Supplemental Information for the Suwannee Cooter

Biological Status Review Report

The following pages contain peer reviews received from selected peer reviewers, comments received during the public comment period, and the draft report that was reviewed before the final report was completed

March 31, 2011

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Peer review #1 from Kenneth Wray

Independent Review of the Biological Status Review for the Suwannee Cooter (*Pseudemys concinna suwanniensis*)
Kenneth P. Wray

1. Completeness and accuracy of the biological information and data analyses:

    This review is thorough given the lack of natural history information for this species. Data analyses are appropriate.

2. Reasonableness and justifiability of the assumptions, interpretations of the data, and conclusions:

    Any assumptions made are conservative and reasonably grounded in the available data for this species. Data interpretation is fair and sound. Conclusions are valid given the results of this review. A status of threatened seems *unwarranted* for this taxon based on this review.

Peer review #2 from Anthony Lau

From: antlau1@gmail.com on behalf of Anthony Lau
To: Imperiled
Subject: Re: Deadline reminder for peer reviews of BSR reports
Date: Monday, January 31, 2011 1:49:28 PM
Attachments: review_suwannee_cooter_LAU.docx

Dear Dr. Haubold,

Please see the attached review on the BSR of the Suwannee Cooter.

Cheers,

Anthony Lau

Anthony Lau
Graduate Student
Dept. of Wildlife Ecology & Conservation
University of Florida
Gainesville, Florida

Elsa M. Haubold, Ph.D.
Leader, Species Conservation Planning Section
Florida Fish and Wildlife Conservation Commission
Tallahassee, Florida

31st January, 2011

RE: Review on Biological Status Review for the Suwannee Cooter

Dear Dr. Haubold,

The biological review group did a tremendous job gathering up-to-date, science-based, peer-reviewed information to support their decision to delist the Suwannee Cooters (*Pseudemys* concinna suwanniensis) from the list of species of special concern in Florida. The biological information included in the BSR is complete as it includes all of the recently published literature on this species (Note: Kornilev et al. 2010 paper is no longer In Press, so the citation should be updated) . In terms of data analyses, the review group may provide stronger support for their decision by including more data on the species population size estimates in some populations, which is available in the literature. The reference to "D. Jackson GIS polygons" in the geographic range section is unclear. "Strong enforcement of 2009 FWC rules that prohibit take of this species" was emphasized as the ground of "expected population growth" of this species, and rightfully so. Population recovery is especially slow in a long-living species such as the Suwannee Cooter. We cannot expect for population recovery if take of this species were to continue. Strong enforcement of the FWC 2009 rules by the commission is recommended.

The report generated from this status assessment contained well-supported arguments and justifiable assumptions. Biological information was interpreted appropriately. Data were sufficient in most sections. Data were insufficient in the "Population size reduction" section, mostly due to the difficulty of long-term monitoring of this long lived species, but data in other sections supports the claim that population sizes in many independent drainages are stable.

In summary, the biological status review included up-to-date information on this species, data presented were sufficient and analyzed accurately, and assumptions made were justifiable if FWC will implement strong enforcement of the newly exact rules that prohibit take. I support the decision to delist this species from the list of species of special concern as it failed to meet the criteria that warrant such status.

Yours sincerely
Anthony Lau

Letters and emails received during the solicitation of information from the public period of September 17, 2010 through November 1, 2010

Email from Yurii Kornilev

Please find attached a short note regarding some recent published data on the Suwannee Cooter, regarding the imperiled species biological status review.
Sincerely,
Yurii Kornilev

Suwannee Cooter (*Pseudemys [concinna] suwanniensis)*
Florida's Imperiled Species Biological Status Review
Yurii V. Kornilev, M.S.
University of Florida

Most published information on the Suwannee Cooter so far has been collected for populations inhabiting spring-fed, crystal-clear water (e.g. Ichetucknee, Wakulla, and Rainbow rivers). Here I summarize some recent published and unpublished data on a population inhabiting an understudied, but typical habitat - blackwater streams (e.g. the Suwannee River and its tributary, the Santa Fe River).

Population size and trends

Between 2006 and 2007, Johnston et al. (in press) studied the turtle assemblage of a 1.1 km stretch of the Santa Fe River, starting from the River Rise, in River Rise Preserve State Park. Of the eight species captured via snorkeling and trapping, the Suwannee Cooter was the most abundant, comprising 54.5% of all individuals captured and 77.9% of the total estimated assemblage biomass (199.8 kg/ha). Using a Jolly-Seber model, mean monthly population size of *Pseudemys suwanniensis* > 175 mm plastron length (subadult females, adult females, adult males) was estimated at 127 individuals (range 104–162). Population density was 42.8 ind./ha.

In 2007, for a section of the Santa Fe downstream from the US Highway 441 bridge, repetitive raw visual counts produced an estimate of 25 adults per ha of river (SD = 39.7; range: 118–258; n = 21 counts; Kornilev 2008). The estimate for total counts was slightly greater (32 individuals/ha; SD = 42.2; range: 177–346; n = 21 counts). In 10 of the surveys, I counted 240–270 individuals per sampling trip. Even though the highest and the lowest counts were made during the same day, the percentage of turtles basking was similar during both surveys.

With comparable sampling effort to capture-recapture, raw counts yielded results with lower variance and seemed adequate for crude abundance estimation as they provide at least a minimum assessment of abundance. Furthermore, visual counts seemed less biased in detecting hatchlings and subadults. However, more rigorous studies are needed for accurate results, including population estimation targeted specifically at open populations.

In the 7.5 km downstream from the River Rise of the Santa Fe river, Suwannee Cooters seem to have a stable and abundant population that includes hatchlings, subadults, and both males and females of reproductive size. Courtship and egg laying have also been observed multiple times. However, reproductive output, nest survival and hatchling survival to adulthood have not been quantified, making it premature to declare the Santa Fe population viable in the long term.

Furthermore, strong evidence exists that suggests that current "high density, abundant populations" are only a fraction of the populations that existed 50–100 years ago, before human impacts increased.

Life history and biology

During the studies of Kornilev (2008), Kornilev et al. (2010), and Johnston et al. (in press), we collected further evidence that large Suwannee Cooters are highly vagile and are capable of covering long distances rapidly (>1.5 km in a day), with few individuals found >5 km from previous capture locations within a few days. For large turtles, the propensity to move

across different habitats and the size of the actively used linear home range varied extensively and were best explained by individual variation rather than by sexual differences.

Furthermore, turtles utilize patchy, non-stable resources such as the availability of logs and vegetation mats for basking and feeding, which also influence their need to traverse habitats. We observed a shift in habitat use, both on a daily and a monthly basis. Therefore, it is necessary to think in kilometers or, better yet, dozens of kilometers when devising protected areas and considering the viability of Suwannee Cooter populations.

Threats to the species

Human collection and consumption were a major threat for the species (Heinrich et al. 2010). An important step in the right direction has been made, with the new regulations prohibiting *Pseudemys* spp. collection, voted by the FWC in 2009. However, stringent enforcement is essential.

As of 2008, debates existed about the addition of four additional large water-bottling companies within 5 km of the riverfront, besides the existing one. By drawing over 492,100 m3 of spring water annually, the proposed changes will likely result in decreased river water levels, changes in river flow, vegetation and animal communities, and could have major adverse ecological effects. Such alterations in the riverine habitat are likely the biggest current threat to the population of the Suwannee Cooter in this section of the river. Efforts for sustainable use of the water resources of the Santa Fe River are currently carried by a non-profit organization, Our Santa Fe River (http://www.oursantaferiver.org/).

A management plan should be devised to control water hyacinth (*Eichhornia crassipes*), an introduced aquatic plant. Common throughout the sampled portion of the river, water hyacinth seem to out compete other plants that provide refugia, surface basking, and food for Suwannee Cooters. In July 2008 *E. crassipes* covered at least 300 m of river surface about 1.5 km upstream from the US Highway 441 bridge and about 200 m of the river adjacent to the public boat ramp. This made boating almost impossible, practically stopped surface flow, and likely negatively impacted aquatic biota.

Boating and recreational uses of the Santa Fe River and similar water bodies are essential for their conservation by creating and maintaining an appreciation of their intrinsic beauty and importance. However, human disturbance, especially caused by recreational boaters, can potential lead to decreased basking opportunities for the turtles as well as increased stress levels, resulting in lowered reproductive output and survival. The limited paddle boating activities observed in 2007–2008 seemed not to have a major influence on the behavior of the turtles in the Santa Fe study site (Kornilev 2008). However, potential increase in stress hormone levels has not been measured, which might be a better indicator for disturbance impacts. Furthermore, an increase in boating traffic as well as the addition to motor boats (largely absent during the study due to the low river levels) might have a largely negative impact.

Literature cited

Heinrich, G.L., T.J. Walsh, N.E. Mattheus, J.A. Butler and P.C.H. Pritchard. 2010. Discovery of a modern-day midden: continued exploitation of the Suwannee Cooter, *Pseudemys concinna suwanniensis*, and conservation implications. *Florida Scientist* 73:14–19. [Available for download at http://www.cnah.org/pdf_files/1442.pdf]

Johnston, G. R., A. Lau & Y. V. Kornilev. Composition of a turtle assemblage in a northern Florida blackwater stream. *Florida Scientist*. *accepted* [File attached]

Kornilev, Y. V., C. K. Dodd, Jr. & G. R. Johnston. 2010. Linear home range, movement, and spatial distribution of the Suwannee Cooter (*Pseudemys concinna suwanniensis*) in a blackwater river. *Chelonian Conservation and Biology*. 9(2): xx–xx. *in press* [Proof attached]

Kornilev, Y.V. 2008. Behavioral ecology and effects of disturbance on the Suwannee Cooter (*Pseudemys concinna suwanniensis*) in a blackwater spring-fed river. Thesis, University of Florida, Gainesville. 117 pp.

[Available for download at http://purl.fcla.edu/fcla/etd/UFE0022700]

Linear Home Range, Movement, and Spatial Distribution of the Suwannee Cooter (*Pseudemys concinna suwanniensis*) in a Blackwater River

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Abstract

A decreased tannin load during 2006–2007 in a northern Florida blackwater river allowed us to make observations on the ecology of the Suwannee cooter (*Pseudemys concinna suwanniensis*), a species otherwise usually studied in clear, spring-fed rivers. We conducted a capture–mark–recapture study of this protected species and recorded the locations of marked individuals throughout a > 7.4-km study site for > 5 months. Large Suwannee cooters can be highly vagile and are capable of covering long distances rapidly (> 1.5 km in a day), with few individuals found > 5 km from previous capture locations. For large turtles, the propensity to move across different habitats and the size of the actively used linear home range varied extensively and were best explained by individual variation rather than by sexual differences. We observed an abundant population, including all size classes. Turtle distribution throughout the site was unequal among river sections and was positively correlated with the number of basking sites and water depth. We recommend basking counts to monitor population trends in blackwater rivers, especially under conditions of high tannin concentrations when hand capturing turtles is difficult.

Chelonian populations are experiencing severe reductions on a global scale through a combination of factors such as habitat degradation, fragmentation, and unsustainable harvest (Gibbons et al. 2000; Turtle Conservation Fund 2002). Long-lived species such as turtles, in particular, are in danger because of a suite of life history and demographic traits, such as delayed maturity and high egg and juvenile mortality, that make them vulnerable to disturbances. Chelonians are major consumers and producers and often attain large community biomass and high density (Tinkle 1958; Plummer 1977; Moll 1990) whose

decline may have far-reaching effects on riverine ecosystems. Despite this, the ecology of river turtles is generally understudied, even in North America (Moll and Moll 2004).

The Suwannee cooter (*Pseudemys concinna suwanniensis*; Fig. 1) is a large (to 437 mm straight-line carapace length and 10-kg body mass) herbivore that can attain relatively large population sizes within the rivers of northern Florida (Jackson and Walker 1997; Jackson 2006 and references therein; Ward and Jackson 2008). The subspecies *P. c. suwanniensis* is restricted to the northern half of Florida and southernmost Georgia, from the Ochlockonee River in northeastern Florida to the Alafia River, which drains into Tampa Bay. In the past and continuing to the present (Heinrich et al. 2010), the subspecies has been taken for human consumption; currently, it is potentially threatened by increasing urbanization, water pollution, and recreational disturbance. Because of locally high biomass (up to 600 kg/river km; Jackson 2006), Suwannee cooters likely have significant influence on trophic interactions within their riverine communities (Marchand 1942; Odum 1957; Jackson and Walker 1997; Huestis and Meylan 2004). Still, many aspects of this species' life history remain unstudied.

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Figure 1 *Pseudemys concinna suwanniensis* study animals basking on the Santa Fe River, Florida, USA. Photo by C. Kenneth Dodd Jr.

Suwannee cooters may be abundant in strikingly different lotic habitats, including spring-fed, crystal-clear water with stable temperature and water level (Ichetucknee, Wakulla, and Rainbow rivers), and in blackwater streams with highly limited visibility due to organic tannins, seasonally fluctuating temperatures, and occasional flooding (the Suwannee River and its tributary, the Santa Fe River; Crenshaw 1955). *Pseudemys c. suwanniensis* is typically captured by snorkeling since it is not prone to entering baited traps. Therefore, most research on Suwannee cooters has been conducted in clear spring-fed rivers, in part because turtles are much easier to observe and capture in such habitats than in tannin-stained blackwater rivers (Marchand 1942, 1945a, 1945b; Kramer 1995; Lagueux et al. 1995; Jackson and Walker 1997; Huestis and Meylan 2004). Until recently, there has been very little research undertaken on Suwannee cooters in blackwater rivers with limited visibility.

Severe droughts in the Santa Fe River basin of north-central Florida in 2006–2007 led to a decreased tannin load and greatly increased water clarity. As a result, we were able to observe and catch turtles via snorkeling, allowing us to study a population inhabiting a normally blackwater stream. We conducted a capture–mark–recapture study to examine habitat use, movement patterns, and the extent of linear aquatic

habitat traversed by Suwannee cooters throughout a warm-season activity period. Such basic biological data, heretofore unavailable for a blackwater river population of this state-listed "Species of Special Concern," has direct implications for devising site-specific strategies for managing and conserving this turtle.

METHODS

Study Site

The study was conducted from 15 May to 13 October 2007 on the Santa Fe River (Alachua and Columbia counties, north-central Florida) in a 3.4-km stretch downstream from the US Highway 441 bridge (hereafter US 441; Fig. 2). We also collected data 4 km upstream from the US 441 bridge to the point where the river reemerges as a first-order spring at the "River Rise." Most of the study site and the surrounding area is managed by the River Rise Preserve State Park and comprises a part of the largest publicly protected area along the Santa Fe River.

enlarge figure

Figure 2 Map of the study site at the Santa Fe River. S01–S16 denote the 16 sections of the study site. Initial captures (group A turtles) were made between S04 and S10. "Public ramp" and "Canoe Outpost" are the only 2 public boat access points near the study site. Shown are the only observations of marked turtles (from groups A and B) outside the study site. River Rise is not shown and is 4 km upstream from the US 441 bridge. River Rise Preserve State Park (RRPSP) is north of the border shown.
Water depth varied throughout the study site from less than 0.2 m to more than 6.5 m but did not fluctuate substantially during our study. The current was slow and consistent throughout the study site except in a few riffles 450 m downstream from the Santa Fe Canoe Outpost, our point of entry onto the river (Fig. 2). The river width was 40 m throughout most of the river but varied locally from 25 to 85 m. Drought during the previous year had lowered the river level substantially, resulting in clear water with good visibility in contrast to the normally tannin-stained water. Lowered water levels (to 20-cm depth) 0.3 km and 3.6 km downstream from US 441 resulted in decreased recreational canoe and kayak traffic. Detailed information on the study site has been presented in Florida Department of Environmental Protection (2003) and Kornilev (2008).

Capture and Marking

We caught 50 Suwannee cooters (group A: 23 ♂, 25 ♀, 2 medium-sized juveniles) during 18–23 May 2007 and attached temperature-sensitive data loggers (iButtons; 9×11 mm, 3 g) on the right posterior marginal scutes. While attempting to retrieve iButtons between 23 July and 8 October 2007, we captured an additional 39 turtles (group B: 12 ♂, 20 ♀, 7 medium-sized juveniles). Group A turtles were initially caught in a 1-km stretch of the river starting 800 m downstream from US 441 (Fig. 2). Subsequent captures and recaptures occurred primarily in the first 2.5 km immediately downstream from US 441.

Turtles were captured by active pursuit while snorkeling or opportunistically by hand (Marchand 1942, 1945a, 1945b; Kramer 1995; Huestis and Meylan 2004), and standard morphometric data were taken in the field (straight-line carapace length [CL], plastron length, body mass, sex, life stage). Each individual was permanently marked by drilling marginal scutes (modified from Cagle 1939) and temporarily marked by painting a large unique number on each clean and dry dorsolateral side of the carapace using a nontoxic white oil-based paint marker (563 Speedry, Diagraph, Marion, IL). After processing, each turtle was released close to the point of capture, and the coordinates were obtained with a handheld GPS unit (Garmin eTrex, Garmin International, Olathe, KS; error: < 15 m).

Movement Observations
The relatively clear water allowed us to paddle the length of the field site and observe and identify turtles that were both basking and swimming. We further supplemented sampling by occasionally kayaking between US 441 and River Rise to detect dispersal beyond our primary study site. Transects were carried out 23 May–15 October, usually between 1100 and 1600 hours to maximize turtle observations.

We cautiously approached and examined every turtle we encountered and looked for the presence of drill holes, an iButton, or a painted number on the carapace. We made an effort to avoid disturbing turtles and inspected basking turtles using binoculars. On encountering a marked turtle, we recorded its approximate position using a handheld GPS, the time of day, whether it was swimming or basking, and its identity.

We used "the minimum direct distance over water between the 2 most distant points of [observation]" (Sexton 1959:137) to estimate the minimum linear aquatic home range and extent of long-term movements. This method was used previously in studies of 2 species of *Pseudemys* (*Pseudemys nelsoni*, Kramer 1995; *P. c. suwanniensis*, Jackson and Walker 1997). Visual observation points were combined with capture data, imported, and plotted on a 2007 satellite image into Google Earth (v. 4.2; Google Inc., Mountain View, CA). When viewing the image from an eye altitude of 200 ± 10 m, we obtained robust measurements of movements by manually tracing midriver distances between turtle observations. We used the minimum distance between observations to estimate movement between different days. In cases of more than one observation of the same individual on the same day, we calculated the minimum distance between observations that the turtle must have covered. We used only data from turtles that were

positively identified and estimated home range only for individuals we observed at least 30 days after original capture.

A separate mark–recapture study headed by G.J. was conducted concurrently in the first 1.1 km of the river starting at River Rise, 4 km upstream from US 441, which allowed us to extend our observations on turtle movement to 7.4 river km. Five monthly sampling sessions of more than 120 person-hours of snorkeling were conducted between May and September 2007; as many turtles as possible were hand captured, marked, and processed. The marking schemes were identical in both studies, and there was no duplication in numbering. However, because of the different goals of that study, few individuals were paint marked, and few exact coordinates of captures and observations were recorded. Therefore, we can report only anecdotal observations on long-distance movement and home range of these turtles.

Spatial Distribution and Abundance

We conducted several pilot transect surveys where we observed an unequal distribution of turtles across the length of the study site. Therefore, we divided the study site into 16 sections of varying lengths based on the following river characteristics that might be biologically important to turtles: major changes in depth (visually detected from the surface), compass orientation (which affects the amount of sunlight exposure during the day), and width.

We conducted 21 counts of both basking and swimming turtles on 13 days between 5 June and 7 July 2007 to quantify the spatial distribution of turtles and to assess relative abundance. Surveys were carried out by a single observer (Y.K.) in a kayak moving in the middle of the river. Thirteen surveys were made going downstream and 8 upstream. Surveys took 2–4 hours each since a variety of observations were being recorded. On encountering large aggregations of basking turtles, the observer slowed and used binoculars to count as many turtles as possible before approaching and possibly disturbing them. The start and finish time of surveys varied, with the earliest surveys begun at 0830 hours and the latest surveys finished at 2000 hours. Most surveys were carried out between 1100 and 1700 hours to maximize the number of turtles basking and increase detection by taking advantage of the best light conditions. Because Suwannee cooters reach sexual maturity around a CL of 190 mm for males and 275–300 mm for females (Jackson and Walker 1997; Huestis and Meylan 2004), instead of life stages, we defined 3 size classes: large (L; CL$\geq$200 mm), medium (M; 70–200 mm CL), and small (S; CL$\leq$70 mm). We recorded the number of individuals per river section in each size class (L, M, or S or only observed a head).

Habitat Assessment

We collected data on 5 environmental variables (Table 1) to examine macrohabitat characteristics that might influence turtle distribution. On 6 August 2007, we took 66 midriver depths at 50-m intervals by dipping 2 3.3-m interlocking PVC pipes graduated at 0.1 m, starting at US 441 and working downstream. During the turtle counts in June and July 2007, we used a digital thermometer to record water temperature

(T_{water}) 20 cm below the surface in the middle of the river at the beginning of each section. Each section's minimum surface area (not hidden by overhanging trees) was determined based on 2007 satellite images using Google Earth. We visually approximated the major compass orientation for each section using the built-in compass tool in Google Earth.
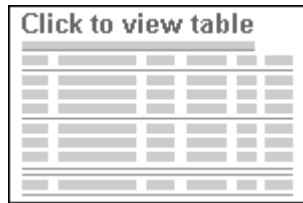
Click to view table

Table 1 Physical parameters of the 16 study sections of the study site in the Santa Fe River, northern Florida. Area = river surface area (ha); depth = mean midriver depth (m); T_{water} = mean midriver water temperature at 20-cm depth; basking sites = number of counted basking objects in the section; direction = approximate downstream river flow using 360-degree compass orientation; total = combined counts for all turtles observed during the 21 sampling periods.

We located 132 known and potential aerial basking objects throughout the study site between 28 June and 12 July 2007. We measured most basking objects (length, width, type of object, angle, height above river surface, depth of water at basking site, distance from shoreline; Kornilev 2008) on which we observed turtles as well as objects that subjectively appeared to be suitable. Although this was not a complete count of basking locations, we attempted to include a representative sample in terms of type (logs, rocks) and position in relation to shoreline and sun orientation. The number of basking sites was relatively stable during the study; that is, it did not change because of changes in water level or the infusion or elimination of objects as a result of storms.

A multivariate regression analysis was performed in R (v. 2.6.2; R Development Core Team 2008) to identify the most important habitat predictor variables for relative abundance based on the raw counts of the various size classes of turtles. We used mean water depth, mean T_{water}, compass direction, section surface area, and number of basking sites counted as independent variables for each river section. Unless otherwise specified, $\alpha = 0.05$ for all statistical tests, and standard deviation is presented as ± 1 SD.

RESULTS

Visual Observations and Captures

Of the 50 turtles from group A, 8 (6 ♂ and 2 ♀) were never positively resighted. We recaptured 12 individuals (3 ♂, 8 ♀, 1 juvenile; 4 individuals were recaptured 2 times and 1–3 times). Of the 39 turtles from group B, 12 (3 ♂, 8 ♀, 1 juvenile) were never positively resighted; we recaptured 8 individuals (2 ♂, 6 ♀, 1 female recaptured twice). Excluding original captures, we acquired 528 locations of turtles from both groups through visual observations and recaptures. We positively identified 69 individuals during 375 sightings; 67 of these sightings were a second or third observation for the same day.

Linear Home Range and Long-Term Movements

We estimated the linear home range for 26 turtles (6 ♂, 19 ♀, 1 medium-sized juvenile) observed more than 30 days after initial capture. The mean distance between initial capture and last observation (recapture or positive resighting) was similar for both sexes (♂: 484 m, ♀: 625 m; Table 2). Females showed a much wider range of distances between initial capture and last observation as well as slightly greater variation and generally larger home ranges than males (♂: 200–1600 m, ♀: 800–2800 m).
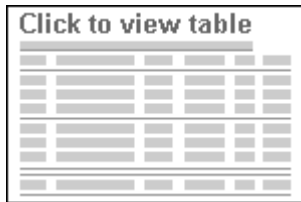

Table 2 Mean distance between initial capture and final observation, based on mark–recapture and visual observation. Days = mean number of days between first capture and last observation; SD = one standard deviation.

We observed pronounced individual variation in patterns of long-distance movements and changes in centers of activity, even though turtles had been handled similarly. Some individuals had strong site fidelity, highlighted by basking on the same log throughout a period of several weeks. Several turtles were consistently positively identified. For example, female #1113 (CL = 325 mm) was observed 8 times in 17 days basking on the same log. Female #1115 (CL = 348 mm) was observed postcapture 7 times in 19 days within a 15-m range; on 2 subsequent observations, she moved 200 m upstream and then returned to her preferred log within 17 days. Female #1173 (CL = 360 mm) moved 450 m upstream after being captured, but within 5 days she returned to the original capture location and was observed on 4 occasions on the same log during the next 16 days. Following some short-distance movements, she was 6 m from where originally captured on her last observation 50 days after capture.

Site fidelity might not be limited to basking sites. At a location where we rarely saw turtles between 0900 and 1700 hours, Y.K. opportunistically caught an unmarked large male with a distinctive stubbed tail on 3 occasions (7 and 11 June, 3 July 2007). Captures occurred between 1900 and 2015 hours, all within 10 m of one another, in the shallow (< 25 cm) gravel rapid between sections 2 and 3 (Fig. 2). Whether the turtle had been feeding on nearby copious submerged vegetation or was in proximity to a nighttime refuge is unknown.

To illustrate the variety of turtle behaviors, we describe the movement patterns of 6 large turtles (4 ♀, 2 ♂) captured initially in the concurrent study in the first 1.1 km downstream from River Rise and later detected downstream from US 441. Interestingly, 4 of these turtles were caught originally during the same sampling session on 7 May 2007. In total, 109 Suwannee cooters were captured 168 times at the River Rise site, but none of these turtles were captured originally downstream of US 441. Since capture

locations were only approximately known, we calculated minimum possible distances; movement data for these individuals are not included in the results presented in Table 2. Although these turtles might have moved longer distances than most turtles from groups A and B, we consider such types of behaviors and responses typical for adult Suwannee cooters from this area.

- A female (#82, CL = 303 mm) caught within the first 200 m downstream from River Rise was recaptured 37 days later in the same area. However, 10 days later, we observed her 1850 m downstream from US 441, >4.7 km from the initial capture site. She was located 58 days later only 115 m upstream from the previous observation.

- A female (#38, CL = 350 mm) caught in 2006 close to River Rise was found 13 months later more than 4 km downstream. During the 31 days she was observed in 2007, the longest distance she moved between observations was 325 m, and the distance from original capture to last observation was 187 m. Even though she was captured 4 times in 2007, retained for 24 hours on 1 occasion, and observed on 3 additional days, she stayed within a shallow area with rapid flow. Limited movement might have been induced by poor health since she had an overall sickly appearance, heavy leech load, and an injury to the lower jaw.

- A female (#74, CL = 374 mm) was captured at River Rise and recaptured 72 days later at the River Rise headspring. She was recaptured 72 days later after a downstream movement of at least 4.4 km. After she was released, she was resighted the same day 1.5 km farther downstream.

- A female (#81, CL = 368 mm) was caught originally at River Rise and recaptured 87 days later at least 3.4 km downstream. Four days later, she was observed about 1.5 km downstream but within 4 days had turned around and moved > 2.1 km upstream. She was recaptured at the River Rise headspring 35 days later and was observed 24 days later about 1.1 km downstream. Three observations made in 2 hours during 1 day showed a downstream displacement of 830 m.

- A male (#91, CL = 290 mm) caught within the River Rise study area was recaptured at least 4.8 km downstream 97 days later. After 8 more days, we observed the turtle 650 m farther downstream. Two later observations during the next 17 days were made less than 100 m apart. Therefore, the longest distance between observations was more than 5.5 km, and the distance from capture to last observation was at least 4.9 km.

- Another long and rapid dispersal we observed was of an unidentified male originally marked upstream at River Rise site and observed 7 days later downstream in our field site. His exact original capture location was unknown, but he moved at least 4.8–5.9 km.

We observed only 3 turtles with an iButton upstream from US 441 despite making more than 15 kayak trips to River Rise throughout the study. An unidentified adult female was observed on 26 and 27 June 2007 at the same basking log 1.2 km upstream from US 441. Based on all original capture points, she had moved upstream 2.2–3.0 km 35–40 days after capture. An adult female (#1145, CL = 341 mm) was caught 111 days after the original capture, 0.5 km upstream from US 441. We could not determine whether these observations pertained to the same or different individuals.

Distribution by Habitat

Overall, the greatest turtle concentrations were in areas around basking sites that allowed numerous turtles to bask simultaneously. Several sections of the river had very similar surface areas but strikingly different abundances; for example, #8 (high abundance) and #10 (low abundance), #3 (low) and #15 (high), and #4 (low) and #13 (high; Fig. 3). Large individuals were observed more than medium and small ones throughout the study site and in general showed widespread distribution. Assuming identical detectability, small turtles seemed to be concentrated in certain sections (e.g., #6 and #14) and were uncommon or absent in most others. Our experience suggests that detectability of all size classes of basking turtles was consistently very high throughout the study.

enlarge figure

Figure 3 Average counts of different size classes across study sections. Twenty-one counts were conducted from 5 June to 7 July 2007. "Only head" denotes observations of turtle heads on the surface that could not be definitely assigned to a size class; the majority were likely large, adult turtles. Error bars = 1 SD.

The distribution of turtles of different size classes along the river was likewise affected by macrohabitat characteristics. The correlation matrix from a multivariate regression analysis of macrohabitat characteristics showed very similar results across size classes, but total counts correlated slightly better than individual size classes (Table 3). Therefore, we present only results based on the total number of turtles counted per section. In the complete model, only the number of basking sites was significant ($t = 2.778$, $p = 0.02$); the model's adjusted R^2 was significant ($R^2 = 0.662$; $F_{5, 10} = 6.889$, $p < 0.01$). The number of basking sites and depth were the best predictors for turtle abundance according to independent stepwise, forward elimination, and backward elimination models. For the best predictors model, the number of basking sites was significant at $\alpha = 0.001$ ($t = 4.637$, $p < 0.01$), depth was significant at $\alpha = 0.05$ ($t = 2.713$, $p = 0.018$), and the model's adjusted R^2 was highly significant ($R^2 = 0.728$; $F_{2, 13} = 21.09$, $p < 0.01$).

Table 3 Correlation coefficients between river section's macrohabitat variables and turtle counts.

River Rise is > 30 m deep with a diameter around 40 m with mostly vertical limestone walls except for a 5×10-m terrace at a depth of around 9 m. Turtles resting on the terrace have been captured with little effort since they usually do not try to swim away. Many individuals were chased for 5 minutes around the Rise. They swam continuously at a depth of around 3–7 m to prevent capture, generally swam along the side of the spring, and were not observed diving deeper into the spring. In addition, we frequently observed courting at various water depths and recorded turtles feeding at or below the surface in shallow (< 1.5 m) locations even though the distribution of bottom-growing vegetation was limited based on depth and water clarity. While snorkeling, we noted *P. c. suwanniensis* escaping directly toward and hiding under submerged logs and debris at depths of 2–9 m but never deeper than 10 m.

Surface area and compass direction were not good predictors of turtle numbers, although we initially hypothesized they might be. Water depth was correlated strongly but nonlinearly with T_{water} and was selected as the preferred predictor; however, this positive relationship was due to the specific study site characteristics and cannot be extrapolated to other locations.

We observed a clumped distribution of hatchlings in the section of the Santa Fe River downstream from River Rise, but we never observed hatchlings within the initial 0.5 km even though adults were abundant. Hatchlings were commonly observed farther downstream. Even though hatchling turtles were not uniquely marked, we repeatedly observed similar numbers and sizes of hatchlings on the same logs as previously detected. Strong site fidelity is to be expected because hatchlings are weaker swimmers than adults and it would be energetically expensive and dangerous for them to move up and downstream through areas inhabited by large predators such as alligators and gars. The clumped hatchling distribution is probably related to proximity to successful nesting sites and the presence of shallow water and vegetation rather than to other river or microhabitat characteristics.

A shift in habitat use was observed, both on a daily and a monthly basis. Certain sections repeatedly had observable turtles mostly during specific times during the day; for example, turtles were often observed feeding in the afternoon in section 4 but were rare during earlier hours. Large aggregations of up to 30 large individuals were commonly observed in shallow vegetation mats composed predominantly of water pennywort (*Hydrocotyle* sp.), small duckweed (*Lemna valdiviana*), water spangles (*Salvinia minima*), and subsurface nonnative hydrilla (*Hydrilla vericillata*) and parrot feather (*Myriophyllum aquaticum*). Turtles were observed surface basking and feeding on such floating vegetation but not on mats dominated by the nonnative water hyacinth (*Eichhornia crassipes*).

DISCUSSION
Home Range, Movements, and Distribution

The extent to which turtles occupy a habitat is largely dependent on the availability of food resources, mates, shelter from adverse conditions and predators, nesting sites, and access to locations that meet specific biophysical requirements, such as thermally optimal basking sites (Boyer 1965). Such resources usually occur patchily, whether in terrestrial or in aquatic habitats. In terrestrial chelonians, habitat use is usually nonlinear through time, with home ranges covering freely accessible, mostly large 2-dimensional landscapes. Assuming that resources are available, movements need not involve wide-ranging frequent travel across the home range, and home ranges, while extensive, may not be very large in diameter.

Riverine species, however, are confined by the linear extent of habitat and live in a 3-dimensional world. Like terrestrial species, resources may not be evenly spaced or confined within proximate sections of river. In addition, fluctuations in river characteristics, such as width, depth, temperature, flow rates, and visibility, further serve to fragment patchy resources. Therefore, it should not be surprising that river-dwelling turtles frequently travel extensive linear distances between feeding, nesting, basking, and shelter locations (e.g., Vogt 1980; Dodd et al. 1988; Pluto and Bellis 1988; Dreslik et al. 2003). Our results confirm that Suwannee cooters do so as well.

On the Santa Fe River, linear home range and movement patterns are extremely variable, as our examples illustrate. The variance of these patterns seems to be explained by individual differences among turtles rather than by sex or size differences or habitat characteristics of the river, such as depth, vegetation beds, or the positioning of basking sites. Similar conclusions have been obtained in several other studies on large emydines. For example, nesting female Suwannee cooters in the Wakulla River, Florida, typically had strong nest site fidelity (within a 200-m segment), although they sometimes nested > 1.7 km away from previous nesting sites (Jackson and Walker 1997). Some individual *Trachemys scripta elegans* have preferred basking sites, whereas others do not (Cagle 1944). We observed similar results in our study.

In other aquatic turtle species (e.g., *T. s. scripta*; Schubauer et al. 1990), males have greater home ranges than females, and gender might influence linear home ranges on the Santa Fe River. At our study site, it appears that there might be a marked difference between the linear home ranges of large and small individuals, but our data are not sufficient to determine if this result is sex or size based. In the few other studies of *P. concinna* movements, Jackson and Walker (1997) noted that larger *P. c. suwanniensis* might have greater home ranges than smaller individuals in western Florida, and in Illinois, male *P. concinna* had greater home ranges and daily movements than females (5.3 vs. 4.9 ha; Dreslik et al. 2003). In all studies of *P. concinna* movements thus far (see also Buhlmann and Vaughan 1991; Sterrett et al. 2008), however, total sample size has been < 9, making generalizations premature.

Linear home range estimators for aquatic turtles must take into account the 3-dimensional aspect of their habitat. Characteristics at the river surface such as river width, presence of basking logs, and vegetation mats undoubtedly influence movements and subsequent home ranges, especially for basking herbivorous

turtles (Marchand 1945b). However, the extent to which these variables alone influence distribution is unclear. Indeed, cryptic factors unseen to surface observers may play an important role in how turtles use riverine habitats. Compared to this study, 2 radio-tracked *P. concinna* in West Virginia were not observed deeper than 2 m, although the maximum water depth was only 3 m; non–radio-tracked turtles also were concentrated in water less than 2 m deep (Buhlmann and Vaughan 1991). Together, these observations suggest that river cooters are most likely to use the uppermost 1–2 m of the water column, although they are familiar with deeper habitats and position themselves to be in close proximity to underwater shelter should escape be necessary.

In conjunction with depth, water clarity might influence turtle movement patterns and spatial distribution. Clarity influences food plant distribution by allowing sunlight to penetrate into the water column. Submerged vegetation grows at greater depths in Florida's clear-water rivers than in blackwater streams. In clear waters, turtles also are able to see distant predators, such as mammals and alligators. Our results suggest a slightly larger female linear home range in the blackwater Santa Fe River than the home ranges of 200–600 m reported in the clear-water Wakulla River (Jackson and Walker 1997). Home range could be inversely proportional to food resource availability, which is likely lower in the blackwater Santa Fe than in the clear-water Wakulla (D. Jackson, *pers. comm.*).

Abundance of turtles appeared to be related to availability of nonstable resources, such as basking locations, and the location and type of such sites influenced individual habitat preferences. For example, in March 2008 after the main study was completed, some of the basking logs and vegetation mats were no longer available because water depth had increased slightly (0.3 m). Turtles were then observed in much greater numbers at locations where previously they were scarce (e.g., sections 2 and 3). Basking site availability plays a key role in motivating turtles to inhabit a specific area (Cagle 1944, 1950; Cagle and Chaney 1950; this study). Our subjective impressions were that turtle size and basking site size were correlated, with larger turtles choosing wider sites. A similar correlation was noted by Boyer (1965), who found that turtles most often emerged on sites no less than two-thirds of their body width.

In addition, spatial distribution and movements could be influenced by social interactions resulting from the presence or absence of other turtles around basking sites. Boyer (1965) provided evidence that turtle aggregation might play a role in basking site selection even when other conditions were the same. Aggregation might be beneficial by increasing the ability of the group to spot predators or increasing mating opportunities (Flaherty 1982; Flaherty and Bider 1984). Another possibility is that after a turtle is observed by conspecifics to use a basking site, other turtles assume it is of sufficient quality and congregate to utilize the resource. We did not observe any intraspecific aggressive interactions.

Our results raise questions as to what extent capture and handling affect the behavior of turtles. Although most turtles were released immediately after marking and were manipulated in a similar manner, the

movement data suggest pronounced individual variation. Recent studies have failed to reach a consensus about the impacts of handling on stress levels and behavioral changes in chelonians (Cabanac and Bernieri 2000, *Glyptemys insculpta*; but see Pike et al. 2005; Kahn et al. 2007, *Gopherus polyphemus*). For aquatic turtles (including *P. c. suwanniensis*), Marchand (1945b:77) reported that an unspecified number of "marked turtles were common in… a distance of about [8 km] from the point of release"; he attributed such movements to dispersal due to stress from prolonged capturing and abnormal density due to release of captured individuals in one location. Suwannee cooters are long lived, have extended home ranges and high adult survivorship, and may not be dependent on limited resources and therefore might exhibit a strong response to disturbance even if predation risk in the form of handling was small (Gill et al. 2001; Beale and Monaghan 2004). Studies on stress hormones should help resolve this question.

The conservation of river biota in northern Florida is complicated by an extensive array of influences involving water and land use and underground recharge. Unlike some terrestrial communities, rivers cannot be conserved in a small-patch framework. What influences part of the river can influence much of it, extending the need for long-term management of entire drainage basins. This interrelationship is especially apparent when the protection of large riverine turtles is included in management plans (Moll and Moll 2004; Jackson 2005). The temporally varying habitat use and long-distance movements by Suwannee cooters in the Santa Fe River illustrate the linear extent that some aquatic biota utilize in order to maintain populations. In order to preserve turtle communities, it is necessary to think in kilometers or, better yet, dozens of kilometers. It is only by understanding spatial use in relatively undisturbed areas that normal baselines for conservation can be met.

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COMPOSITION OF A TURTLE ASSEMBLAGE IN A NORTHERN FLORIDA BLACKWATER

STREAM

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ABSTRACT: *We conducted a mark-recapture study of the turtle assemblage inhabiting a 1.1 km reach of the Santa Fe River within River Rise Preserve State Park in northern Florida during drought conditions in 2006 and 2007. In 154 man-hours of snorkeling, we hand-captured eight species, including two Florida listed Species of Special Concern – the Suwannee Cooter* (Pseudemys concinna) *and Alligator Snapping Turtle* (Macrochelys temminckii). *Species diversity (Shannon H') and species evenness (Pielou J') were 1.23 and 0.59, respectively. The most abundant species was* P. concinna, *comprising 54.5% of all individuals captured and 77.9% of the total assemblage biomass. Biomass density of the entire assemblage was estimated to be 199.8 kg/ha. This is the first detailed description of a turtle assemblage occurring in a blackwater stream habitat in the southeastern United States.*

Key Words: turtle, assemblage, Santa Fe River, blackwater stream, *Macrochelys temminckii, Pseudemys concinna*, Suwannee Cooter

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THE southeastern United States is a center of great turtle diversity, with more

native species than any other region in the Western Hemisphere (Iverson, 1992;

Buhlmann et al., 2009). Of the region's 42 native species, at least 31 are known to occur

in rivers or streams (Jackson, 2005; Moll and Moll, 2004; Meylan, 2006a; Ernst and

Lovich, 2009), but few studies have investigated the composition and structure of entire

assemblages in these habitats. The only lotic habitat well studied in this regard is the

spring-fed river, primarily due to the ease with which many species can be captured by

hand while snorkeling (e.g. Marchand, 1942; Giovanetto, 1992; Meylan et al., 1992;

Huestis and Meylan, 2004; Hrycyshyn, 2007; Sterrett, 2009). This highly effective

sampling technique is typically not possible in low visibility alluvial rivers and

blackwater streams, making studies of complete turtle faunas very difficult in these

systems. Other sampling methods have been used to study river turtle assemblages (Vogt,

1980; Fachin-Teran et al., 1995; DonnerWright et al., 1999; Moll and Moll, 2004), but

they can be more logistically challenging (e.g., fyke nets) or more biased in favor of

certain species (e.g., baited hoop nets).

During 2006 and 2007, drought conditions in northern Florida resulted in

unusually high water clarity in many of the region's blackwater streams, including the

Santa Fe River. Taking advantage of these conditions, we conducted a mark-recapture

study of the turtle assemblage in a portion of the Santa Fe River, relying on hand captures

while snorkeling, as well as by trapping with baited hoop nets. Prior to our study, little

was known about the turtles of the Santa Fe River, besides the occurrence of 11 species

(Iverson and Etchberger, 1989; Meylan, 2006a) and limited demographic information

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about the Alligator Snapping Turtle (*Macrochelys temminckii*) (Moler, 1996; Pritchard, 2006).

In this study, we provide the first detailed description of a turtle assemblage occurring in a blackwater stream in the southeastern United States. Specifically, we describe the assemblage inhabiting a 1.1 km reach of the Santa Fe River within River Rise Preserve State Park in terms of species richness, species composition, relative abundance of species, relative biomass of species, species diversity, species evenness, and total biomass. We also present estimates of population density and biomass of each turtle species inhabiting our study area. Our data are compared with those from other lotic systems in the southeastern United States.

METHODS—*Study site*—Originating in the Santa Fe Swamp in northern Florida, the Santa Fe River is classified as a blackwater stream (Florida Natural Areas Inventory, 2010), but it is a heterogeneous system that becomes increasingly spring-fed as it flows along its ~95 km course to the Suwannee River (Hornsby and Ceryak, 1998; Scott et al., 2004; Butt et al., 2007). Approximately 40 km downstream from its origin, the Santa Fe River disappears underground into a swallet known as the Santa Fe River Sink and then re-emerges 5 km away within River Rise Preserve State Park at a site known as the Santa Fe River Rise. This study was conducted within the 1.1 km reach of the Santa Fe River immediately downstream from the Rise (Florida Department of Environmental Protection, 2003). Within the 3.2 ha study site, the river is 20–30 m wide and bordered by floodplain swamp and floodplain forest (Florida Department of Environmental Protection, 2003). The water is typically tannin stained, but clarity increases during

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periods of drought when the majority of discharge from the Rise is groundwater from the Floridan Aquifer (Martin and Dean, 2001). During our study, water depths ranged from 0.1 m in the shallowest areas to 8.0 m in the deepest areas, with the majority of the site approximately 1.5–2.0 m deep. The substrate was primarily cobble in most areas but solid limestone in deeper water. Coincident with a considerable decrease in water flow beginning in July 2006, algae rapidly colonized the substrate. By September 2006, algae completely covered all substrate except in the deepest areas. Other aquatic vegetation was limited to floating mats of pennywort (*Hydrocotyle* sp.) and duckweed (*Lemna* sp.). Submersed aquatic plants were absent. Partially submerged fallen trees and completely submerged logs were abundant throughout. The temperature of the water emerging from the Rise varies seasonally between 21.0°C and 25.3°C (Martin and Dean, 2001).

Sampling—Between May 2006 and September 2007, the turtle assemblage was sampled using two techniques. To sample diurnally active/visible species, we conducted one-day snorkeling sessions (n = 18) during which all observed turtles were pursued by a small group of snorkelers (typically 2–4), captured by hand, and placed in a canoe for processing. To capture cryptic omnivorous or carnivorous species potentially not observed while snorkeling, we conducted trap sessions using hoop traps baited with cut fish. During each trap session (n = 13), 4–8 small hoop traps (76.2 cm diameter, 2.5 cm mesh) and 2–4 large hoop traps (121.9 cm diameter, 6.4 cm mesh) were distributed throughout the study area in the late afternoon and then checked and removed the following morning. Each trap set overnight constituted one trap-night.

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Each captured turtle was identified to species, measured to the nearest mm (straight midline carapace length, straight midline plastron length, maximum carapace width, maximum height), and weighed to the nearest g. Sex was determined based on sexually dimorphic features reported by Ernst et al. (1994). For all species except the Florida Softshell (*Apalone ferox*), turtles were individually marked by drilling holes in the marginal scutes and peripheral bones (Cagle, 1939; Jackson, 1970; Gibbons, 1990). To mark *A. ferox*, Passive Integrated Transponder (PIT) tags were inserted into the muscle and connective tissue between the plastron and the pelvis just lateral to the midline (Runyan and Meylan, 2005). Alligator Snapping Turtles (*Macrochelys temminckii*) were also marked with PIT tags but insertion was into the ventrolateral tail musculature following Trauth et al. (1998). Measuring and marking were conducted at the capture site, and all turtles were released within 30 min of capture.

To determine population density (# of individuals per ha) of each species, we initially estimated population density of the most abundant species, Suwannee Cooter (*Pseudemys concinna*), and then estimated densities of all other species based on the assumption that our samples were representative proportions of each species. Following Dreslik et al. (2005), we estimated population density of each species as $N_{PC}/P_{PC} = N_i/P_i$, where N_{PC} = population density of *P. concinna*, P_{PC} = proportion of *P. concinna* individuals in the sample, N_i = population density estimate of the ith species, and P_i = proportion of the ith species. To estimate population density of *P. concinna*, we used the Jolly-Seber model and capture data from monthly snorkeling sessions during 2007 to estimate population size and then divided the monthly mean of this value by the area of the study site (3.2 ha).

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Biomass (kg per ha) of each species was calculated by multiplying mean body mass by population density. The sum of all species biomass densities was considered the total biomass density of the turtle assemblage.

RESULTS—During 154 man-hours of snorkeling and 104 trap-nights, we captured, marked, and released 300 individual turtles representing 8 native species, including two species listed by the Florida Fish and Wildlife Conservation Commission (FWC) as Species of Special Concern – the Suwannee Cooter (*Pseudemys concinna*) and Alligator Snapping Turtle (*Macrochelys temminckii*) (Table 1). The most effective sampling method was snorkeling, yielding 93.0% of all individuals captured and all eight species found in this study. The rate of hand capture was 2.40 turtles per man-hour of snorkeling (*Apalone ferox* = 0.01, *Kinosternon baurii* [Striped Mud Turtle] = 0.01, *M. temminckii* = 0.02, *P. concinna* = 1.46, *P. floridana* [Peninsular Cooter] = 0.10, *P. nelsoni* [Florida Redbelly Turtle] = 0.05, *Sternotherus minor* [Loggerhead Musk Turtle] = 0.53, *Trachemys scripta* [Yellowbelly Slider] = 0.21). In contrast, hoop traps captured only three species. The rate of trap capture was 0.32 turtles per trap night (*A. ferox* = 0.01, *M. temminckii* = 0.01, *T. scripta* = 0.30). Because trapping did not detect any additional species and disproportionately sampled *A. ferox*, *M. temminckii*, and *T. scripta*, all estimates of population and assemblage parameters are based solely on data derived from hand captures via snorkeling.

The most abundant species in the assemblage was *Pseudemys concinna*, in relative abundance of individuals as well as in relative biomass (Table 2). At the family level, Emydidae was the dominant group with *P. concinna*, *P. floridana*, *P. nelsoni*, and

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Trachemys scripta comprising 69.6% of all individuals captured and 89.0% of total biomass. Within this family, the relative abundance of individuals was 78.4% *P. concinna*, 13.9% *T. scripta*, 4.1% *P. floridana*, and 3.6% *P. nelsoni*. Within *Pseudemys*, the relative abundance of individuals was 91.0% *P. concinna*, 4.8% *P. floridana*, and 4.2% *P. nelsoni*. Overall, species diversity (Shannon H') and species evenness (Pielou J') were 1.23 and 0.59, respectively.

Mean monthly population size of *Pseudemys concinna* > 175 mm plastron length (subadult females, adult females, adult males) was 127 (range 104–162). Because these individuals comprised 92.7% of the *P. concinna* captured, the total population including unsexed juveniles was estimated to be 137 individuals. Population density was 42.8 individuals per ha. Mean body mass was 3.642 kg, resulting in a biomass density of 155.9 kg/ha. When biomass densities of all species are summed, the total biomass density of the assemblage is 199.8 kg/ha (Table 2).

DISCUSSION—With approximately 25% of the southeastern United States native freshwater turtle species (and two Florida Species of Special Concern) occurring in our relatively small 3.2 ha study area, it is apparent that the Santa Fe River is an important reservoir of turtle diversity. Of the 11 species previously documented to occur in the Santa Fe River, we captured all but three (*Chelydra serpentina* [Snapping Turtle], *Sternotherus odoratus* [Common Musk Turtle], *Kinosternon subrubrum* [Florida Mud Turtle]) at our site. However, we did capture *C. serpentina* and *S. odoratus* 2 km downstream from this site (G. Johnston, unpublished). *Kinosternon subrubrum* was not encountered during our fieldwork, but it may occur in quiet backwaters associated with

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the river. No other native species are expected to occur in the Santa Fe River. Two other freshwater turtles (*Clemmys guttata* [Spotted Turtle] and *Deirochelys reticularia* [Chicken Turtle]) occur in northern Florida, but neither is typically associated with riverine habitats (Ewert et al., 2006; Meylan, 2006b; Ernst and Lovich, 2009).

We cannot assume that the assemblage data reported for our study area are representative of the Santa Fe River as a whole. Although it is a blackwater stream, it is a physiographically diverse system that is increasingly influenced by springs as it flows along its 95 km journey to the Suwannee River. Variation in water clarity, temperature, pH, aquatic vegetation, canopy cover, woody debris, and substrate composition in different regions of the river likely affect turtle assemblages. For example, limited sampling farther downstream suggests that *Chelydra* and *Trachemys* are more abundant in spring-influenced areas with soft substrate, high water clarity, and abundant submerged aquatic plants (G. Johnston, unpublished). The heterogeneous distributions of these omnivorous species may further influence the abundance of other species through competitive interactions.

In addition to interpreting our findings cautiously with respect to the habitat where the turtles were sampled, it is important to evaluate the assemblage within the context of the prevailing weather conditions during the study. Because this study was conducted during a period of drought, composition of the assemblage reported here may not reflect the assemblage at the same site during non-drought conditions. This is due to the possible immigration of primarily lentic species such as *Kinosternon baurii*, *Pseudemys floridana*, *P. nelsoni*, and *Trachemys scripta* from surrounding floodplain swamps as they dried during 2006 and 2007. Furthermore, *Macrochelys temminckii* may

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have emigrated to deeper sites downstream as water levels at our site decreased. Future assessments of the assemblage at this site should be made during droughts, as snorkeling is the most efficient survey method but dependent on clear water conditions. Continued surveys will be necessary, given potential threats to the turtles such as agricultural pollution, illegal harvest for human consumption, and removal of water from the Santa Fe River drainage for human use (Jackson, 2005).

A critical assumption of our study was that the relative abundance of species captured while snorkeling accurately represented the actual assemblage. Although no sampling method is completely without bias, we did capture almost every individual that we observed while snorkeling. In the shallow, clear-water conditions under which this study was conducted, the turtles most likely to be unobserved were the small individuals. One species that was probably underrepresented in our sample was *Sternotherus minor*. Because of the abundance of algae covering the substrate of the river, this small benthic species was more difficult to detect visually while snorkeling. Despite the likely underestimation of the number of *S. minor* inhabiting our study area, our estimates of relative biomass among species and total biomass of the assemblage are probably not far from reality due to the low individual masses of *S. minor*. With regard to the relatively low number of juvenile *P. concinna*, our reported numbers are not likely to be an artifact of sampling methods. Using the same methods at other sites in the Santa Fe River, we have captured hundreds of these individuals (G. Johnston, unpublished).

Comparisons of the River Rise Preserve State Park assemblage with other turtle assemblages in lotic systems in the southeastern United States are hampered by the limited number of comparable studies. The best available data are from spring-fed rivers

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in Florida and southwestern Georgia (Table 3). The River Rise Preserve State Park assemblage is generally similar to these assemblages in terms of species richness, species diversity, and species evenness. The primary difference between the two habitat types is the abundance of turtles. Turtle density can be substantially higher in spring-fed rivers, likely due to their higher primary productivity (Table 3). With regard to species composition, differences among assemblages appear to be a consequence of the geographic locations of the sites that have been studied. In particular, two members of the southwestern Georgia assemblages (*Apalone spinifera* [Spiny Softshell], *Graptemys barbouri* [Barbour's Map Turtle]) do not occur as far south as the reported Florida assemblages, and two additional species (*Macrochelys temminckii, Trachemys scripta*) do not occur as far south as Rainbow Run and the Wekiva River. One species present in all of the Florida assemblages (*Pseudemys nelsoni*) does not occur as far north as the southwestern Georgia sites. The Wekiva River is outside the geographic range of *P. concinna* (Jackson, 2006).

Despite their differences in species composition, southeastern United States river turtle assemblages appear to be similar on a broader taxonomic level. Emydids dominate the percentage of individuals at all sites that have been studied (Santa Fe River 69.6% [this study], Rainbow Run - 1942 73.4% [Marchand, 1942], Wekiva River 59.0% [Hrezyzn, 2007], Ichawaynochaway Creek 79.6% [Sterrett, 2009], Spring Creek 91.8% [Sterrett, 2009]), though Rainbow Run did exhibit an anthropogenically related decline in *Pseudemys* abundance in the decades following Marchand's (1942) study (Giovanetto, 1992; Meylan et al., 1992; Huestis and Meylan, 2004). Future studies of spring-fed

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systems within the Santa Fe River drainage should provide more informative assessments of how habitat variation affects freshwater turtle assemblage structure.

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Table 1. Number of individuals of each species captured in River Rise Preserve State Park (2006, 2007) using two different sampling methods: hand capture while snorkeling and baited hoop traps. Eight individuals (1 *Macrochelys temminckii*, 7 *Trachemys scripta*) were captured by both methods.

Species	Snorkeling	Trapping	All Captures
Apalone ferox	2	1	3
Kinosternon baurii	2	0	2
Macrochelys temminckii	3	1	3
Pseudemys concinna	152	0	152
Pseudemys floridana	8	0	8
Pseudemys nelsoni	7	0	7
Sternotherus minor	78	0	78
Trachemys scripta	27	27	47
Total	279	29	300

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Table 2. Estimates of abundance of each species in River Rise Preserve State Park (2006, 2007) based on hand captures via snorkeling.

Species	Relative Abundance	Relative Biomass	Population Density (turtles/ha)	Mean mass (kg)	Biomass Density (kg/ha)
Apalone ferox	0.007	0.012	0.5	4.300	2.150
Kinosternon baurii	0.007	0.001	0.5	0.179	0.090
Macrochelys temminckii	0.011	0.087	0.9	20.500	18.450
Pseudemys concinna	0.545	0.779	42.8	3.620	154.936
Pseudemys floridana	0.029	0.028	2.3	2.490	5.727
Pseudemys nelsoni	0.025	0.029	2.0	2.870	5.740
Sternotherus minor	0.280	0.011	22.0	0.095	2.090
Trachemys scripta	0.097	0.054	7.6	1.401	10.648

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Table 3. Comparison of turtle assemblages in lotic ecosystems in the southeastern United States. [a] = this study, [b] = Marchand (1942), [c] = Iverson (1982), [d] = Meylan et al. (1992), [e] = Hrczyzn (2007), [f] = Sterrett (2009).

Site	Species Richness	Shannon Diversity (H')	Evenness (J')	Population Density (turtles/ha)	Biomass Density (kg/ha)
[a]Santa Fe River (FL) 2006, 2007	8	1.23	0.59	78.6	199.8
[b,c]Rainbow Run (FL) 1942	7	1.39	0.71	228	>695.3
[d]Rainbow Run (FL) 1990	6	0.91	0.51	236	>22.3
[e]Wekiva River (FL) 2000-2005	7	1.51	0.78	>385	>1305
[f]Ichawaynochaway Creek (GA) 2007, 2008	8	1.33	0.64	n/a	n/a
[f]Spring Creek (GA) 2007, 2008	8	1.26	0.61	n/a	n/a

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Copy of the Suwannee cooter BSR draft report that was sent out for peer review

Biological Status Review
for the
Suwannee Cooter
(*Pseudemys concinna suwanniensis*)

EXECUTIVE SUMMARY

The Florida Fish and Wildlife Conservation Commission (FWC) directed staff to evaluate all species listed as Threatened or Species of Special Concern as of 1 September 2010. Public information on the status of the Suwannee cooter was sought from September 17 through November 1, 2010. The five-member biological review group (BRG) met on November 9-10, 2010. Group members were Bill Turner (FWC lead), Chris Lechowicz (Sanibel-Captiva Conservation Foundation), Peter Meylan (Eckerd College), Paul Moler (independent consultant), and Travis Thomas (FWC) (Appendix 1). In accordance with rule 68A-27.0012 F.A.C, the BRG was charged with evaluating the biological status of the Suwannee Cooter using criteria included in definitions in 68A-1.004 and following protocols in the *Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 3.0)* and *Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1)*. Please visit http://myfwc.com/docs/WildlifeHabitats/Imperiled_EndangeredThreatened_FinalRules.pdf to view the listing process rule and the criteria found in the definitions.

The BRG concluded from the biological assessment that the Suwannee cooter did not meet criteria for listing, so staff recommends delisting the Suwannee cooter.

This work was supported by a Conserve Wildlife Tag Grant from the Wildlife Foundation of Florida.

BIOLOGICAL INFORMATION

Taxonomic Classification – The Suwannee cooter is treated here as a subspecies of the widely distributed river cooter, *Pseudemys concinna*, an arrangement followed by most major treatments through the mid-1990s (Crenshaw 1955, Conant 1975, Conant and Collins 1991, Ernst et al. 1994). Although Seidel (1994) suggested elevating the taxon to full species status as *P. suwanniensis* based largely on perceived disjunction from other river cooters, Jackson and colleagues showed that Suwannee cooters were little differentiated from *P. concinna* immediately to the east or west (Jackson 1999, Jackson and Walker 1997). Thus, there exists little evidence to support species-level distinction of *suwanniensis*, and this was apparently accepted by Seidel, who once again listed *suwanniensis* as a subspecies (Seidel and Dreslik 1996).

Life History and Habitat Requirements – Unlike other species of *Pseudemys*, the river cooter, including the Suwannee cooter, is strictly a turtle of rivers and river-associated habitats. It inhabits blackwater, alluvial, and spring-fed rivers, and also survives in some impoundments

(e.g., Lake Talquin [Ochlockonee River] and Lake Rousseau [Withlacoochee River]). Key habitat features are moderate current, ample aquatic vegetation for feeding, and appropriate surfaces for basking (Jackson 2006). The species is sufficiently salt-tolerant to venture into brackish to saline waters at river mouths (Carr 1952, Jackson and Walker 1997, Jackson 2006). Suwannee cooters feed principally on aquatic vegetation and algae (Allen 1938, Marchand 1942, Carr 1952, Lagueux et al. 1995, Bjorndal et al. 1997). Females grow larger than males, reaching a maximum size of nearly 17 inches carapace length and more than 22 lbs, establishing this as the largest member of the family Emydidae. Females require 10-15 years to mature, but life expectancy may exceed 30 years. The lengthy nesting season extends from late March to early August. Each adult female lays clutches of 8-27 eggs 4 or more times per season. However, few nests survive predation (Jackson and Walker 1997).

Population Status and Trend – Insufficient baseline data exist to provide a definitive quantitative assessment of regional population status. Suwannee cooters have been harvested for food, which has reduced populations from historic numbers. Many lines of evidence indicate a downward trend in Suwannee cooter populations for much of the 20th century: the massive assemblages noted on the Suwannee River by Carr (1952) are no longer reported; comparative data across many decades at the Rainbow River point to substantial decline from harvest (Marchand 1942, Huestis and Meylan 2004); industrial pollution extirpated the Fenholloway River population in the second half of the century (Jackson and Ewert 1998, Jackson 1999); and the existence of large shell "middens" at multiple sites in the 1990s and 2000s confirm widespread, continuing harvest despite regulations (Jackson 2006, Heinrich et al. 2010). Viable populations, some at least moderately large (Jackson and Walker 1997, Kornilev et al. 2010, Johnston et al. *in press*), still exist in all rivers but one within the subspecies' historic range.

Geographic Range and Distribution – For this review, we follow Jackson and Walker (1997), who recognized the Suwannee cooter as comprising those populations occurring from the Tampa Bay region (Alafia River) northwestward to approximately the Ochlockonee River just west of Tallahassee. River cooters from the remainder of the Florida panhandle (Apalachicola River and westward) are referred to as *P. c. concinna*, although the Apalachicola region may represent a zone of intergradation (Jackson 2006). The species' occurrence in the Silver River, a tributary of the Atlantic Coast-draining Ocklawaha/St. Johns River drainage, is attributable to the translocation to (and escape from) the old Ross Allen Silver Springs Reptile Institute decades ago (Jackson 2006).

Quantitative Analyses – We know of no PVA models that have been developed to estimate the probability of extinction of the Suwannee cooter.

BIOLOGICAL STATUS ASSESSMENT

Threats – Not surprisingly given its size and catchability (via snorkeling and traps), the Suwannee cooter has a long history of harvest for meat (Carr 1940, 1952) that has continued to the present (Heinrich et al. 2010). Undoubtedly, this suppressed populations locally (Huestis and Meylan 2004, P. Meylan *pers. commun.*) and regionally (Jackson 2006, Heinrich et al. 2010). Although FWC rules have limited possession since the 1970s, there appear to have been periodic

large harvests of Suwannee cooters for meat as attested to by piles of discarded shells observed throughout the Suwannee cooter's range during the 1970s to mid-2000s (Jackson 2006, Heinrich et al. 2010). Legal take of cooters was prohibited by rule changes enacted by FWC in 2009. Because rivers tend to be relatively stable and persistent systems compared to most Florida habitats, outright habitat destruction is not a major threat to this turtle. Nonetheless, human-generated impacts to the integrity of Florida's river systems, including their floodplains, affect Florida's riverine turtles (Jackson 2005). Chemical pollution (from industries such as pulp mills, and waste products from cities and agricultural activities) pose a potential threat to riverine turtle, though even a major chemical spill along one inhabited river would not endanger the species' statewide population. The Fenholloway River in Taylor County, from which Suwannee cooters were extirpated by pollution, serves as an example that river-wide extirpation is possible (Jackson 1999). Siltation from road crossings, borrow pits, or other situations can reduce the suitability of smaller streams, including reducing the amount of light available to support photosynthesis of Suwannee cooter food plants. Although the species inhabits impoundments within its range, the long-term impacts on the Suwannee cooter of converting flowing freshwater systems to still or slow-flowing systems is unstudied. Increasing pressure from water bottling companies that wish to tap Florida's springs threatens water levels, flow regimes, and floodplain communities in several rivers (e.g., Santa Fe River: Kornilev 2010 *in press*). As for all turtles, predation, particularly by raccoons and fish crows, accounts for the loss of a majority of nests (> 90% along the Wakulla River) as well as some adult females (Jackson *pers. commun.*). Additional potential predators include wild hogs and invasive fire ants. Nest flooding following very heavy regional rains also destroys entire clutches in some years (Jackson and Walker 1997). No evidence to date has documented that Suwannee cooters suffer from epidemic diseases that might jeopardize populations. However, the occurrence of at least two instances of necrotic shell disease in the species elsewhere (Lovich et al. 1996, Garner et al. 1997) suggests the need to monitor Florida populations regularly. Although vehicle-induced mortality on roads is low because the species rarely wanders on land except to nest, mortality from boat strikes may be significant in some populations (G. Heinrich *pers. commun.*).

Statewide Population Assessment – Findings from the BRG are included in Biological Status Review Information tables.

LISTING RECOMMENDATION – Staff recommends delisting the Suwannee cooter because it did not meet the listing criteria.

SUMMARY OF THE INDEPENDENT REVIEW

To be added after peer review.

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	Species/taxon:	Suwannee cooter

Biological Status Review Information
Findings

Species/taxon: Suwannee cooter
Date: November 9-10, 2010
Assessors: Chris Lechowicz, Peter Meylan, Paul Moler,
Bill Turner and Travis Thomas
Generation length: 20-25 years

Criterion/Listing Measure	Data/Information	Data Type*	Criterion Met?	References
*Data Types - observed (O), estimated (E), inferred (I), suspected (S), or projected (P). Criterion met - yes (Y) or no (N).				
(A) Population Size Reduction, ANY of				
(a)1. An observed, estimated, inferred or suspected population size reduction of at least 50% over the last 10 years or 3 generations, whichever is longer, where the causes of the reduction are clearly reversible and understood and ceased[1]	insufficient data, possible; see next category	S	N	
(a)2. An observed, estimated, inferred or suspected population size reduction of at least 30% over the last 10 years or 3 generations, whichever is longer, where the reduction or its causes may not have ceased or may not be understood or may not be reversible[1]	Although extirpation of one of the smaller populations from pollution (Fenholloway River) post-1950 is not reversible, other causes of decline have ceased, are understood, and are reversible	I	N	
(a)3. A population size reduction of at least 30% projected or suspected to be met within the next 10 years or 3 generations, whichever is longer (up to a maximum of 100 years) [1]	At least some expected recovery from past population declines as result of closure of legal take in 2009	I	N	
(a)4. An observed, estimated, inferred, projected or suspected population size reduction of at least 30% over any 10 year or 3 generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased or may not be understood or may not be reversible.[1]	At least some expected recovery from past population declines as result of closure of legal take in 2009	P	N	
[1] based on (and specifying) any of the following: (a) direct observation; (b) an index of abundance appropriate to the taxon; (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat; (d) actual or potential levels of exploitation; (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.				
(B) Geographic Range, EITHER				
(b)1. Extent of occurrence < 20,000 km^2 (7,722 mi^2) OR	ca. 29,000 km^2	E	N	D. Jackson GIS polygon
(b)2. Area of occupancy < 2,000 km^2 (772 mi^2)	ca. 200 km^2	E	Y	D. Jackson GIS polygons
AND at least 2 of the following:				

a. Severely fragmented or exist in ≤ 10 locations	≥12 river drainages as locations. Species has limited mobility over terrestrial habitat but may move through the gulf (saline tolerant and good swimmers), so is not severely fragmented.	I	N	
b. Continuing decline, observed, inferred or projected in any of the following: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent, and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals	With strong enforcement of 2009 FWC rules prohibiting take, population likely to grow. Habitat quality likely to decline with increasing human population & land use changes	S	Y	
c. Extreme fluctuations in any of the followang: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals	No; extreme fluctuations unlikely in long-lived species; rivers relatively stable.	O	N	
(C) Population Size and Trend				
Population size estimate to number fewer than 10,000 mature individuals AND EITHER	No, likely >10,000	S	N	
(c)1. An estimated continuing decline of at least 10% in 10 years or 3 generations, whichever is longer (up to a maximum of 100 years in the future) OR	No legal take as of 2009, but this will require strong enforcement and continued protection	I	N	
(c)2. A continuing decline, observed, projected, or inferred in numbers of mature individuals AND at least one of the following:	With strong enforcement of 2009 FWC rules prohibiting take, population likely to grow.	P	N	
a. Population structure in the form of EITHER	No, numbers in several drainages probably exceed 1,000.	S	N	Jackson & Walker 1997, Huestis & Meylan 2004, Jackson 2006
(i) No subpopulation estimated to contain more than 1000 mature individuals; OR				
(ii) All mature individuals are in one subpopulation	Occurs in at least 12 independent drainages.	O	N	Jackson 2005, 2006
b. Extreme fluctuations in number of mature individuals	No; extreme fluctuations unlikely in long-lived species; rivers provide relatively stable habitat.	O	N	Jackson 2005, 2006
(D) Population Very Small or Restricted, EITHER				
(d)1. Population estimated to number fewer than 1,000 mature individuals; OR	Population likely more than 1,000 individuals. Thomas has about 1,000 marked in Suwannee.	S	N	Jackson & Walker 1997, Huestis & Meylan 2004, Jackson 2006, Thomas pers. commun. 2010
(d)2. Population with a very restricted area of occupancy (typically less than 20 km^2 [8 mi^2]) or number of locations (typically 5 or fewer) such that it is prone to the effects of human activities or stochastic events within a short time period in an uncertain future	ca. 200 km^2	E	N	D. Jackson GIS polygons
(E) Quantitative Analyses				
e1. Showing the probability of extinction in the wild is at least 10% within 100 years	No specific models	S	N	

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Initial Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria are met)
Meets no criteria	
Is species/taxon endemic to Florida? (Y/N)	N

If Yes, your initial finding is your final finding. Copy the initial finding and reason to the final finding space below. If No, complete the regional assessment sheet and copy the final finding from that sheet to the space below.

Final Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria are met)
Meets no criteria	

Regional Assessment

		Species/taxon:	Suwannee cooter
1		Species/taxon:	Suwannee cooter
2	Biological Status Review Information	Date:	November 9- 10, 2010
3	Regional Assessment	Assessors:	Chris Lechowicz, Peter Meylan, Paul Moler,
4			Bill Turner and Travis Thomas
5			
6			
7			
8	Initial finding		
9			
10	2a. Is the species/taxon a non-breeding visitor? (Y/N/DK). If 2a is YES, go to line 18. If 2a is NO or DO NOT KNOW, go to line 11.		N
11	2b. Does the Florida population experience any significant immigration of propagules capable of reproducing in Florida? (Y/N/DK). If 2b is YES, go to line 12. If 2b is NO or DO NOT KNOW, go to line 17.		N
12	2c. Is the immigration expected to decrease? (Y/N/DK). If 2c is YES or DO NOT KNOW, go to line 13. If 2c is NO go to line 16.		
13	2d. Is the regional population a sink? (Y/N/DK). If 2d is YES, go to line 14. If 2d is NO or DO NOT KNOW, go to line 15.		
14	If 2d is YES - Upgrade from initial finding (more imperiled)		
15	If 2d is NO or DO NOT KNOW - No change from initial finding		
16	If 2c is NO or DO NOT KNOW- Downgrade from initial finding (less imperiled)		
17	If 2b is NO or DO NOT KNOW - No change from initial finding		No change
18	2e. Are the conditions outside Florida deteriorating? (Y/N/DK). If 2e is YES or DO NOT KNOW, go to line 24. If 2e is NO go to line 19.		
19	2f. Are the conditions within Florida deteriorating? (Y/N/DK). If 2f is YES or DO NOT KNOW, go to line 23. If 2f is NO, go to line 20.		
20	2g. Can the breeding population rescue the Florida population should it decline? (Y/N/DK). If 2g is YES, go to line 21. If 2g is NO or DO NOT KNOW, go to line 22.		
21	If 2g is YES - Downgrade from initial finding (less imperiled)		
22	If 2g is NO or DO NOT KNOW - No change from initial finding		
23	If 2f is YES or DO NOT KNOW - No change from initial finding		
24	If 2e is YES or DO NOT KNOW - No change from initial finding		
25			
26	Final finding		No Change

Appendix 1. Calculation of generation time presented at the BSR group meeting

Generation length is defined as the average age of parents of the current cohort, which is greater than the age at first breeding and less than the age of the oldest breeding individual. We estimate generation length for the Suwannee Cooter as follows. Jackson & Walker (1997) estimated minimum age of maturity (from plastral annuli) of females at 10-13 yrs, with this possibly being an underestimate. Based on recapture of marked nesting females, Jackson (2003) estimated longevity to exceed 25 years. Even 30 years is a conservative estimate (D. Jackson, unpublished data). Male ages are unknown but probably similar. A fairly conservative estimate of generation length = (10 + 30) / 2 = 20. A range of 20-25 years is reasonable.

Appendix 2. Biological Review Group Members Biographies

Chris Lechowicz is the Interim Director of the Wildlife Habitat Management Program and staff herpetologist at the Sanibel-Captiva Conservation Foundation where he has worked since 2002. He has a B.S. in Zoology and Computer Science from Southern Illinois University at Carbondale and will complete his M.S. in Environmental Science from Florida Gulf Coast University in 2010. Chris's focus is on riverine turtles with a specialty on the Genus *Graptemys*. Chris is a member of the IUCN/SCC Tortoise and Freshwater Turtle Specialists Group as well as a board member of the Florida Turtle Conservation Trust.

Dr. Peter A. Meylan received his Ph.D. from the University of Florida. He is a Professor of Biology at Eckerd College in Saint Petersburg, FL. His research interests include the evolutionary history, ecology, and conservation biology of amphibians and reptiles, especially turtles. Current research includes 2 sea turtle projects: an investigation of the ecology and migrations of sea turtles of Bocas del Toro Province, Panama (funded by the Wildlife Conservation Society) and the Bermuda Turtle Project, which is a cooperative project with the Bermuda Aquarium and the Caribbean Conservation Corporation (as well as continuing to work with Florida freshwater turtles with the Eckerd Herpetology Club on the Rainbow River). He has many scientific articles on turtles and is the editor of a book on the biology and conservation of Florida turtles.

Paul E. Moler received his M.S. in Zoology from the University of Florida in 1970 and his B.A. in Biology from Emory University in 1967. He retired in 2006 after working for 29 years as a herpetologist with FWC, including serving as administrator of the Reptile and Amphibian Subsection of the Wildlife Research Section. He has conducted research on the systematics, ecology, reproduction, genetics, and conservation biology of a variety of herpetofaunal species in Florida, with primary emphasis on the biology and management of endangered and threatened species. He served as Chair for the Florida Committee on Rare and Endangered Plants and Animals in 1992–94, Chair of the Committee on Amphibians and Reptiles since 1986, and editor of the 1992 volume on amphibians and reptiles. Paul has more than 90 publications on amphibians and reptiles.

Travis Thomas received a Bachelor's Degree in 2008 from the University of Florida in Natural Resources Conservation. He is currently pursuing a Masters Degree in Wildlife Ecology and Conversation under the supervision of Dr. Perran Ross. His primary research focuses on the ecology and management of fauna in riparian systems. He was hired by FWC in 2008, and he has worked on numerous projects concerning reptile and amphibian ecology. He worked for 3 years in the Herpetology Dept. under Dr. Kenneth Krysko at the Florida Museum of Natural History. He has spent time as a volunteer on numerous projects in Kenya, Africa, under the supervision of Leigh Ecclestone and the Kenyan Wildlife Service. He has published several notes on the ecology and distribution of reptiles and is currently a co-author on a study of the ecology of M. temminckii in O'Leno State Park as well as the primary author on a study of the morphology of M. temminckii.

William M. Turner received his B.S. from Erskine College and M.S. in Biology from the University of South Alabama. From 2003 to 2007, he was the Herpetological Coordinator for the Wyoming Game and Fish Department. In Wyoming, he conducted statewide surveys for amphibians and reptiles, focusing on emerging amphibian diseases and the impacts of resource development native reptiles. Since 2007, he has been the Herp Taxa Coordinator for FWC in the Division of Habitat and Species

Conservation. He has conducted research on native amphibians and reptiles in Florida, Alabama and Wyoming that has resulted in several published papers and reports.

Appendix 3. Summary of letters and emails received during the solicitation of information from the public.

Yurii Kornilev (M.S., University of Florida) provided a 3-page commentary and recommendations, supplemented by two recent publications (Kornilev et al. 2010, Johnston et al. in press; see Literature Cited) focusing on aspects of ecology of the Santa Fe River population of Suwannee Cooter.

APPENDIX 3. **Information and comments received from independent reviewers.**

Will be added after review.