the species occurrence often as small, isolated colonies.

Loss, fragmentation, and degradation of fragile wetland habitat are the primary threats to the northern population of *G. muhlenbergii* (USFWS 2001). With the loss of family farms in southeastern Pennsylvania, wetlands that were formerly grazed or periodically mowed or burned, are now subjected to natural succession that gradually transforms emergent wetlands into shaded scrub-shrub or forested swamps, unsuitable for the continued existence of a bog turtle colony. Smaller sedge meadow sites can all but disappear due to succession in less than 20 years (Lee and Norden 1996).

In Pennsylvania, most known colonies of the species are located in the heavily populated southeastern part of the State. Residential, commercial, and industrial development; road construction; and agricultural practices have destroyed countless acres of bog turtle habitat in the past. Continued suburban sprawl and associated road construction adjacent to bog turtle areas result in increased road mortality, disturbances to surface and groundwater hydrology, changes to the vegetative community, and human contact. Construction of roads also degrades or eliminates dispersal corridors between areas of nearby suitable habitat. Replacement of more "movement friendly" bridges with culverts can present physical and possibly behavioral barriers to the species. Sedimentation and increased nutrients degrade habitats by decreasing microtopography (i.e., hummocks), accelerating succession, and changing the vegetative composition by decreasing diversity and increasing invasive species. Increased stormwater runoff may result in higher water levels, increased pollutants (herbicides, oils, sediments, etc.), and increased scour to the wetlands (and adjacent streams). Groundwater withdrawal (for drinking water, agriculture) may dry up wetland habitats.

Invasive plants such as reed canarygrass (*Phalaris arundinacea*), common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and even cattail (*Typha latifolia*) can form dense homogenous stands eliminating or reducing basking and nesting areas and making movements more difficult. Establishment by alien woody species such as multiflora rose (*Rosa multiflora*) and succession by native species such as red maple (*Acer rubrum*) create shading and can contribute to higher transpiration rates, degrading the habitat for bog turtles. Mowing or cutting of vegetation in wetlands – legal in Pennsylvania – may degrade or eliminate the area as suitable habitat and can physically harm or kill individual turtles or destroy their elevated nests.

Due to their rarity, small size, and handsome appearance, the demand for bog turtles as pets is a major reason of their decline in numbers (Hulse et al. 2001, USFWS 2001). In recent years, several undercover operations have resulted in the arrest and prosecution of poachers and others involved with the illegal herpetofauna trade in Pennsylvania and other nearby states. To reduce illegal collection, the locations of most bog turtle sites are not public knowledge. However, this may hamper conservation efforts, because potential local "watchdogs" are unaware of the species' presence.

Bury (1979) and Klemens (in USFWS 2001) list a variety of potential predators. Although predation of bog turtles is difficult to measure, it is likely that predation from raccoons (*Procyon lotor*) and other mammals that forage along the edges of water bodies is higher in smaller, more linear systems where there is a greater edge to area ratio. Predation rates are also probably greater near agricultural and suburban areas because of the increased number of human "subsidized" predators, (e.g., raccoons, opossums [*Didelphis marsupialis*], et al.).

The bog turtle frequently occurs in small, isolated colonies. This makes the entire colony susceptible to inbreeding and vulnerable to predation, human collection, habitat loss, and localized pollution events (e.g., chemical spill). It also can give the perception that the species is more common, whereas the isolated colonies may be functionally extinct.

### Conservation and Management Needs

An accepted conservation plan was prepared by Klemens for the northern population of the bog turtle (USFWS 2001). Many of the recommended conservation and management priorities are currently being conducted in Pennsylvania. A few of the tasks, e.g., the development (and use) of standardized bog turtle survey protocols, have already been completed. We offer additional comments specific to these priorities in Pennsylvania below.

The first Habitat Conservation Plan (HCP) for the bog turtle is currently under development in Pennsylvania. This particular plan strives to identify and conserve the best bog turtle sites within three watersheds in southeastern Pennsylvania and Delaware and to protect these sites in perpetuity. HCPs in other watersheds should be developed and implemented.

Several government agencies have roles, directly or indirectly, affecting the bog turtle or its habitat. The U.S. Fish and Wildlife Service (USFWS) and the PFBC regulate the "take" (i.e., collection, harm, kill, etc.) of bog turtles, but neither agency regulates its habitat. The PA Department of Environmental Protection and U.S. Army Corps of Engineers both regulate work in wetlands and watercourses. However, neither agency can require an upland buffer nor prohibit the mowing or cutting of vegetation in a wetland unless a permit is required. As part of their permit process, a screening for potential bog turtle habitat must be conducted. The habitat screening and subsequent conservation and mitigation requirements can be powerful tools in bog turtle conservation. Both the PA Department of Conservation & Natural Resources and PA Game Commission manage lands containing bog turtle populations. The PA Department of Transportation is continuously upgrading roads, replacing bridges and culverts, and conducting other maintenance activities within the range of the bog turtle. Several non-profit conservation organizations own or hold easements on bog turtle wetlands. In early 2006, Project Bog Turtle North, a non-profit organization consisting of conservation groups and concerned individuals and companies, was formed. It is hoped that this group can work effectively with the aforementioned agencies to share resources to establish and implement conservation priorities for the long-term preservation of the species.

#### Monitoring and Adaptive Management

Klemens (in USFWS 2001) discusses periodic monitoring (at least every five years) of known sites for population trends and for changes and threats to the habitat. Parameters to be monitored include, but are not limited to, population size and recruitment, succession, invasive plants, predation, conditions of hydrology, and changes to upland buffers. Periodic surveillance for poachers or environmental impacts (e.g., illegal filling or draining) should suffice on sites where access is limited or prohibited. However at other sites, surveillance for these activities will need to be more frequent, if not continuous; neighborhood watch groups may be necessary (USFWS 2001). We conclude that it is unlikely that any metapopulations of bog turtles within Pennsylvania will persist through the 21<sup>st</sup> century without active management from conservation biologists, private landowners, regulatory agencies, and the general public.

#### Research Needs

Klemens (in USFWS 2001) described research/survey priorities for the northern population of the bog turtle within an Implementation Schedule. We have summarized and modified his plans somewhat to be more specific for research and survey needs in Pennsylvania.

In Pennsylvania the most critical research/survey needs are: (1) identify extant and historical sites in southeastern and eastern Pennsylvania, especially where developmental pressure is the highest; (2) survey riparian systems between known sites for other areas of habitat and for dispersal corridor suitability; (3) survey other areas of suitable habitat within the watershed and watersheds adjacent to those with known populations; (4) survey historical sites and adjacent areas of suitable habitat in northwestern Pennsylvania; (5) conduct further studies on life history and ecology to improve our knowledge on population dynamics, movements (especially related to dispersal between colonies), genetics, and predation rates; (6) conduct research on controlling invasive plant species; and (7) prepare a predictive GIS model to assist in locating new potential bog turtle sites.

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