BEFORE THE SECRETARY OF THE INTERIOR

PETITION TO LIST THE SOUTHERN POPULATION OF THE BOG TURTLE (*Glyptemys muhlenbergii)* UNDER THE ENDANGERED SPECIES ACT AS AN ENDANGERED OR THREATENED SPECIES AND TO CONCURRENTLY DESIGNATE CRITICAL HABITAT

Nathanael Stanek / Turtle Conservancy

JANUARY 13, 2022

CENTER FOR BIOLOGICAL DIVERSITY

Notice of Petition

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Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. § 1533(b); Section 553(e) of the Administrative Procedure Act, 5 U.S.C. § 553(e); and 50 C.F.R. § 424.14(a), the Center for Biological Diversity hereby petitions the Secretary of the Interior, through the United States Fish and Wildlife Service ("FWS," "Service"), to protect the southern population of the bog turtle (*Glyptemys muhlenbergii*) as an endangered or threatened species.

Bog turtles occur in two geographically distinct populations: a northern population and a southern population. The U.S. Fish and Wildlife Service already found the northern population to be a distinct population segment ("DPS") in its 1997 listing decision.[1] The southern bog turtle population is also a distinct population segment (DPS) that is discrete, significant, and threatened with extinction by all five factors listed in ESA Section 4(a)(1).

The southern bog turtle population is discrete and markedly separated from the northern population by physical and behavioral factors. The northern and southern populations of *Glyptemys muhlenbergii* are separated by 250 miles across West Virginia, Virginia, Maryland, and Delaware. The southern bog turtle population is geographically, reproductively, and genetically isolated from the northern population and is a discrete DPS.

[1] USFWS 1997. 59609.

The southern bog turtle population is also biologically and ecologically significant. The southern bog turtle occurs across five states in the southern U.S. and represents nearly 50% of the species' range.[2] The southern population provided refugia for *Glyptemys muhlenbergii* during glaciation and subsequently provided the source for northern populations to recolonize.[3] In the past 200 years, agriculture and development in Maryland, Delaware, Virginia, and West Virginia have isolated the northern and southern populations of bog turtles.[4]

Loss of the southern population would result in a significant gap in the range of *Glyptemys muhlenbergii* and jeopardize its survival. The southern bog turtle population has collapsed. Only 14 viable sites containing fewer than 2,000 individuals remain. Nearly all of its remaining sites are in serious decline.[5] Fewer than 500 acres of mountain bog habitat are left across its entire five-state southern range. The southern bog turtle DPS requires immediate and complete protection as a federally endangered species.

The U.S. Fish and Wildlife Service has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on the Service. Specifically, the Service must issue an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." FWS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition" (16 U.S.C. § 1533(b)(3)(A)).

The Center for Biological Diversity also requests that critical habitat be designated for the bog turtle concurrently with the species being listed, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R. § 424.12. Critical habitat is essential to protecting the bog turtle from further harm and population decline. Bog turtle critical habitat consists of wetlands, surrounding buffer habitat, upland habitat, and migratory corridors between sites, which are essential to their long-term genetic health and survival.

The U.S. Fish and Wildlife Service has discretion with the scale at which it publishes critical habitat information. Published critical habitat designation should be publicly presented range-wide or at the county level.

The petitioner has submitted substantial scientific information in this petition indicating that listing the southern population of the bog turtle is warranted; however, because one of the chief threats to the bog turtle is overutilization, the petition does not include the exact locations of populations or individuals. Instead, the petition cites publicly available information regarding the location of bog turtles and identifies the threats that jeopardize its survival. For exact population location information, and for any other questions about the petition, please contact Will Harlan at wharlan@biologicaldiversity.org / 828-230-6818. The petitioner understands and expects that

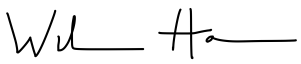
[2] USFWS 1997. 59609.
[3] Ernst and Lovich 2009. 263-273.
[4] *Id.*
[5] NCWRC 2018. 5.

location information about the bog turtle will be protected from disclosure in the event of a Freedom of Information Act request and in any future rulemakings regarding the species.

The Center for Biological Diversity ("Center") is a nonprofit, public interest environmental organization dedicated to the protection of imperiled species and the habitat and climate they need to survive through science, policy, law, and creative media. The Center is supported by more than 1.7 million members and online activists throughout the country. The Center works to secure a future for all species, great or small, hovering on the brink of extinction. The Center submits this petition on its own behalf and on behalf of its members and staff with an interest in protecting the bog turtle and its habitat.

Please contact Will Harlan at 828-230-6818 or email me at wharlan@biologicaldiversity.org if you have any questions or need any clarification on the information in this petition.

Sincerely,



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Southern Population of the Bog Turtle (*Glyptemys muhlenbergii*) Petition
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EXECUTIVE SUMMARY

U.S. Fish & Wildlife Service

The bog turtle is North America's smallest and rarest turtle species—and its most imperiled. Bog turtles (*Glyptemys muhlenbergii)* are the most endangered North American freshwater turtles, and they have lost over 90 percent of their population and habitat.

Bog turtles are separated geographically into two populations: a northern population extending from New York to Maryland, and a southern population stretching from southern Virginia to north Georgia.

The bog turtle was given protection in 1973 by CITES, the Convention on International Trade in Endangered Species. The northern population of the bog turtle was listed as a threatened species under the Endangered Species Act in 1997; the southern population was also included as threatened due to similarity of appearance. This status does not provide southern bog turtles or their habitat the same level of protection as northern bog turtle populations.

Since 1997, southern bog turtle numbers have crashed. The southern population has declined by art least 50 percent in the past twenty years.[6] Only 14 viable populations remain across its entire five-state southern range. The southern bog turtle's total known population is likely less than 2,000 individuals.

The remaining population consists of very few juvenile turtles. Extremely low juvenile survival rates and little to no recruitment is leading to a population precipice: adults are rapidly disappearing, and no juveniles are replacing them.

The southern population of the bog turtle is threatened by all five of the Section 4(a)(1) factors: habitat destruction, overutilization, disease and predation, inadequacy of existing regulatory mechanisms, and natural and manmade factors affecting its continued existence.

Draining, ditching, damming, and development threaten most of the southern bog turtle's remaining wetlands habitat. Only 500 acres of mountain bog habitat remains across its entire southern range.[7] Wetlands species face a nearly thousandfold greater risk of extinction compared to other species.[8] At least three federally listed species share the same wetlands as bog turtles, and several other rare and imperiled state-listed species also depend on bog turtle wetlands.[9]

Roads are already a significant source of bog turtle mortality. New interstate expansion and road construction projects across the southern population's range have destroyed significant bog turtle strongholds and fragmented habitat. Remaining bog turtle populations are increasingly isolated and unable to migrate.

Bog turtles are also one of the most popular animals in the wildlife trade. Their small size and attractive appearance make them a prized species in many black markets. Poaching continues to wipe out populations across their range.

Disease and predation have also significantly increased, especially in the last 10 years, and natural and manmade factors including invasive species and climate change have degraded habitat and further reduced populations. Succession, fire suppression, overgrazing, and lack of funding for wetlands management have led to even greater southern bog turtle losses. Despite heroic efforts from state and federal agencies to protect the bog turtle, current "similarity of appearance" protections have proven wholly inadequate to stem the steep decline of southern bog turtles.

The southern population of the bog turtle is in danger of extinction across the entirety of its range and warrants immediate listing as an endangered species.

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[6] Holden 2021. 5.
[7] Weakley and Schafale 1994. 359.
[8] Burkhead 2012. 806.
[9] Federally listed montane wetlands species include the mountain sweet pitcher plant (*Sarracenia rubra ssp. jonesii*), swamp pink (*Helonias bullata*), and bunched arrowhead (*Sagittaria fasciculata*).

INTRODUCTION

Gary Peeples / U.S. Fish & Wildlife Service

The bog turtle is one of the most endangered turtles on the planet.[10] The bog turtle (G*lyptemys muhlenbergii)* is a diminutive, semi-aquatic turtle that is widely recognized as one of the most endangered turtles in North America. The distinctively small turtle with bright orange neck markings has been targeted by poachers for decades. Most of the bog turtle's wetlands habitat has been lost, and its few remaining disjunct sites face new threats from development, roads, fragmentation, poaching, and predation. Bog turtle populations have experienced a 90 percent decline in population in the past century,[11] and its southern population has seen an even steeper decline in the past 20 years.

The northern population of the bog turtle was listed as threatened on November 4, 1997, by the U.S. Fish & Wildlife Service.[12] The agency noted that the species "is threatened by a variety of

[10] Rosenbaum *et al.* 2007. 331.
[11] IUCN 2021.
[12] The species was listed by USFWS as *Clemmys muhlenbergii* in 1997. Nucleotide sequencing in 2001 resulted in an updated scientific name of *Glyptemys muhlenbergii.* USWFWS records databases including ECOS continue to use *Clemmys muhlenbergii* for bog turtle records.

factors including habitat degradation and fragmentation from agriculture and development, habitat succession due to invasive exotic and native plants, and illegal trade and collecting."[13]

The southern population of the species was included in the listing decision as threatened due to similarity of appearance, but this status does not provide southern bog turtles with any protection for their habitat.[14] Southern Appalachian wetlands are one of the rarest and most endangered ecosystems in the country. They have declined by 90 percent across the southern bog turtle's range. Southern Appalachia was once home to over 5,000 acres of mountain bogs. Today fewer than 500 acres remain.[15]

Loss of wetlands habitat—along with poaching, predation, roads, invasive species, pollution, and climate change—have resulted in a collapse of southern bog turtle populations. The southern population of the bog turtle has crashed over the past two decades and is now on the brink of extinction. Subpopulations and sites are disappearing across its five-state range. Only 14 sites contain a minimum viable population threshold of 40 adults. Few juveniles are found anywhere. Loss of subpopulations and sites, extremely low juvenile survival rates, and little to no recruitment have resulted in dwindling, aging bog turtle population struggling for survival.

The southern population's listing as threatened "due to similarity of appearance" has failed to protect southern bog turtles or their habitat. Despite sustained efforts by federal and state agencies, the southern bog turtle's numbers have dropped by at least 50 percent in the past two decades.[16] Fewer than 2,000 individuals remain.

All five factors identified in Section 4 of the Endangered Species Act are contributing to the southern bog turtle's crash: habitat destruction, overutilization, disease and predation, inadequacy of existing regulations, and natural and manmade factors.[17]

Protecting bog turtles and their habitat would protect other endangered species, including federally listed species such as the mountain sweet pitcher plant (*Sarracenia rubra ssp. jonesii*), swamp pink (*Helonias bullata*), and bunched arrowhead (*Sagittaria fasciculata*). Rare salamanders, including the four-toed salamander (*Hemidactylium scutatum)*, also depend on bog turtle habitat.

NatureServe has assessed the bog turtle as Imperiled (G2) across its entire range: in its southern range, South Carolina and Tennessee subpopulations are Critically Imperiled (S1).[18] IUCN lists the bog turtle as Critically Endangered.[19]

The southern population of the bog turtle will go extinct in the wild unless it is listed immediately as an endangered species.

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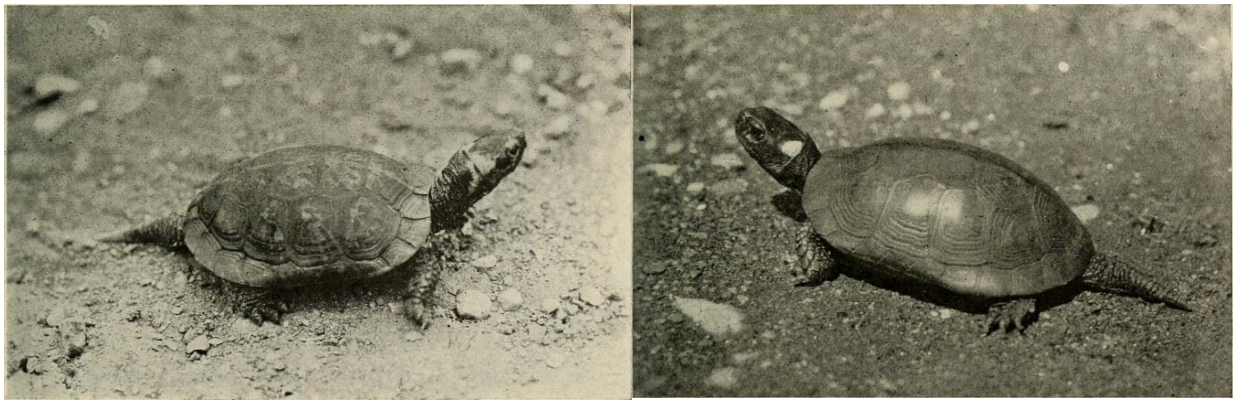
[13] USFWS 1997. 59605.
[14] *Id.*
[15] Weakley and Schafale 1994. 359.
[16] Holden 2021. 5.
[17] ESA Section 4 (16 U.S.C. § 1533(a)(1)).
[18] NatureServe 2021.
[19] IUCN 2021.

BIOLOGICAL INFORMATION

Taxonomy

Kingdom	Phylum	Class	Order	Family	Genus	Species
Animalia	Chordata	Reptilia	Testudines	Emydidae	Glyptemys	muhlenbergii

The bog turtle is a diminutive, wetland-dependent reptile endemic to the eastern United States. It is a semiaquatic turtle in the family Emydidae. Turtles are among the most threatened of vertebrate orders, with nearly 50 percent of turtles species currently listed as threatened or endangered by the International Union for the Conservation of Nature (IUCN). The IUCN lists the bog turtle as critically endangered.[20]



American Museum of Natural History

The bog turtle was first noted in the 18th century by the botanist Gotthilf Heinrich Ernst Muhlenberg, who discovered more than 150 plant species. While conducting a botanical survey in Lancaster County, Pennsylvania, Muhlenberg first observed the small turtle near his millpond.[21] In 1801, Johann David Schoepff named Muhlenberg's discovery as *Testudo muhlenbergii* in Muhlenberg's honor.

In 1829, Richard Harlan renamed the turtle *Emys muhlenbergii*. The species was subsequently renamed *Calemys muhlenbergii* by Louis Agassiz in 1857, and *Clemmys muhlenbergii* by Henry Watson Fowler in 1906.[22]

The genus *Clemmys* originally included several species, including the spotted turtle, wood turtle, and bog turtle. However, nucleotide sequencing and ribosomal DNA analyses in 2001 revealed that bog turtles and wood turtles (*Glyptemys insculpta*) are closely related, but neither is directly related to spotted turtles. Bog turtles and wood turtles have been separated into the genus

[20] IUCN Red List 2021.
[21] Ernst and Lovich 2009. 264.
[22] Bickham 1996. 90.

Glyptemys.[23] The genus name *Glyptemys* is derived from the Greek words *giypt* (carved) and *emys* (turtle). Bog turtles diverged from wood turtles between 15 and 20 million years ago.[24]

The bog turtle's genotype consists of 50 chromosomes, and studies of variations in mitochondrial DNA indicate low levels of genetic divergence among bog turtle colonies.[25]

Appearance

Jonathan Hall / NCWRC

Bog turtles are characterized by their small size, dark brown shell and body, and large red, orange, or yellow blotches on both sides of its head. Shell lengths of bog turtles average between 3 and 4 inches. The largest bog turtle ever recorded was 4.5 inches.[26]

The main identifying character of bog turtles is the brightly colored blotch located behind the eye on each side of the head. In different populations, these blotches vary from yellow, yellow-

[23] Amato 2008. 570.
[24] Massachusetts DFW 2020.
[25] Rosenbaum 2007. 331.
[26] Tryon and Herman 1990. 37.

orange, orange, and orange-red. The size and shape of the blotches also vary among populations and are dependent on the turtle's age. Newly hatched bog turtles possess large blotches that are light in color, while adults have more fragmented and brightly colored blotches.[27]

The carapace is usually black to dark brown and may be marked with lighter white-to-yellow sunburst rays of color in the individual scutes. The plastron is usually black with varying amounts of white or yellow patches. The neck, limbs, and tail are very dark brown or black, occasionally with streaks of red or orange.[28] Juvenile carapaces usually have a conspicuous keel, and their plastron is yellow with a black blotch in the center.[29]

Sexual dimorphism is pronounced in bog turtles. Unlike many other turtles, males are larger than females and possess thicker, more robust heads. Carapace lengths average 3.5 to 4 inches in males, while females are slightly smaller with an average of 3 to 3.75 inches in length.[30]

Males have larger, squared heads than females. Their tails are longer and thicker, and they also have a concave plastron, flared rear marginal scutes, and a streamlined appearance. Females have a flat plastron and a taller, domed carapace.[31]

The bog turtle may sometimes be confused for a small or juvenile Eastern box turtle (*Terrapene carolina*), but the box turtle has a hinged plastron and a brightly colored carapace, and it lacks the bog turtle's singular bright orange spot on its neck. The wood turtle (*Glyptemys insculpta*) is the only other turtle within the bog turtle's genus. The wood turtle also lacks the bog turtle's single orange spot on its neck, and the wood turtle has a sculptured carapace with pyramidal scutes and a long tail.[32]

Behavior

The bog turtle is an ectothermic reptile that alternates seasonal warm-weather activity with cold-weather dormancy. Bog turtles spend most of their time under the water, buried in mud, or hiding in thick vegetation, making them very difficult to locate.[33] Bog turtles are primarily diurnal, though nocturnal activity such as nesting has been reported.[34] They tend to be more

[27] Turtle Taxonomy Working Group 2012.
[28] *Id.*
[29] *Id.*
[30] Ernst and Lovich 2009. 264.
[31] *Id.*
[32] Virginia Herpetological Society 2021.
[33] Stratmann, Floyd, and Barrett 2016. 332.
[34] Ernst and Lovich 2009. 265.

active on cloudy days than on bright sunny days.[35] Bog turtles do not thrive in high temperatures.[36] They will estivate during hot weather.[37]

Bog turtles can begin surface activity as early as mid-March in the South. The greatest bog turtle activities occur from mid-April through September. Elevation affects the timing and length of the major phases of the activity cycle. In the foothills, bog turtles have a longer active season than turtles in the higher mountain sites.[38]

Gary Peeples / U.S. Fish & Wildlife Service

On cool days, bog turtles bask in the sun, often from the surface of shallow waterways or on sedge or grass tussocks. During hot weather, they tend to be inactive and may estivate under vegetation or in burrows with sphagnum moss substrate.[39]

Winter survival requires that bog turtles undergo a period of cold-weather hibernation. Winter dormancy is probably longer at higher elevations than in the foothills.[40] From October to early

[35] Virginia Herpetological Society 2021.
[36] Apodaca pers. comm. 2021.
[37] Ernst and Lovich 2009.
[38] Herman 2003. 14.
[39] *Id.*
[40] *Id.*

April, they hibernate either alone or in groups of 12 individuals, and these groups can sometimes include other species of turtles. They usually hibernate in partially submerged networks of burrows and tunnels in mud or vegetation. They may also hibernate at the base of a tree or in other animal burrows. Bog turtles emerge from hibernation in spring when the air temperature is between 16 and 31 °C (61 and 88 °F).[41]

Both male and female bog turtles can sometimes be aggressively territorial, defending a home range that can vary from 30 square meters to over 7 acres.[42] A male bog turtle will attack other males if they venture within 15 centimeters (5.9 inches) of his position. An aggressive male will crawl toward an intruder with his neck extended. As he approaches his foe, he tilts his carapace by withdrawing his head and raising his hind limbs. If the other male does not retreat, a fight of pushing and biting can follow. The bouts typically last just a few minutes, with the larger and older male usually winning.[43] The female is also aggressive when threatened. She will defend the area around her nest, usually up to a radius of 1.2 meters (3.9 ft), from encroaching females, but when a juvenile approaches, she ignores it, and when a male appears she surrenders her area (except during mating season).[44]

Both males and females are capable of homing from distances of a half-mile or more.[45]

Bog turtles can migrate long distances to find new habitat. Males exhibit greater migration distance and seasonal activity than females, and they have been observed traveling 2.7 kilometers.[46]

Bog turtles cross roads to reach preferable habitat and breeding sites. Many bog turtles are killed by vehicles on roads each year. Road mortality has become a leading cause of turtle decline.[47]

Diet

Bog turtles are omnivores. Bog turtles feed only during the day, but usually not during the hottest hours.[48] They consume their food on land or in the water.[49] Known prey include a variety of insects, beetles, earthworms, slugs, snails, millipedes, crayfish, tadpoles, duckweed, watercress, skunk cabbage, blackberries, strawberries, plant parts, and seeds of pondweed and sedges.[50] They occasionally scavenge dead animals and opportunistically capture small vertebrates such as tadpoles, frogs, and salamander larvae.[51]

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[41] *Id.*
[42] *Id.*
[43] Lovich, Ernst, Zappalorti, and Herman 1991. 75.
[44] Ernst and Lovich 2009. 267.
[45] Ernst and Lovich 2009. 267.
[46] Carter 1999. 171.
[47] Gibbs and Shriver 2002. 1647.
[48] Ernst and Lovich 2009. 265.
[49] *Id.*
[50] *Id.*
[51] *Id.*

Life Cycle

Rosie Walunas / U.S. Fish & Wildlife Service

Justin Dalabas / U.S. Fish & Wildlife Service

Bog turtles typically become sexually mature between six and ten years of age; sexual maturity age appears to vary geographically. Shoemaker concluded in 2013 that bog turtles reached sexual maturity at nine years of age because gravid females were never observed with fewer than nine annuli. [52]

Bog turtles mate from late April to early June. Unlike other turtles, females do not lay eggs in a sandy or soil substrate, but rather choose to build nests in clumps of vegetation, making bog turtles especially dependent on specific wetland vegetation.[53]

The bog turtle copulation session usually lasts for 5–35 minutes, typically during the afternoon, and may occur on land or in the water.[54] Like many testudines, male bog turtles have a concave plastron to enable them to position themselves atop a female. Males also have a longer and thicker tail that protrudes beyond its carapace to reach the female's cloaca. The male cloaca is located toward the end of the tail, while the female cloaca is positioned inside the plastron. Males climb cling tightly to the edge of a female's carapace and places his tail beneath hers.[55]

During the courtship ritual, the male gently bites and nudges the female's head. Younger males tend to be more aggressive during copulation, and females sometimes try to avoid an over-aggressive male. However, as the female ages, she is more likely to accept the aggressiveness of a male and may even take the role of initiator. If the female yields, she may withdraw her front limbs and head.[56] In a single season, females may mate once, twice, or not at all, and males try to mate as many times as possible.[57]

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[52] Shoemaker 2013. Results paragraph 1.
[53] Ernst and Lovich 2009. 265.
[54] *Id.*
[55] Virginia Herpetological Society 2021.
[56] Ernst and Lovich 2009. 268.
[57] *Id.*

Nesting takes place between April and July, with most eggs laid in June. Using her hind feet and claws, the female digs a cavity in a dry, sunny area of a bog, and lays her eggs in a grass tussock or on sphagnum moss.[58] The nest is typically 3.8 to 5.1 centimeters (1.5 to 2.0 in) deep and 5 centimeters (2.0 in) in circumference.

Females lay one to six eggs per clutch, with a mean of three. The eggs are white, elliptical, and on average 3.4 centimeters (1.3 in) long and 1.5 centimeters (0.59 in) wide.[59] A female bog turtle can lay 30 to 45 eggs in her lifetime.[60]

After the eggs are laid, they are left to undergo an incubation period that lasts for 42 to 80 days. The eggs are vulnerable during the incubation period, and often fall prey to mammals and birds.[61] In addition, eggs may be jeopardized by flooding, drought, and frost.

Baby bog turtles are about 2.5 centimeters (0.98 in) long when they emerge from their eggs.[62] Females are slightly smaller at birth and tend to grow more slowly than males. Juveniles almost double in size in their first four years and are fully grown around five or six years old.[63]

The bog turtle spends its life almost exclusively in the wetland where it hatched. The average lifespan of a bog turtle is 20 to 30 years, but it can live up to 50 years or more.[64] The oldest documented bog turtle lived 61 years.[65]

Habitat

Bog turtles are a highly specialized species that occupies a relatively narrow range of shallow and often ephemeral wetlands such as bogs, fens, wet meadows, and sedge marshes. Bog turtles can occur from sea level up to 1500 meters (4,500 feet) in elevation.[66]

The wetlands inhabited by bog turtles are considered some of the rarest and most imperiled habitat types in the Southeast.[67] Suitable habitat is relatively open with slowly flowing small spring-fed streams, rivulets, or surface seepages with soft, silty bottom substrates, and with vegetation dominated by clumped grasses and sedges. The highest quality sites also include sphagnum moss, unaltered hydrology, stable groundwater levels around 8 centimeters, a large area that receives full sun, deep and loose soils with root substructures or tunnels, and adequate vegetation for concealment when basking.[68] Viable bog turtle populations occur in seepage slopes or terraces along headwaters of small to moderate size streams. Sites occupied by bog

[58] Beane et. al. 2010. 167
[59] Ernst and Lovich 2009. 267-268.
[60] Herman 1992. 1108.
[61] Ernst and Lovich 2009. 268.
[62] *Id.*
[63] *Id.*
[64] USFWS 2010b. 1-2.
[65] Nature Conservancy 2020. 1-2.
[66] USFWS 2010b. 1-2.
[67] Weakley and Schafale 1994. 359-360.
[68] NCWRC 2018. 3-4.

turtles are infrequently flooded, so they are not found on large, flat floodplains of major rivers or streams.

Gabrielle Graeter / N.C. Wildlife Resources Commission

Bog turtle habitat also includes adjacent forests and vegetative buffers and corridors surrounding wetlands. These buffers and corridors are essential for feeding, migration, and dispersal. A 2018 study found bog turtles inhabiting areas with closed canopies and high densities of woody stems, especially in the spring and fall. These areas appear to be essential for traveling to and from hibernacula.[69] Bog turtles utilize more densely vegetated areas for hibernation and may be incidentally found in a wide variety of habitats when making long-distance movements.[70] The continued existence of these habitat mosaics, as well as the ecological connections between these areas, is required to maintain bog turtle populations.[71]

Southern bog turtles tend to migrate farther than northern bog turtles.[72] There is evidence that southern bog turtles also use stream corridors for dispersal.[73] Bog turtles have also been

[69] Roos and Maret 2018. 11-14.
[70] Buhlmann, Tuberville, and Gibbons 2008. 252.
[71] *Id.*
[72] Travis *et al*. 2018. 265-66.
[73] Somers *et al.* 2007. Feaga 2010.

documented using upland habitat and deciduous and coniferous forests for migration.[74] Upland migration corridors in an era of increasingly fragmented habitat and changing climate is critical for the bog turtle's persistence in the region.[75]

Bog turtle habitat also includes a mosaic of micro-habitats that include dry pockets, forest edge, and saturated areas near the headwaters of streams or small tributaries. The habitats are often strip-like transitional zones between drier upland areas and wooded swamp or marsh.[76] Biotic diversity is often very high in these habitats, with over 150 plant species reported in one small Tennessee bog.[77]

Bog turtle habitat in the species' southern range is often characterized by thick sphagnum moss, crested fern, rhododendron and laurel, or an associated marsh dominated by ferns, sedges, rushes, sweet flag, and cattails. Several plant species commonly associated with bog turtle habitats include sphagnum moss, alders, willows, sedges, spike rushes, jewelweed, arrow arum, red maple, skunk cabbage, cattails, and bulrushes. Pedestal vegetation, such as tussock sedge and sphagnum moss, is utilized for nesting and basking.[78]

Sphagnum moss (*Sphagnum spp*.) is the dominant ground cover in many bog turtle habitats. Sphagnum moss acts as a living sponge to hold up to 26 times its weight in water. Sphagnum acts as a reservoir that holds and releases water during droughts and dry spells. The open habitat allows maximum sunlight to warm the herbaceous layer providing bog turtles with basking and nesting sites. One of the bog turtle's ultimate limitations is a closed canopy, which cuts off surface light and warmth.[79]

Unless disrupted by fire, beaver activity, grazing, or periodic wet years, open-canopy wetlands are slowly invaded by woody vegetation and undergo a transition into closed-canopy, wooded swamplands that are unsuitable for habitation by bog turtles.[80] Historically, bog turtles probably moved from one open-canopy wetland patch to another, as succession closed wetland canopies in some areas.[81]

Bog turtles inhabit sub-climax seral wetland stages and are dependent on riparian systems that are unfragmented and sufficiently dynamic to allow the natural creation of meadows and open habitat to compensate for the closing-over of habitats caused by ecological succession. Bog turtles traditionally have dispersed between habitat patches of changing vegetation within a long-term, stable, wetland complex.

Fire may have played a significant role in maintaining the open nature of bog turtle wetlands historically.[82] Beavers have also been important in maintaining the open-canopy wetlands

[74] Carter *et al.* 2000. Feaga 2010.
[75] Shoemaker and Gibbs 2013. 330-331.
[76] USFWS 2001. 1-2.
[77] Tryon and Herman 1990. 39.
[78] Herman 2003. 16.
[79] *Id.*
[80] Stratmann, Barrett, and Floyd 2016. 199.
[81] Ernst and Lovich 2009. 267.
[82] *Id.*

essential for this species' survival. In addition, muskrat (*Ondatra zibethicus*) and meadow vole (*Microtus pennsylvanicus*) help maintain bog turtle habitat and provide travel pathways.[83]

Southern bog turtle habitat is highly fragmented and disjunct, which has led to isolated sub-populations with limited genetic diversity. Most of the occupied bog turtle habitat across its southern range is privately owned.[84]

Current and Historic Distribution

Bog turtles occupy a highly discontinuous and fragmented range in the eastern United States of America. Within this range, they tend to occur in small, widely separated colonies.[85]

Historically, bog turtles were more widespread across the Eastern U.S., but then the bog turtle experienced a dramatic population decline as colonies were forced south by glaciation. Receding glaciers led to a post-Pleistocene expansion as bog turtles moved back to their former northern range.

Today, the northern and southern populations of *Glyptemys muhlenbergii* are genetically and geographically isolated by 250 miles across most of Maryland, Delaware, Virginia, and all of West Virginia. For management purposes, two general populations are recognized: a northern population and a southern population.

The northern population extends from eastern New York and western Massachusetts south through southeastern Pennsylvania and New Jersey to northern Maryland and Delaware, with outlying populations in northcentral New York and western Pennsylvania.

The southern population extends from southern Virginia, western North Carolina, and eastern Tennessee to extreme northeastern Georgia. There are no longer any known bog turtle populations in South Carolina. Elevations of southern population bog turtle sites range from 710 to 4500 feet, with the majority known from 2000 to 3000 feet elevation. The southern population generally occurs at higher elevations than the northern population. Sex ratios in the bog turtle's southern range average 1 male to 1.3 females per site.[86] There are no reliable morphological or genetic differences between bog turtles in these designated populations.[87]

[83] Kiviat 1978. 196.
[84] NCWRC 2018. 1.
[85] Ernst and Lovich 2009. 267-269.
[86] *Id.*
[87] *Id.*

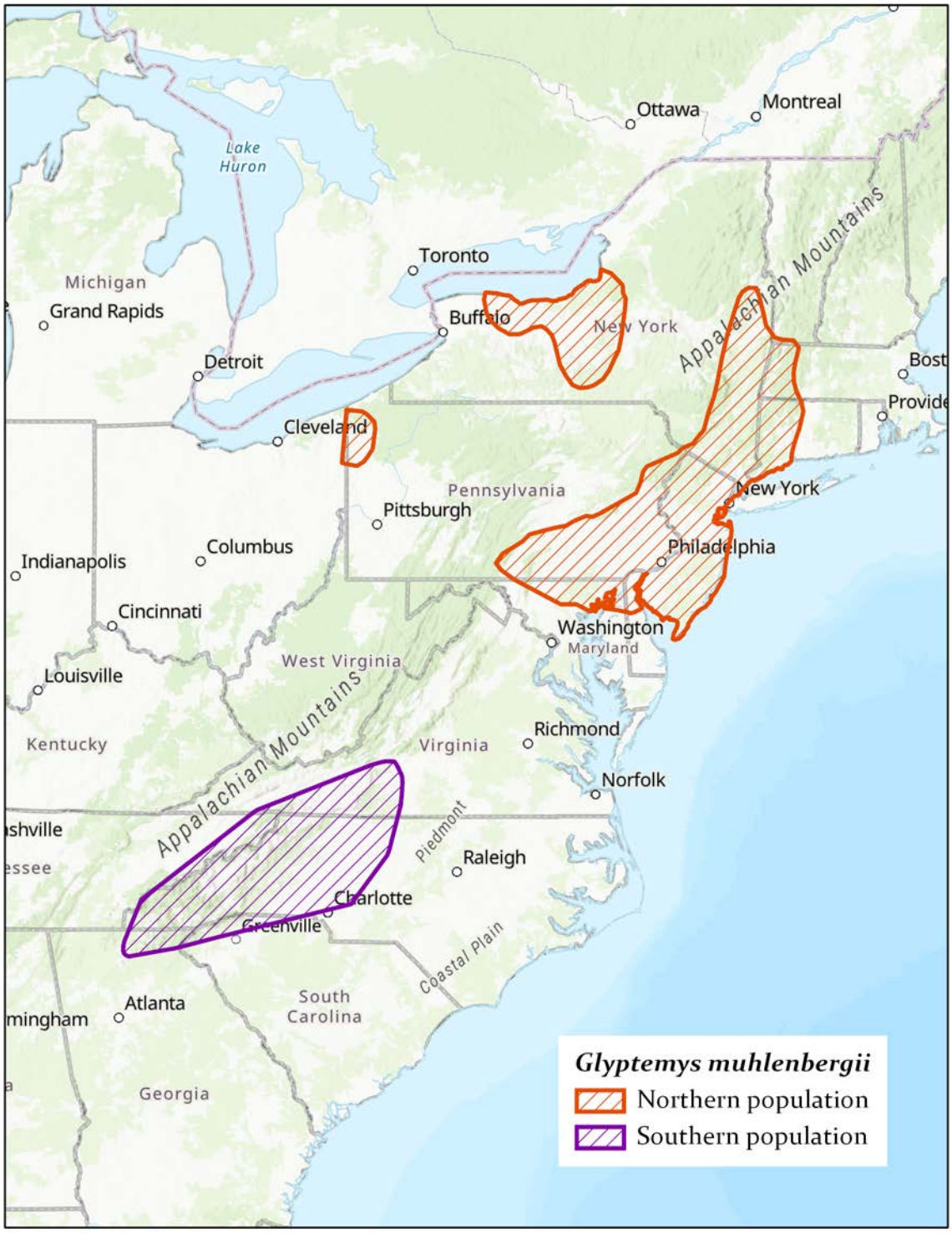

Figure 1. Current range of Glyptemys muhlenbergii*: northern population and southern population.*

The southern population of bog turtles are especially limited in their southern range by ecological and physiological constraints. Bog turtles prefer temperatures between 20-26 degrees Celsius.[88] High temperatures are more common in the southern population range, and wetlands and flat areas are more rare, due to the more mountainous geography of its southern range. As a result, bog turtles are naturally more limited in their southern range.[89]

Farming and habitat destruction in central Appalachia and the mid-Atlantic has likely resulted in the extirpation of bog turtles across all of West Virginia and most of Virginia, Maryland, and Delaware, leading to the 250-mile geographic separation of northern and southern populations.[90] Historical loss of beavers across the region has also contributed significantly to the loss of available bog turtle habitat.[91]

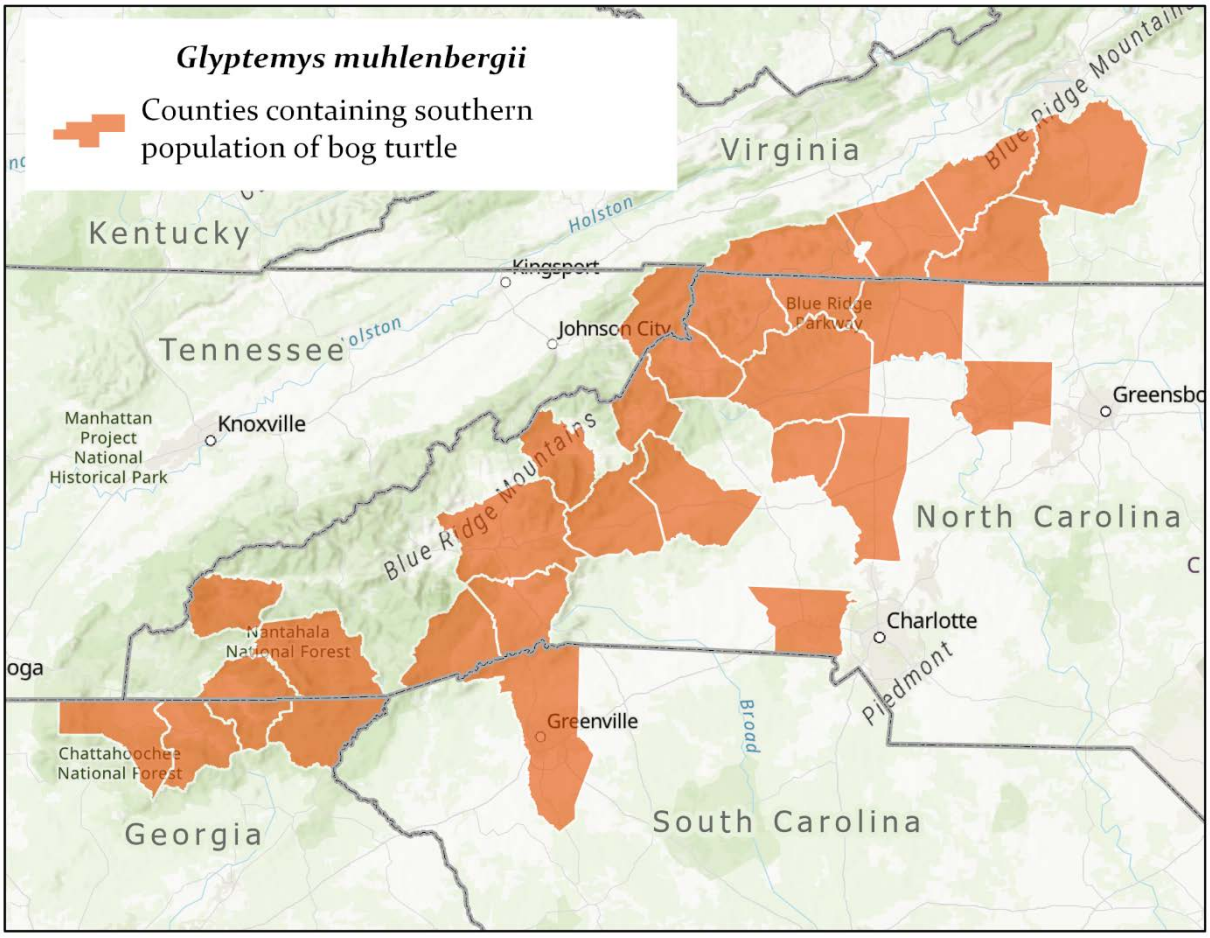

Figure 2. Current range of Glyptemys muhlenbergii *southern population by county. Only 14 viable populations remain across its entire five-state range.*

[88] Faega and Haas 2015.
[89] Apodaca pers.comm. 2021.
[90] I*d.*
[91] USFWS 2010b.

DISTINCT POPULATION SEGMENT

Bog turtles occur in two geographically distinct populations: a northern population and a southern population. The U.S. Fish and Wildlife Service already found the northern population of *Gleptymys muhlenbergii* to be a distinct population segment (DPS) in its 1997 listing decision:

"According to the Service's policy on Distinct Population Segments (61 FR 4725), three elements are considered regarding the potential recognition of a DPS as endangered or threatened—(1) discreteness of the population segment in relation to the remainder of the species to which it belongs; (2) the significance of the population segment to the species to which it belongs; and (3) the population segment's conservation status in relation to the Act's standards for listing.

"With respect to the bog turtle, the northern population meets the ''discreteness'' criterion in that it is markedly separated from the southern population by a distance of approximately 250 miles. Evidence of such discreteness may include genetic or morphological differences, but this is not a requirement. The northern population of the bog turtle meets the ''significance'' criterion because loss of this DPS, which occurs in seven States and represents over 50 percent of the species' range, would result in a significant void in the range and distribution of the species. The ''status'' criterion is met in that the northern population of the bog turtle, when evaluated with respect to the Act's listing factors, qualifies for listing as threatened."[92]

The southern bog turtle population is also a distinct population segment that is discrete, significant, and threatened with extinction by all five factors listed in ESA Section 4(a)(1).

The southern bog turtle population is discrete and markedly separated from the northern population by physical and behavioral factors. The northern and southern populations of *Glyptemys muhlenbergii* are separated by 250 miles across West Virginia, Virginia, Maryland, and Delaware. A 2018 study showed that bog turtle genetic differentiation among populations was strongly predicted by geographic distance.[93] As geographic distance between bog turtle populations increases, bog turtle populations' genetic distance proportionally increased.[94] The southern bog turtle population is geographically, reproductively, and genetically isolated from the northern population and is a discrete DPS.

The southern bog turtle population is also biologically and ecologically significant. The southern bog turtle occurs across five states in the southern U.S. and represents nearly 50% of the species' range.[95] The southern population provided refugia for *Glyptemys muhlenbergii* during glaciation and subsequently provided the source for northern populations to recolonize.[96] In the past 200 years, agriculture and development in Maryland, Delaware, Virginia, and West Virginia have

[92] USFWS 1997. 59609.
[93] Dresser, Pierson, and Fitzpatrick 2018. Results, paragraph 3.
[94] *Id.*
[95] USFWS 1997. 59609.
[96] Ernst and Lovich 2009. 263-273.

isolated the northern and southern populations of bog turtles.[97] Loss of the southern population would result in a significant gap in the range of *Glyptemys muhlenbergii* and jeopardize its survival. At the time of the 1997 listing, the southern population was assumed to be larger than the northern population.[98] It has become evident in the past two decades that the southern bog turtle population has collapsed and is now likely in even greater danger of extinction than the northern population. Very few viable southern bog turtle sites remain, and most are in serious decline.[99] The southern bog turtle DPS requires immediate and complete protection as a federally endangered species.

[97] *Id.*
[98] USFWS 1997. 59609.
[99] NCWRC 2018. 5.

POPULATION STATUS

Gary Peeples / U.S. Fish & Wildlife Service

Bog turtle populations have experienced a 90 percent decline in population in the past century,[100] and its southern population has seen a steep decline in the past 20 years.[101]

The bog turtle occurs only in the eastern United States, with distinct northern and southern populations separated by a 250-mile gap through most of Virginia and West Virginia. Although populations were once abundant in the Southern Blue Ridge of North and South Carolina and Georgia, the bog turtle is now facing unprecedented challenges to its survival.

The bog turtle's historic range was continuous from upstate New York to north Georgia.[102] Two bog turtle fossils have been found in Cumberland Cave, Maryland and near Charleston, South Carolina. Populations in West Virginia and northern Virginia have been extirpated, creating geographically discrete northern and southern populations.

The southern bog turtles' historic range included most of southern and central Appalachia and the surrounding foothills, valleys, and plateaus. Populations were clustered around early seral wetlands with migratory corridors of dense vegetation. Its range included present-day Georgia to

[100] IUCN 2021 / Knoerr 2021. 2.
[101] NCWRC 2018. 1.
[102] *Id.*

Virginia and included the Cumberland Plateau, Blue Ridge, and Piedmont physiographic provinces. Historically, southern bog turtle populations occurred in ten river basins in the Southeast in both the Mississippi-Ohio and Atlantic drainages.[103]

In 1997, the northern population of bog turtle was listed as federally threatened. The southern population was not simultaneously listed because limited information existed at the time regarding threats and survey coverage. It has become evident in the past two decades that the southern population faces many of the same threats as the northern population, and its population is collapsing even more rapidly. An estimated 90% of bog turtle wetlands habitat has been lost in the southern Blue Ridge.[104] Few viable bog turtle populations remain, and most are in serious decline.[105]

A 10-year mark-recapture study of 11 bog turtle populations in 2013 funded by the U.S. Fish and Wildlife Service found that the minimum viable population (MVP) threshold for a stable population of bog turtles is around 40 turtles and as few as 15 females.[106] This threshold does not account for inbreeding depression, demographic and environmental stochasticity, and other environmental disturbances and catastrophes.

Today, there are 14 or fewer bog turtle sites with 40 individuals or 15 females across its entire southern range.[107] Very few to no juvenile bog turtles are found at most sites.[108]

The southern population of bog turtles has 223 historical records across Georgia, North Carolina, Tennessee, and Virginia.[109] Only a single individual was observed at most sites. Many of these records have not been verified or updated in over two decades. Many sites are likely extirpated.[110]

While species with long generation times typically have high adult survival, adult bog turtle survival rates appear to be low and unstable in a 2017 study of North Carolina populations.[111]

Few viable bog turtle populations, dangerously low juvenile survivorship, and little to no recruitment suggest that the southern bog turtle's survival is imminently threatened. There are now estimated to be fewer bog turtles in the southern population than in the northern population.

Based on the latest data and estimates from state agencies, the southern population of bog turtles likely consists of fewer than 2,000 individuals.[112]

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[103] Tryon and Herman 1990. 50.
[104] NCWRC 2018. 1.
[105] *Id*.
[106] Shoemaker 2013. 324.
[107] Bog Turtle Database 2021. Virginia Department of Wildlife Resources, North Carolina Wildlife Resources Commission, Tennessee Wildlife Resources Agency, South Carolina Department of Natural Resources, and Georgia Department of Natural Resources provided their most recent state turtle data from the Bog Turtle Database. This data is displayed by state in Figure 3.
[108] *Id.*
[109] *Id.*
[110] *Id*.
[111] Tutterow, Graeter, and Pittman 2017. 293.
[112] Bog Turtle Database 2021.

State	Total bog turtle sites	Sites with 40 or more individuals or 15 females
North Carolina	118	10
Virginia	89	2
Tennessee	2	2
Georgia	8	0
South Carolina	6	0
TOTAL	**223**	**14**

Figure 3. Summary of bog turtle occurrence and abundance across its five-state southern range. Only 14 bog turtle populations of 40 or more individuals remain.

Most remaining bog turtle sites are found in the Blue Ridge physiographic province in North Carolina, but some have been found in the upper Piedmont along the base of the Blue Ridge Escarpment. Bog turtle records exist within the Middle Tennessee-Hiwassee, Upper Tennessee, French Broad-Holston, Savannah, Santee, Upper Pee Dee, Kanawha, and Roanoke River basins.[113] Below is a summary of bog turtle population status by state.

North Carolina

North Carolina contains most of the remaining southern bog turtle population and a majority of its range.[114] There are 118 confirmed historical occurrence records for bog turtles in North Carolina wetlands.[115] However, wetlands have been lost or destroyed in nearly half of these sites.[116] Many more sites have significant reductions in size or quality from destructive human activities. Most of the sites have not had a recent turtle record.

Since 2007, 49 wetland sites had at least one bog turtle captured; 22 sites have five or more turtles captured; and 18 sites have 10 or more turtles captured.

Only 10 sites in North Carolina—8 percent of all known sites—meet the minimum viable population threshold of 40 turtles. Only two of those sites have stable populations.[117] All of the remaining sites in North Carolina are in steep decline.[118]

The population declines have become especially prevalent since 2010. Over the past ten years, wildlife officials and volunteers have observed that sites that previously sheltered bog turtles are

[113] NCWRC 2018. 5-7.
[114] Tutterow, Graeter, and Pittman 2017. 293.
[115] NCWRC 2015.
[116] Bog Turtle Database 2021.
[117] Bog Turtle Database 2021.
[118] NCWRC 2018. 5-6.

empty. No turtles were found at most sites visited in the past ten years across the southern bog turtle range.[119]

Of the few sites where turtles were found, nearly all of the individuals were adults. Very few young or juvenile turtles were found in any of the North Carolina sites, and only a few juvenile turtles were found across its entire southern range.[120]

In a recent analysis, adult survivorship of bog turtles in North Carolina varies from 0.855 to 0.942 among eight intensively sampled sites, a low survival rate and below the 0.96 adult survival estimate documented for northern bog turtle populations.[121] Juvenile survivorship varies from 0.510 to 0.68.[122] Populations across sites are dominated by older individuals with very few to no juveniles.[123]

As a result, the southern bog turtle is on a genetic precipice. Genetic diversity across the southern population remains adequate currently, but the next generation of bog turtles is almost nonexistent, and a genetic bottleneck is expected to further threaten the bog turtle's survival.[124]

In addition, gene flow among scattered, disjunct subpopulations of bog turtles is extremely limited, further threatening the long-term health of the southern bog turtle. Dispersal limitation within a fragmented landscape has played a key role in the decline of bog turtles.[125] Current rates of dispersal among bog turtles are critically low due to extreme geographic isolation and the imposition of anthropogenic barriers such as roads.[126]

As early as 2001, U.S. Fish and Wildlife Service concluded that "North Carolina bog turtle populations are likely declining and without additional efforts, local and regional extirpations may occur."[127] Since then, North Carolina populations have crashed in all but a few remaining sites. Low juvenile survival rates, little to no recruitment, and extremely low numbers of viable sites make it even more difficult for populations to recover on their own.

South Carolina

South Carolina does not have any known populations of bog turtles. South Carolina Department of Natural Resources reports 6 historical records of bog turtles consisting of single individuals and no known juveniles.[128] No remaining bog turtle populations of 30 or more individuals

[119] *Id.*
[120] *Id.*
[121] Tutterow, Grater, and Pittman 2017. 295-299. Shoemaker and Gibbs 2013. 3329.
[122] Tutterow, Graeter, and Pittman 2017. 295-299.
[123] *Id.*
[124] Tutterow, Graeter, and Pittman 2017. 299.
[125] Shoemaker and Gibbs 2013. 329-330.
[126] Rosenbaum 2007. 331.
[127] NCWRC 2018. 1.
[128] Bog Turtle Database 2021.

remain. A 2020 survey was not able to document bog turtles at any previously known locations.[129]

Georgia

Georgia has 11 records of bog turtles in northeastern Georgia in Fannin, Rabun, Towns, and Union counties.[130] At six of these sites, only a single individual was observed. In three sites, the associated population is apparently extirpated due to habitat succession and site drainage. Two populations are located on Chattahoochee National Forest lands, but the future viability of one of these populations is uncertain due to low turtle numbers and limited suitable habitat. Two populations on private lands are currently believed to contain viable populations. They are the source of hatchling turtles for a head-starting and population establishment project within restored mountain bog habitat on federal land.[131]

Virginia

Virginia Department of Wildlife Resources reports 89 sites in four counties in the extreme southwestern portion of Virginia.[132] At least two of these sites have likely been extirpated.[133] Most sites have only one or a few turtles.[134] In a 2019 mark-recapture study of six wetlands, site abundance ranged from six to 14 individuals.[135] According to Virginia Department of Wildlife Resources, only one or two of the sites in Virginia met the Shoemaker minimum viability threshold of 40 individuals or 15 females.[136]

At six sites in Virginia, bog turtle abundance has declined by 50% since 1997.[137] Anthropogenic habitat destruction, increased predation, and roads were identified as the causes of decline. [138]

Tennessee

Tennessee has only two populations of bog turtles. One of the populations is a translocation population where over 150 turtles have been placed over the past 30 years. This population currently has approximately 50 individuals.[139] The second population in Tennessee has around 40 turtles.[140]

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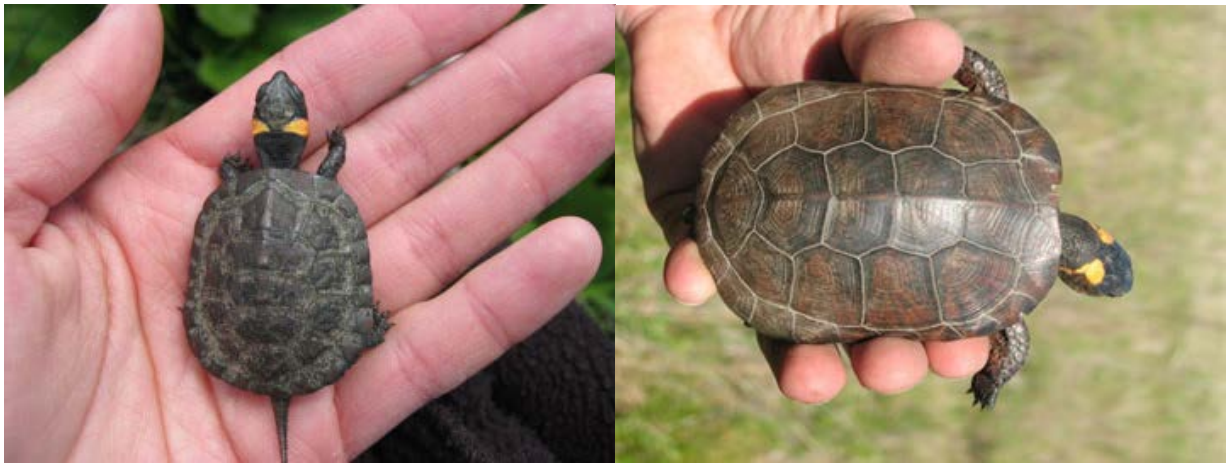
[129] Stratmann, Floyd, and Barrett 2020. 333.
[130] Georgia DNR 2011. 1-2.
[131] *Id.*
[132] Virginia DWR / Bog Turtle Database 2021.
[133] Holden 2021. 4.
[134] Virginia DWR / Bog Turtle Database 2021.
[135] Holden 2021. 4.
[136] Virginia DNR / Bog Turtle Database 2021.
[137] Holden 2021. 4.
[138] *Id.*
[139] Tennessee Wildlife Resources Agency / Bog Turtle Database 2021.
[140] *Id.*

THREATS



U.S. Fish & Wildlife Service

Present or threatened destruction, curtailment, or modification of habitat or range

Habitat loss is a major factor for the past and present decline of the bog turtle across its entire range. Fewer than 1200 acres of mountain bog habitat remain across the turtle's entire range.[141]

Historically, wetlands have been reduced by at least 50 percent since European arrival.[142] Today, wetland ecosystems are disappearing three times faster than forests and one of the world's most endangered ecosystems, according to a 2021 IUCN report.[143]

In the past two decades, wetlands loss has accelerated across the range of the southern population of the bog turtle. The draining and ditching of wetlands, the conversion of wetlands for agriculture, logging, industrial and commercial development, succession, lack of wetlands management, and interstate and road construction are primary drivers of bog turtle habitat loss. These activities have also severely fragmented remaining habitat and created physical barriers to movement and migration, further isolating bog turtles from other sites and preventing the gene flow necessary to sustain the species.

Loss and degradation of wetlands habitat

[141] Herman and Tryon 1997. 364. / Weakley and Schafale 1994. 359.
[142] Dahl 2011. 108.
[143] Elbein 2021. Paragraph 6.

Bog turtles' montane freshwater wetlands are among the rarest and most imperiled habitat types in the Southeast.[144] An estimated 90 percent of freshwater wetlands and bog habitats have been lost in the Southeast. [145]

As a result, the bogs that remain are more isolated on the landscape, with metapopulations of bog turtles composed of fewer or only one remaining population. As a result, remaining populations are more susceptible to extirpation.

Most wetland drainage has been for agriculture, livestock, ponds, or other forms of human development.[146] Almost every remaining mountain bog shows evidence of past human manipulation.[147] Many remaining wetlands are downhill from pastures, agricultural fields, orchards, nurseries, and Christmas tree farms, all of which can result in increased runoff of fertilizers and pesticides.[148] This increase in nutrients, toxins, and sediments threaten the suitability for bog turtle habitat and threaten the health of bog turtles. Increased eutrophication of wetlands can damage the sphagnum moss and other native plants essential to the bog turtle's habitat.[149] Pesticides have been shown to cause complete mortality of snapping turtle eggs, even when used at 10 percent of the recommended dosage.[150]

Approximately 85 percent of known bog turtle habitat across its southern range is privately owned with no long-term protective measures in place. About 60% of wetland sites (44 of 74 sites) in North Carolina do not have any conservation measure or easement.[151] In addition, many aging farms are changing hands and transitioning to new ownership.

Development

Development threatens nearly all remaining southern bog turtle sites. Development may include residential, commercial, or industrial land use conversion, but it almost always includes an increase in impermeable surfaces. More impermeable surfaces results in increased stormwater runoff and erosion bringing additional nutrients and pollutants into bog turtle habitat.[152]

Development also lowers the water table due to the sinking of wells and when roads act as a barrier to the normal flow of surface water. Development also leads to increased traffic and road mortality, surface water pollution, and accelerated succession by invasive plants. Untimely mowing or burning and the use of pesticides on adjacent agricultural fields also degrades bog turtle habitat.[153]

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[144] Noss, LaRoe, and Scott 1995. 95.
[145] Weakley and Schafale 1994. 359-360.
[146] Tesauro and Ehrenfeld 2007. 293-294.
[147] NCWRC 2018. 6-9.
[148] *Id.*
[149] *Id.*
[150] de Solla, Palonen, and Martin 2014. 102-103.
[151] NCWRC 2018. 7.
[152] *Id*.
[153] USFWS 1997. 59615.

Additional sedimentation of wetlands from development can result in a thick layer of mineral soil on top of the saturated, organic soils of a bog. This mineral layer dramatically alters the habitat and can make it difficult for bog turtles to access the saturated soils.[154] And increased stormwater runoff can result in the channelization and head-cutting of wetlands that make it more difficult for the continent's smallest turtle to overcome.

Water consumption from more residential wells and commercial and industrial activity reduces groundwater discharge to the wetland and results in less groundwater available for bog turtle wetlands habitat.[155]

Bog turtle habitat also includes adjacent vegetative buffers surrounding wetlands and forested corridors for mating, feeding, dispersal and migration. These forested corridors are increasingly being lost to development. A bog turtle wetland in Henderson County, N.C., is now surrounded on all sides by encroaching residential neighborhoods, effectively preventing migration and gene flow. Increased bog turtle predation from domesticated animals and human commensal mesopredators such as raccoons, opossum, skunks, and foxes has been observed, and the wetlands have been degraded by increased lights, traffic, and waste.[156]

Development and agricultural intensification also bring vehicles and equipment, such as tractors, bush hogs, and lawn mowers, that can result in injuries and death to turtles.[157] The North Carolina Wildlife Resources Commission and Project Bog Turtle partners have captured three injured and two dead bog turtles with long, deep injuries to the shell that appear to be caused by a blade.[158]

Industrial and commercial development threaten key bog turtle habitat, including one of the previously healthiest bog turtle sites in North Carolina. A manufacturing facility is under construction, and the status of the bog turtles who once inhabited the bog remains unknown.[159] More commercial and industrial development is planned for the property.

In the past forty years, development has increased 568% in western North Carolina, where most remaining southern bog turtles are located.[160] Development is expected to increase another 63% by 2030. By 2030, the average rate of development will be 16.3 acres per day in western North Carolina.[161] The population of the 19-county region is expected to approach 1 million, and an additional 145,374 acres of land will be developed, the equivalent of an area nearly six times the area within Asheville's city limits.[162]

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[154] Feaga 2010. 55.
[155] Brennan *et al.* 2001. 52.
[156] Knoerr, Graeter, and Barrett 2020. 6. / NCWRC pers. comm. October 15, 2021.
[157] USFWS 2010a. 24-29.
[158] NCWRC pers. comm. October 15, 2021.
[159] NCWRC pers. comm. 2021.
[160] Gleave 2010. 1.
[161] *Id.*
[162] *Id.*

Vehicles and roads

Vehicle collision is one of the greatest threats to bog turtles.[163] Bog turtles often attempt to cross roads.[164] At least six bog turtle road kills have been reported in North Carolina, including a gravid female.[165] Many more are likely hit and not observed or reported. Semi-terrestrial turtles lose greater than 5% of their population annually from roads.[166]

Road mortality also skews turtle populations toward males. Sexually mature females completing nesting migrations are likely much more susceptible to road-induced mortality than males.[167] Females more often make Researchers have found more male turtles than females in wetlands surrounded by high-density roads.[168] For most small populations of turtles, the loss of a single female per year results in a negative growth rate.[169] Because remaining bog turtle subpopulations are so small, the loss of a single gravid female could result in local extirpation. Beyond direct mortality, roads result in habitat fragmentation, decreased dispersal between sites, reduced abundance, and loss of genetic diversity.[170]

Bog turtles already have small, discrete populations. When a small population loses even one turtle a year to an adjacent road, the population is likely suffering a slow decline from which it will be difficult to recover. Long-term demographic studies of turtle populations have indicated that as little as 2-3% annual road mortality is likely to cause population declines.[171]

Road mortality also reduces bog turtle's ability to disperse, which reduces gene flow and can slowly drive a population to extinction.[172] Bog turtles are especially susceptible to local extirpations because of their small population size and dependence on rare, isolated wetlands habitat.[173]

A bog turtle site in Buncombe County is now surrounded by new residential developments, and new roads now bisect the surrounding forest. North Carolina Department of Transportation has proposed widening a two-lane state highway to four lanes. North Carolina Department of Transportation plans to begin right-of-way acquisition for the widening project in 2024 and begin construction by 2027. If completed, the four-lane highway would destroy bog turtle habitat

[163] Gibbs and Shraver 2002. 1647.
[164] NCWRC 2018. 11.
[165] NCWRC pers. comm. October 15, 2021.
[166] Gibbs and Shriver 2002. 1647.
[167] Steen and Gibbs 2004. 4.
[168] *Id.*
[169] Gibbs and Steen 2002.
[170] Marsh and Jaeger 2015. 42.
[171] Gibbs and Shriver 2002. 1647.
[172] Marsh and Jaeger 2015. 42.
[173] Apodaca *et al.* 2012. 913.

and one of the last montane freshwater sloughs in the state. The four-lane expansion would further restrict bog turtle migration, dispersal, and gene flow.

Three additional bog turtle wetland habitats have already been destroyed by the road expansion projects in Buncombe and Henderson Counties. The project has resulted in the draining and filling of adjacent wetlands once inhabited by bog turtles. Fill dirt and concrete now cover the wetlands. No mitigation measures were in place to protect bog turtle habitat. The full protection of the Endangered Species Act for the southern population of bog turtles may have prevented the unnecessary loss of its increasingly rare habitat.

Livestock overgrazing

Overgrazing can cause excessive soil exposure, denuding of moss and herbaceous vegetation, and destruction of rare plants found in bog turtle wetlands.[174] In addition, intensive grazing can increase nutrient loads in these habitats. The average cow has 12 bowel movements a day that deposit 23 kilograms of feces.[175] Significant increases in nutrient concentrations and pollution can occur when cattle are stocked at high density can harm native vegetation like sphagnum moss and facilitate invasion by exotic vegetation.[176] Livestock can also trample bog turtles, and a large number of livestock on or near a wetland can pose a significant threat to the bog turtle population.[177]

[174] NCWRC 2018. 9-10. / Tesauro and Ehrenfeld 2007. 293.
[175] Hoorman 2005. 1-2.
[176] USFWS 2001. 20. / Tesauro and Ehrenfeld 2007. 20.
[177] Tesauro and Ehrenfeld 2007. 293.

Overutilization

Pete Pattavina / U.S. Fish & Wildlife Service

The South is home to the most turtle species in the world, which makes the region a prime target for poachers in the illegal wildlife trade. The bog turtle is a highly prized exotic pet that fetches thousands of dollars on a thriving black market. Poaching rare turtles like the bog turtle is a multimillion-dollar industry, with poachers combing the wetlands of Eastern North America for rare turtles and then shipping them to buyers, mainly in Asia and Europe.[178] Many bog turtles are sold online and in pet shops. The rarer the turtle, the more valuable they become on the black market. With so few remaining bog turtles, they can sell for tens of thousands of dollars.[179]

Rare turtles represent the fourth largest source of wildlife sold on the black market. While once sought as a delicacy or as a source for medicines, turtles are now mainly bought as unusual pets. Demand for rare turtles in Asia has skyrocketed, especially in the last five to ten years. A 2018

[178] Abel 2020. Paragraphs 7-17.
[179] *Id.*

meta-analysis of the impact of turtle trade concluded that turtles are the most imperiled vertebrates globally.[180] North American species including the bog turtle are especially prized and popular.[181]

The World Wildlife Fund noted special concern for illegal trafficking of the bog turtle, a critically endangered species with limited habitat, small populations, delayed reproductive maturity, low reproductive success—and extremely high poaching pressure.[182]

The Fish and Wildlife Service has concluded that the general consensus among bog turtle researchers, nongame biologists, and law enforcement officials is that illegal collecting is occurring at a much higher rate than is reported or detected.[183]

Collection pressure may cause such severe declines that subpopulations are completely eliminated or become functionally extinct.[184] Because bog turtle populations are precariously small and isolated, the loss of a single breeding female could result in the collapse of a bog turtle colony. Few bog turtle eggs successfully hatch, and even fewer hatchlings reach maturity. One or two turtles poached from a population annually is enough to drive localized extinction.[185] Once bog turtles at a site drop below the Shoemaker threshold, the population likely will not recover and is headed toward extirpation.[186] Several southern bog turtle sites in North Carolina and Virginia are functionally extinct because of poaching.[187]

In 1989, a large number of turtles were collected from a bog in Henderson County, and turtles showed up on the illegal market in Ohio.[188] In the years since that site was poached, the bog turtle population has consisted almost exclusively of old turtles, despite having high quality habitat. It has never recovered into a site with a good mix of age classes, which has been attributed to the loss of many breeding individuals from this poaching event.[189]

Biologists in Georgia, Tennessee, North Carolina, and Virginia have attempted to curtail bog turtle poaching by carving notches into bog turtle shells to make them less marketable and easier to identify.[190]

Partners for Amphibian and Reptile Conservancy and North Carolina Wildlife Resources Commission have worked with undercover law enforcement to protect remaining populations of bog turtles. But with limited funding and personnel, their success has been limited.

Previously, one of the bog turtle's largest populations was found in a rare montane floodplain slough forest in western North Carolina. The site hosted dozens of bog turtles, including

[180] Rhodin *et al.* 2018. 155.
[181] Maron 2019. Paragraph 10.
[182] Abel 2020. Paragraphs 7-17.
[183] USFWS 1997. 59617.
[184] Ernst and Lovich 2009. 269-270.
[185] Abel 2020. Paragraphs 7-17.
[186] *Id.*
[187] *Id.*
[188] NCWRC 2018 (D.W. Herman). 9.
[189] *Id.*
[190] Abel 2020. Paragraphs 7-17.

juveniles. Today, that bog turtle population has been entirely eliminated—likely by poaching.[191] The site is located close to an urban center and is easily accessible from a major highway. No bog turtles have been observed at this location in over a decade.[192]

Disease and predation

U.S. Fish & Wildlife Service Southeast Region

Disease

Species with small populations, such as the bog turtle, are more vulnerable and less resilient to disease.[193] Bog turtles often suffer from both viral and bacterial infections. Bacteria that cause pneumonia in the genera *Aeromonas* and *Pseudomonas* have been observed in bog turtles. Pneumonia was documented as the potential cause of death for two turtles in North Carolina and Virginia in 2005.[194] Bacterial aggregates have also been found in the lungs of two deceased specimens discovered in 1982 and 1995 from colonies in the southern population. In addition, leeches and parasitic flies also plague some populations.[195]

In the past decade, there have been increasing reports of sick and dead bog turtles with gray or whitish discoloration, skin lesions, sloughing of skin, and loss of claws, toes, or limbs.

[191] Petranka pers. comm. 2019.
[192] *Id.*
[193] Knoerr et al. 2021. 2.
[194] Carter et al. 2005. 170.
[195] Ernst and Lovich 2009. 271.

The U.S. Fish and Wildlife reported that 14 bog turtles were found dead at one site in Pennsylvania. *Mycoplasma* and *Ranavirus* were among the suspected causative agents.[196]*Mycoplasma* is a bacterial agent that has previously affected other turtle species, and it has been identified at bog turtle sites. It has the potential to cause serious declines in bog turtle populations.[197]

Predation

Raccoons, skunks, opossums, dogs, foxes, and wading birds prey on bog turtles. Adults are sometimes found with missing limbs and gnawed shells.[198] Their shells offer little protection from predators. The bog turtle's main defense when threatened by an animal is to bury itself in soft mud.[199]

Southern bog turtles have suffered unusually high predation rates of nests, especially in the past decade. Increased development near bog turtle wetlands habitat has attracted more meso-mammal predators, including raccoons, skunks, foxes, and opossum. These human-commensal predators consume both bog turtles and their eggs. Predation by mesopredators such as raccoons appears to increase with higher human density.[200] Other known or suspected predators of bog turtles include snakes, egrets, herons, coyotes, muskrats and snapping turtles.[201] As development encroaches further upon bog turtle habitat, domesticated and feral dogs and cats may also prey on bog turtles and their nests.[202]

Camera traps have documented increased predation of turtle nests by mesopredators. Increased nest predation may also help explain the lack of young and juvenile bog turtles across nearly all sites. Low nest success and juvenile survival may be the most critical factor in the persistence of the species. Predation impairs reproductive recruitment and skews the population age structure towards older individuals.[203]

Bog turtle nests have low hatch success rates. Only 28 percent of eggs hatched from bog turtle nests in a 2015 study of North Carolina bog turtle sites.[204] Nest predation was the primary cause of failure.[205]

[196] USFWS 2014a. 1-5.
[197] USFWS 1997. 59618.
[198] Virginia Herpetological Society 2021. 1.
[199] Ernst and Lovich 2009. 266.
[200] USFWS 1997. 59618.
[201] Ernst and Lovich 2009. 266.
[202] Holden 2021. 65. 84.
[203] USFWS 1997. 59618.
[204] Zappalorti et al. 2017. 194.
[205] Knoerr, Graeter, and Barrett 2020. 6-7.

Predation rates of bog turtle eggs in Pennsylvania were 12 to 57 percent over a two-year period.[206] 40 to 74 percent of bog turtle eggs were depredated over a two-year period in Maryland. In New York, researchers documented a 62 percent predation rate.[207]

State agencies across the bog turtle's southern range have achieved some success with predator exclusion cages for nests.[208] A 2017 study of predator exclusion devices for northern population bog turtle nests significantly lowered nest depredation rates.[209] And in North Carolina, nests with predator exclusion devices increased hatch success rate to 80 percent.[210]

However, predator exclusion cages have limitations. detection of bog turtle nests is often difficult and time- and labor-intensive. It can be challenging to visually locate nests at many sites, since bog turtles are adept at concealing nests within vegetation. Despite intensive surveying, biologists were unable to locate any nests at two sites in 2020 and were only able to find a few nests at most other sites.[211]

Inadequacy of existing regulatory mechanisms

Existing federal, state, and local regulatory mechanisms are inadequate to protect against the threats to the southern population of the bog turtle, which include habitat destruction, overutilization, disease, predation, invasive species, and climate change. Despite dedicated efforts by federal and state agencies over the past 24 years, existing mechanisms have not stemmed the increasing loss of bog turtles and their habitat across its entire southern range. Even "threatened due to similarity of appearance" protections under the Endangered Species Act have failed to prevent steep declines in the southern population of bog turtles.

Current regulations and designations that incidentally protect the bog turtle are the result of planning and informational documents that are not legally binding and present voluntary recommendations. Voluntary and unenforceable conservation efforts are simply *per se* insufficient as "regulatory mechanisms" under 16 U.S.C. 1533(a)(1)(d): "Voluntary actions, like those planned in the future, are necessarily speculative …. Therefore, voluntary or future conservation efforts by a state should be given no weight in the listing decision.[212]

[206] Zappalorti *et al.* 2017. 199-200.
[207] USFWS 2001. 19-23.
[208] NCWRC 2020. 29-30.
[209] Zappalorti 2017. 200.
[210] NCWRC 2020. 29-30.
[211] *Id.*
[212] See *Oregon Natural Resources Council v. Daley.*

U.S. Fish & Wildlife Service

Federal mechanisms

Endangered Species Act: Threatened Due to Similarity of Appearance

The southern population of the bog turtle is listed as threatened due to similarity of appearance. In 1997, the Fish and Wildlife Service listed the northern population of *Glyptemys muhlenbergii* as threatened. Because the southern population closely resembled the northern population, the agency granted the southern population special status as threatened due to similarity of appearance:

"*Presently, the origin or locality of a specimen cannot be determined. This poses a problem for federal and state law enforcement agents trying to stem illegal trade in the threatened northern population. The listing of the southern population as threatened due to similarity of appearance eliminates the ability of commercial collectors to commingle northern bog turtles with southern ones or misrepresent them as southern bog turtles for commercial purposes. For these reasons, the Service is listing the southern population (occurring in the states of Georgia, North Carolina, South Carolina, Tennessee, and Virginia) as threatened due to similarity of appearance.*"[213]

This special rule exempts incidental take of the southern population of bog turtles. Incidental take results from, but is not the purpose of, the carrying out of an otherwise lawful activity. Wetlands ditching and draining, the application of pesticides, livestock grazing, and other

[213] USFWS 1997. 59622.

activities that result in the incidental take of a bog turtle are be considered a violation of the act in Georgia, North Carolina, South Carolina, Tennessee, and Virginia.[214]

This special exemption allows continued degradation of bog turtle habitat and places the southern population at increasing risk of extinction. With increasing threats and decreasing numbers, the southern bog turtle now requires the full protection of the Endangered Species Act.

Convention on International Trade in Endangered Species (CITES)

On July 1, 1975, the bog turtle was added to Appendix II of the Convention on International Trade in Endangered Species (CITES). On June 11, 1992, it was transferred from Appendix II to Appendix I. Export and import permits are required from the exporting and importing countries before an Appendix I species can be transported, and an Appendix I species cannot be transported for commercial purposes.

Despite its listing as an Appendix I species, bog turtles have been increasingly harvested by illegal collectors over the past three decades. Enforcement of CITES has been lacking, and poaching of bog turtles remains a significant threat to the species' long-term survival.

Section 404 of the Clean Water Act

Section 404 of the Clean Water Act regulates the discharge of dredge or fill material into the waters of the United States. The U.S. Army Corps of Engineers and the U.S. EPA are responsible for administering section 404. Section 404 requires that project proponents obtain a permit before undertaking activities in the waters of the United States that involve dredge or fill material. Under the CWA section 404 program, destruction of bog turtle habitat continues to be authorized.[215] Furthermore, the bog turtle is affected by agricultural practices—such as draining and ditching of wetlands—which are entirely exempt from regulation under section 404.

National Forest Management Act

The National Forest Management Act (NFMA) of 1976 regulates the multiple uses of the nation's forests including to "provide for diversity of plant and animal communities…" (g)(3)(B). Additional requirements for forest management based on NFMA state that to comply with ecosystem integrity and diversity requirements the plan must "…maintain the diversity of plant and animal communities and support the persistence of most native species in the plan area."[216]

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[214] *Id*.
[215] *Id.*
[216] See Section 219.9 of the National Forest Management Act.

Even with the additional provisions of the 2012 planning rule, this law is inadequate for the conservation of the bog turtle because most bog turtle sites occur on private lands, and bog turtle sites on national forest lands remain vulnerable to the impacts of timber harvests, mining, pipelines, oil and gas drilling, and road construction.

The U.S. Forest Service manages some southern bog turtle sites, but under its multiple use mandate, the agency has flexibility in weighing the impacts of timber projects on bog turtle habitat. The U.S. Forest Service's draft Environmental Impact Statement and Forest Plan for the Nantahala-Pisgah National Forest—which shelters the most southern bog turtle habitat—proposes quadrupling the timber harvests across the forest and reducing the size of buffers for intermittent and ephemeral streams, which will further jeopardize bog turtle habitat.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider the effects of their actions on the environment through the utilization of environmental assessments and environmental impact statements. These reports must disclose any adverse impacts to the environment—including impacts rare and sensitive species such as the bog turtle. However, the law only requires agencies to disclose the impacts of their actions; it does not prohibit agencies from choosing alternatives that will negatively affect individuals or populations of the bog turtle. Additionally, because the southern population of the bog turtle is only listed as "threatened due to similarity of appearance," the bog turtle's habitat receives no protection.

The Wilderness Act

The Wilderness Act of 1964 allows for the designation of protected wilderness areas on public land to "…retain its primeval character and influence, without permanent improvements or human habitation." Wilderness areas protect many species from human impacts. However, only a very small number of bog turtles are found in any designated wilderness areas or wilderness study areas across its southern range. The protections provided by the Wilderness Act are not currently sufficient to protect the species.

State mechanisms

Virginia

Glyptemys muhlenbergii is a listed as a state endangered species in Virginia, which prohibits direct take of bog turtles.[217] Virginia Department of Wildlife Resources' 2015 Wildlife Action

[217] Virginia Department of Wildlife Resources 2021. 1.

Plan ranks the bog turtle as Tier I and a Species of Greatest Conservation Need.[218] Virginia Department of Wildlife Resources is developing a Bog Turtle Management Plan in 2022.[219] The Virginia Department of Wildlife Resources monitors bog turtle sites in the state and works with Virginia Tech to identify potential new sites. However, there are no legally actionable state-level mechanisms or enforcement measures to protect bog turtle populations or their habitat in Virginia. Only one or two viable populations remain. State mechanisms are inadequate to protect the bog turtle in Virginia.

North Carolina

The North Carolina Wildlife Resources Commission lists the bog turtle as threatened, which prohibits direct take. North Carolina Wildlife Resources Commission has also developed a Conservation Plan for the Bog Turtle that aims to identify threats, maintain and maximize the number of viable populations, further knowledge, and expand outreach efforts. The plan also identifies ten actions needed, including management plans for bog turtle sites, schedules of habitat management needs for all populations, and long-term protection of bog turtle habitat.[220]

Project Bog Turtle is an independent, private-sector, volunteer conservation initiative dedicated to the preservation of the southern population of bog turtles and their habitats. Project Bog Turtle was launched in 1995 as a subsidiary of the North Carolina Herpetological Society. Project Bog Turtle conducts surveys and monitors populations at bog turtle sites across North Carolina. It also works to directly protect turtle habitat and advise federal and state agencies.

Bog Learning Network is a collaboration to protect Southern Appalachian bogs through collaboration, wetlands stewardship, applied conservation, and adaptive management. While regionwide in scope, its steering committee is primarily based in North Carolina, and much of its research and stewardship has focused on North Carolina wetlands and bog turtle habitat.

North Carolina Wildlife Resources Commission, Project Bog Turtle, and the Bog Learning Network have provided incredible data, fieldwork, and habitat protection. However, despite these heroic long-term efforts, bog turtle populations continue to decline rapidly across North Carolina. Only ten total sites in North Carolina have viable populations. Unfortunately, state mechanisms in North Carolina have proven inadequate to protect bog turtles.

South Carolina

The bog turtle is listed as a state endangered species in South Carolina previously occurring in the Blue Ridge and Piedmont eco-basins.[221] However, South Carolina has no known active bog

[218] *Id.*
[219] Virginia Department of Wildlife Resources pers. comm. 2021.
[220] NCWRC 2020. 31-32.
[221] South Carolina Department of Natural Resources pers. comm. 2021.

turtle sites.[222] In 2020, South Carolina passed a law limiting the possession of native species of turtles and completely restricting the possession of any state listed turtles, including the bog turtle.[223]

There is suitable wetlands habitat for bog turtles in South Carolina, but there are no programs currently in place to protect any remaining bog turtles or restore bog turtle sites or populations. South Carolina's Wildlife Action Plan lists bog turtles as a high priority species, but no bog turtle monitoring programs are currently included in the plan. There are no known bog turtle populations remaining in South Carolina. State mechanisms are inadequate to protect bog turtles in South Carolina.

Tennessee

The Tennessee Wildlife Resources Agency (TWRA) lists the bog turtle as threatened. The Tennessee Department of Environment and Conservation (TDEC) considers bog turtles very rare and imperiled. TWRA describes current threats to the bog turtles as follows: "Populations are under considerable threat due to the loss of their mountain bog habitat from farming, wetland destruction, and development. Also, Bog Turtles are at risk from being collected and sold in the commercial pet trade."[224] State listing prohibits direct take of bog turtles. However, state listing does not provide any additional legally actionable state-level protections for bog turtle habitat. Only two viable populations remain, and one is a translocation. State mechanisms are inadequate to protect bog turtles in Tennessee.

Georgia

Bog turtles are listed as endangered in Georgia under the authority of the Goergia Endangered Wildlife Act, which prohibits direct take of individuals. However, there is no protection for bog turtle habitat in Georgia unless it occurs on state-owned land.

Georgia Department of Natural Resources has been actively monitoring bog turtle sites and surveying for additional sites since 2004. Georgia DNR has analyzed over 350 potentially suitable wetland sites, via remote assessment and visited 250 sites. It has intensely surveyed 30 of those sites, and it has been able to identify 5 new sites over the past 15 years. Despite this herculean surveying and monitoring effort, bog turtle populations continue to decline across the state. State mechanisms are inadequate to protect the bog turtle in Georgia.

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[222] *Id.*
[223] South Carolina Department of Natural Resources 2020. 1.
[224] Tennessee Wildlife Resources Agency 2021. 1.

Other natural or manmade factors affecting the continued existence of the species

U.S. Fish & Wildlife Service

Invasive species

Many bog turtle populations are already threatened by invasive plants.[225] Habitat destruction and fragmentation, development, road construction, and climate change are likely to exacerbate the the impact of invasive plants on bog turtles and their habitat. Development and soil disturbance often lead to the introduction of invasive species that threaten bog turtle habitat. Vegetation like purple loosestrife (Lythrum salicaria), multiflora rose (Rosa multiflora), reed canary grass (Phalaris arundinacea), and common reed (Phragmites australis) degrades bog turtle habitat by eliminating the open, sunny conditions required by the bog turtle.[226]

Bog turtle wetland habitat is especially vulnerable to invasions by aggressive non-native plants. The accumulation of debris, sediments, water, and nutrients in wetlands facilitates invasions of invasive plants.[227] Most invasive wetland species grow as a monotype, resulting in lower biodiversity, altered habitat structure, and modified food webs.[228]

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[225] Tesauro and Ehrenfeld 2007. 297-98.
[226] *Id*.
[227] Zedler and Kercher 2004. 431.
[228] *Id.*

The following invasive plants have been documented in bog turtle wetlands across its southern range:

Autumn olive (*Elaeagnus umbellata*)
Chinese lespedeza (*Lespedeza cuneata*)
Chinese privet (*Ligustrum sinense*)
Chinese silvergrass (*Miscanthus sinensis*)
Japanese barberry (*Berberis thunbergii)*
Japanese honeysuckle (*Lonicera japonica*)
Japanese knotweed (*Polygonum cuspidatum*)
Japanese stiltgrass (*Microstegium vimineum*)
Multiflora rose (*Rosa multiflora)*
Oriental bittersweet (*Celastrus orbiculatus*)
Purple loosestrife (*Lythrum salicaria*)
Reed canarygrass (*Phalaris arundinacea*)
Yellow flag iris (*Iris pseudacorus*)

There are several documented cases of invasive plant species forming a monotype in bog turtle wetlands and affecting the habitat quality.[229]

Wildlife not native to the bog may also pose a threat to bog turtles, especially any species that affects nest success and juvenile or adult survivorship, such as the red imported fire ant *(Solenopsis invicta*), which has been documented in eight counties with bog turtle records in North Carolina.[230] Fire ants have been observed preying upon nests of other larger turtle species, including gopher tortoises, snapping turtles, Florida cooters, and yellow-bellied sliders.[231]

Climate change

Bog turtles are more naturally limited across their southern range by geographic and physiographic constraints. Bog turtles are exposed to higher temperatures and have fewer naturally available wetlands across their southern range.[232] Climate change is expected to increase average and daily maximum temperatures across the bog turtle's southern range.[233]

The most recent climate models for the Southeast also indicate that the intensity and duration of both storms and droughts will increase.[234] Intense rainfall events would likely flood many bogs, leading to scouring and further increasing nutrient loads.[235] Increased flooding in southern wetlands has already been observed, leading to channelization and head-cutting, or gully ditch

[229] Blossey 2002. 413.
[230] Allen, Epperson, and Garmestani 2004. 90-92.
[231] *Id.*
[232] Apodaca pers. comm. 2021.
[233] EPA 2017.
[234] NCWRC 2015. 723-728.
[235] *Id.*

forming within wetlands that create impassable topography for diminutive bog turtles.[236] Sediment from more frequent and intense storms is expected to lead to increased sedimentation in bog turtle wetlands, smothering nests and habitat with accumulating layers of silt. Changes in storm intensity will also likely decrease the frequency of groundwater recharge .[237]

An increase in storm and flood events is expected to inundate more bog turtle nests. Flash flooding of southern bog turtle wetlands already washes out many bog turtle nests each year and degrades wetlands habitat.[238]

More stochastic weather patterns may also slow incubation rates and prevent eggs from hatching before cold weather arrives. In 2020, this slow nest incubation was observed at sites in North Carolina: as a result, hatching was delayed until mid-October and many eggs failed to hatch.[239]

A recent study specifically aimed at predicting the effects of climate change on Southern Appalachian bogs indicated that sphagnum moss may be most affected.[240] Temperature increases are expected to outpace precipitation increases in Southern Appalachian bogs, which will inhibit sphagnum growth. Dominant vegetation is likely to shift from sphagnum moss to woody shrubs, which will intensify the need for habitat management.[241] Invasive plants are likely to become increasingly prevalent in bogs as vegetation dominance shifts away from sphagnum.[242] Climate change in the Southeast is also expected to increase the frequency and intensity of drought, causing loss of water and reliability in bog turtle habitat. Drought also stresses bog turtles and makes them more susceptible to disease.[243]

Succession and lack of wetlands management

Bison, elk, beavers, and natural fire or indigenous-ignited fire kept wetlands open historically. Many of these sources of wetlands disturbance have been eliminated or dramatically curtailed. Without these disturbances, bog turtle populations are threatened by habitat degradation from natural vegetative succession. Wetlands' herbaceous grasses and sedges are replaced over time by a canopy layer of trees that lower the water table and shade out the floor. Without adequate sunlight, bog turtles struggle to reproduce and nest successfully, threatening the continued persistence of this species.[244]

State wildlife agencies across the southern population range have secured Partners for Fish and Wildlife grants to fund bog turtle habitat management, but the funds typically only support basic

[236] NCWRC 2018. 8.
[237] Karl *et al.* 2009. 412.
[238] Apodaca pers. comm. 2021.
[239] NCWRC 2020. 30.
[240] Schultheis *et al.* 2010. 417.
[241] *Id.*
[242] NCDENR 2010. 1-6.
[243] Apodaca pers. comm. 2021.
[244] NCWRC 2018. 7.

annual clearing for a few key sites. Most bog turtle sites across its southern range receive minimal or no habitat management, largely due to lack of funding and personnel.[245]

Small population size and other biological factors

The southern bog turtle's small, discrete populations scattered widely across the landscape make the species especially vulnerable.[246] Its already-precarious population size makes it even less likely for the species to overcome the compounding threats of habitat loss, genetic isolation, poaching, disease, predation, invasive species, and climate change. The southern population of the bog turtle has been especially impacted by habitat loss and fragmentation by roads and development, which has further isolated populations and prevented gene flow between sites. Because of its small population size and lack of recruitment, inbreeding depression and reduced fitness are concerns.[247]

The bog turtle has several other biological factors that make it exceptionally vulnerable to local extirpation and range-wide declines: its long delay in reaching sexual maturity, low fecundity, low juvenile recruitment rate, and low vagility.[248] Bog turtles do not reach sexual maturity until six to ten years of age, and early life stages are extremely vulnerable in the bog turtle's open wetlands habitat. Bog turtle fecundity is low compared to other turtles: females lay between one and six eggs, which is relatively few compared to other turtles.[249]

Bog turtles also have small home ranges and low vagility. Home ranges average between 0.42 and 3.29 acres for males and 0.16 to 3.11 acres for females.[250] Movement and migration has become increasingly difficult and dangerous as wetlands habitat and corridors are destroyed. Isolation and habitat fragmentation prevent recolonization of existing habitat or expansion into new habitats and further jeopardize the survival of this species.[251]

Very few juveniles are observed at remaining bog turtle sites across the southern population range. Low hatch success is also contributing factor: only 28 percent of eggs hatched from bog turtle nests in a 2015 study of North Carolina bog turtle sites.[252] Adult survival rates are also relatively low for bog turtles compared to other turtles. Low adult survival rates and low fecundity may make bog turtles more sensitive to changes in juvenile survival.[253]

Low juvenile survival rates are also due to vulnerability of nests to predation and compounding factors spanning a six-to-ten-year period without reproductive replacement.[254] As a result,

[245] NCWRC 2020. 31-32.
[246] Knoerr *et al.* 2021. 1, 7-9.
[247] Shoemaker 2013. 329-330.
[248] USFWS 1997. 59620.
[249] Tutterow, Graeter, and Pittman 2017. 299.
[250] Carter *et al*. 1999. 857-859.
[251] *Id.*
[252] Zappalorti et al. 2017. 194.
[253] Tutterow, Graeter, and Pittman 2017. 298.
[254] Knoerr *et al*. 2021. 2. / Ernst and Lovich 2009. 270.

populations across the entire southern bog turtle range skew heavily toward older individuals and include few or no juveniles.[255]

The combination of small populations, low fecundity, low nest success, and low adult and juvenile survival rates of southern bog turtle populations may result in regional extirpation of the species.

[255] Knoerr *et al*. 2021. 7-8.

REQUEST FOR CRITICAL HABITAT

We encourage the U.S. Fish and Wildlife Service to designate critical habitat for the southern population of the bog turtle concurrent with its listing. Critical habitat as defined by Section 3 of the ESA is: (i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) the specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species (16 U.S.C. § 1532(5)).

Congress recognized that the protection of habitat is essential to the recovery and/or survival of listed species, stating that: "classifying a species as endangered or threatened is only the first step in ensuring its survival. Of equal or more importance is the determination of the habitat necessary for that species' continued existence… If the protection of endangered and threatened species depends in large measure on the preservation of the species' habitat, then the ultimate effectiveness of the Endangered Species Act will depend on the designation of critical habitat."[256]

The southern population of the bog turtle urgently needs critical habitat protection to be issued concurrently with its endangered species designation. The southern population of the bog turtle will not survive without protection of its remaining wetlands, buffers, upland habitat, and migration corridors. Critical habitat is essential to protecting the bog turtle from further harm and population decline. Bog turtle critical habitat consists of wetlands, surrounding buffer habitat, upland habitat, and migratory corridors between sites, which are essential to the bog turtle's long-term genetic health and survival.

The U.S. Fish and Wildlife Service has discretion with the scale at which it publishes critical habitat information. Published critical habitat designation should be publicly presented range-wide or at the county level. All site-specific data should be kept confidential. Because bog turtles' critical habitat includes upland forests and migratory corridors, FWS can protect the bog turtle's complete critical habitat without revealing specific locations.

Because one of the chief threats to the bog turtle is overutilization, the petition does not include the exact locations of populations or individuals. Instead, the petition cites publicly available information regarding the location of bog turtles and identifies the threats that jeopardize its survival. We understand and expect that location information about the bog turtle will be protected from disclosure in the event of a Freedom of Information Act request and in any future rulemakings regarding the species.

[256] H. Rep. No. 94-887 at 3 (1976).

CONCLUSION

Jonathan Mays / NCWRC

In 1997, the U.S. Fish and Wildlife Service cited three reasons not to grant the southern population of the bog turtle the same protections as the northern population: discovery of new populations, lack of information on threats to the southern population, and lack of survey information. [257] In the past 24 years, substantial surveys across all five states in the bog turtle's southern range have shown that the population is in steep decline. Discoveries of a few new populations have not offset the overwhelming loss of sites across its entire range. The southern population of the bog turtle is crashing, and the few remaining viable populations are increasingly isolated and under threat.

Information on threats to bog turtles also has increased substantially in the past 24 years. Several new studies of the southern population of bog turtles have identified the key factors driving their decline. These are the same five factors listed under Section 4(a)(1) of the Endangered Species

[257] USFWS 1997. 59613.

Act: destruction of habitat, overutilization, disease and predation, inadequacy of existing mechanisms, and natural and manmade factors.

Specifically, bog turtle wetland habitat is being drained, ditched, dammed, developed, and destroyed at an alarming rate across its southern range. Roads and development are resulting in direct bog turtle mortality and increasing habitat fragmentation and isolation. Stormwater runoff from impervious surfaces floods more wetlands with pollution. Poachers continue to illegally harvest bog turtles, especially in the South, which is already a biological hotspot for freshwater turtle diversity. Anthropogenic mesopredators such as raccoons and opossum accompany encroaching human development and prey upon bog turtles, and diseases remain a serious threat to bog turtles' long-term health. Despite sustained efforts by state agencies and volunteers, bog turtle populations continue to crash in every state. Unsustainably low juvenile recruitment magnifies the dangers to bog turtles' survival. Climate change and invasive species are fundamentally altering the hydrology and smothering the essential vegetation of the bog turtles' remaining wetlands.

Only 14 viable bog turtle populations remain across its entire southern range. Very few juveniles are found in any remaining sites. The bog turtle urgently needs the full protection of the Endangered Species Act as a federally endangered species.

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