CONSERVATION BIOLOGY OF FRESHWATER TURTLES AND TORTOISES

A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group

Edited by

Anders G.J. Rhodin, John B. Iverson, Peter Paul van Dijk,
Craig B. Stanford, Eric V. Goode, Kurt A. Buhlmann, and Russell A. Mittermeier

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Suwannee Alligator Snapping Turtle

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Macrochelys suwanniensis Thomas, Granatosky, Bourque, Krysko, Moler, Gamble, Suarez, Leone, Enge, and Roman 2014 – Suwannee Alligator Snapping Turtle

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Summary. – The Suwannee Alligator Snapping Turtle, *Macrochelys suwanniensis* (family Chelydridae), is a large, aquatic freshwater species that is genetically and morphologically distinct from other *Macrochelys* populations. The species is endemic to the Suwannee River drainage in southern Georgia and northern Florida, where it occupies the mainstem Suwannee River and most of its larger streams and tributaries. However, it is considered rare in the headwaters, including the extreme upper Suwannee River and Okefenokee Swamp. A capture-recapture study in the mainstem Suwannee River suggests high annual adult apparent survival (0.99) and estimated the population size to be ~1,200–2,700 individuals (~7 turtles per river km). Despite these findings, the population trend is considered uncertain, potentially stable or slightly declining. Population structure, sex ratios, densities, and mean body size vary across sites, likely reflecting natural variation in riverine habitat and resources availability in the Suwannee drainage. Males tend to reach much larger sizes in the more biologically productive sections of the Suwannee and Santa Fe rivers. The high proportion of large males (≥45 kg) indicates that the Suwannee drainage was likely spared from past commercial and local overharvest, which has plagued other *Macrochelys* populations. A study in the upper and middle sections of the Suwannee River found home range size to be individually variable and temporally dynamic in response to water levels. Turtles move linearly within the river channel and utilize bank-associated habitats such as woody debris and undercut banks, but during flooded conditions, turtles move laterally into the floodplain, likely to access new resources that are generally unavailable. Reproductive biology and diet remain poorly understood but may resemble those of *M. temminckii,* the Western Alligator Snapping Turtle. Although possession and harvest are illegal, incidental mortality from ingested fishing hooks and entanglement in bank-set fishing gear poses a significant threat to populations. Recent research indicates that ~10% of radiographed individuals were found to have ingested fishing hooks lodged in the throat or gastrointestinal tract, potentially posing a significant health risk. This is an immediate conservation concern because *M. suwanniensis* populations can rapidly decline due to small increases in adult mortality. Over the long-term, increasing water withdrawals, decreasing water quality, and frequent sewage spills represent emerging threats to population persistence. *Macrochelys suwanniensis* is considered Threatened in both Florida and Georgia, and recently the U.S. Fish and Wildlife Service also listed the species as federally Threatened under the Endangered Species Act.

Distribution. – USA. Endemic to the Suwannee River drainage in southern Georgia and northern peninsular Florida.

Synonymy. – *Macrochelys suwanniensis* Thomas, Granatosky, Bourque, Krysko, Moler, Gamble, Suarez, Leone, Enge, and Roman 2014.

Subspecies. – None recognized.

Status. – IUCN 2025 Red List: Vulnerable (VU C1; assessed 2025); CITES: Appendix II (USA, as *Macrochelys temminckii* [*sensu lato*]; assessed 2023); US ESA: Threatened (assessed 2024); Florida: Threatened; Georgia: Threatened.

Figure 1. Adult male *Macrochelys suwanniensis* (CL = 627 mm) from the Rock Bluff Spring, Suwannee River, Florida, USA. Photo by Kevin M. Enge.

Taxonomy. — Gerard Troost first proposed *Chelonura temminckii* as the scientific name of the Alligator Snapping Turtle in an 1834 manuscript, and Harlan (1835) first published the name and formally described the turtle, giving full credit to Troost (Bour 1987; Pritchard 1989). Because *Chelonura* is a synonym of *Chelydra*, Gray replaced the genus with *Macrochelys* (Gray 1856a) and *Macroclemys* (Gray 1856b) in separate publications written in 1855 (Pritchard 1989). Apparently unaware of Gray's names for the genus, Agassiz (1857) proposed the name *Gypochelys lacertina* in a large monograph on North American turtles (Pritchard 1989). Strauch (1862) misspelled the genus as *Macroclemmys*. Webb (1995) determined that *Macrochelys* was the first printed name (senior synonym), contradicting Smith (1955), who had thought *Macroclemys* was the earlier and therefore valid name.

Figure 2. Adult male *Macrochelys suwanniensis* from the Suwannee River, Florida, USA, showing pink lingual lure. Photo by Travis M. Thomas.

Thomas et al. (2014) described the Suwannee (*Macrochelys suwanniensis*) and Apalachicola (*M. apalachicolae*) Alligator Snapping Turtles as distinct from the Western Alligator Snapping Turtle (*M. temminckii*) based upon genetic differentiation and differences in skull and carapace morphology. This taxonomic arrangement recognized the distinct Suwannee lineage identified by Roman et al. (1999) using mtDNA and Echelle et al. (2010) using an analysis of seven microsatellite DNA. Thomas et al. (2014) found Roman's eastern clade (Suwannee lineage) to be the most distinct both genetically and morphologically. Subsequent morphological and genetic analyses have further validated *M. suwanniensis* as a distinct species (Murray 2014; Apodaca et al. 2023), and it has been recognized as such by Crother (2017) and the Turtle Taxonomy Working Group (TTWG 2017, 2021, 2025). However, the published morphology and genetics of *M. apalachicolae* were reviewed by Folt and Guyer (2015) and synonymized by them under *M. temminckii* based on what they concluded was a lack of diagnosability. More recent genetic analysis by Apodaca et al. (2023) validated its genetic distinctness and suggested it could indeed be considered a separate species, but held off on resurrecting it, pending morphological studies (TTWG 2025).

Description. — *Macrochelys suwanniensis* is a large, aquatic freshwater turtle species. Although anecdotal reports mentioned in Pritchard (1989) suggest

Figure 3. Juvenile *Macrochelys suwanniensis*. *Top*: Alapaha River, Hamilton County, Florida (105 mm CL); *Center*: Suwannee River, Florida. Photos by Kevin Enge. *Bottom*: Alapaha River, Berrien County, Georgia. Photo by Dirk Stevenson.

Figure 4. Hatchling and yearling *Macrochelys suwanniensis*. *Top*: Columbia County, Florida. Photo by Jake Scott. *Center and Bottom*: Yearling *M. suwanniensis* from the Little River, Cook County, Georgia. Photos by Greg Brashear.

Macrochelys may reach sizes >140 kg, these accounts are not supported by verifiable empirical evidence. The largest known *M. suwanniensis* was captured in the Suwannee River near White Springs, Florida, in the early 1970s (Pritchard 1989). It measured 713 mm straight-midline carapace length (midline CL; method D in Iverson and Lewis 2018), 801 mm maximum straight-line carapace length (Max SCL; method B in Iverson and Lewis 2018), 619 mm maximum carapace width, and 236 mm maximum head width (Johnston et al. 2023). The turtle was never weighed, but Johnston et al. (2023) used morphometric data collected from adult male *M. suwanniensis* and suggested it likely weighed between 67.6 and 86.3 kg. Still, a turtle of this size would be an atypical observation, and it is plausible that the individual originated from White Springs but spent enough time in captivity to grow to this size. Long-term sampling in the Suwannee drainage indicates that *M. suwanniensis* rarely exceeds 645 mm CL and 56 kg in the wild, suggesting it might have smaller maximum body sizes compared to *M. temminckii*. Maximum body size is typically reported using CL and mass, yet the largest individual CL does not always have the largest mass and vice versa. For example, Thomas et al. (2023a) captured a male from the Suwannee River with a midline CL of 650 mm that weighed 54.5 kg; however, another male with a smaller CL of 633 mm weighed notably more (58.0 kg). Similarly, Johnston et al. (2015b) reported a female measuring 492 mm CL that weighed 25 kg, but a female with a smaller CL (476 mm) was heavier (26.5 kg) in the middle Suwannee River (Thomas and Enge, unpubl. data).

Macrochelys suwanniensis is sexually dimorphic, with males obtaining much larger sizes (i.e., two to three times the size), but similar-sized males and females are difficult to distinguish from one another. Allometric elongation of

Figure 5. Adult male *Macrochelys suwanniensis*. *Left*: Suwannee River near Rock Bluff Spring, Florida (55 kg); *Center*: "blonde" turtle from the Suwannee River near Suwannee Springs, Florida (45 kg); *Right*: New River, Florida (29 kg). Photos by Kevin Enge.

Figure 6. Adult female *Macrochelys suwanniensis*. *Left*: Suwannee River near White Springs, Florida. Photo by Kevin Enge: *Center*: the Withlacoochee River. Photo by Greg Brashear. *Right*: Kyphotic turtle from the Suwannee River near Rock Bluff Spring. Photo by Jake Scott.

the plastron-to-vent length (PVL; see Carr et al. 2023a) occurs in males at ca. 425 mm CL (Johnston, Thomas, and Enge, unpubl. data) and is the only external morphometric measurement that is proportionally different between the sexes (Johnston et al. 2015b). Like *M. temminckii, M. suwanniensis* possesses three longitudinal rows of prominent keels along the carapace that tend to curve posteriorly. These three ridges are very distinct in juveniles (Fig. 3) but become smoother with age. The posterior carapacial edge is serrated, and the carapace has a row of 2–5 supramarginal scutes on each side between the marginals and first three costals. The species possesses a large head with powerful jaws that taper anteriorly. The eyes are positioned on the sides of the head and have conical protuberances above and below. The carapace of hatchlings and juveniles is typically dark brown (Fig. 3) but may lighten with age to a dark gray-brown or yellowish-brown (Figs. 5 and 6).

Hatchlings and juveniles have soft bumps, flaps, and papillae on their dark skin; the papillae cornify with age, and the skin becomes wrinkled. The skin and plastron of adults are a light brown, grayish tan, or ivory (Fig. 7), and the heads of large male and some female

Figure 7. Plastrons of *Macrochelys suwanniensis* from the Suwannee River, Florida. *Left*: Juvenile; *Center*: Adult female; *Right*: Adult male. Photos by Kevin Enge.

Figure 8. Mouths of *Macrochelys suwanniensis* from the Suwannee River, Florida. Left: juvenile; right: adult male. Photos by Kevin Enge.

M. suwanniensis are typically completely or partially yellow (Figs. 5 and 6). The long tail has three rows of tubercles above and numerous small scales below, but the elevated dorsal scales are less prominent than in snapping turtles (*Chelydra serpentina*) (Ernst and Lovich 2009).

On occasion, atypical body shapes have been reported in both Florida and Georgia. For example, a kyphotic juvenile was captured in the Alapaha River, Georgia, which had a CL of 306 mm and a carapace width (CW) of 269 mm. In addition, a kyphotic adult female captured on the Suwannee River, Florida, measured 397 mm CL, had a CW of 363 mm, and weighed 22.5 kg (Fig. 6; Enge et al. 2022). Based on capture-recapture data in Florida, a typical female with that mass would measure 447–463 mm CL (Enge et al. 2022). Also, a scoliotic female from the Santa Fe River, Florida, measured 430 mm CL and weighed 18.4 kg (Godwin et al., in press).

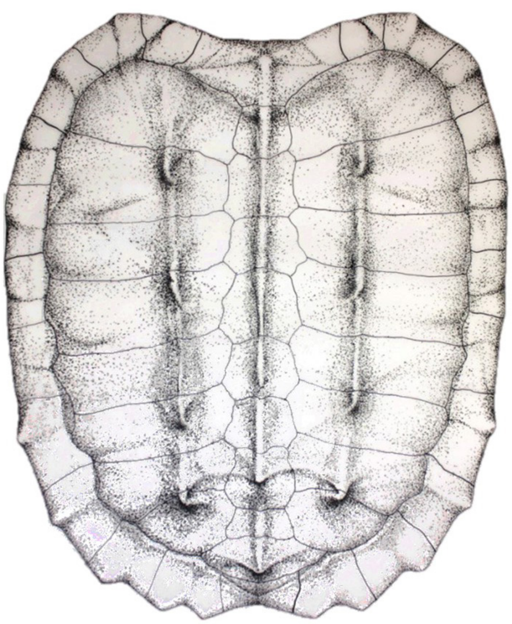

Figure 9. Carapace of *Macrochelys suwanniensis* showing osteology (neurals, pleurals, peripherals, nuchal, pygal, suprapygal). Artwork by Mandi Carr.

The interior of the mouth of juvenile *M. suwanniensis* is grayish in color and patterned with black speckles (Fig. 8). The number of speckles decreases, and the mouth lining becomes a light pink or white color as turtles age, although the jaw lining may remain black (Fig. 8). The color of the lingual lure, a wormlike appendage that is wiggled to lure prey (Spindel et al. 1987), seems to be similar to what has been reported in *M. temminckii*, and likely depends upon both the pigmentation of the tissue and the presence of blood near the surface in the lingual appendage mucosa (Glorioso et al. 2023).

Hatchling *M. temminckii* have lures that appear bright red and contrast sharply with the dark mouth lining (Winokur 1982), whereas lures of older juveniles and adults have variable amounts of pigmentation and are typically pink, gray, or white (Spindel et al. 1987, Glorioso et al. 2023). The lingual lure of adults is less vividly colored and vermiform than that of juveniles, and it is less obvious against the lighter mouth lining (Ewert et al. 2006). Allen and Neill (1950) claimed that the lingual lure becomes brightly colored only when active, and Glorioso et al. (2023) found that the coloration of an individual's lingual lure may change over time and even between captures.

Little information is currently available for *M. suwanniensis* hatchling size, but *M. temminckii* hatchlings from the Apalachicola River measured 34–45 mm CL and weighed 11.5–20.5 g (Ewert et al. 2006). Allen and Neill (1950) captured specimens of what is now known as *M. suwanniensis*, and their observations of captive turtles maintained in Silver Springs, Florida, were presumably *M. suwanniensis*. Hatchlings from a single clutch from Silver Springs had a mean midline CL of approximately 44 mm (Allen and Neill 1950). Two hatchling *M. suwanniensis* from the Santa Fe River measured 37 mm and 41 mm midline CL and weighed 22.0 g and 22.5, respectively (Enge, Thomas, and Johnston, unpubl. data).

Osteology. — According to Thomas et al. (2014), *M. suwanniensis* is morphologically distinguished from other *Macrochelys* by a wider, lunate shaped carapacial caudal notch (Fig. 9) that is bounded by the pygal and peripheral bone set 11 (a feature shared with *Chelydra*). However, this is not always the case, and on occasion *M. suwanniensis* lacks the typical wide, lunate caudal notch. However, the pygal is sutured medially (composed of two bones) and often lacks serrations, whereas peripheral bones 11 have one or two serrations.

Other distinctive morphological features of *M. suwanniensis* include the following: the distal rib end of pleural 1 enters the posterior third of peripheral 3, costal scute set 1 broadly overlaps onto the nuchal, the dermal scale on the frontals is very wide, and the processus trochlearis oticum has developed proximal and distal protuberances.

On the skull, the squamosal contacts the opisthotic anteriorly when viewed in dorsal aspect, the mandible is broad with expanded triturating surfaces and developed labial rugosity just anterior to the coronoid, and the posterior projection of the squamosal is acutely angled in lateral aspect, dorsally straight or downwardly directed, and posteriorly extensive past the plane of the quadrate (Thomas et al. 2014). An analysis by Murray et al. (2014) determined that *M. suwanniensis* is unique in having more robust skulls that are nearly as wide as they are long.

Distribution. — *Macrochelys suwanniensis* is endemic to the Suwannee watershed, which drains an area estimated as 28,500 km^2, with approximately 11,033 km^2 of the drainage located in northwestern peninsular Florida and the remainder in southcentral Georgia (TTWG 2025) (Figs. 10 and 11).

The Suwannee River is one of the longest undammed rivers in the eastern United States (Benke 1990), and its main tributaries are the Alapaha, Withlacoochee, and Santa Fe rivers. The Suwannee River originates at the 200,000 ha Okefenokee Swamp, and Pritchard (1989) supposed *Macrochelys* was rare based on the lack of observations. Pritchard further proposed that *Macrochelys* populations may have declined sharply in the Suwannee River since the 1930s due to overharvest, which was widespread in other systems.

However, recent studies indicate that overharvest did not occur in the Suwannee River. Instead, *M. suwanniensis* appears to be naturally rare in the upper Suwannee River, likely due to limited resource availability (Thomas et al. 2023). This conclusion is supported by Jensen and Birkhead (2003), who failed to capture *M. suwanniensis* in upper Suwannee River in Georgia despite extensive sampling.

In 1912, one of the Cornell University expeditions collected a skull (AMNH 69731) in the Okefenokee Swamp, Ware County, Georgia. Carr (1952) provided two photographs of a female from the Okefenokee Swamp. De Sola and Abrams (1933) mentioned that Alligator Snapping Turtles were "frequently hooked in the old drainage canal (St. Mary-Suwanee Canal) near Camp Cornelia in the Okefenokee." A large male (GMNH 52076) was photographed in 2019 in the Suwannee Canal near the Richard S. Bolt Visitor Center (site of the former Camp Cornelia) in the Okefenokee Swamp National Wildlife Refuge near the confluence of the Suwannee Canal and Cornhouse Creek, a tributary of the St. Mary's River (Enge et al. 2021b). The same turtle was likely photographed there in May 2022 (iNaturalist 119335777).

Macrochelys suwanniensis apparently does not occur in the St. Mary's River or its tributary streams (Allen and Neill 1950; Pritchard 1989; Jensen and Birkhead 2003), but the eastern portion of the Okefenokee Swamp, where Camp Cornelia is located, is in the St. Mary's drainage (Edwards et al. 2013). On 29 April 2021, an adult male (470 mm midline CL; 23.7 kg) was scooped from a canal during aquatic vegetation removal at the Okefenokee Swamp Park, Ware County, near the northern extent of the Okefenokee Swamp (Stegenga et al. 2023). This record represents the nearest documented occurrence of a native, extant *Macrochelys* inhabiting a river system draining into the Atlantic Ocean, whereas all other populations are found in drainages that empty into the Gulf of Mexico.

Intensive trapping (174 trap nights) in the mainstem of the Suwannee River upstream of White Springs, Florida, failed to catch *M. suwanniensis*, but turtles were documented from small tributaries in this area in both Georgia (Jones, Suwannoochee, and Toms creeks) and Florida (Hunter and Rocky Creeks) (Jensen and Birkhead 2003; see Enge et al. 2021b). In 2022, three *Macrochelys suwanniensis* (a male, female, and juvenile) were captured during 12 trap nights approximately 25 river km upstream from White Springs, Florida.

However, additional surveys conducted 50 river km further upstream from White Springs failed to capture *M. suwanniensis* (Thomas and Enge, unpubl. data). In both Florida and Georgia, the species occurs in the Alapaha and Withlacoochee rivers, and Georgia tributaries of these streams: Alapahoochee River, Little River, New River, Okapilco Creek, Piscola Creek, Warrior Creek, and Willacoochee River (Jensen and Birkhead 2003; Enge et al. 2021b). In Florida, the species occurs in the Santa Fe River and its tributaries: Cow Creek, Ichetucknee River, New River, and Olustee Creek (Johnston et al. 2015b; Jackson and Thomas 2018; Enge and Steen 2020; Enge et al. 2021b).

The genus *Macrochelys* was once distributed more extensively in the Florida peninsula (Ewert et al. 2006). Fossil records of *Macrochelys* exist from the Tampa Bay area, upper Peace River, and three sites in the Atlantic drainage that currently drain into the St. Johns River (Hulbert 2001; Ewert et al. 2006). The provenance of hatchling *Macrochelys* found in Florida in Hogtown Creek in Gainesville, Alachua County (Enge, pers. obs), and in the St. Johns River, Orange County (UF-Herpetology 166530), are unknown.

Macrochelys was caught in the Ocklawaha River (St. Johns River drainage) in Marion County, Florida, in 1916 (AMNH 8287) and 1955 (KU 61844), and more recent, unverified observations exist from there. The 1916 specimen has been lost, but the 1955 specimen is a small juvenile with plastron scutellation resembling *M. suwanniensis* (Enge and Fedler, in press) and could have come from Ross Allen's Reptile Institute in nearby Silver Springs (Pritchard 1989). Limited trapping (26 trap nights) in the Ocklawaha River failed to detect *Macrochelys* (Mays et al. 2015). However, an introduced population of *M. suwanniensis* is established in the Homosassa River (>50 km south of the Suwannee River), Citrus County, Florida (Enge et al., in press). A few *Macrochelys,* which likely represent releases of captives or specimens translocated

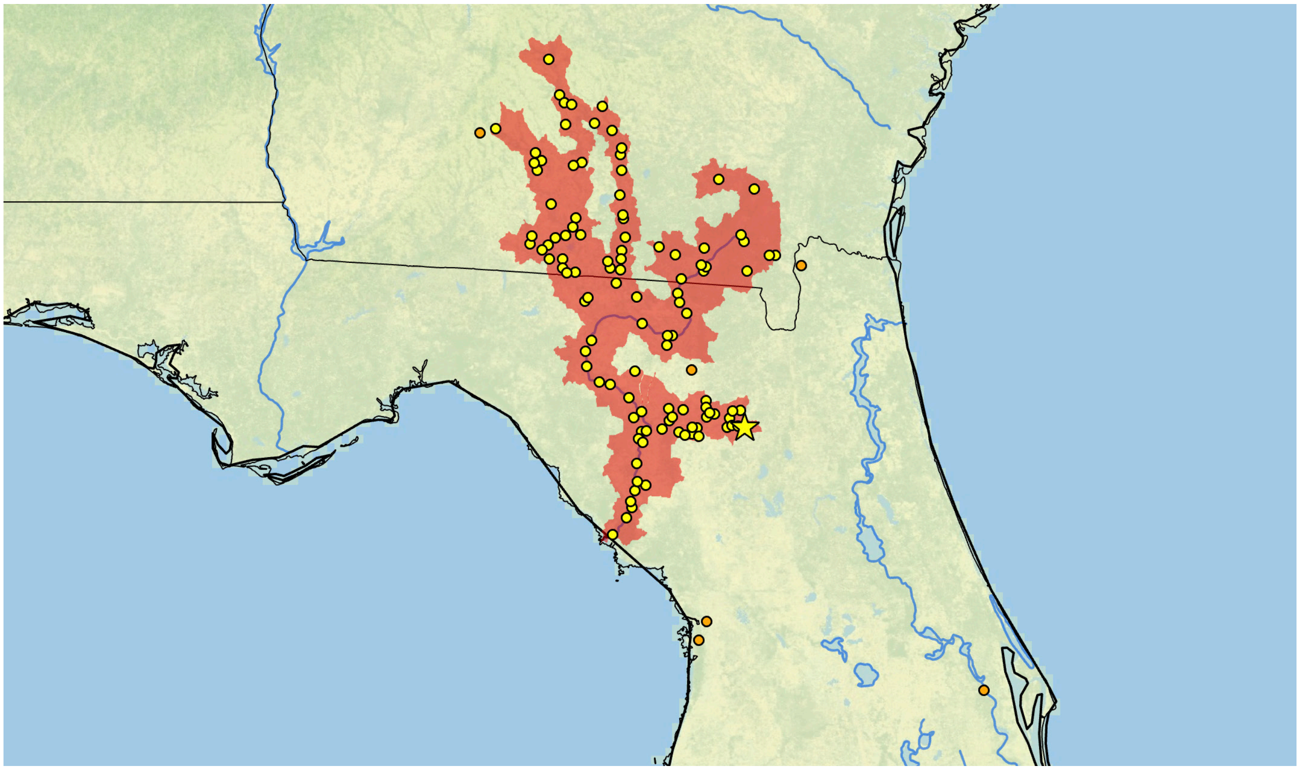

Figure 10. Estimated historical indigenous distribution of *Macrochelys suwanniensis* in Florida and Georgia, southeastern USA. Yellow dots = museum and current and historical occurrence records of presumed native populations based on literature and online records (TTWG 2025); orange dots = probable non-native introductions, translocations, or erroneous records; star = type locality. Colored shading = estimated historical indigenous range. Distribution is based on fine-scaled GIS-defined level 12 HUCs (hydrologic unit compartments) constructed around verified localities and then adding HUCs that connect known point localities in the same watershed or physiographic region, and similar habitats and elevations as verified HUCs, and further adjusted based on data from the literature and the authors. Map by Chelonian Research Foundation.

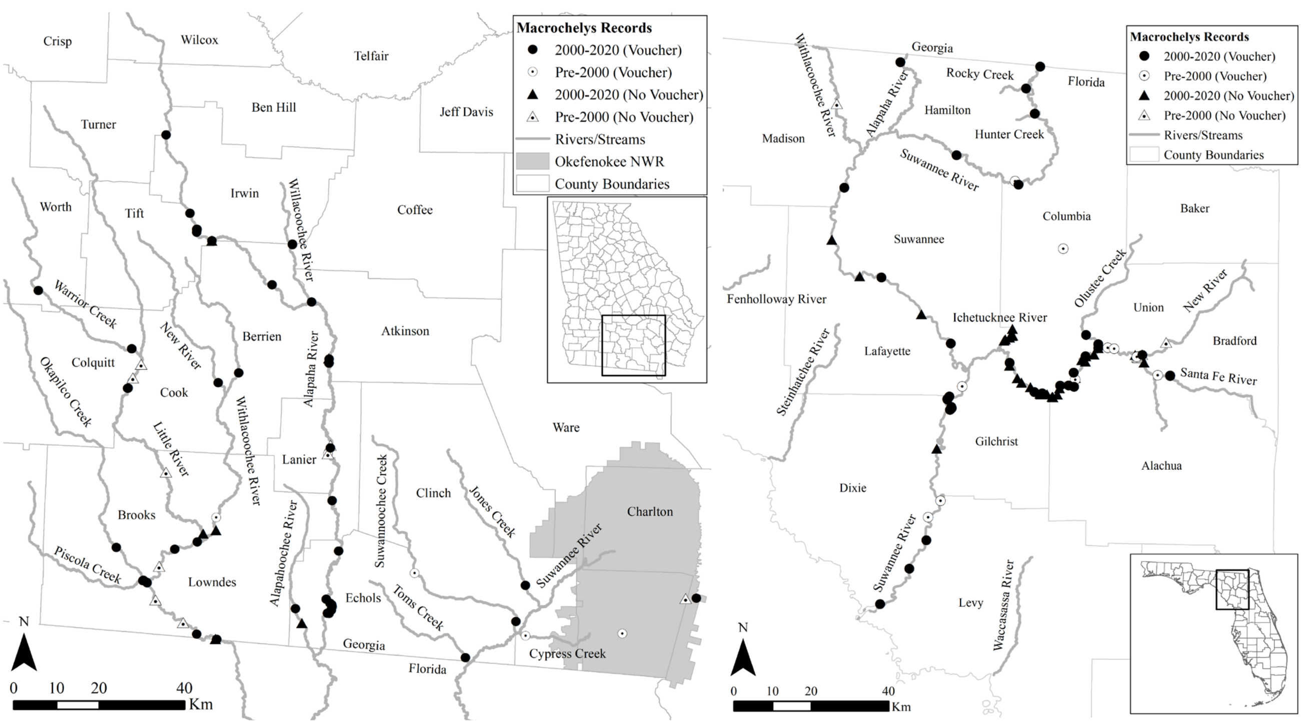

Figure 11. Locations of *Macrochelys suwanniensis* occurrences in Georgia (*left*) and Florida (*right*) pre-2000 and 2000–2020.

from other drainages, have been reported from three (Aucilla, Wacissa, and Wakulla rivers) of the seven small streams that separate the Suwannee River from the Ochlockonee River to the west, but this region is considered to represent a distribution gap for *Macrochelys* (Pritchard 1989; Ewert et al. 2006; Enge et al. 2021b).

Habitat and Ecology. — Habitat and ecology of *M. suwanniensis* appear to be somewhat similar to that of the more well-studied *M. temminckii*, and ongoing research on populations in the Santa Fe and Suwannee rivers in Florida and in the Alapaha River in Georgia have provided insights on habitat use, movements, and population ecology.

Habitat Use. — The species inhabits rivers, small streams, and adjacent floodplain swamps, ponds, and lakes throughout the Suwannee drainage. The system consists of the Suwannee River, and its major tributaries the Santa Fe, Alapaha, and Withlacoochee rivers. The mainstem Suwannee River is somewhat atypical, and it undergoes dramatic changes due to natural geochemical processes, which influence turtle populations, and recognizing these complexities is essential for understanding *M. suwanniensis* populations and is briefly summarized in the following paragraphs.

The mainstem Suwannee River is heavily influenced by northern Florida's unique geology, which causes shifts in the river's water chemistry, biological productivity, and ecological structure. For example, the upper Suwannee is narrow, shallow, and characterized by acidic, low-nutrient, dark colored waters that lack biological productivity. However, examining the river where it drains into the Gulf of Mexico, the river is suddenly a large, nutrient-rich, and highly productive river.

These natural landscape changes were so remarkable that the Suwannee River Water Management District (SRWMD) divided the river into six distinct 'ecological reaches' based on their unique biological and ecological conditions (Hornsby et al. 2000) and understanding these unique river sections is critical for better understanding *M. suwanniensis* populations. The six ecological reaches consist of: 1) Upper River Blackwater, 2) Cody Scarp Transitional, 3) Middle River Calcareous, 4) Lower River Calcareous, 5) Tidal Riverine, and 6) Estuarine (Hornsby et al. 2000).

Thomas et al. (2023) used a stratified random sampling design to examine *M. suwanniensis* populations across 12 different sites where each ecological reach was represented by two different study sites. Thomas et al. (2023) were able to capture *M. suwanniensis* in every site except for the lower estuary site, where tidal fluctuation can rapidly shift the river from freshwater to full sea water. Their findings revealed that *M. suwanniensis* density, population structure, and body size varied by the ecological reaches described by Hornsby et al. (2000), but general turtle populations were best described by a coarser spatial framework driven by larger-scale shifts in biological productivity and resource availability that create three broader river sections: 1) upper river, 2) middle river, and 3) lower river.

The upper river section of the Suwannee River is dark water, very acidic, and maintains very low nutrient concentrations, which limit biological productivity (Hornsby et al. 2000). The lack of primary production is evident by the absence of mollusk populations (Williams et al. 2014). This section lacks a typical floodplain and consists of incised banks and limestone bluffs. The flow is typically low, but it can drastically increase during large rain events. Thomas et al. (2023) found smaller mean body sizes and lower *M. suwanniensis* abundance in this section, which correspond to the limited resource availability and low biological production. Recent surveys farther upstream of White Springs, Florida, resulted in few captures, indicating abundance is consistently low in the upper Suwannee River in both Florida and Georgia.

The middle river section is preceded by a transitional zone where the river crosses the Cody Scarp, a prominent limestone geological feature. This area receives a substantial input of buffered groundwater, which rapidly increases pH levels and allows accumulated organics to be biologically available (Ceryak et al. 1983). In addition, several other parameters such as conductivity, magnesium, nitrogen, and calcium increase substantially (Raulston et al. 1998; Katz et al. 1999). Thomas et al. (2023) reported a major increase in *M. suwanniensis* abundance and an even 1:1 sex ratio; however, mean body sizes did not increase in this section. This transitional zone does not reflect either the upper or middle river section, but embodies an area where turtle populations respond to increased biological resources. Ongoing research aims to better understand the population in this transitional area (Thomas, Enge, and Husband, unpubl. data).

The middle river section continues to see ground water input, and total river discharge increases by more than 47% (Pittman et al. 1997). This is primarily due to the Santa Fe River, the largest tributary of the Suwannee, along with additional water inputs that change the river's classification from blackwater stream to a slightly colored, alkaline river (Hornsby et al. 2000). This section also sees a major increase in floodplain area and the river channel is wider and deeper. Interestingly, *M. suwanniensis* populations have high abundances in this section, but dominated by large adult males. In fact, mean body size increases markedly, with individuals exhibiting both larger body dimensions and proportionally greater length and mass relationship. The proportion of individuals exceeding 45 kg is substantially higher compared to the other sections of river, suggesting that turtles take full advantage of the increase in biological productivity and additional available resources (Thomas et al. 2023).

The lower river section encompasses the stretch between Fanning Springs and the lower Suwannee Es-

Figure 12. Riverscapes inhabited by *Macrochelys suwanniensis*, illustrating the extreme variation in occupied habitats across the Suwannee River drainage. **Top row:** *Left*: Upper river section of the Suwannee River near White Springs, Florida; *Right*: Upper Suwannee River downstream of White Springs, Florida (photos by Travis Thomas). **Middle row:** *Left*: Middle river section of the Suwannee River at Rock Bluff, Florida (photo by Mark Clark); *Right*: Lower section of the Suwannee River near the confluence at the Gulf of Mexico, Florida (photo by Travis Thomas). **Lower row:** *Left*: Freshwater spring run on the Santa Fe River (photo by Sally Lanigan); *Middle*: Lower Santa Fe River where Poe Springs empties into the river channel (photo by Tyler Jones); *Right*: Small creek that drains into the Santa Fe River near Fort White, Florida (photo by Travis Thomas).

tuary where the river empties into the Gulf of Mexico. This section is characterized by a wide, deep channel, a broad floodplain, and diverse riverine habitats. Much of the section is located in the Lower Suwannee National Wildlife Refuge, so residential development and human population growth is limited. Much of this section consists of expansive floodplains with undisturbed and abundant wildlife populations. However, *M. suwanniensis* abundance is lower here than the middle river section, adult sex ratio is even at 1:1, and adult males have smaller mean body sizes compared to the middle river section, despite greater resources and more habitat availability (Thomas et al. 2023). These authors hypothesized that increased levels in competition between *M. suwanniensis* and more abundant apex species, mainly the American Alligator (*Alligator mississippiensis*), could cause the observed pattern. The lower river section does have increases in species richness, larger alligators, and the presence of marine predators such as sharks. The lower river section is influenced by tidal forces and varying flow rates, which makes sampling more challenging; however, although this might explain lower capture rates in this section, it does not explain the 1:1 sex ratio and smaller mean body sizes compared to the middle river section.

The lower river section eventually transitions into the Suwannee Estuary, and there is a sharp habitat shift from forested floodplain to saltmarsh. The paucity of *M. suwanniensis* in the lower Suwannee Estuary may result from reduced available habitat or avoidance of water with higher salinities. *Macrochelys* are occasionally found in estuarine conditions (Jackson and Ross 1971; Ewert et al. 2006; Enge et al. 2021a), but they probably do not reside in these areas for long periods. The only *M. suwanniensis* captured in the Suwannee Estuary was at the very upper portion and within a small stream that presumably had a lower salinity (Enge et al. 2014).

The Santa Fe River, the major Florida tributary of the Suwannee River, begins as a blackwater stream in swamps near Lake Santa Fe and Lake Alto and disappears underground for ca. 5 km approximately 60 km from its origin. The upper Santa Fe River lacks submerged aquatic macrophytes but has abundant fallen trees and submerged logs. Water temperatures fluctuate between 5°C and 31.3°C. Portions of the stream may dry during extreme droughts, and shallow water may flow over a limestone bridge during floods, connecting the two sections of stream. The Santa Fe River changes from a blackwater stream after it receives input from at least 45 artesian springs (Scott et al. 2004), increasing its water clarity, thermal stability, and mineral content. *Macrochelys suwanniensis* inhabits upper and lower portions of the Santa Fe River, associated springs, and the 9.7 km, spring-fed Ichetucknee River (Johnston et al. 2015b). In the lower Santa Fe River, *M. suwanniensis* is found in both blackwater and spring-influenced habitats, whereas *C. serpentina* is primarily found in spring-fed areas, which have softer substrates and abundant submerged aquatic vegetation (Johnston et al. 2016).

The Alapaha and Withlacoochee rivers, which originate in the Tifton Uplands of southcentral Georgia, are blackwater streams with soft, acidic water of high organic content that tend to inundate their narrow floodplains for extended periods of time (Wharton 1978; Edwards et al. 2013). In northern Florida, portions of both streams disappear underground into sinkholes during periods of low water (McConnell and Hacke 1993; Torak et al. 2010). Stevenson (2019) trapped *M. suwanniensis* in swamp lakes associated with the Alapaha and Willacoochee rivers in Georgia. Juveniles are readily observed surfacing to breathe among the concrete rubble below a dam on the Little River in Georgia, where they can be seen at sunset and at night foraging and investigating rocks, vegetation, and other structures (Greg Brashear, pers. comm.).

Macrochelys temminckii has been reported to prefer denser canopy cover compared to *M. suwanniensis* (Riedle et al. 2006; Howey and Dinkelacker 2009). However, this apparent difference in habitat preference may be confounded by environmental conditions, such as stream depth and water clarity. A large portion of the Suwannee River and its tributaries have dark-colored, tannin-stained water, rendering overhead cover superfluous and functionally unnecessary (Thomas et al. 2024). It is more likely that overhead cover is simply correlated to instream woody debris. In fact, Thomas et al. (2024) conducted a study of *M. suwanniensis* movements during a 1.5-year period, with findings revealing that turtles selected any habitat associated with underwater structure regardless of canopy cover. In addition, *M. suwanniensis* selected shallower depths closer to the bank during the day when they were sedentary, probably for ease in breathing or simply because their selected habitats are closer to the bank. While *M. suwanniensis* primarily used instream woody debris, turtles also often selected undercut bank habitat.

In the Suwannee River, water levels can rise and fall rapidly, potentially affecting the availability of habitats selected by *M. suwanniensis*. During low water levels, important habitats such as undercut banks and woody debris associated with banks became less available, and submerged instream woody debris in the river channel became extremely important. During high water levels, turtles often used inundated floodplains, which likely provided new foraging habitat (Thomas et al. 2024).

Foraging Behavior and Diet. — The diet of *Macrochelys* includes fish, crustaceans, mollusks, insects, aquatic salamanders, snakes, turtles, small alligators, birds, mammals, and plant material that may include quantities of grapes, acorns, and palmetto and tupelo fruits (Pritchard 1989; Sloan et al. 1996; Harrel and Stringer 1997). In Florida, *M. suwanniensis* in the Suwannee River defecated seeds from pawpaw (*Asimina* sp.) fruits (Enge et al. 2014) and fragments of snail and mussel shells (Allen and Neill 1950). In addition, *M. suwanniensis* from the Santa Fe River have defecated green algae, acorns (*Quercus* sp.), common persimmon (*Diospyros virginiana*) seeds, wild grape (*Vitis* sp.) seeds, crayfish (*Procambarus spiculifer*) exoskeleton fragments, snail (*Elimia* sp. and *Pomacea* sp.) opercula and shell pieces, loggerhead musk turtle (*Sternotherus minor*) bones, and even a complete skeleton of a nine-banded armadillo (*Dasypus novemcinctus*; Ewert et al. 2006; Johnston et al. 2015a; Johnston, unpubl. data). Thirty-five percent of the persimmon seeds collected from *M. suwanniensis* feces germinated, suggesting a possible role of *M. suwanniensis* as a seed disperser (Johnston et al. 2015a). In a stable isotope (δ13C and δ15N) analysis of turtles from the Santa Fe River, Denton et al. (2023) found low dietary niche overlap between *M. suwanniensis* and *C. serpentina*. Adult *M. suwanniensis* fell outside of the *C. serpentina* core isotopic niche. Adult

M. suwanniensis consumed mostly fish (e.g., *Lepomis* sp.), with less consumption of crayfish, snails, plants, and macroalgae. Juvenile *M. suwanniensis* consumed a higher proportion of crayfish and other small fish (e.g., *Gambusia* sp. and *Notropis* sp.) than adults. Captive *M. suwanniensis* attempted to lure musk (*Sternotherus* sp.) and mud (*Kinosternon* sp.) turtles (Allen and Neill 1950).

Adult *Macrochelys* are apparently opportunistic scavengers (Elsey 2006), but juveniles feed predominantly upon small fish that are often lured into striking distance using their lingual lure (Spindel et al. 1987; Pritchard 1989). Acoustic tracking of *M. suwanniensis* at night revealed adults moving upstream from bank to bank, primarily in shallow water and periodically probing the substrate with their heads to detect food (Thomas et al. 2024). This behavior was also noted in another instance where turtles pressed their snouts to the substrate, presumably smelling for food (see Moler *in* Ewert et al. 2006). Foraging typically occurs at night (Allen and Neill 1950; Ewert et al. 2006), but *M. suwanniensis* has been seen foraging and captured in the afternoon shortly after baited hoop traps were set (Enge, pers. obs.; Stevenson, pers. obs.).

Activity Patterns. — *Macrochelys suwanniensis* was active year-round in the upper and middle Suwannee River (Thomas et al. 2024), but activity probably decreases at low water temperatures (Enge et al. 2014). However, Johnston (unpubl. data) observed several active individuals (six juveniles, four females, seven males) while snorkeling in the Santa Fe River at night (1900–2400 hrs) during January and February 2011 (water temperature 16–20ºC). Four individuals were captured in baited hoop traps in the Santa Fe River on 10 December 2023 (water temperature 21.4ºC). Captive *M. suwanniensis* ceased feeding when the air temperature fell below 18.3ºC (Allen and Neill 1950). These authors also claimed that *M. suwanniensis* cannot remain submerged for more than 40–50 min at water temperatures of 21–24ºC. Kail et al. (2010) reported a large male (615 mm CL) that remained submerged for 8.25 hrs in December 2009 in a spring-fed portion of the Santa Fe River, but the veracity of this observation is dubious at best. Aerial basking is rare in *M. suwannineisis*, but Thomas (2009) observed a juvenile (186 mm CL) basking in partial sunlight in October 2008 ca. 2 m from the bank of the Santa Fe River.

Movements and Home Ranges. — A telemetry study using acoustic tags in the upper and middle Suwannee River in Florida found that home ranges were dynamic and varied by water levels (Thomas et al. 2024). That study estimated linear home ranges (mean ± SE) for nine males (3.9 ± 0.8 km), five females (2.0 ± 0.3 km), and two juveniles (2.7 ± 1.9 km), but the authors did not detect any difference between sexes. Overall, *M. suwanniensis* movements were strongly influenced by water levels. During flood stage, mean home range sizes increased notably, rising from 12.7 ha to 29.7 ha in the upper river site, and from 41.6 ha to 112.5 ha in the middle river site (Thomas et al. 2024). While the linear estimates for home range did not change during flooded conditions, *M. suwanniensis* home range sizes increased mainly due to their lateral movements in the floodplain (Thomas et al. 2024). The authors also noted their small sample size, which could have reduced their ability to detect a difference among sex/age class, but overall movements seemed individually variable. For example, two large males weighing >50 kg each had the largest (8.1 km) and smallest (1.1 km) linear home ranges.

During flood stage, 13 of 16 turtles tracked via acoustic tags moved from the river channel into the inundated floodplain (Thomas et al. 2024); additionally, five animals (three males and two females) repeatedly moved back and forth between the floodplain and the river channel, and they continued making overland movements until the connecting water path dried up. A large male (52. 7 kg) utilized a floodplain spring and stayed until after the aquatic path dried entirely; however, the turtle continued moving between the spring and the river (i.e., over land; Thomas et al. 2024). Overland movement in *Macrochelys* is considered rare but does happen for nesting purposes (see Carr et al. 2024). In the Suwannee drainage, a road-killed juvenile (ca. 250 mm CL) was found along the Santa Fe River (Ewert et al. 2006), and an adult was observed on 17 July 2012 crawling in receding, shallow water flowing across the land bridge between the upper and lower Santa Fe River, Columbia County, after flooding by Tropical Storm Debby (Johnston et al. 2015b; UF-Herpetology 190178). Smaller turtles are agile on land and walk with their bodies elevated off the ground, like *Chelydra*, but large adult females and adult males tire quickly on land and usually drag their bodies along the ground. However, overland movements by *M. suwanniensis* may be more common than previously thought (Thomas et al. 2024), especially in areas that possess larger floodplains.

Reproduction. — Dobie (1971) found that both sexes of *M. temminckii* in Louisiana attained sexual maturity in 11–13 yrs, but other researchers have suggested maturity requires 13−21 yrs in females and 11−21 yrs in males (Sloan et al. 1996; Tucker and Sloan 1997). The smallest known gravid female *M. suwanniensis* measured 403 mm CL, but female maturity probably occurs at ca. 340–360 mm CL based on growth modeling (Thomas, Enge, and Johnston, unpubl. data). Male turtles may not sexually mature until ~425 mm CL (based on elongation of the PVL), but more evidence is needed to confirm this. Five juvenile *M. suwanniensis* in the upper Santa Fe River grew 12.3–18.9 mm/yr, leading to an estimated age of sexual maturity of ca. 19 yrs for females and 22 yrs for males (Johnston et al. 2012). A juvenile male (290 mm CL) in the Suwannee River grew an average of 16 mm annually in 9 yrs (Thomas and Enge, unpubl. data), but growth rates are likely site specific and may vary greatly by resource availability. Three large males (> 600 mm CL) in the Suwannee River grew only 2–5 mm CL and gained 0–2 kg in 9 or 10 yrs (Thomas and Enge, unpubl. data). Four large males (> 600 mm CL) in the lower Santa Fe River grew 0–3 mm CL per yr, and one male in the upper Santa Fe River grew only 1 mm CL (547 to 548 mm) in almost 13 yrs (Johnston, Thomas, Enge, unpubl. data).

Several studies (e.g., Allen and Neill 1950; Dobie 1971; Ewert and Jackson 1994) have indicated that female *Macrochelys* produce only one clutch annually, and some may occasionally skip years (Dobie 1971). Captive *M. suwanniensis* in northcentral Florida engaged in courtship from February through April and oviposited 21 April–15 June (Allen and Neill 1950). A male *M. suwanniensis* was observed atop a female caught on a bank-set fishing line (i.e., bush hook, bank line) at night on 7 December 2020 in the Suwannee River in Lafayette County, Florida (Enge and Murray 2021). This represents the first observation of mating of *M. suwanniensis* in the wild and the earliest observation of mating in *Macrochelys* (Enge and Murray 2021).

Combat between male *M. suwanniensis* has been observed in September, October, and December outside of the presumed courtship and mating season (Enge et al. 2023). This could indicate that the mating season is prolonged or that male–male aggression is not associated with sexual competition but may include territorial defense, particularly when reduced water volume in small streams makes it difficult for turtles to avoid each other (Enge et al. 2023). Combat involves wrestling and biting of heads and front feet, and it is usually accompanied by dramatic bubbling of the water surface from submerged turtles (Enge et al. 2023).

Nesting ecology of *M. suwanniensis* remains poorly understood, and only a handful of observations have been made. Freshly dug *M. suwanniensis* nests have been found from 29 March to 21 May in Florida (Jackson and Thomas 2018; Carr et al. 2023b; Thomas and Enge, unpubl. data). Reported nest sites were on the upslope of a dirt road near the New River in Union County, Florida, upland pine forest just upslope of upland mixed forest along the Ichetucknee River, and in a residential yard within 20 m of Cow Creek, a small tributary of the Santa Fe River (Jackson and Thomas 2018). These limited data indicate that female *M. suwanniensis* nest 15–78 m from water (Carr et al. 2023b). A GPS-tracked female nested on 23 April from 0900 to 1100 hrs on the narrow berm separating the Suwannee River from its floodplain near Branford, Florida (Thomas and Enge, unpubl. data). The limited information available in Florida and Georgia suggests that *M. suwanniensis* nests in partially open, sandy areas (e.g., sandhill, river bluffs, and sand roads) close to water (Carr et al. 2023b).

Clutch sizes of *M. temminckii* along the lower Apalachicola River in Florida averaged ca. 36 eggs (range 17−52; Ewert and Jackson 2006). Two *M. suwanniensis* clutches that were salvaged because of flooding concerns contained 43 and 47 eggs (Jackson and Thomas 2018). Radiographed females from the Suwannee (462 mm CL) and Santa Fe (427 mm CL) rivers contained 32 and 25 eggs, respectively (Thomas, Johnston, and Enge, unpubl. data). In 2024, two additional clutches were salvaged from rising floodwaters and contained 26 and 38 eggs (Thomas, Enge, Johnston, unpubl. data).

The mean egg diameter of these 64 salvaged eggs was ca. 38 mm (range 31–41 mm), with a mean mass of ca. 31 g (range 27–36 g; Thomas, Enge, Johnston, unpubl. data). Interestingly, the mean number of eggs of these six clutches from salvaged nests and a radiographed gravid female was 35, which is similar to *M. temminckii* in western Florida (see Ewert and Jackson 2006). Captive *M. suwanniensis* deposited a mean of 24.5 eggs (*n* = 6, range 16–44), and a clutch laid on 3 June hatched 11–19 September (Allen and Neill 1950).

Hatching of *M. suwanniensis* may be similar to *M. temminckii* in Florida, which occurred in the Apalachicola River in August after ~100−110 days of incubation (Ewert and Jackson 1994). However, *M. suwanniensis* nesting is thought to occur in April in the Suwannee and Santa Fe rivers, so hatching might occur earlier in the summer (Thomas, Johnston, and Enge, unpubl. Data). Incubation temperature influences sex determination in *Macrochelys*, with constant incubation temperatures of 25–27ºC producing mostly males and temperatures of 29ºC and 30ºC producing only females (Ewert et al. 1994).

Population Structure. — Juveniles comprised ca. 21%, adult females 17%, and adult males 61% of a sample (*n* = 155) in the Suwannee River in Florida (Thomas et al. 2023). Juveniles comprised 24%, adult females 44%, and adult males 32% of a sample (*n* = 109) in the Santa Fe River (Johnston et al. 2015b). Juveniles comprised 32%, adult females 34%, and adult males 34% of a sample (*n* = 79) in the Alapaha River between Willacoochee and Statenville, Georgia (Stevenson, unpubl. data). However, it should be noted that most of these studies were conducted using baited hoop traps, which may not be effective at capturing the smallest sized juveniles.

In the Suwannee River mainstem, size classes were skewed toward larger (CL) individuals, and 42% of adult males weighed ≥45 kg. However, most of these individuals were captured in the middle river section, which also possessed male skewed sex ratios (Thomas et al. 2023). Overall, adult male CL ranged 431–650 mm (mean = 500 mm) and adult female CL ranged 344–470 mm (mean = 415 mm). Additionally, adult male mass ranged 18.0–57.1 kg (mean 37.8 kg), whereas adult female mass ranged from 10.0–22.5 kg (mean = 16.5 kg) in the Suwannee River.

Adult females were significantly larger in the upper Santa Fe River (mean CL = 436 mm, range = 336–492 mm) than in the lower Santa Fe River (mean CL = 407 mm, range = 329–449 mm), but male body size did not differ between river sections, although the six largest males (>600 mm CL) came from the lower section (Johnston et al. 2015b). Interestingly, this is the inverse of findings from a study conducted in the Suwannee River that found adult males significantly larger in some sections of river (Thomas et al. 2023). In the Santa Fe River, adult females were proportionately heavier in the upper river, but the relative mass of adult males was similar between the two river sections (Johnston et al. 2015b). In the Alapaha and Withlacoochee River drainages in Georgia, females measured 340–472 mm CL and males 375–590 mm CL (Stegenga 2019; Stevenson 2019). These Georgia drainages appear to have fewer large males compared to the Suwannee and Santa Fe rivers in Florida, which could be an artifact of resource limitations in smaller streams.

The adult sex ratio for the entire Suwannee River in Florida differed from 1:1, with males predominating 3.8:1 (Thomas et al. 2023). The adult sex ratio was skewed towards males in the middle river section by 4:1, but the adult sex ratio was an even 1:1 in the upper and lower Suwannee River (Thomas et al. 2023). The upper Santa Fe River had a female-skewed adult sex ratio (1:2), but the lower river had an equal sex ratio (Johnston et al. 2015b). The adult sex ratio was 1:1 in the Alapaha River, Georgia (Stevenson, unpubl. data). Compared to other studies on *Macrochelys*, the study in the Suwannee River was the only one with an observed sex ratio skewed towards males and with a preponderance of large adult males, which likely indicates that commercial harvest never occurred in the mainstem Suwannee River.

Mortality. — During a study along the Suwannee River in Florida, Enge et al. (2014) observed or had reports of four dead turtles in or near their study sites with undetermined causes of mortality, and a dead adult male was observed in the Suwannee River near Mayo, Florida, in 2016 (UF-Herpetology 190179). Since all take and harvest of *M. suwanniensis* was prohibited in 1992 in Georgia and in 2009 in Florida, the primary source of adult mortality is suspected to be either from long-term trauma caused from ingesting fishing hooks or drowning from being caught, entangled, and drowned in passive fishing gear (e.g., bank lines, bush hooks, trot lines). One adult turtle died during a significant flooding event (Enge et al. 2014), and a large adult male (641 mm CL) was found dead of unknown causes in the upper Santa Fe River in 2022. In 2023, another large adult male was found dead in the Santa Fe River, and a smaller turtle (390 mm CL) was found dead in the Suwannee River near Bell, Florida; these turtles had no evidence of external trauma (Enge, pers. obs.).

Like elsewhere, in Florida (Ewert et al. 2006), raccoons (*Procyon lotor*) are likely the primary nest predators, and red imported fire ants (*Solenopsis invicta*) may pose a threat to embryos in pipped eggs or emerging hatchlings. Of course, nests are threatened by flooding and other environmental threats. The presence of carapacial pitting may represent tooth marks from alligators, which presumably mainly attack smaller turtles.

Parasites and Other Symbionts. — Allen and Neill (1950) and Neill and Allen (1954) noted the occurrence of filamentous algae on the carapaces of some individuals, along with an abundance of associated crustaceans such as cladocerans, copepods, ostracods, and amphipods. Leeches (*Placobdella* sp.) are commonly observed on the limbs, neck, carapace, and/or plastral seams (Johnston, unpubl. data). The basking individual reported by Thomas (2009) had an unusually large leech load (>250 leeches; Johnston, unpubl. data). Leeches are a vector for the blood parasite *Haemogregarina macrochelysi* (Telford et al. 2009), which has been detected in all *M. suwanniensis* sampled (Rebecca Hardman, pers. comm.).

Population Status. — Based on a capture-recapture study at 10 sites along the mainstem Suwannee River in Florida, Thomas et al. (2022) estimated a population density of 6.6 turtles/river km, indicating a population of ca. 1,709 (range estimate 1,205–2,694; 95% CI) *M. suwanniensis* from the town of White Springs to the Suwannee Estuary (approximately 259 river km). Both adult males and females had very high annual apparent survival rates (0.99), whereas juveniles had lower annual apparent survival rates (0.32–0.45; Thomas et al. 2022). Both post-breeding, stage-structured matrix population models suggested an "uncertain" population trend (maybe stable or slightly declining), with the population growth rate being most sensitive to changes in adult survival. These findings indicate the importance of adult survival for long-term population viability. In fact, even a small amount of adult mortality could cause population level declines in *M. suwanniensis*, so minimizing adult mortality should be prioritized in any management plan (Thomas et al. 2022).

Although several studies are underway, at the time of this writing, robust capture-recapture estimates are unavailable for the tributaries of the Suwannee River. While catch per unit effort (CPUE) data should be interpreted with caution, it can be used conservatively as an index for a general estimate of individuals present (i.e., relative abundance rates; see Table 1). In the Suwannee River, relative abundance was highly dynamic and varied by site and by river sections. The middle river section had a higher CPUE compared to the upper and lower sections (Table 1). Relative abundance was low upstream of White Springs in Florida and Georgia and near zero in the Suwannee Estuary (Table 1). However, many variables could have affected trapping success in the estuary, including the wide width of the river and variable tidal flow. The Suwannee River (excluding the estuary and extreme upper river) and the upper Santa Fe River had similar relative abundance, but relative abundance was reduced in one site

Table 1. Trapping results for *Macrochelys suwanniensis* from the Suwannee drainage in Georgia and Florida. TN = number of trap nights; CPUE = Catch Per Unit Effort = number of turtles captured per trap night.

Drainage and Stream	TN	CPUE	Source
Upper Suwannee River			
Suwannee River, GA	146	0	Jensen and Birkhead 2003; Enge et al. 2021b
Jones Creek, GA	2	0	Enge et al. 2021b
Suwannoochee Creek, GA	20	0.10	Jensen and Birkhead 2003; Enge et al. 2021b
Cypress Creek, GA	4	0	Enge et al. 2021b
Tom's Creek, GA	11	0.45	Enge et al. 2021b
Rocky Creek, FL	6	0.33	Enge et al. 2021b
Hunter Creek, FL	3	0	Enge et al. 2021b
Suwannee River, N of White Springs, FL	56	0.05	Enge et al. 2021b; Thomas and Enge, unpubl. data
Suwannee River, Reach 1, FL	124	0.19	Enge et al. 2021b
Middle Suwannee River			
Suwannee River, Reach 2, FL	123	0.29	Enge et al. 2021b
Suwannee River, Reach 3, FL	170	0.26	Moler 1996; Enge et al. 2021b
Suwannee River, Reach 4, FL	144	0.38	Enge et al. 2021b
Lower Suwannee River			
Suwannee River, Reach 5, FL	142	0.20	Moler 1996; Enge et al. 2021b
Suwannee River, S of Fowler's Bluff	26	0.16	Thomas and Enge, unpubl. data
Suwannee Estuary			
Suwannee River, Reach 6, FL	120	0.01	Enge et al. 2021b
Alapaha and Withlacoochee Drainages			
Alapaha River, GA	420	0.24	Jensen and Birkhead 2003; Enge et al. 2021b; Stevenson, unpubl. data
Alapaha River, FL	13	0.15	Enge et al. 2021b
Alapahoochee River, GA	4	0.25	Enge et al. 2021b
Alapahoochee River, FL	10	0	Enge et al. 2021b
Willacoochee River, GA	5	0.40	Enge et al. 2021b
Withlacoochee River, GA	91	0.08	Jensen and Birkhead 2003; Enge et al. 2021b
Withlacoochee River, FL	23	0.26	Enge et al. 2021b; Thomas and Enge, unpubl. data
New River, GA	3	0	Enge et al. 2021b
Okapilco Creek, GA	14	0.21	Jensen and Birkhead 2003; Enge et al. 2021b
Piscola Creek, GA	14	0.27	Jensen and Birkhead 2003; Enge et al. 2021b
Little River, GA	43	0.09	Jensen and Birkhead 2003; Enge et al. 2021b
Warrior Creek, GA	15	0.33	Enge et al. 2021b
Santa Fe Drainage			
Upper Santa Fe River	212	0.27	Johnston et al. 2015; Enge et al. 2021b; Thomas and Enge, unpubl. data
Lower Santa Fe River	321	0.14	Moler 1996; Johnston et al. 2015; Enge et al. 2021b; Thomas and Enge, unpubl. data
New River	6	0.50	Enge et al. 2021b
Ichetucknee River	24	0.08	Johnston et al. 2015; Enge et al. 2021b
Olustee Creek	17	0.18	Enge et al. 2021b
Streams in the Big Bend Region			
Steinhatchee River, FL	12	0	Enge et al. 2021b
Fenholloway River, FL	8	0	Enge et al. 2021b
Econfina River, FL	5	0	Enge et al. 2021b
Aucilla River, FL	34	0	Moler 1996; Enge et al. 2021b
Wacissa River, FL	8	0	Enge et al. 2021b
St. Marks River, FL	16	0	Moler 1996; Enge et al. 2021b
Wakulla River, FL	7	0	Enge et al. 2021b
Waccasassa River, FL	9	0	Enge et al. 2021b

in the lower Santa Fe River (Table 1). However, recent sampling in a different site in the lower Santa Fe River has produced higher rates (CPUE = 0.44) compared to previous efforts (Thomas, Enge, and Johnston unpubl. Data). Limited trapping of tributaries of the Santa Fe River produced variable CPUEs (Table 1).

Overall, relative abundance in tributary streams was apparently lower in Georgia than in Florida (Table 1). Enge et al. (2021b) had sufficient trapping effort in Georgia to conclude that relative abundance was higher in the Alapaha River than in the Withlacoochee River, and subsequent trapping of the Alapaha River yielded an overall CPUE of 0.24 in 420 trap nights (Table 1). Enge et al. (2021b) could not conclude that some streams lacked *M. suwanniensis* or had a low or high relative abundance because trapping effort was insufficient or trapping conditions were poor because of water levels, stream current, limited cover, or other factors. Although extensive trapping in the Suwannee River downstream of the Okefenokee Swamp has failed to capture *M. suwanniensis* (Jensen and Birkhead 2003; Enge et al. 2021b), the species has been trapped in several tributaries in the upper Suwannee (Table 1).

Threats to Survival. — Perhaps the greatest immediate threat for *M. suwanniensis* populations is incidental mortality from accidental ingestion of fishing tackle and drowning from entanglement in passive fishing gear (e.g., limblines, bushhooks, trotlines). Ingested fishing hooks come from both active anglers targeting catfish on the bottom and passive set lines set at variable depths. Ingested fishing hooks can perforate the digestive tract lining and eventually cause death in turtles, and ingested monofilament line can cause severe digestive blockage resulting in chronic health issues or death (D. Heard, pers. comm.). Of 26 *M. suwanniensis* of both sexes and age groups radiographed in the Suwannee drainage, 15.4% had hooks lodged in their gastrointestinal tracts (Shook et al. 2023). An adult female contained three ingested hooks, and another female had a single hook in the same location as 14 months earlier (Shook et al. 2023). One small juvenile was found to have ingested five fishing hooks in the Suwannee River (Thomas, unpubl. data). In addition, passive set lines are often abandoned, and with rapidly fluctuating water levels, entangled or hooked turtles are more prone to drowning. Recreational anglers, particularly those who bottom-fish, are known to capture catch *M. suwanniensis* even during daytime hours (Enge et al. 2014; Shook et al. 2023). Enge et al. (2014) trapped a turtle from Dowling Park on the Suwannee River that had a fishing hook embedded in its upper left forelimb, and a juvenile from the Withlacoochee River and two juveniles from the Alapaha River in Georgia had fishing hooks in their mouths (Shook et al. 2023).

The area around the Suwannee River is one of the least populated in the state, and the predominant land uses are agriculture and silviculture (Raulston et al. 1998). Growth and development along the Suwannee River have been limited because of floodplain management ordinances, land use plans, and public land acquisition programs (Raulston et al. 1998). Submerged timber, known as 'deadhead' logs, are trees that were cut down with axe until the beginning of the 20th century. Typically, these logs were cut and floated down river in large numbers where they could be hauled out, transported, and sold. Over the century, tens of thousands of logs were lost or abandoned and sunk to the bottom of the river where they became important habitat.

However, during the past 30 years, a significant market formed that allowed individuals to locate, float, and sell these logs. In fact, the State of Florida initiated a deadhead log removal program in 2000; permits are issued by the Florida Department of Environmental Protection. From 2000 to 2008, more than 16,000 logs were removed from Florida rivers, but this is likely a conservative estimate (Kaeser and Litts 2008). In the Suwannee drainage in Florida, deadhead logging is permitted in most of the navigable rivers of the drainage (mainstem Suwannee River until Fanning springs, lower Santa Fe River, and the entire Withlacoochee River; McFarland 2016). A study reported that *M. suwanniensis* utilizes woody debris habitats nearly exclusively, and removal of this habitat could have a negative impact on the species because of its importance as primary refugia during low-water periods.

Other threats to *M. suwanniensis* populations come from human-induced water pollution. For example, the City of Valdosta, Georgia, frequently has major raw sewage spills of suspended solids into the Withlacoochee River. This could lead to major impacts on turtle health, including disease, stress, and the accumulation of toxins due to the species' trophic position. Although groundwater quality seems decent in the Suwannee Basin, the middle section of the Suwannee River is increasingly impacted by nutrients, particularly nitrates and nitrites, due to groundwater contamination from croplands, poultry farms, dairies, and septic tanks (Raulston et al. 1998). Modeling found that areas of the Suwannee watershed in Florida with a large proportion of agricultural cover were consistently associated with larger increases in groundwater pollutant loads than areas with urban or forest cover, after controlling for depth to water table (Bawa and Dwivedi 2019). Chaffin et al. (2008) established reference ranges for complete blood count, plasma biochemistry values, trace metals, and nutrient parameters for *M. suwanniensis* from the Santa Fe River. Blood mercury levels (mean = 0.603 ppm) of the Santa Fe River turtles exceeded those from six other *M. temminckii* populations in Florida and Georgia.

Perhaps the biggest concern is the unsustainable use and withdrawal of groundwater in the region. Increases in human populations and water-intensive agriculture practices paired with less rainfall in the drainage has led to reduced flows. In fact, water levels in the Floridan

Aquifer have declined in northern Florida over the past 70 yrs due to increased groundwater extraction and reduced groundwater recharge (Knight 2015). A study found that from 1995–2008, the number of drought days in the Suwannee drainage (4.23 months/year) has increased substantially compared to historic rates from 1942–1995 (0.42 months/year), and a lack of rainfall combined with higher water withdrawals has caused a reduction in water discharge in the Suwannee Estuary (Seavey et al. 2011). Also, reduced input from springs can decrease water clarity and decrease primary productivity, potentially affecting turtle populations (Johnston et al. 2015b, 2016; Enge et al. 2021b). Obviously, declining water quality paired with declining water flow is a major threat to this species, and these factors could impact prey items, habitat quality, and resource availability.

Conservation Measures Taken. — Florida prohibited the sale of *Macrochelys* in 1972 and limited personal possession to one turtle in 1974, effectively banning commercial harvest. *Macrochelys temminckii* was listed by the Florida Fish and Wildlife Conservation Commission (FWC) as a Species of Special Concern until 2009, when rule changes prohibited the take of all *Chelydra* and *Macrochelys*. A biological status review by the FWC (2011) recommended that *M. temminckii* be delisted. After the taxonomic reclassification by Thomas et al. (2014), the FWC (2017) reevaluated all three defined species at the time (*M. temminckii, M. apalachicolae*, and *M. suwanniensis*), recommending that only *M. suwanniensis* be listed as Threatened because of its restricted distribution; this listing change went into effect in December 2018. Georgia did not prohibit commercial harvest of *Macrochelys* until 1989, 17 yrs later than Florida, but it listed *Macrochelys* as Threatened in 1992.

In 2006, *M. temminckii* was included in Appendix III of CITES (USFWS 2005) and uplisted to Appendix II (as part of *M. temminckii* sensu lato) in 2023, which requires federal oversight and export permits that monitor and limit international trade. The USFWS was petitioned in 1983 (USFWS 1984) and in 2012 (Adkins Giese et al. 2012) to federally list *M. temminckii*, and species status assessments (SSAs) were conducted for *M. temminckii* and *M. suwanniensis*. The draft SSA for *M suwanniensis* was completed in 2020 (USFWS 2020). The 12-month finding by the USFWS (2021) determined that *M. suwanniensis* warranted being listed as federally Threatened under the Endangered Species Act, and this listing went into effect on 29 July 2024 (USFWS 2024).

The conservation status of *M. suwanniensis* was also recently assessed for the IUCN Red List of Threatened Species and was determined to meet the criteria for a listing as Vulnerable (Thomas et al. 2025).

Conservation Measures Proposed. — Although targeted take of *M. suwanniensis* is prohibited in Florida and Georgia, incidental take occurs from the setting of fixed, passive fishing gear (e.g., trotlines, bush hooks, bank lines). To address this, the FWC (2018) developed a species action plan that identified the need to investigate the effects of trotlines and bush hooks on Alligator Snapping Turtles. The Georgia Department of Natural Resources also identified the need to investigate the effects of this type of fishing on all aquatic turtle species, and it recommended that trotlines and bush hooks be checked daily and removed when not in use to prevent snagging and entanglement of nontarget animals (https://georgiabiodiversity.org/natels/profile?es_id=17826).

Regulations should be considered to limit turtle hook occurrence and research is needed to better understand what effect passive and active fishing has on turtle populations. While prohibition of this type of fishing in the Suwannee drainage is a potential conservation measure, it might be more effective to engage stakeholders and anglers to identify simple solutions to limit the impact on this threatened species. One common-sense approach that we believe should be considered is to ban the use of stainless-steel fishing hooks in the Suwannee drainage, as common iron-based fishhooks will oxidize and deteriorate, which could limit their ability to persist in the environment when abandoned and possibly limit turtle mortality when ingested.

Current Research. — Gerald Johnston continues to conduct long-term (2004–present) ecological research on the turtle assemblage in the Santa Fe River, including the natural history and population dynamics of *M. suwanniensis*. Kim Titterington and Becky Hardman are studying blood chemistry, health parameters, and reproductive biology. In 2020, Travis Thomas and Kevin Enge initiated long-term monitoring in three sections of the Suwannee River that were surveyed in 2011–2013. Information obtained from this study will provide refine population models and determine trends. Thomas and Enge received funding in 2021–2026 to establish additional monitoring sites on the Santa Fe and Withlacoochee rivers, determine population extent upstream of White Springs and in the estuary of the Suwannee River, and find nesting sites along the Suwannee River using a variety of satellite tags. In 2020, Dirk Stevenson, Greg Brashear, and Chris Coppola initiated population monitoring of the *M. suwanniensis* population inhabiting the Alapaha River of southern Georgia. These projects combined will allow researchers to determine the population trend drainage-wide and identify important nesting areas for protection.

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