Status of Historical Translocations of Gopher Tortoises Outside of Their Geographic Range in Central Alabama

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Abstract: The gopher tortoise (*Gopherus polyphemus*) is a species of concern in the southeastern United States, and its distribution is within the range of the longleaf pine (*Pinus palustris*). One conservation strategy within the state of Alabama has been translocation of adult tortoises to other areas with longleaf pine and sandy soils, including areas outside the current accepted species' range. Prior examples of such tortoise translocations occurred in two counties in central Alabama: one in the 1960s in Macon County and another in the 1980s in Autauga County. Both introductions occurred near the Coastal Plain fall-line, which is deemed the northernmost landmark designation that tortoises were historically presumed to reside. The status of these translocated tortoise populations had not been recently assessed. Therefore, we surveyed the two locations, captured individuals, and qualitatively examined the minimum known number of alive adult tortoises. We found populations of tortoises at both translocation sites, including evidence of reproduction and recruitment. Notably, we found two marked tortoises (one at each of the two relocation sites) from the original translocations, indicating that translocated tortoises survived in these new areas for 30 and 49–56 years, respectively. Although inference about translocation success is limited by overall low tortoise projected densities, our results suggest tortoise populations can persist in areas of Alabama outside their mapped geographic range, including on soil types not documented previously.

Key words: introduction, population density, reptile, relocation

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The gopher tortoise is a keystone species in the Coastal-Plain of the southeastern United States, having more than 330 commensal species documented using its burrows (Jackson and Milstrey 1989, Lips 1991, Kinlaw and Grasmueck 2012, Dziadzio and Smith 2016). Gopher tortoises prefer soft, sandy soils, with open canopies and an open understory dominated by herbaceous groundcover (Kaczor and Hartnett 1990). While gopher tortoises are mostly associated with mature, longleaf pine (*Pinus palustris*) forests within upland sandhill communities, they also occur in other cover types, including xeric hammocks and ruderal communities (Auffenberg and Franz 1982) and in areas highly fragmented by land use change (Noss 1995, Ashton and Burke 2007). Due to the effects of habitat loss and associated risks to the resulting small, isolated populations, such as disease prevalence (e.g., Upper Respiratory Tract Disease) and high nest mortality, the gopher tortoise is state-protected throughout its range and listed as federally threatened by the U.S. Fish and Wildlife Service in Louisiana, Mississippi, and in Alabama west of the Mobile and Tombigbee Rivers (TESII 1995).

To aid in gopher tortoise recovery efforts, translocations, or the relocation of individuals from one area to another (Berry 1986, IUCN 2013, Morris et al., 2021) have been used in many states as a strategy to establish populations in new areas (Tuberville et al. 2005, Soehren 2006). Post-release monitoring following translocation is important to assess the success of the translocation for newly released animals and can determine the presence of harmful effects from the move (Seddon and Armstrong 2016). Unfortunately, post-release monitoring has not been a common practice until more recently, especially with herpetofaunal species like the gopher tortoise, and thus the success of translocation efforts and their effects on recipient communities are often unknown (Dodd and Seigel 1991, Tuberville et al. 2005).

The documented range of gopher tortoise encompasses 25 counties in central and southern Alabama (Figure 1), occurring within the Coastal Plain and along its accompanying northern sandhill ridge in more northern counties (e.g., Speake 1986, Spillers and Speake 1993, Guyer and Bailey 1993, Patton 1996). At least 20 of these counties exhibit soils preferred by tortoises for burrowing, which is one of the habitat characteristics used to justify

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translocations (Guyer and Bailey 1993, Guyer et al. 2011). Translocation of gopher tortoises occurred in at least five documented conservation projects in Alabama since at least 1967, typically as attempts to preclude conservation status listings (Speake 1986, Speake 1987, Soehren 2006).

Information regarding these translocations and persistence of translocated populations has been limited to personal communications (D. Spillers, Fort Rucker, C. Guyer, Auburn University, B. Abbott, Alabama Department of Conservation and Natural Resources [ADCNR], and E. Shelton-Nix, ADCNR, personal communications), field notes (Patton 1996), or final research reports submitted to the ADCNR (Speake 1986, 1987). Between 1967 and 1986, multiple translocations of gopher tortoises were made by researchers from Auburn University to sites in Macon and Autauga counties (Figure 1), to areas where the species had not been documented. From 1967 to 1974, 30 adult tortoises of unknown sex were hard-released on private property in northeastern Macon County approximately 5.15 km north of Alabama Highway 80 (D.A. Speake, R.H. Mount, and K. Patton, Auburn University, personal communications; roughly 86.9–114.9 km north of the species range in either Bullock or Russell Counties, respectively). Individuals were marked with rounded drill bits along their marginal scutes (Figure 2a). At the time of release, no tortoise burrows were observed in the area (R.H. Mount and K. Patton, Auburn University, personal communications). On 1 April 1986, an additional 25 adult tortoises (10 females and 15 males) marked with rounded drill bits along their marginal scutes were hard-released in locations around Autauga County (specifically in or near the Autauga Wildlife Management Area, approximately 19 km northwest of Prattville; Speake 1986) approximately 105.25 km north of their geographic range.

To date, there have been two known attempts to assess the success of the Macon County translocation: Patton (1996) captured and marked nine adult tortoises in 1992 with a triangular file along the marginal carapace scutes (Figure 2b). In 1996, seven adult tortoises were captured, including three recaptures from 1992 near the same mapped burrow (Patton 1996). Juveniles were also noted during recaptures, indicating that tortoises reproduced in the

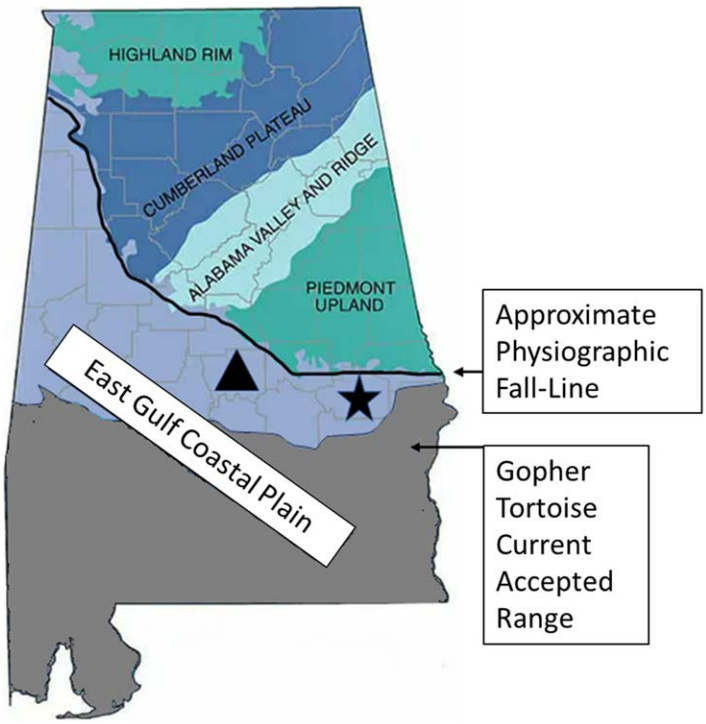

Figure 1. Survey sites of translocated gopher tortoise (*Gopherus polyphemus*) populations in Autauga (black triangle) and Macon (black star) counties, Alabama, June–July 2016. Colors represent the physiographic breakdown of the five major land formations in Alabama, including the East Gulf Coastal Plain, where the gopher tortoise naturally occurs (gray), occurring south of the fall-line.

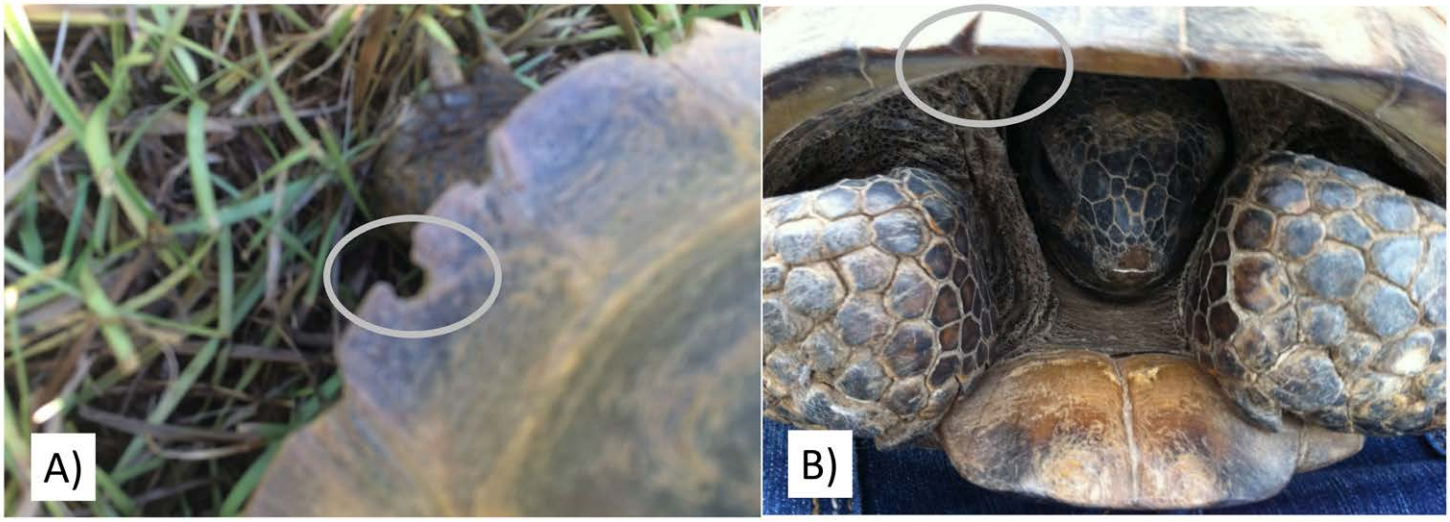

Figure 2: Tortoise carapace field marking methods: (A) Round filing on carapace is the older marking method from an Autauga County, Alabama, tortoise (originally released in 1986), and (B) triangular filing method of marking tortoise carapaces use in 2016 surveys.

translocated area, consistent with the reproduction of the original translocated individuals. However, no tortoises from the original release were captured during the surveys, and sex or age of the individuals was not recorded (Patton 1996). The Autauga County translocation effort was originally a study to assess gopher tortoise dispersal and habitat use in new areas, and the translocated individuals were initially monitored via radio telemetry to follow their movements. This translocated tortoise population was only resampled for mark-recapture individuals and number of burrows in 1987, one year after release, in which 19 of the originally released tortoises were recovered and signs of nesting were observed (Speake 1986, 1987).

Because gopher tortoise populations in Macon and Autauga counties have not been surveyed in decades, their status was unknown. Therefore, we sought to: (1) ascertain if the translocated gopher tortoise populations were still present, and (2) note any evidence of reproduction. Knowledge about the status of these translocated populations is valuable to conservation efforts for tortoises in Alabama and may provide valuable insights about the potential for future translocations of tortoises outside of their current range.

Study Area

We conducted surveys at two sites in Alabama: (1) 32.37 ha of privately owned land in southern Macon County and (2) 984 ha of Autauga County's Wildlife Management Area (AWMA, including the area of original tortoise translocation; Speake 1986) now owned by the ADCNR. Both sites had plant species composition characteristic of the longleaf pine ecosystem, including longleaf pine, turkey oak (*Quercus laevis*), winged sumac (*Rhus copallinum*), prickly pear cactus (*Opuntia humifusa*), loblolly pine (*Pinus taeda*), southern red oak (*Quercus falcata*), and a variety of grasses and forbs. In AWMA, soils included combinations of Troup-Blanton-Alaga and Troup-Shibuta-Bibb soils, which are sandy loam soils with intermittent clay components (Speake 1986, NRCS 2023), while the Macon County site included Uchee, Cowart, and Marvyn type soils, which are inherently more rocky and less sandy with varying proportions of loam (NRCS 2023).

Methods

During June–July 2016, we conducted 2-wk surveys at each site to locate tortoise burrows. Two to four viewers conducted a systematic scan for all burrows (active and inactive) at every site starting from a centralized location (Guyer et al. 2012). Surveys for burrows continued in a radiated fashion from each located burrow until no new burrows could be located within a minimum of 100 meters. Once a burrow was located, it was marked with flagging tape, given an identification number, and the GPS coordinates were recorded. Roads, rocky outcrops and montane areas, property boundaries, and densely wooded areas with thick canopies served as delimited areas excluded from surveys. We identified burrows as active or inactive, in which an active burrow was defined by fresh tortoise tracks, an unobstructed or freshly dug D-shaped opening, the sound of tortoise thumping inside the burrow, or other indicators of tortoise presence outside the burrow (e.g., feces, nail clippings, or the tortoise itself; Hermann et al. 2002, Styrsky et al. 2010). An inactive tortoise burrow had the same obvious D-shaped opening but with an obstructed entrance and no fresh tracking leading into or out of the burrow with possible leaf litter debris. Importantly, inactive burrows were not distinguished from potentially abandoned burrows.

We trapped all active adult burrows using Tomahawk (Tomahawk Live Trap, Hazelhurst, Wisconsin) live animal traps of various sizes (similar to and including Model 207) placed and set over the burrow opening. Traps were weighted down with dirt substrate and covered with burlap and vegetation for shade. We checked all traps at least twice daily over a 2-wk period. All captured animals were measured and sampled for blood unrelated to this study. Upon capture, tortoises were given a unique identification mark with a triangular file along the marginal scutes if they were not otherwise marked (Figure 2b). Because the number of captured tortoises differed from the number of active burrows, we indexed projected population density two ways: by using the observed number of tortoises captured (minimum number alive: MNA) and the observed number of burrows deemed active. Both methods have traditionally been used to assess gopher tortoise populations (McCoy and Mushinsky 1992, Hermann et al. 2002, Guyer et al. 2011, Guyer 2012). At each site, the number of active burrows and tortoises captured were divided by the number of hectares surveyed to obtain an index of burrow density and a tortoise density (Guyer et al. 2012). Only adult burrows were included in burrow density estimates. Burrow density was meant to be an index of tortoise activity or movement within the areas, whereas tortoise density was interpreted as an estimate of minimum potential population density at a given site, based on number of captured tortoises.

Results

During the 2016 surveys, we found 34 burrows (19 active, 9 inactive, and 6 juvenile) across the two sites. In Macon County, we found 12 adult burrows, with five being active. Approximately six hatchling/juvenile burrows were found but were difficult to assess for occupancy. At AWMA, 16 adult burrows were found, of which 14 were active. Hatchling and juvenile burrows were observed but were not counted.

Traps set at active adult burrows resulted in an 80% capture rate

Table 1. Summary results from surveys of two gopher tortoise translocated populations in Autauga and Macon counties, Alabama from June to July 2016.

Site	Active burrows	Inactive burrows	Juvenile burrows	Hectares surveyed	Tortoises captured	Burrows ha^{-1}	Tortoises ha^{-1}	Capture efficiency
Autauga	14	2	NA	984	7	0.02	0.007	50%
Macon	5	7	6	32.37	4	0.4	0.12	80%

in Macon County and 50% in AWMA (Table 1). Eleven adult tortoises were captured: seven at AWMA (three males; four females) and four at our Macon site (two males; two females; Table 1). We captured two male tortoises from the original translocations, identified by unique markings of rounded drilling on their carapace scutes (i.e., from the Patton 1996 study; Figure 2). One individual was at the AWMA site, approximately 30 years after its release, and the other at the Macon site, 49–56 years after its release. Both individuals had carapaces of nearly smooth scutes (e.g., barely any visible annuli to count rings for determining age). Burrow and tortoise densities were calculated at each site to be 0.4 burrows ha^{-1} and 0.12 tortoises ha^{-1} in Macon County, and 0.02 burrows ha^{-1} and 0.007 tortoises ha^{-1} in AWMA (Table 1). For the first time noted, tortoises were also found using Uchee and Cowart series soils in this study.

Discussion

In this study, we re-examined the presence and density of gopher tortoises translocated to two sites outside of their traditionally recognized range in central Alabama. We found adult, juvenile, and hatchling individuals and burrows at both central Alabama translocation sites, indicating the translocations were successful in establishing new populations. While naturally occurring gopher tortoise populations fall short of the Coastal Plain fall-line, results from this study suggests that the species can persist within this area and may be able to do so elsewhere within the northern extent of the East Gulf Coastal Plain. We observed gopher tortoises outside of the original translocation boundaries (and our study area), including on neighboring private properties at our Macon County site. Efforts to engage private landowners around our study area to gain permission to assess adult and juvenile tortoises not counted during this study could provide a more accurate regional population estimate and inform additional characteristics of habitat use.

Our recaptures of translocated individuals from both original release sites were unexpected. Given that only mature tortoises were originally translocated, the recaptured tortoise from Autauga County was likely older than 42 years of age and the recaptured tortoise from Macon County was likely at least 61 years old (i.e., if adult tortoises were released around the first year of sexual maturity, approximately 12 years of age or when the carapace exceeds 180 mm; McRae et al. 1981). However, the overall low projected tortoise densities from MNA at both sites calls into question the sustainability for long-term success of the translocations due to dispersal or mortality. One concerning caveat for these low densities is that small populations of gopher tortoise do well only when land is managed well for the species (Folt et al. 2021), but much of the original translocated area, like most gopher tortoise habitat (Wigley et al. 2012), was located on and around private property, in which land management practices have not always been conducted specifically to benefit the species. The highest projected tortoise density from our MNA index occurred at the Macon County site (0.12 tortoises hectare^{-1}). This projected estimate of tortoise density is similar to densities found in Conecuh National Forest (e.g., 0.14–0.32 tortoise ha^{-1}; Goessling et al. 2020), though our MNA is based on a much smaller area.

In the recognized gopher tortoise range, such as in southern Alabama, sandy-loam varieties of soil (i.e., Alaga, Blanton, and Troup soils) are common and considered priority gopher tortoise soils because they are >1.0 m in depth to facilitate deep burrow creation and digging. Other moderate or suitable tortoise soils are Florala and Shubuta soils (0.5–1.0 m in depth; Guyer et al. 2011; Guyer et al. 2012). AWMA had Troup-Blanton-Alaga and Troup-Shibuta-Bibb soils, similar to that of what is found in the southern Coastal Plain. Interestingly, even though AWMA had the lowest burrow and tortoise projected densities, priority and suitable soils of Troup-Blanton-Alaga and Troup-Shibuta-Bibb combinations were found commonly in a predominately sandy-loam distribution in areas where tortoises burrowed, suggesting that AWMA has soil characteristics conducive with supporting tortoises (Speake 1986, NRCS 2023). At the Macon County site, however, the most common soil types found were of the harder/rockier varieties of the Uchee and Cowart Series (UcB and UcE2; NRCS 2023). To our knowledge, this is the first study to document the use of Uchee or Cowart series soil-types by gopher tortoises. Since Uchee and Cowart sandy loam soils have not been ranked in terms of their usage by tortoises, future studies should examine these soils further, as well as soil impact on aggregated burrow distributions that may structure tortoise social interactions.

Our survey indicates that the translocations made in the 1960s and 1980s to an area outside the purported range of the gopher tortoise have created disjunct tortoise populations with reproduction occurring. Whether these translocations should have occurred

outside of the tortoise's recognized range remains an open question. Though translocation may be an effective conservation strategy for the species, the subject is debated due to an insufficient understanding of translocation success from poor post-release monitoring and of how these translocations could affect other resident native species (Ricciardi and Simberloff 2009). Because we do not know if tortoises were ever native to this area (due to zero or limited documentation), this translocation should be viewed with caution. Future monitoring of translocation sites should also include impacts to all other wildlife (e.g., competition, disease, or other mechanisms) as well when surveying tortoises.

Given the long-term persistence of both translocated populations, we suggest that tortoises located in Macon and Autauga counties should be included in future statewide evaluations of tortoise conservation status and management planning. Despite the persistence of both populations, there is a need to assess population growth rates to determine whether these central Alabama populations are viable, and if not, whether efforts should be taken to bolster the populations. One limitation of our study is the limited data collected on hatchling and juvenile burrows. Another limitation is that we were only able to obtain permission from one of four landowners with tortoise presence in Macon County near the original translocation. Because we were only able to survey 32.37 of approximately 200 hectares of possible translocation terrain, the overall status of this population remains unknown. Therefore, we recommend additional engagement with private landowners to gain further insight into the extent of the spread of gopher tortoises in these areas due to migration and recruitment since their translocated release. Most importantly, this qualitative study shows that tortoises survive outside of the currently recognized habitat characteristics (e.g., soil types), even beyond that of their historically recognized range. This information is important to tortoise management going forward considering rapid urbanization and their ever-fragmenting habitat range in the southeastern U.S.

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