A COMPARISON OF MOVEMENTS AND BURROW USAGE BETWEEN INDIGENOUS AND RELOCATED GOPHER TORTOISES (Gopherus polyphemus) IN A FALL LINE SANDHILLS COMMUNITY

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A Comparison of Movements and Burrow Usage Between Indigenous and Relocated Gopher Tortoises (*Gopherus polyphemus*) in a Fall Line Sandhills Community

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ABSTRACT

The movements and burrow use of twenty (ten relocated and ten indigenous to the relocation site) adult gopher tortoises (*Gopherus polyphemus*) were followed during the late spring, summer and early autumn in Talbot County, Georgia. The objectives of this study were to determine whether relocated gopher tortoises developed fidelity to a relocation site, and whether indigenous tortoises reacted adversely to relocated tortoises released in their proximity. Ten tortoises in the right-of-way of a highway construction project were captured, fitted with transmitters, and relocated to a 336 hectare tract of land, 3.2 km east of Geneva, Talbot, County, Georgia. Concurrently, ten tortoises indigenous to the relocation site were captured, fitted with transmitters, and returned to their burrows. Captured gopher tortoises were released into three areas separated by blackwater branch swamps along the northern edge of the relocation site: one area contained five indigenous tortoises; a second area contained five relocated tortoises; and a third area contained five indigenous and five relocated tortoises. Tortoises were tracked using a radio receiver from 22 May to 4 November 1996. Their movements, azimuth, and burrow use were recorded initially every day for seven days following their release then every three days thereafter (weather permitting). Social interactions observed were also recorded.

Two relocated tortoises left the relocation site and the transmitter on an indigenous tortoise failed within the first week after being released. A third relocated tortoise returned to the vicinity of its capture burrow immediately north of the relocation site, in late October. The remaining relocated and all indigenous tortoises stayed near their release burrows or traveled to new areas on the relocation site where they remained. Treatment (tortoises

released in isolation, released with indigenous, or released with relocated tortoises), gender, and source (relocated or indigenous) had a significant effect on the behavior of the tortoises. Interactions among these variables were also significant. Males occupied more burrows and had a greater number of interburrow movements than females. Also, relocated tortoises released with indigenous tortoises or indigenous tortoises released with relocated tortoises occupied a greater number of burrows and had a greater number of interburrow movements than indigenous or relocated tortoises alone. The average distance traveled from the release burrow to each burrow occupied by a particular tortoise was found to be significant or highly significant for all examined factors; namely, treatment, gender, and source. Interactons between treatment, and/or gender, and/or source were also significant or highly significant. Tortoises released in areas with both indigenous and relocated tortoises moved a greater average distance than tortoises released in isolated areas. Males moved a greater average distance than females. Relocated tortoises (both sexes combined) moved a greater average distance than indigenous tortoises. Relocated female tortoises occupied the fewest burrows, moved the least number of times, and had the lowest average distance traveled compared to all tortoises studied. Because of the contrast in movement patterns among indigenous and relocated tortoises, only gender was found to be significant when the total distance traveled was compared. Due to wide variation among individuals in the distance moved from their release burrow to the last burrow occupied there was no significant difference in terms of gender, treatment, source, or their interactions. The 17 tortoises that were monitored for the duration of this study occupied 110 burrows and moved 193 times. Overall, males moved a total of 135 times compared to females who moved a total of 58 times. Seasonal differences in the number of movements were found to be significant. The number of movements recorded during July and August were approximately twice the number recorded during June, September, and October. Despite these differences the release of relocated tortoises among indigenous tortoises did not appear to have a pronounced negative impact on the latter group of tortoises. The movements patterns of relocated male tortoises towards the end of the study suggests they had become acclimated to the relocation site. The restricted movements of the relocated females may be due to repressive behavior by indigenous tortoises that were in close proximity to them.

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DEDICATION

Dedicated to Thomas Gaither Morpeth for his support and invaluable assistance in the research and preparation of this thesis.

INTRODUCTION

The gopher tortoise *(Gopherus polyphemus)* is a large, herbivorous reptile indigenous to the Coastal Plain, and the only extant species of the genus found east of the Mississippi River. In its current range, the gopher tortoise is distributed in small, disjunct populations along the southeastern Coastal Plain between Jasper and Hampton counties South Carolina, Tangipahoa Parish, Louisiana, and south into the Florida peninsula. In Georgia, tne gopher tortoise is typically associated with longleaf pine-turkey oak communities. The species is listed as threatened by the state because of habitat modification, elimination of fire from longleaf pine-turkey oak communities, repeated use of off-road vehicles in dune areas, and human predation (Auffenburg and Franz 1982). Overall, gopher tortoise numbers have been substantially reduced throughout their range. The gopher tortoise now has local protection in each of the six states in which it occurs, and federal protection in Louisiana, Mississippi, and western Alabama (Burke et al. 1996).

Gopher tortoises have` adapted to xeric environments with well drained sandy soils associated with Late Cretaceous, Late Tertiary, and Quaternary deposits. Before these ecosystems were altered, the dominant trees were longleaf pine (*Pinus palustrus*), turkey oak (*Quercus laevis*), bluejack oak (*Q. incana*), and dwarf post oak (*Q. margaretta*). A variety of herbaceous plants (especially legumes and grasses) provided food for the tortoises. The growth of woody vegetation was controlled by periodic burning that was a result of lightening strikes (Landers and Buckner 1981).

Gopher tortoises are long-lived (40 to 60 years), slow to reach sexual maturity, and moderate to large in body size (Bury and Germano 1994). Large forelimbs enable the tortoise to excavate deep burrow systems that vary in length and depth with an enlarged chamber at the end. Most of their lives are spent in burrows where high moisture content and more constant temperatures prevail. The humidity of the burrow environment may help tortoises avert desiccation during times of little rainfall (Cox et. al 1987). Burrows also provide shelter from extreme climatic conditions and protection from predators (Witz et al. 1991). Gopher tortoise burrows are also used by many commensals for refuge from predation, as a site for feeding or reproduction, and even as a permanent micro-habitat for one or all life history stages. To date, 60 vertebrate and 302 invertebrate species (many of them are threatened or endangered) use tortoise burrows (Jackson and Milstrey 1989). McRae et al. (1981) reported that females use an average of four burrows and males an average of seven burrows annually and the extent of movements varies seasonally.

Increasing development often places gopher tortoise populations at risk due to human expansion. A popular remedy has been to capture and relocate tortoises to either undisturbed or reclaimed areas. This has resulted in the most numerous and extensive relocations and translocation of any amphibian or reptile species. Tortoise relocation is advocated by environmental consultants and regional planning councils with little thought to biological impacts (Diemer 1984). Although thousands of animals have been moved, there is a critical lack of information on the long-term success or failure of relocation projects. Information is also lacking on how translocated tortoises released into areas with established indigenous populations affect those populations.

Study Site Habitat

The natural community of the Fall Line Sandhills (the habitat in which the study was conducted) is an open canopy forest, that has evolved on sand deposits of Miocene and Cretaceous origin, which may reach a depth of five meters or more. This xeric community is found in a narrow band south of the Fall Line that separates the Coastal Plain from the Piedmont regions of Georgia. The habitat in its natural state is an extremely dry forest of small deciduous oaks (*Quercus laevis, Q. marilandica, Q. incana*) less than 5m high with or without an overstory of longleaf pine (*Pinus palustris*). Dominant shrubs are haws (*Cretaegus flava, C. uniflora*), winged and poison sumac (*Rhus copallina, R. toxicodendron*), and blueberry (*Vaccinium tenellium*). Blackberry *(Rubus lacinatus*) is common in disturbed areas. Wiregrass (*Aristida sp.*), broomgrass *(Andropogon sp.*), reindeer lichen (*Cladonia sp.*), gopher apple (*Chrysobalanus oblongifolius*), dwarf dandelion (*Krigia virginica*), yucca (*Yucca filamentosa*), and prickly pear cactus (*Opuntia stricta*) were common at the donor and the relocation site and are important food sources for the gopher tortoise (Wharton 1989).

The Sandhills Community is at the northern edge of their range. At this latitude, tortoise activity declines in September and October as temperatures are getting cooler (Birkhead and Stokes 1996). However, tortoises have been observed basking on their aprons on sunny winter days (R. Birkhead pers. comm.). Activity increases when ambient temperatures approach 27° C or higher in the late spring reaching a peak during June, July and August (Birkhead and Stokes 1996).

Previous Studies

Most of the research on gopher tortoise relocation efforts has taken place in Florida (Bard 1989; Burke 1989; Diemer 1984, 1986, 1989, 1992; Fucigna and Nickerson 1989;

Godley 1989; Layne 1989; and Stout et al. 1989). Relocation is one option suggested by the Florida Game and Fresh Water Fish Commission (FG&FWFC) in an attempt to preserve gopher tortoise populations (Witz et al. 1991). In 1984, a gopher tortoise relocation policy statement was issued by the FG&FWFC. Two technical reports published by the FG&FWFC followed: the first addressed habitat protection requirements for gopher tortoises (Cox et al. 1987), the second was a collection of papers presented at Gopher Tortoise Relocation Symposium Proceedings (1989). The second report made recommendations for the capture and relocation of gopher tortoises in regard to permits, population densities, habitats, relocation site preparation, and trapping and handling. The authors of the report further stated that the FG& FWFC did not generally approve and typically discouraged the relocation of wildlife as a perceived solution to land development-wildlife conflicts. However, in instances where development of a site was imminent and all reasonable possibilities had been exhausted to accommodate the welfare of a particular on-site species, the Commission would issue permits to relocate those individuals jeopardized by impending development.

Research on gopher tortoise populations and relocation efforts in Georgia have not been as extensive. Landers (1981) released 79 tortoises on four sites in Decatur County, Georgia, and concluded that only about 41% of the introduced tortoises remained near the release sites three years after relocation. Nine of 12 tortoises released on one site enlarged man made starter burrows that were still in use three years later. Although less than 50% of the relocated tortoises remained, breeding colonies were established where none had been previously. In southeastern Georgia, 47 tortoises were excavated from 5m high berms on a military installation and relocated to a long, narrow sand ridge west of Savannah. When a follow-up visit was made to the relocation site, several marked animals were observed and evidence of reproduction was noted (Diemer 1989).

The scientific community is not in agreement on gopher tortoise relocation. Concerns about mixing of locally adapted gene pools, loss of genetic variability, the potential for outbreeding depression, and potential disruption of indigenous tortoise populations by relocates are some concerns. Cox et al. (1987) feel that relocation of gopher tortoise populations should be considered only when other efforts to protect existing gopher habitats have failed or when individual animals are threatened. The principal threat to tortoise conservation is habitat loss, and efforts should be concentrated on the preservation of habitat. Furthermore, diseases and parasites may become more widespread by the mixing of isolated populations, locally adapted gene complexes in both donor and recipient populations may be broken down, and existing social structure may be disrupted. Only recently have gopher tortoise relocation projects attracted the attention of scientists and field biologists. Their concern has helped increase monitoring and documentation on the survival of relocated tortoises (Dodd and Seigel 1991). For a reptile, *G. polyphemus* has an elaborate social system involving spatiotemporal territoriality and a male dominance hierarchy based on body size. Relocates may displace residents or in turn, be driven away by residents (Diemer 1989).

Relocation Site Selection

Gopher tortoise relocation, whether it is an individual or a colony, is complicated and time consuming. The first, and probably the most important factor is finding a suitable relocation site. Site selection must involve consideration of tortoise movements and behavior, including the animal's tendency to disperse, the size of its home range, and its homing ability

(Berry 1986). Private lands are scarce and public lands (i.e., state and local parks) often become "dumping grounds" for displaced tortoises with little thought given to habitat suitability, possible overpopulation, spread of disease, or gene pool mixing. The best relocation site is one that is in the same geographic location as the donor site. Recent research has shown that female gopher tortoises vary latitudinally in size, age at sexual maturity, and in the winter dormancy period. Clinal variation in morphology and color have also been observed in both sexes (Diemer 1984). Distinct genetic types (based on morphology and color) may exist in different regions of the Coastal Plain of Georgia. Also, diseases and parasites identified with gopher tortoises can be transmitted to healthy populations. Because of the uncertainty of these factors, relocations should be localized as much as possible (Landers 1981).

Another consideration, when choosing a relocation site, is its distance from the donor site. Several species of turtles, including gopher tortoises, exhibit Type II orientation. That is, they can select a compass heading and travel in a straight line, often for several hundred meters. Some tortoises can and do return home or show homing tendencies when displaced short distances of 0.5 - 5 km. If moved greater distances, they may settle, disperse, or attempt to return home (Berry 1986). McRae et al. (1981) relocated four male gopher tortoises and later discovered them 1.9 - 7.7 km from the release site, all heading in the general direction toward where they had been removed. Layne (1989) compared resident and relocated tortoises based on the maximum recorded distances they moved from the original capture or release site. These distances ranged from zero to 1408 meters (mean=366m) for residents and 12 to 1951 meters (mean=534m) for relocates. In both groups, mean maximum distances moved by males exceeded those of the females. The greater maximum distances moved between release and recapture sites and the longer distances between successive recapture of relocated tortoises may reflect attempted homing or a search for a suitable home site. Tortoises displaced a few kilometers or less may return home. Layne concluded by saying, "Comparative studies of survivorship and other aspects of demography along with life histories of relocated and resident tortoises in a variety of habitats are needed to provide an adequate database for developing guidelines for relocating tortoises into occupied habitats that will maximize survival of relocated individuals without adverse impacts on residents."

Gibbons (1986) described two potential problems in desert tortoise (*G. agassizii*) relocation programs because of a population's history in response to habitat changes (assuming they respond to habitat alteration by leaving an area that has become unsuitable). First, desert tortoises in a population slated to be relocated may have traveled long distances to reach the site from which they were to be removed. These relocated tortoises might have been familiar with a much larger area than would normally be expected and therefore may have attempted to return to former habitats. A second problem was that certain habitat characteristics might have been considered important or even beneficial to those attempting the relocation, whereas in fact, the habitat was not a preferred one but only one where the tortoises lived by default.

Capture, Confinement, and Release

Once a relocation site has been found, several methods can be used to capture gopher tortoises. The most common, successful, and safest (for the tortoise) method for capturing tortoises is pitfall trapping (a five-gallon bucket buried in the ground at the burrow entrance and camouflaged). It is labor intensive, and may require waiting weeks until the tortoise leaves its burrow. In addition, large tortoises can climb out of a pitfall trap and escape. Other methods such as hand digging, pulling (hooking with a wire and dragging the tortoise out with a pole), or using earth moving equipment are last resort methods and are used when time is limited. Coordinating a relocation attempt between biologists and contractors is also important. A relocation attempt by a Jacksonville utility company working with a consultant failed when the sandhill was bulldozed the day after bucket traps were installed (Diemer 1984).

Once captured, the tortoises are transported to a prepared relocation site. Lohoefener and Lohmeier (1986) recommended the temporary penning of tortoises at the release site and providing starter burrows to enhance site fidelity. However, tortoises penned before being released may be additionally stressed by the confinement, experience a greater exposure to the elements, or they may injure themselves trying to dig under or claw through wire enclosures. Confinement of tortoises in groups also increases the chances of an outbreak or the transmission of disease (Hawkins and Burke 1989). Because it is the desire for relocation efforts to be a success, the possible benefits of penning tortoises before release may out-weigh the risks. Recent relocation efforts in Florida and Georgia (Godley 1989, Stout et. al. 1989, Hawkins and Burke 1989, Fucigna and Nickerson 1989, Birkhead and Stokes 1996) have used habitat enhancement, initial penning, and starter burrows to improve the fidelity of the tortoises that have been relocated. In Florida three populations (N=285) of tortoises were relocated onto two phosphate-mined sites 80km from the donor sites. One was reclaimed to pasture and the other to sand pine scrub. Juveniles and adults were separated and penned prior to release. Sixty-five tortoises were transported and held in a holding pen at the pasture relocation site. Approximately 11 days later all adult tortoises (N=60) were stolen from the holding pen. Eighty-three tortoises were later released at this site. Of these, 40 tortoises (ten fitted with transmitters) were released into unpenned starter burrows and the remaining 43 (ten fitted with transmitters) were penned for a minimum of 14 days before also being released into unpenned starter burrows. None of the 83 tortoises released stayed in their starter burrow for more than one day. The results showed that the behavior of tortoises penned prior to released did not differ from tortoises not confined, nor did penning increase site fidelity, only two of the 20 tortoises fitted with transmitters remained in the pasture (Godley 1989). During January and February 1986, 41 gopher tortoises were relocated from a development site in Palm Beach County, Florida to a Boy Scout Camp in Martin County, Florida. Seventeen relocated and six indigenous tortoises were fitted with transmitters and placed into 6m x 6m holding pens with starter burrows dug by hand to a depth of 0.3m. The tortoises were confined for two weeks before being released. Transmitters failed on two of the released tortoises; all others were radio-located once a week for 12 weeks and monthly thereafter for 18 months. Two relocated tortoises left the relocation site, but all others remained within 1100m of the initial holding pens. The resident tortoises remained within a 200m radius of their points of capture. Mean survival times of residents exceeded those of the relocated tortoises; they also had more restricted movements than relocated individuals. Relocated tortoises remained in or near the relocation area and did not have a negative impact on the resident tortoises (Fucigna and Nickerson 1989).

Bard (1989) followed and compared the movements and survival of relocated and indigenous tortoises released at the University of Central Florida (UCF). Twenty-nine (12 relocated and 17 indigenous) tortoises were fitted with radio transmitters and tracked from 1985 to 1989. The relocated tortoises were initially penned and provided with starter burrows before their release. Resident tortoises were released at their capture site. Within 12 months, seven of the relocated tortoises had died or were lost, compared with two of the resident tortoises. After 41 months, only two relocated tortoises and three resident tortoises remained. Many relocated tortoises traveled long distances, crossed major roads, and entered hydric areas, (41.7%) left the site or died shortly after release and were not recovered. The resident tortoises released stayed in the areas where they been captured and released although the majority had died after 42 months .

For comparison, Layne (1989) released 44 relocated gopher tortoises at seven different locations from 1968 through 1981. No special procedures, (i.e., pre-release penning or provision of artificial burrows) were followed before releasing the tortoises; animals were simply placed in a suitable habitat during the day. The results of this study showed: 1) relocated tortoises introduced singly into an occupied habitat with no special pre-release treatment have a moderate survival rate (64% of that of residents), 2) larger individuals (>169 mm plastron length) had a higher survival rate than smaller individuals, 3) the mean distance moved by relocated male tortoises from their release sites was greater than the mean distance moved by resident males from their original capture site, 4) mean distance moved by relocated females was less than that of resident females, 5) in both groups males moved farther than females, with relocated males moving the greatest distance from release sites.

Habitat destruction and predation of juveniles and adults has reduced the number of gopher tortoises. As a result, their range has been reduced to isolated areas containing small, fragmented populations. Trapping and relocating tortoises who are at risk from habitat loss is one method used in efforts to preserve the species. After considering the background information presented here it becomes apparent that additional information on tortoise relocation is needed. It is hoped that this study will provide new information on how well relocated tortoises accept a new location and whether indigenous tortoises are affected adversely by relocated tortoises released in their proximity. This was accomplished by examining burrow use, frequency of movements, and distances moved between and among indigenous and relocated gopher tortoises. This thesis contains the results of a study designed to examine the behavior patterns among populations of indigenous and relocated tortoises both as isolated groups and in close proximity to one another and that the information obtained will be useful in planning and executing future relocation projects involving this threatened species.

Objectives

The objectives of this research were to assess the effects relocated tortoises had on tortoises that were indigenous to a relocation site, and to ascertain whether the relocated tortoises behaved significantly different from the indigenous tortoises. Questions addressed by this study were: 1) did relocated tortoises establish fidelity to the relocation site, 2) did the movements of relocated and resident tortoises differ, 3) did the movements of indigenous tortoises near relocated tortoises differ from the movements of indigenous tortoises that were more distant from relocated tortoises, and 4) did movement patterns of males and females in indigenous and relocated populations differ?

MATERIALS AND METHODS

In 1994, prior to the start of this study, the proposed Fall Line Freeway right-of-way was surveyed by the consulting firm of Greenhorne and O'Mara, for the presence of tortoise burrows. Active burrows were found and, because the tortoise is listed as threatened in the State of Georgia, a decision was made by the Georgia Department of Transportation (GDOT) to relocate the tortoises to a suitable site. Columbus State University was asked to prepare a proposal regarding this relocation. A request was made to Mead Coated Board for permission to relocate the tortoises on a 335.7-hectare tract of their land 3.2 kilometers east of Geneva, Talbot County, Georgia. The proposed relocation site was chosen because it fulfilled many guidelines recommended by the FG&FWFC (1989); the proposed relocation site was not more than 80 kilometers north or south of the donor sites (latitude variations in genotype and phenotype have been described in the gopher tortoise Douglass and Layne 1978, and Landers et al. 1982). The relocation and donor sites had similar soil types and vegetation. A population of indigenous tortoises were already present in all suitable habitats on the relocation site. The introduction of ten additional tortoises would probably not exceed the carrying capacity of the relocation site, which had numerous inactive or abandoned burrows available to the relocated tortoises. Permission was granted by Mead Coated Board and an agreement was formulated between Mead Coated Board, GDOT, and Columbus State University (CSU), to relocate the tortoises.

Description of Donor Sites

The donor sites for translocated tortoises were three sections of the proposed Fall Line Freeway right-of-way (ROW) in Taylor and Talbot Counties, Georgia. The first was a power line right-of-way 1.1 kilometers northeast of the relocation site; the second was 6.4

kilometers east of the relocation site near Junction City, along 2.4 kilometers of another power line right-of-way; and the last was in Butler, Georgia 30.6 kilometers east of the relocation site. The first two sites were adjacent to Georgia Highway 96, and the Butler site was adjacent to Georgia Highway 137, near the Butler city limits.

Before the tortoises were released onto the relocation site, they were given identification numbers using a method described later in this section. Two tortoises (1012 and 8006), were trapped near Butler, Georgia approximately 0.5 kilometers southeast of Georgia Highway 137, and 34 kilometers east of Geneva, Georgia. This habitat was an area of scrub oaks and haws with an overstory of longleaf pine, bordered on the east by an open field. Seven tortoises (4001, 3001, 3002, 3003, 3004, 3005, and 8003), were captured on a power line right-of-way in Junction City, Georgia. The area on the south side had been clear cut of sandpines (*Pinus clausa*) and part of the right-of-way had evidence of heavy equipment traffic and burning. The western portion of the north side of the power line was planted in mature sand pines: further east these pines had been selectively removed. A variety of herbaceous plants and stump sprouts representative of sandhills vegetation could be found along the right-of-way. One tortoise (8008) was captured on a power line right-of-way 1.1 kilometers northeast of the relocation site. Mature longleaf pines bordered the right-of-way to the southwest; a pasture was to the northeast. The right-of-way had a variety of herbaceous plants and stump sprouts characteristic of mature sandhills vegetation.

Description of Relocation Site

The experimental areas (Figure 1) where the tortoises were to be released were located on the northern edge of the relocation site. The predominant soils found on this site belonged to the Lakeland series, consisting of excessively drained, highly permeable soils that formed from sandy marine sediment and have a depth of 5 meters or more in places (T. Danley pers. comm.). Most of the property was planted in longleaf pine in 1988. The young pines were interspersed with scrub oaks, shrubs, and herbaceous plants associated with the Fall Line Sandhills plant community. South of the release sites were three areas of loblolly pine planted in 1991, and one experimental plot planted in 1965. The north boundary of the study site was bordered by a railroad right-of-way that ran approximately northeast-southwest. Georgia Highway 96, paralleled the railroad track immediately to the north. A burning program has not been carried out by Mead, and as a result, woody vegetation in some areas is dense and litter has accumulated. The property is both defined by and subdivided by dirt roads used by hunting clubs and Mead personnel. The burrows of indigenous tortoises were in evidence and could be found among the younger longleaf and loblolly pines where the canopy was open. Burrows were also found along the edges of roads, deer trails, and other open areas that provided good foraging and traveling conditions.

The experimental areas (Figure 2) extend for approximately 1.5 kilometers in a northeast-southwest direction along the northern boundary of the relocation site and were chosen for the high quality of gopher tortoise habitats and their accessibility. Each was separated by blackwater branch swamps fed by seeps or streams draining north to south as described in Wharton (1989). It was hoped that these wetland areas would serve as a barrier to tortoises released within each area. One area was designated to be for the release of indigenous tortoises only (5002, 5005, 5008, 1017 and 5012, shown by vertical bars, Figure 2). A second area was designated to be for relocated tortoises only (3001, 3002, 3003, 3004, and 3005, shown by horizontal bars, Figure 2). A third area was designated to be indigenous and relocated tortoises released together (indigenous tortoises 1011, 4004, 4005, 8007, and 8009; relocated tortoises 1012, 4001, 8003, 8006, and 8008, indicated by cross bars, Figure 2). Three indigenous tortoises were found in area designated for relocated tortoises only, during the initial survey. These were trapped, relocated to the northeastern most area of the property and released into inactive burrows prior to the release of the relocated tortoises.

Trapping and Tracking Methods

Active and inactive burrows on the Fall Line Freeway right-of-way that were located and marked on a GDOT aerial map in 1994 by Greenhorne and O'Mara were inspected again with an infrared camera in late March and early April 1996. Ten burrows were identified as active (with tortoises). These were marked on the GDOT map and flagged with surveying ribbon. Concurrently, the location of all burrows (active and inactive) in the northern portion of the relocation site was determined with a Trimble Pathfinder global positioning unit, flagged with surveying ribbon, and noted on an aerial map of the property. These burrows were also examined using the infrared camera to ascertain the presence of tortoises. Burrows that contained tortoises were also noted on the aerial map.

Nineteen adult (nine relocated and ten indigenous) tortoises were captured by burying five gallon buckets provided with drainage holes flush with the top level of the burrow entrance (pitfall traps). Buckets were covered with manila paper and sprinkled with sand for camouflaging. The traps and burrow entrance were shaded with canopies made from silt fencing material nailed to wooden stakes. Traps were checked daily in the mid-afternoon.

Pitfall traps were opened from 18 April 1996 through 3 June 1996, and tortoises were captured from 21 April to 8 June 1996. Most were caught before they had left the vicinity of their burrows for the first time. One adult tortoise from the Butler, Georgia donor site was excavated by hand.

Following capture, tortoises were taken to Columbus State University and placed individually in large plastic tubs in the field room on campus. Tortoises were held from one to 39 days to allow the simultaneous release of indigenous tortoises back into their burrows, followed by the release of all the relocated tortoises a week later. Those held longer than a week were allowed to exercise and had an opportunity to graze at least once a week until their release. They were also provided with herbaceous vegetation at least twice a week; typically dandelion (*Taraxacum officinal*) and kudzu (*Pueraria lobata*), during their confinement.

Tortoises were measured, (carapace length, plastron length, bridge width and bridge height in cm), sexed, and weighed (gm). The age was determined by counting, whenever possible, the number of distinct abdominal annuli (growth rings). Each tortoise was permanently marked by drilling the marginal scutes using a scheme depicted in Attachment 4 of the Gopher Tortoise Symposium Proceedings (FG&FWFC,1989). The numbering scheme used could quickly identify the tortoise's release area and burrow. The first number (thousands) represented the area and the other three numbers (1's, 10's, and 100's) identified the burrow number in which they were released. All tortoises were released in the afternoon with no pre-release treatment. Indigenous tortoises were returned to their burrows after transmitter attachment. They were allowed to reacclimate for several days, before relocated tortoises were released. Relocated tortoises were released into ten inactive burrows in their designated areas after transmitter attachment. When released with indigenous tortoises, they were placed as close to the latter as possible.

All tortoises were fitted with AVM Model AMPCB-10120-LD (AVM Instrument Company, LTD. 2356 Research Dr., Livermore, CA 94550. USA) radio transmitters equipped with 2-year batteries and a whip antennae attached with PC7 epoxy (Protective Coating Co., Allentown, PA 18102. USA) to their carapaces. The combined weight of the epoxy and transmitter was approximately 40 grams. Six of the transmitters placed on indigenous tortoises were thermosensitive so that carapace temperature could be determined. An AVM Instrument Company Portable Telemetry Receiver Model LA12-DS with a Yagi antenna was used to track the tortoises. Tortoises were located daily for seven days immediately following their release, then every three days thereafter until 4 November 1996. When a tortoise moved, the distance and azimuth from its last location were initially determined by pacing and the use of a hand held compass. The locations were subsequently determined with the Trimble Pathfinder global positioning unit at the end of the activity season. Tortoises that left the relocation property were captured to remove their transmitters and were released at their last location.

Data Analysis

The statistical program Keystat from Oakleaf Systems Computer Software, P.O. Box 472, Decorah, IA 52101-0472 was used to do an analysis of variance (3-way ANOVA) on each of the six dependant variables recorded: time in release burrow before first move; number of different burrows used; number of interburrow movements; total distance moved between burrows; distance from final burrow to release burrow; and average distance to all burrows used from the release burrow. The independent variables were gender, treatment (indigenous tortoises released in isolation, relocated tortoises released in isolation, and indigenous and relocated tortoises released together), and source (indigenous or relocated). In order to achieve a balanced 3-way ANOVA design among all dependant variables, all sets that had more than two values for indigenous male tortoises had the intermediate value eliminated from the set. An analysis of variance (one-way ANOVA) was also done to determine the significant difference among the average total monthly movements of all the tortoises. Keystat was used to run a regression analysis on the relationship between the number of days tortoises were held in the laboratory, and the number of days tortoises remained in their release burrow before moving.

The individual maps in Appendix B were created by the Arcview GIS mapping program, field notes, and computer generated maps showing the geographical position of burrows occupied, as recorded by a Trimble Pathfinder global positioning unit. The placement of burrows and routes between burrows is as accurate as map size and scale will allow. All routes traveled between burrows are shown as straight lines and may not reflect the use of nearby roads or paths used by a particular tortoise to travel from one burrow to another. The dates by each burrow occupied (or off set by a dotted line) indicate the date the tortoise was located there. The number of times a tortoises traveled between a pair of burrows is indicated by a number adjacent to the line (or off set by a dotted line) connecting the burrows.

Figure 1. Map of the relocation site showing the distribution of planted Longleaf and Loblolly pines, an experimental plot, and the locations of Blackwater Branch Swamps.

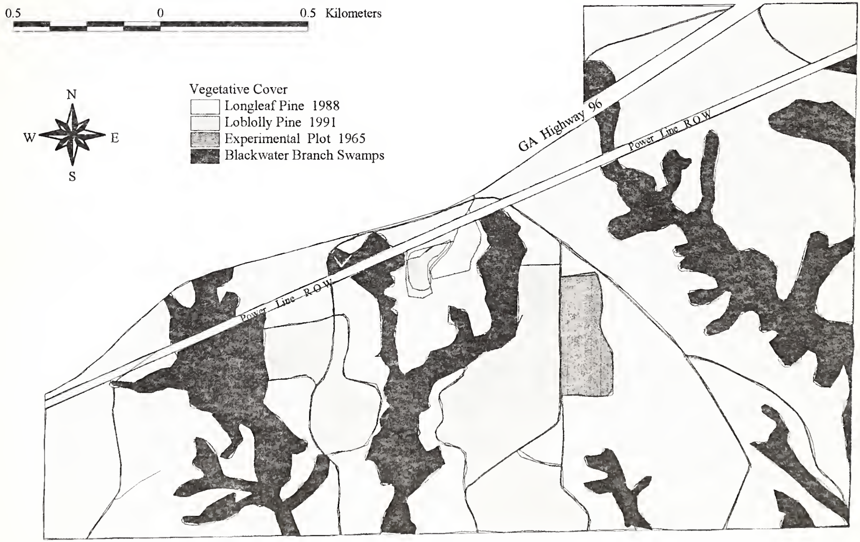
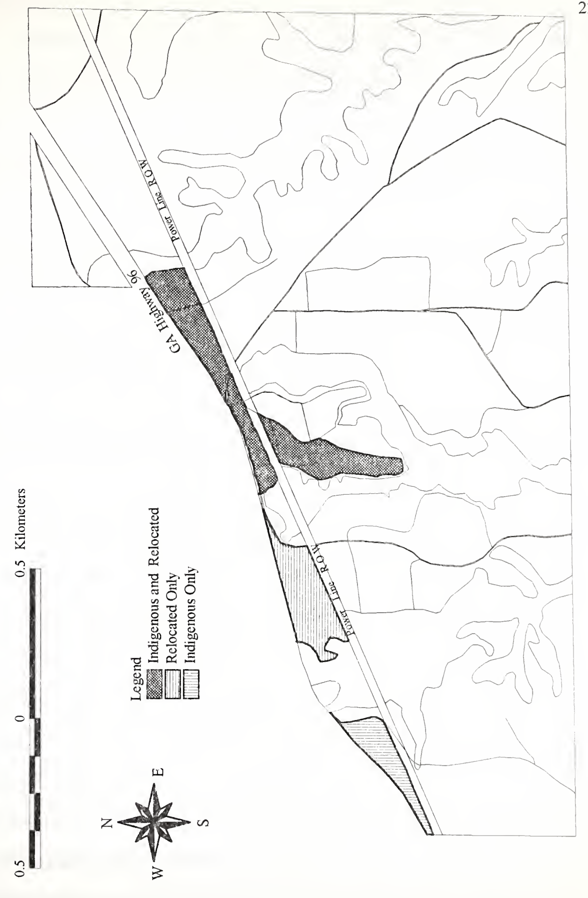

0.5 0 0.5 Kilometers
N
W
E
S
Vegetative Cover
Longleaf Pine 1988
Loblolly Pine 1991
Experimental Plot 1965
Blackwater Branch Swamps
GA Highway 96
Power Line ROW
Power Line ROW

Figure 2. Map of the relocation site showing the release areas for indigenous tortoises only, relocated tortoises only, and indigenous and relocated tortoises released together.



0.5
0
0.5 Kilometers
N
E
S
W
Legend
Indigenous and Relocated
Relocated Only
Indigenous Only
GA Highway 96
Power Line R.O.W.
Power Line R.O.W.

RESULTS

Nineteen tortoises were captured between 18 April and 3 June , 1996, using pitfall traps. Ten tortoises were caught within seven days of opening traps at their respective burrows. With the exception of one tortoise that was excavated by hand on 25 April, the remaining tortoises were caught within 27 days after the traps were opened. The specific dates and length of time taken to capture each tortoise can be found in Table 1. Prior to their release each tortoise was weighed, sexed, measured, and their growth rings were counted when possible (Table 2). Based on their carapace lengths, all would be considered adults.

From the onset of the study, movement patterns clearly differed between indigenous and relocated tortoises and between males and females. Two relocated male tortoises, 3003 (released with only relocated tortoises) and 8003 (released with indigenous tortoises) left the relocation site within ten days. Both tortoises traveled in the same direction, but not toward their capture location. They were found above ground 3579m and 3305m respectively from their release burrows. The remaining four relocated male tortoises stayed on the relocation site into the inactive period (4 November 1996) with one exception. Tortoise 8008, which had been relocated into the area with indigenous tortoises, left his release burrow the day of his release and traveled in the direction of his original burrow (north), until he reached the railroad track. He traveled east and west along the track using ten burrows and moving 18 times over a period of 147 days. Between 21 October and 24 October 1996, he crossed the railroad track and Georgia Highway 96 and was found near his capture site on 24 October 1996. Because this tortoise remained on the relocation site for essentially the entire time tortoises were monitored, the data obtained from him was included in the analysis. The three remaining relocated male tortoises, the six indigenous male tortoises (both those released in isolation, and those released with relocated tortoises), and all eight relocated and indigenous female tortoises remained on the relocation site. The presence of roads on the relocation site may have influenced the direction and distance tortoises traveled as relocated and indigenous (marked and unmarked) tortoises were observed traveling along them. In fact, five tortoises fitted with transmitters, that had moved from one area to another may have used roads to circumvent the blackwater branch swamps separating the release areas. In areas where tortoises remained for long periods, well-worn trails between burrows were observed.

No significant correlation was found ($r = -1.382E-02$, $n = 18$, $df = 17$) between the number of days tortoises were held in the laboratory and the length of time they remained associated with their release burrow (Table 3, Figure 3, and Figure 4). The number of days tortoises remained in their release burrow varied from zero, for five of the tortoises, to one tortoise that did not move away from her release burrow during the entire activity period (138 days).

The number of burrows occupied by each tortoise was compared (Figure 5). There was no significant difference between tortoises that had been relocated or were indigenous to the relocation site (source) with respect to the number of burrows occupied (3-way ANOVA, $df = 1, 1, 8$; $F = .51$, $p > 0.05$). However, the area where a relocated or indigenous tortoise was released (treatment) was significant (3-way ANOVA, $F = 5.57$, $df = 1, 1, 8$; $p < 0.05$). Tortoises that were released in areas containing only indigenous tortoises or in areas containing only relocated tortoises occupied an average of six burrows ($n = 8$), whereas tortoises released into areas containing both indigenous and relocated tortoises occupied an average of nine burrows ($n = 8$). Gender was also found to have had a significant effect on the number of burrows occupied (3-way ANOVA, $F = 6.58$, df = 1, 1, 8; $p < 0.05$). Male tortoises in all treatment areas occupied a greater number of burrows ($\bar{x} = 8$; n=8) than female tortoises ($\bar{x} = 5$; n=8). The 3-way ANOVA test also indicated that interaction between source, and/or gender, and/or treatment was significant. That is, relocated female tortoises that were released with indigenous tortoises occupied significantly (3-way ANOVA, $F = 5.57$, df = 1, 1, 8, $p < 0.05$) fewer burrows than relocated and indigenous males in all areas, indigenous females in all areas, and relocated females released with only relocated tortoises.

The results on the number of interburrow movements (Figure 6) are similar to the results for number of burrows occupied. That is, there was no significant difference (3-way ANOVA, $F = .08$, df = 1, 1, 8; $p > 0.05$) between tortoises that had been relocated or were indigenous to the relocation site (source), with respect to the number of interburrow movements. Treatment again had a significant effect (3-way ANOVA, $F = 9.07$, df = 1, 1, 8; $p < 0.05$) on the number of interburrow movements. Tortoises that were released into areas containing only indigenous tortoises or into areas containing only relocated tortoises moved an average of 11 times ($n = 8$) compared to tortoises released into areas containing both indigenous and relocated tortoises which moved an average of 13 times ($n = 8$). Whether a tortoise was a male or a female (gender) also had a significant effect on the number of interburrow movements (3-way ANOVA, $F = 9.67$, df = 1, 1, 8; $p < 0.05$). Male tortoises in all treatment areas moved a greater number of times ($\bar{x} = 16$; $n = 8$) than female tortoises in all areas ($\bar{x} = 8$; $n = 8$). The results for the number of interburrow movements were similar to the results for number of burrows occupied. Interactions between source, gender, and treatment were found to be significant. Female tortoises that were released with indigenous tortoises had significantly (3-way ANOVA, $F = 8.49$, df = 1, 1, 8, $p < 0.05$) fewer interburrow movements, than relocated and indigenous males in all areas, indigenous females in all areas, and relocated females released with only relocated tortoises.

The average distance traveled from the release burrow to each burrow occupied by a particular tortoise is shown in Figure 7. All factors; treatment, gender and source, and interactions between treatment, and/or gender, and/or source were found to be significant or highly significant. Where a particular tortoise was released (treatment) had a highly significant effect (3-way ANOVA, $F = 28.10$, df = 1, 1, 8; $p < 0.001$) on the average distance traveled between burrows. This factor was dependent on whether a tortoises were released into areas containing only indigenous tortoises, areas containing only relocated tortoises, or released into areas containing both relocated and indigenous tortoises. Tortoises released in areas with both indigenous and relocated tortoises moved an average of 575m between burrows ($n = 8$), whereas those released in areas with only indigenous or only relocated tortoises moved an average of 274m between burrows ($n = 8$). Gender also had a highly significant effect (3-way ANOVA, $F = 41.11$, df = 1, 1, 8; $p < 0.001$) on average distance moved between burrows. Male tortoises moved an average distance of 712m ($n = 8$), while females moved an average distance of 137m ($n = 8$). Source (indigenous or relocated) was also found to have an highly significant effect (3-way ANOVA, $F = 11.55$, df = 1, 1, 8; $p < 0.01$) on the average distance moved. Indigenous tortoises moved an average distance of 373m ($n = 8$), whereas relocated tortoises moved an average distance of 662m ($n = 8$). All interactions (i.e. among gender, and/or treatment, and/or source) were also found to be either significant or highly significant. For the average distance traveled, the interaction between treatment and gender was highly significant (3-way ANOVA, $F = 46.90$, $df = 1, 1, 8$; $p < 0.001$), as was the interaction between gender and source (3-way ANOVA, $F = 13.59$, $df = 1, 1, 8$; $p < 0.01$). Interaction was significant between treatment and source (3-way ANOVA, $F = 7.37$, $df = 1, 1, 8$; $p < 0.05$) and between treatment, gender, and source (3-way ANOVA, $F = 10.64$, $df = 1, 1, 8$; $p < 0.05$). The two relocated male tortoises released with indigenous tortoises moved the greatest average distance between burrows, 1567m and 2105m. The two relocated female tortoises released with indigenous tortoises moved the least average distance, 38m and 23m between burrows. In addition, female relocated tortoises in all areas moved an average distance of 68m (n = 4) between burrows compared to male relocated tortoises released in all areas, who moved an average distance of 1258m (n = 4).

The difference in the movement patterns between indigenous and relocated tortoises becomes more apparent when total distance traveled among burrows (Figure 8) is compared to average distance traveled (Figure 7). In contrast to the average distance moved between burrows where all dependent and independent factors were significant, only gender (males > females) was significant (3-way ANOVA, $F = 11.01$, $df = 1, 1, 8$; $p < 0.05$) for the total distance moved. When relocated male tortoises did move, they traveled a greater average distance than indigenous tortoises before locating another burrow. Except, for gender differences, the total distance traveled was very similar among all the indigenous and relocated tortoises. Male tortoises moved an average total distance of 2329m (n = 8) among all burrows occupied, compared to female tortoises who moved an average total distance of

599m (n = 8) among all burrows occupied.

The distance tortoises moved from their release burrow to the last burrow occupied before becoming dormant is shown in Figure 9. Because there was wide variation among individuals with respect to this variable, there was no significant difference in terms of gender, treatment, source or their interactions. The distance ranged from zero to 851m ($\bar{x}$ = 510m n=4) for relocated male tortoises and from zero to 377m ($\bar{x}$ = 125m n=5), for indigenous male tortoises. Among female tortoises, the distance ranged from 41m to 452m ($\bar{x}$ = 250m; n=4) for indigenous tortoises and ranged from 0m to 70m ($\bar{x}$ = 27m; n=4) for relocated tortoises.

Only one new burrow was excavated during the course of this study. Tortoise 1011 (an indigenous male that was released with relocated tortoises) excavated a burrow between 13 July and 16 July. All other burrows used by the tortoises were inactive or abandoned burrows already in existence.

The 17 tortoises that were monitored for the duration of this study occupied 110 burrows and moved 193 times. Overall, males moved a total of 135 times compared to females who moved a total of 58 times. Seasonal differences in the number of movements made were found to be highly significant (1-way ANOVA, $F = 4.09$, $df = 1, 8$, $p < 0.01$). The number of movements recorded during July and August were approximately twice the number made during June. September, and October (Table 5). Use of a single burrow by two tortoises was observed on seven different occasions (Table 4). On five occasions, a male was located in the same burrow with a female. On the two other occasions a male was located in the burrow of another male.

Table 1. Summary of the dates pitfall traps were set, the dates tortoises were captured, and the number of days that elapsed before their capture.

Tortoise Group	Tortoise ID and Sex	Location * Trapped	Date Trap Set	Date Captured	Days Elapsed
Indigenous with Relocated	1011 - Male	RELOC	4-20-96	5-06-96	16
	4004 - Male	RELOC	4-21-96	5-05-96	14
	4005 - Male	RELOC	4-21-96	5-16-96	25
	8007 - Female	RELOC	5-30-96	6-01-96	2
	8009 - Female	RELOC	5-24-96	5-25-96	1
Relocated with Indigenous	8003 - Male	ROW - J.	5-12-96	6-02-96	21
	8006 - Male	ROW - B.	4-18-96	4-21-96	3
	8008 - Male	ROW - G.	5-12-96	5-18-96	6
	4001 - Female	ROW - J.	5-12-96	5-25-96	13
	1012 - Female	ROW - B.	4-18-96	4-25-96 **	
Isolated Indigenous	5002 - Male	RELOC	4-21-96	5-16-96	25
	5005 - Male	RELOC	4-21-96	5-05-96	14
	5008 - Male	RELOC	4-21-96	5-04-96	13
	1017 - Female	RELOC	4-21-96	5-17-96	26
	5012 - Female	RELOC	6-03-96	6-05-96	2
Isolated Relocated	3003 - Male	ROW - J.	5-12-96	5-14-96	2
	3004 - Male	ROW - J.	5-12-96	5-14-96	2
	3005 - Male	ROW - J.	5-12-96	5-16-96	4
	3001 - Female	ROW - J.	5-12-96	6-08-96	27
	3002 - Female	ROW - J.	5-12-96	5-15-96	3

* ROW = Proposed Fall line Freeway right-of-way
G = near Geneva, Talbot, County, Georgia;
B = Near Butler, Taylor County, Georgia;
J = Junction City, Talbot County, Georgia .

** Tortoise excavated on this date.

Table 2. Sex, weight, measurements, and number of growth rings for tortoises captured on the Fall Line Freeway right - of - way in Taylor and Talbot Counties, Georgia and on the relocation site, 3.2 km east of Geneva, Talbot County, Georgia.

Tortoise Population	Tortoise ID and Sex	Weight	Carapace Length	Carapace Width	Bridge Height	Plastron Length	Growth Rings
Indigenous with Relocated	1011 - Male	3.80 kg	28.10 cm	21.90 cm	12.80 cm	29.85 cm	indeterminate
	4004 - Male	4.60 kg	31.70 cm	24.20 cm	13.40 cm	31.60 cm	approx. 24
	4005 - Male	4.90 kg	31.00 cm	22.80 cm	12.80 cm	28.10 cm	approx. 27
	8007 - Female	5.15 kg	32.80 cm	24.70 cm	13.50 cm	31.95 cm	24
	8009 - Female	4.30 kg	30.60 cm	22.30 cm	12.20 cm	29.90 cm	indeterminate
Relocated with Indigenous	8003 - Male	3.40 kg	27.00 cm	20.60 cm	12.00 cm	27.50 cm	22
	8006 - Male	3.70 kg	28.10 cm	21.40 cm	12.45 cm	26.20 cm	indeterminate
	8008 - Male	4.40 kg	30.50 cm	22.60 cm	12.40 cm	29.35 cm	indeterminate
	4001 - Female	4.20 kg	29.90 cm	21.90 cm	12.40 cm	27.95 cm	approx. 25
	1012 - Female	4.80 kg	32.40 cm	23.35 cm	13.70 cm	30.80 cm	approx. 23
Isolated Indigenous	5002 - Male	3.25 kg	26.70 cm	19.40 cm	11.70 cm	26.05 cm	approx. 22
	5005 - Male	2.70 kg	25.40 cm	20.00 cm	10.80 cm	25.10 cm	indeterminate
	5008 - Male	3.10 kg	27.10 cm	20.40 cm	11.35 cm	27.20 cm	16
	1017 - Female	3.55 kg	27.10 cm	20.30 cm	12.20 cm	26.75 cm	15
	5012 - Female	3.40 kg	27.30 cm	20.30 cm	11.65 cm	26.40 cm	25
Isolated Relocated	3003 - Male	3.50 kg	27.75 cm	21.50 cm	12.00 cm	27.35 cm	approx. 21
	3004 - Male	3.90 kg	30.20 cm	20.90 cm	12.00 cm	30.20 cm	approx. 23
	3005 - Male	3.05 kg	27.60 cm	19.50 cm	11.60 cm	27.30 cm	21
	3001 - Female	------	29.75 cm	21.90 cm	12.30 cm	28.40 cm	approx. 21
	3002 - Female	5.00 kg	31.00 cm	22.70 cm	12.50 cm	29.60 cm	approx. 22

Table 3. Length of time tortoises were held in the laboratory, and the length of time they remained associated with their release burrow on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia

Tortoise Status	Tortoise ID and Sex	Date Captured	Date Released	No. of Days Held	No. of Days in Release Burrow Before Moving to Another Burrow
Indigenous with Relocated	1011 - Male	6-May-96	21-May-96	15	18
	4004 - Male	5-May-96	21-May-96	16	0
	4005 - Male	16-May-96	21-May-96	5	14
	8007 - Female	1-Jun-96	6-Jun-96	5	4
	8009 - Female	25-May-96	27-May-96	2	0
Relocated with Indigenous	8003 - Male [a]	2-Jun-96	11-Jun-96	9	5
	8006 - Male	21-Apr-96	30-May-96	39	31
	8008 - Male [b]	18-May-96	30-May-96	12	0
	4001 - Female	25-May-96	30-May-96	5	123
	1012 - Female	25-Apr-96	30-May-96	35	56
Isolated Indigenous	5002 - Male	16-May-96	21-May-96	5	16
	5005 - Male	5-May-96	21-May-96	16	56
	5008 - Male [c]	4-May-96	21-May-96	17	---
	1017 - Female	17-May-96	21-May-96	4	26
	5012 - Female	5-Jun-96	6-Jun-96	1	0
Isolated Relocated	3003 - Male [d]	14-May-96	30-May-96	16	0
	3004 - Male	14-May-96	30-May-96	16	9
	3005 - Male	16-May-96	30-May-96	14	47
	3001 - Female	8-Jun-96	11-Jun-96	3	138
	3002 - Female	15-May-96	30-May-96	15	29

a. Left relocation site 7 days after release, above ground when found.
b. Left relocation site 147 days after release, in burrow when found.
c. Transmitter failed 7 days after release.
d. Left relocation site 9 days after release, above ground when found.

Table 4 . Co-occupancy of burrows used by tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia

Date Observed	Burrow Number	Tortoises Involved
28-30 May 1996	8 - 4	Indigenous Male 4004 and Indigenous Female 8009
6-8 June 1996	8 - 7	Indigenous Male 4004 and Indigenous Female 8007
28-Jul-96	unmarked	Relocated female 3002 and unmarked indigenous male
3-Aug-96	newly excavated	Indigenous Male 1011 and relocated female1012
28-Aug-96	9 - 3	Indigenous male 4004 and indigenous male 4005
28-Aug-96	1-12	Indigenous male 1011 and relocated female 1012
24-Sep-96	9 - 3	Indigenous male 4004 and indigenous male 4005

Table 5. Monthly movements of tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

Tortoise Status	Tortoise ID and Sex	June	July	August	September	October
Indigenous with Relocated	1011 - Male	2	3	9	1	0
	4004 - Male	2	2	2	0	1
	4005 - Male	3	2	8	3	2
	8007 - Female	2	5	2	2	0
	8009 - Female	5	4	5	2	2
Relocated with Indigenous	8003 - Male [a]	-	-	-	-	-
	8006 - Male	0	5	6	1	3
	8008 - Male [b]	1	4	5	2	5
	4001 - Female	0	0	0	0	1
	1012 - Female	0	1	1	0	0
Isolated Indigenous	5002 - Male	5	6	7	3	3
	5005 - Male	0	4	8	6	2
	5008 - Male [c]	-	-	-	-	-
	1017 - Female	2	2	0	0	3
	5012 - Female	2	1	4	0	1
Isolated Relocated	3003 - Male [d]	-	-	-	-	-
	3004 - Male	2	6	5	1	0
	3005 - Male	0	3	0	0	2
	3001 - Female	0	0	0	0	0
	3002 - Female	0	5	0	4	2
Total		*26*	*53*	62	25	27

a. Left relocation site 7 days after release, above ground when found.
b. Left relocation site 147 days after release, in burrow when found.
c. Transmitter failed 7 days after release.
d. Left relocation site 9 days after release, above ground when found.

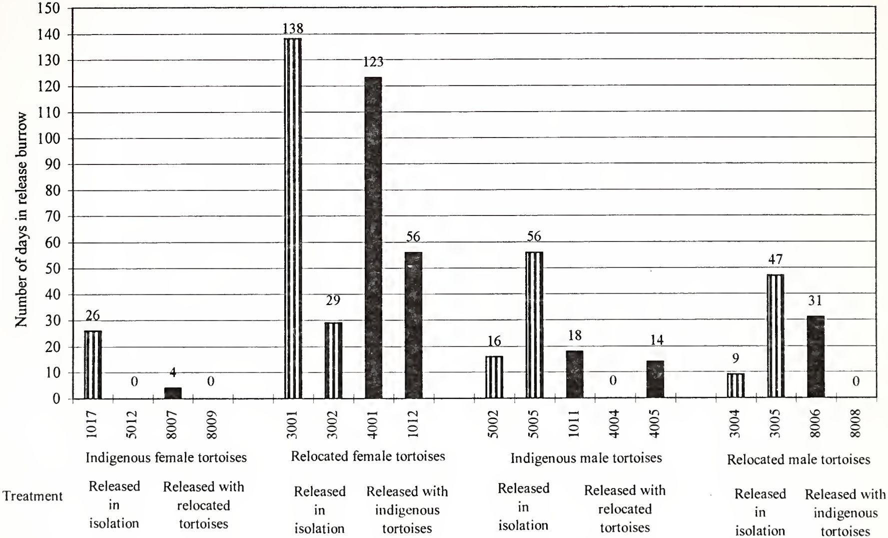


Figure 3. A comparision of the number of days female and male tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia, remained in their release burrow before moving.

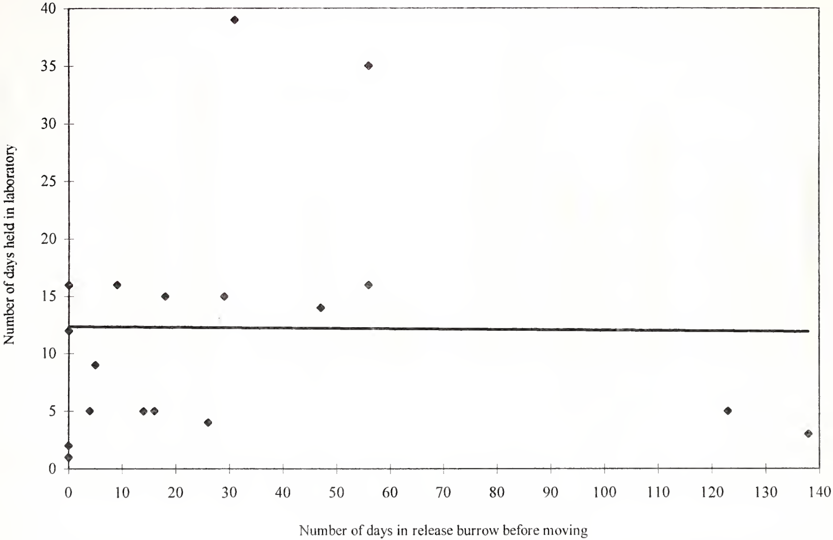


Figure 4. Relationship between the number of days tortoises were held in the laboratory and the number of days they remained in their release burrows before moving (r = - 1.382 E = - 02).

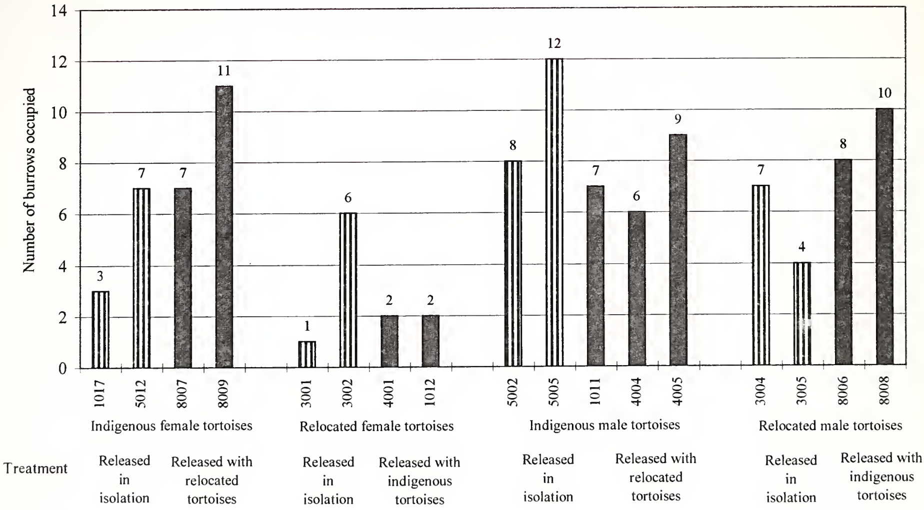


Figure 5. A comparision of the number of different burrows occupied by female and male tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

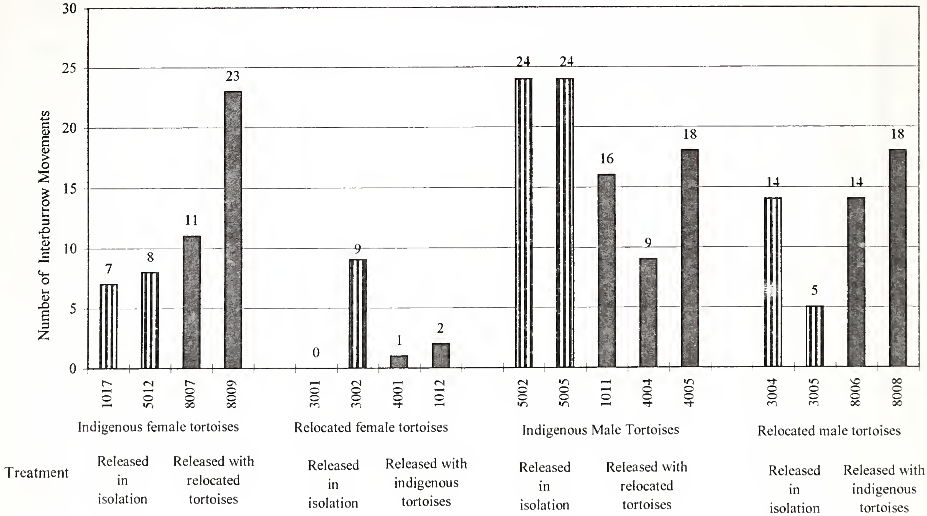


Figure 6. A comparision of the number of interburrow movements between female and male tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

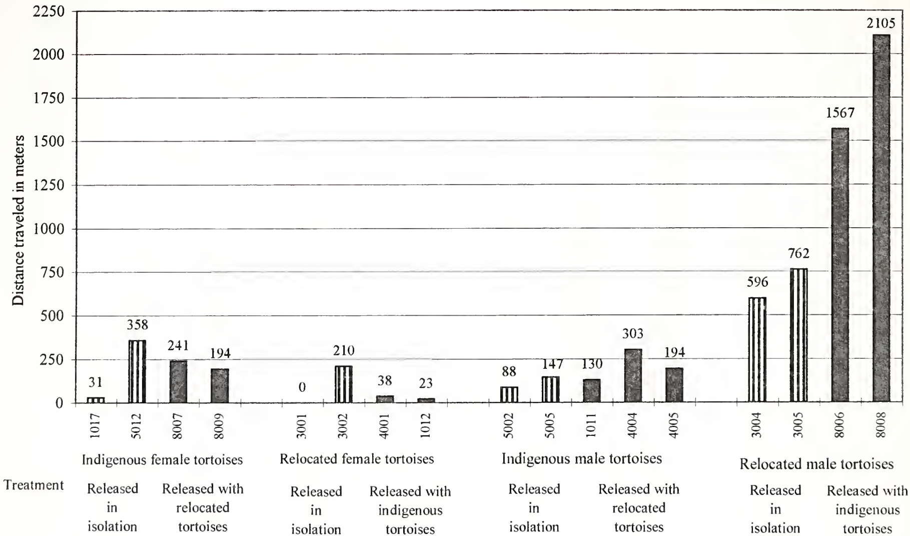


Figure 7. A comparision of the average distanced traveled from the release burrow to all burrows occupied by female and male tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

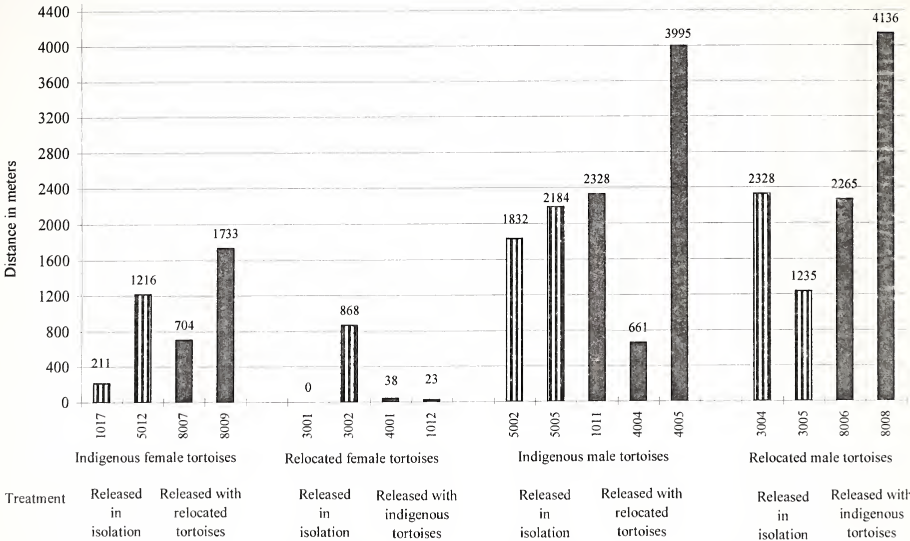


Figure 8. A comparision of the total distance traveled among female and male tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

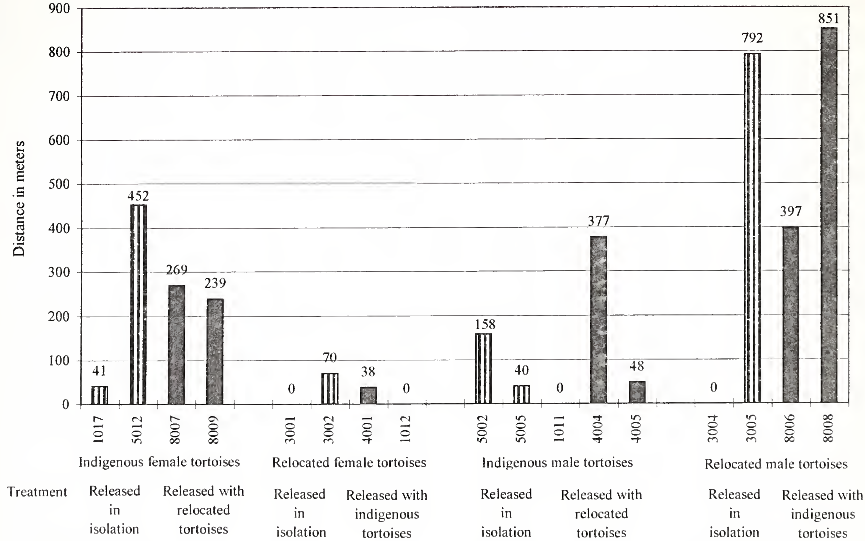


Figure 9. A comparision of the distance traveled from the final burrow occupied to the release burrow, for female and male tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

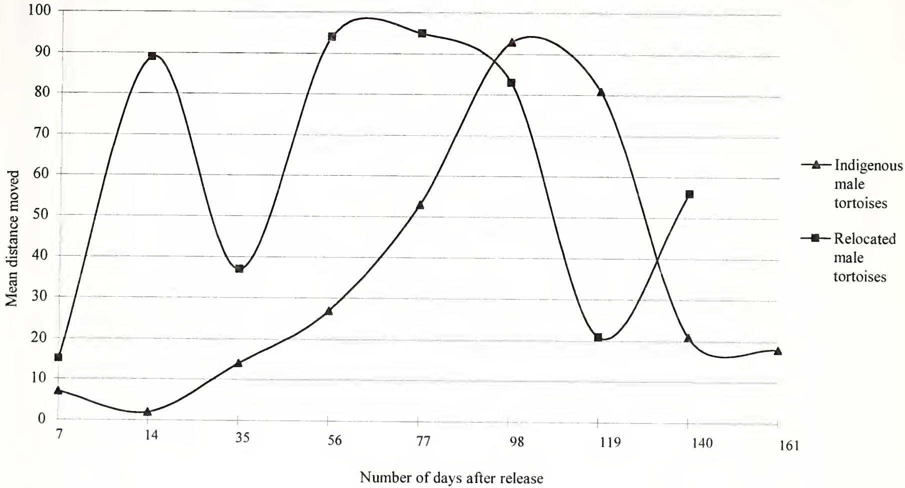


Figure 10. A comparison of the mean distance traveled after release by indigenous and relocated male tortoises released on or indigenous to a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

DISCUSSION AND CONCLUSION

Although gopher tortoise relocation efforts have taken place for many decades by well-meaning individuals and biologists, there is still a need for basic information regarding the effect relocation has on these reptiles. Only recently, by using radio transmitters attached to the carapace, have researchers been able to better document the behavioral responses of relocated tortoises, and indigenous tortoises that have had relocated tortoises placed among them. As with the desert tortoise, the increasing scarcity of suitable, unoccupied, gopher tortoise habitats in Florida and other southeastern states will probably force greater emphasis on relocations into sites with resident populations (Layne 1989). Relocation of desert tortoises into an area with a resident population, even if the density is below the carrying capacity, has high potential for disrupting the resident social system (Berry 1986). A report by Landers (1981) does not support this view, "It was determined that tortoises could be easily established where a few individuals were already present." I found that releasing relocated tortoises into indigenous populations does not appear to have a significant adverse effect on the indigenous tortoises, nor on relocated individuals that are released into indigenous populations.

Nineteen tortoises monitored for this study were captured in the early spring by placing pitfall traps at the burrow entrance. There is some question whether the season in which a tortoise is captured and relocated has an affect on site fidelity. Diemer (1989) has reported that attempting a relocation effort during the late summer or fall, a time when tortoises may already be migrating to winter burrows, may increase the tendency for relocated tortoises to disperse. Although I think the time of year tortoises were trapped may be important, further information is needed to determine if the season, in which tortoises slated for relocation are captured, affects their fidelity to the relocation site.

Although several tortoises were caught within a week of placing a trap at a burrow, it is recommended that bucket traps remain in place for a minimum of 30 days because of the unpredictability of tortoise behavior. At the present time it is still unclear what motivates a tortoise to leave its burrow. Patience was rewarded when four tortoises in this study were finally captured in pitfall traps after 25, 26, and 27 days had elapsed.

After being captured, the ten relocated tortoises and ten indigenous tortoises were held varying lengths of time (tortoises caught first were held the longest) in order to re-release indigenous tortoises first. In this study the number of days tortoises were held before release and the number of days they remained in their release burrow before moving showed no correlation. These results are supported by a previously published reports by Stout et.al (1989) and Berry (1986).

Burrow use and interburrow movements by tortoises in the present study were consistent with previous published papers on tortoise relocation. I found that indigenous tortoises occupied more burrows and moved more frequently then relocated tortoises; and that males moved more than females. Also, the comparisons of interburrow movements, number of burrows occupied, average distance moved, and total distance moved were either significant or highly significant with respect as to gender, source, treatment and all interactions among the above variables. These variables were significant because indigenous tortoises were perhaps more familiar with their surroundings. Because they may have known the locations of previously occupied burrows, they moved more readily from one to another which resulted in more interburrow movements and a greater number of occupied burrows. Relocated male tortoises were in contrast; not familiar with their surrounding and therefore moved longer distances between burrows, finding such burrows through random wanderings, or following scent trails left by other tortoises. "The means by which tortoises locate burrows in unfamiliar habitat is unknown although olfaction probably plays an important role in their detection," Birkhead and Stokes (1996). The greater distances and frequencies of movements among male tortoises in general may also be the result of males actively searching for females.

Female gopher tortoises in this study (indigenous and relocated) did not move as often, nor as far when they did move compared to male tortoises. Three female indigenous tortoises initially moved several hundred meters while one remained at her release burrow. One female left, than returned to her initial release area, and two others remained, near their initial site of capture and release, moving between several burrows within 50m or less to each other. The relocated female tortoises not being familiar with their release area, and not being as aggressive as male tortoises, remained very close to their release burrows. The tortoises benefited from the excellent quality of the habitat on the relocation site. The abundance of ground cover vegetation and inactive burrows provided foraging opportunities and shelter within short distances of their release burrows were, in combination with the previous factor may have been the reason relocated female tortoises moved so little.

By mid-summer, I found that the distances relocated male tortoises that still remained on the relocation site had moved between burrows had decreased (Figure 10). This decrease in movement may have occurred because relocated males were becoming acclimated with their surroundings and establishing site fidelity (home ranges) to the relocation site. As other burrows were located in an area, the distances traveled among them could be minimized. Movement patterns also changed from a straight line compass heading for hundreds of meters to a more random pattern among neighboring burrows. This change in behavior of relocated male tortoises is reflected in the distance recorded from the release burrow to the last burrow occupied. The final distance for relocated tortoises was not significantly different from indigenous tortoises. One relocated male tortoise even returned to his release burrow at the end of the activity season, after moving hundreds of meters away. The movement patterns I observed in this study have been described in several other studies on gopher tortoise relocation. For example, Layne (1989), " ... reported that both resident and relocated males moved more than females with the difference being more pronounced in the relocated group. This difference may reflect a higher level of aggression of resident males toward relocated males than toward relocated females; also, the maximum distance relocated females moved from their release burrows to successive recapture points were only 45% to 54% of those for relocated males, compared with the respective distances of 73% and 69% obtained from resident females." Bard (1989) noted that, "indigenous tortoises had a greater number of interburrow movements, but traveled shorter distances between burrows com-pared to relocated tortoises." Stout et al. (1989) reported similar results, "... relocated tortoises had moved greater overall distances than had indigenous tortoises." Berry (1986) found that among desert tortoises adult males may be more aggressive, active, and may disperse farther than females and juveniles.

At the end of an activity season, all nine of the indigenous tortoises (one transmitter failed) and seven of the ten relocated tortoises released remained on the relocation site. This percentage is higher than reported in other papers on gopher tortoise relocation. A relocation study in Mississippi carried out under conditions similar to this study (tortoises released singly without any special pre-release treatment in areas with natural populations), resulted in only one (5%) of 19 individuals surviving one season. The authors concluded that "... simple release of relocated tortoises may not be worthwhile," (Lohoefener and Lohmeier 1986). Other published papers, as well as this study, contradict these findings. Berry (1986) reported 50% of the desert tortoises (*G. agassizii*) relocated still remained on a relocation site 12.5 months after being released, and 32% of tortoises released remained at a second site after six years. Stout et al. (1989) reported 58% of 12 relocated tortoises remained on or near one of three relocation sites. At a second site 55% of nine tortoises released remained at the end of ten months, and at the last site (a fenced 16ha preserve) 100% of twenty-five tortoises relocated remained. Layne (1989) reported 29% of relocated tortoises survived at least one to 14 years. He concludes that, " in some cases, tortoises introduced into natural populations may have relatively good survival." In a summary on restocking success on four sites in southwestern Georgia, Landers (1981) concluded about 41% (estimated by burrow count) of the relocated tortoises remained near their release sites three years after relocation.

The greatest activity in the present study as evidenced by interburrow movements occurred during July and August. Diemer (1992) reports the long distance movements by adult males occurred primarily in late July and August, coinciding with the late summer and fall period of spermatogenesis. In the present study, activity decreased more than 50% during September and October. McRae et al. (1981) correlated gopher tortoise activity patterns with ambient temperature. They determined that the frequency of activity measured by trapping active burrows, and monitoring tortoises fitted with transmitters, increased linearly with the gradual warming trend. Similar activity patterns have been reported by Birkhead and Stokes (1996). If a time constraint is associated with a particular relocation project, trapping tortoises at the peak of activity (July and August) as opposed to spring or fall could be beneficial because fewer trapping days would be required.

Homing tendencies and dispersal by relocated tortoises has also been a concern. Berry (1986) reported that tortoises displaced a few kilometers or less may return home. Diemer (1984) describes how a "harvested" tortoise relocated 1.3 km away from its former home returned to within 32m of its original burrow. Mc Rae et al. (1981) noted that four relocated male tortoises were found along roads between 1.9 and 7.7 km from the release point heading in the general direction of their former home. Two tortoises left the relocation site early in the present study. However, they did not travel in a compass heading that would have taken them back to the donor site. One male tortoise did however return to his capture area approximately a kilometer away. Although two relocated male tortoises left the relocation site shortly after their release, and one left near the end of the activity season, the three remaining relocated males, all four relocated females, and all indigenous tortoises remained on the relocation site.

Monitoring the tortoises daily for a week after release, then every three days thereafter was helpful in preventing the loss of a tortoise after its release, as they are capable of traveling hundreds of meters in a day. Furthermore, the availability of numerous inactive burrows in what was felt to be optimal gopher tortoise habitat may have been beneficial to relocated tortoises while they sought food and shelter as they established site fidelity. In other words, because these tortoises were relocated to an optimal habitat in which other tortoises were present stresses typically associated with relocation were reduced.

In summary, male tortoises moved more often and occupied a greater number of burrows than female tortoises. There was no significant difference in movements and burrow use between indigenous male tortoises that were released with relocated tortoises and indigenous male tortoises that were released only with other indigenous tortoises. On the other hand, a significant difference was seen in the movement patterns of relocated male tortoises and indigenous male tortoises both in regard to the number of burrows occupied and the number of interburrow movements. This could be because indigenous tortoises (male and female) are more familiar with the location of burrows and though they moved more often, they traveled shorter distances on the average among the burrows they occupied. Relocated tortoises are not familiar with the location of burrows in their release area and made fewer interburrow movements. When they did move they traveled a greater average distance then indigenous tortoise before locating another burrow. Gender was a significant factor because male tortoises are generally more active and will aggressively seek mates over long distances. When the average distance traveled between the release burrow and all other burrows occupied is considered, significant differences between gender, treatment, source, and the inter-action of gender, and/or source, and/or treatment occurred. Overall, relocated male tortoises traveled a greater distance than all other tortoises. Female tortoises occupied fewer burrows and moved shorter distances than male tortoises. Indigenous female tortoises released with relocated tortoises and indigenous females released in areas with only indigenous tortoises did not differ significantly in their burrow usage and distances moved. Relocated female tortoises were the most restrictive in their movements. These tortoises occupied fewer burrows, had fewer interburrow movements, and traveled shorter distances than indigenous females, or indigenous and relocated male tortoises. There was also a significant difference between the behavior of relocated female tortoises released with indigenous tortoises and those released in areas with only relocated tortoises. Those relocated female tortoises that were released with indigenous tortoises occupied the fewest burrows, and had the fewest number of interburrow movements. They also traveled the least distance (both average and total) compared to all tortoises in all treatment areas. There was no significant difference among any group in the distance from the release burrow to the final burrow occupied.

Despite the controversy associated with its use as a conservation strategy, relocation could soon become a critical factor in helping sustain gopher tortoise populations in Georgia. Genetic exchange among partially isolated populations normally occurs by migration and emigration. Local populations may only be partially isolated from other gene pools, with some probability that genetic exchange does occur between them. An endangered or threatened species (such as gopher tortoises) may not experience a normal gene flow equilibrium in some parts of its range. Many gopher tortoise populations in the fall line sandhills and other locations have been lost, and remaining populations are dangerously small and fragmented (Birkhead and Wester 1993). Habitat destruction, blockage of migratory routes, clear-cutting, urbanization, and other human activities isolate populations that would normally experience genetic exchange with other populations. Moving individuals and combining small isolated populations, such as that done here simulates natural gene flow by artificial means (Meffe et al. 1997). The subdivision and development of large, intact land-scapes can isolate wide-ranging species, alter migration routes, and disrupt crucial ecosystem functions. Habitat fragmentation represents the greatest threat to biodiversity in most rural communities (Sawhill 1997). Gopher tortoise relocation if carefully planned can simulate gene flow, thereby helping maintain a degree of genetic viability in populations within a region. Protecting existing habitat should however remain the top priority in any conservation strategy because the gopher tortoise is a keystone species. Every effort should be made to identify as many of the commensals as is possible that are associated with gopher tortoise burrows.

After only one activity season of monitoring these tortoises, it is to soon to draw conclusions on the long term success of this relocation study. The relocation project has been a success by answering the objectives and in adding new information about the responses of gopher tortoises to change. Because it is not always possible to preserve gopher tortoise habitat that is scheduled for development, the results obtained here support those who believe that it is worthwhile to attempt the relocation of gopher tortoises into suitable habitats especially those with indigenous populations. In concurrence with opinions of other researchers, gopher tortoises can be relocated short distances ($\leq$ 32 km) to areas in which indigenous tortoises are present. The effects associated with these efforts appear to be minimal.

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APPENDIX - A

Guidelines for Gopher Tortoises Relocations

Presented 1 February 1988 by the State of Florida Game and Fresh Water Fish Commission

"The following guidelines have been developed specifically to constitute what is acceptable to the commission as measures which would effect such maximization of success potential when, as a last resort, gopher tortoises are deemed in need of relocation (FG&FWFC 1989)."

These guidelines are as follows; a permit is required for a gopher tortoise capture-relocation project that includes local, state, and federal approval for the proposed land use involved, and a permanent management commitment for relocation recipient sites compatible with gopher tortoise survival; applicants must show they are trained or experienced in such work. Because tortoises become dormant during winter, relocations should not be undertaken during the winter months and releases should not be made during the hottest part of the day at sites where shade is limited. No more than four weeks before relocation, all potential gopher tortoise habitats on a given development site should be throughly surveyed and burrows found active or inactive are to be plotted on maps for future reference. Sites selected as recipient sites should be of a similar habitat as the donor site or shown to be suitable for gopher tortoise occupancy. The carrying capacity of the recipient site should be determined and sites at or near carrying capacity should not be selected as a recipient site. Relocation of 20 or fewer tortoises should be to recipient sites with indigenous tortoises; relocation of more than 20 tortoises should be to recipient sites that are either vacant or with indigenous populations below the carrying capacity of that site. Relocated tortoises may be moved any distance east or west but no more than 50 miles north or south of the donor sites; areas that may have populations of genetically unique tortoises should not overlap or abut sites where relocated tortoises are being released; recipient sites should be surveyed prior to relocation and all burrows plotted on a map and categorized as "active," "inactive," or "old"; tortoises can be excavated from burrows, trapped or otherwise captured by non-harmful means. If trapped, bucket traps should be covered with paper or non fraying cloth and overlain with soil. Traps should be shaded, provided with drainage holes, and checked daily for a minimum of 28 consecutive days. Captured tortoises must be transported quickly and under shaded and sanitary conditions; on already occupied release sites, relocates should be distributed throughout the site and, when possible released at “old”or “inactive” burrows. One year after release, recipient sites should be throughly resurveyed and all encountered burrows are plotted on maps and categorized as “active”, “inactive,” or “abandoned (old) “. Any tortoise mortality or debilitating injury occuring during the capture, relocation, and release phases of a relocation is to be reported.

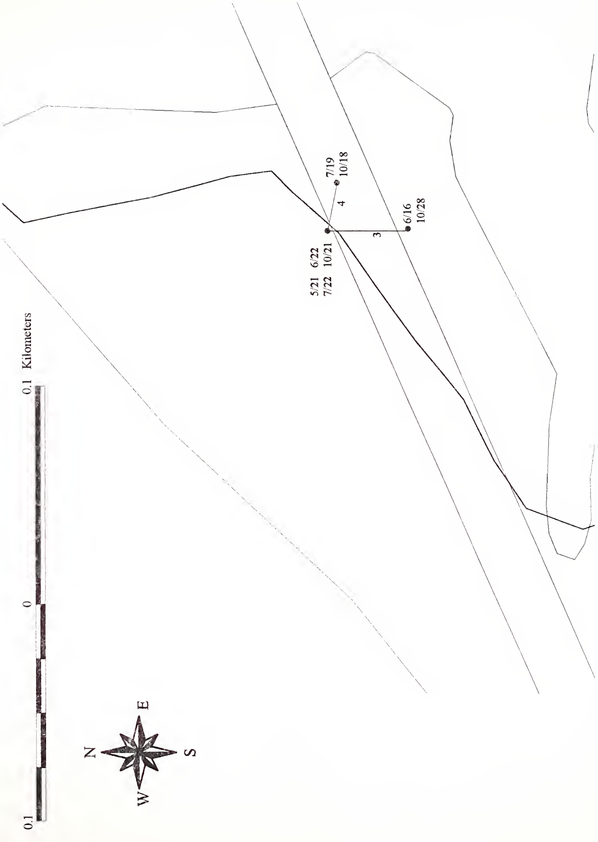
APPENDIX - B

Study Areas Showing Movements and Burrows Occupied

The following 17 maps show enlarged sections of the relocation site. The movements and burrows occupied by each indigenous and relocated tortoise monitored in this relocation study are shown in detail.

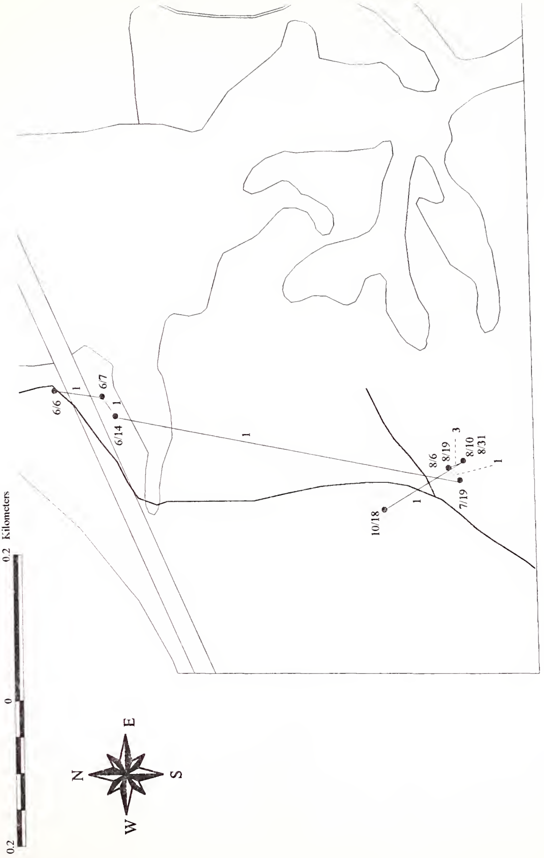
The individual maps were created by the Arcview GIS mapping program, field notes, and computer generated maps showing the geographical position of burrows occupied, as recorded by a Trimble Pathfinder global positioning unit. The placement of burrows and routes between burrows is as accurate as map size and scale will allow. All routes traveled between burrows are shown as straight lines and may not reflect the use of nearby roads or paths used by a particular tortoise to travel from one burrow to another. The dates by each burrow occupied (or off set by a dotted line) indicate the date the tortoise was located there. The number of times a tortoises traveled between a pair of burows is indicated by a number adjacent to the line (or off set by a dotted line) connecting the burrows.

Map 1. Movements and burrows occupied by indigenous female tortoise 1017, released with indigenous tortoises only, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

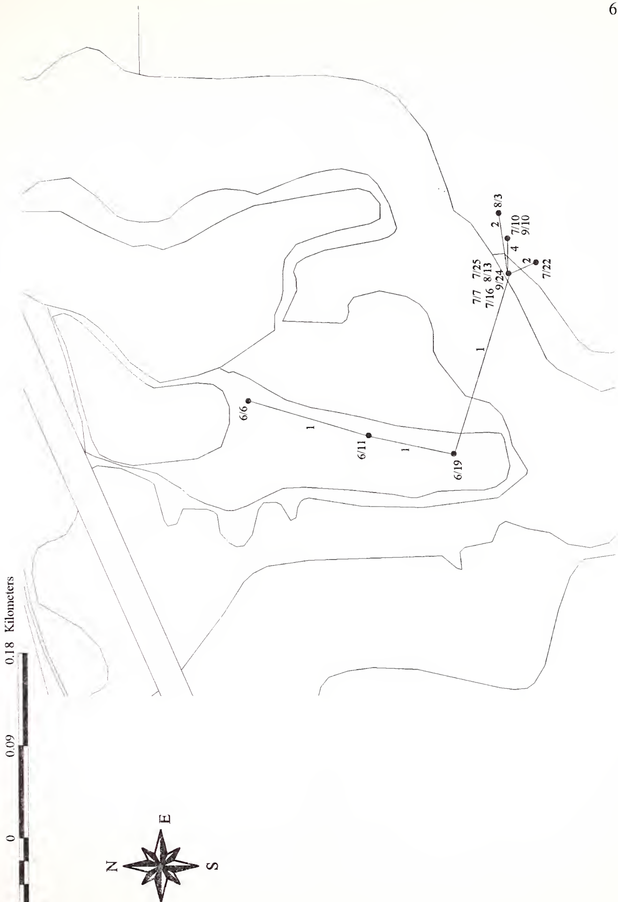


7/19
10/18
4
6/16
10/28
3
5/21 6/22
7/22 10/21
0.1 Kilometers
0
0.1
N
E
S
W

Map 2. Movements and burrows occupied by indigenous female tortoise 5012, released with indigenous tortoises only, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.2 Kilometers
0
0.2
N
E
S
W
6/6
6/7
6/14
8/6
8/19
8/10
8/31
7/19
10/18
1
3

Map 3. Movements and burrows occupied by indigenous female tortoise 8007, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

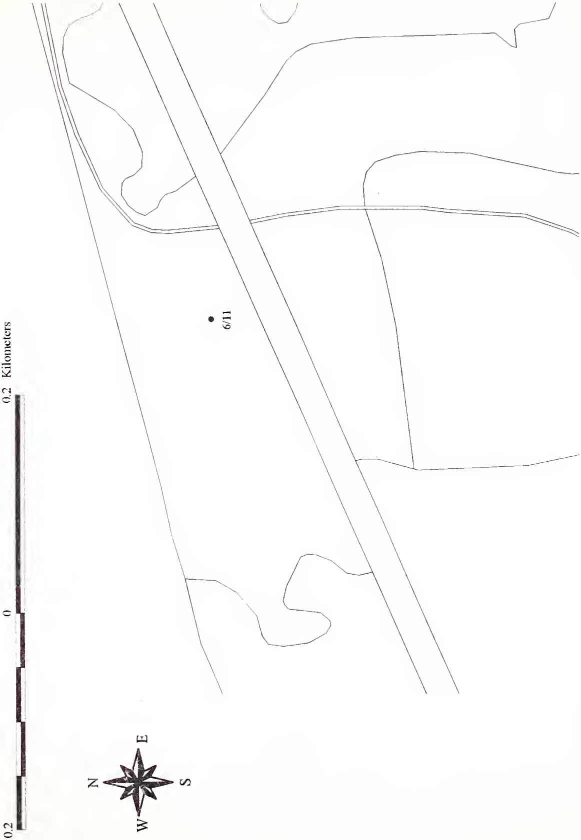


0.09
0
0.09
0.18 Kilometers
N
E
S
W
6/6
6/11
6/19
1
1
1
7/7
7/16
7/25
8/13
9/24
2
4
2
8/3
7/10
9/10
7/22

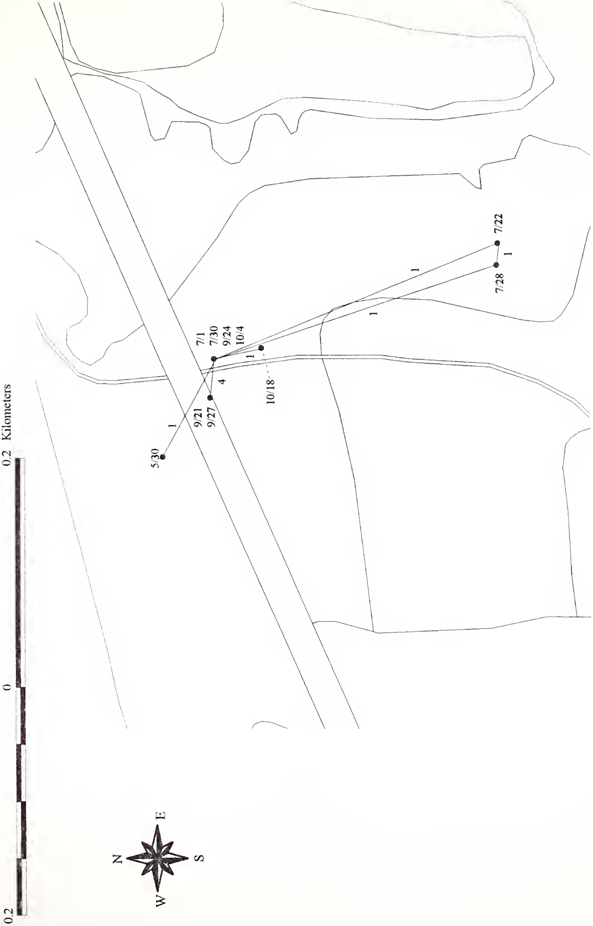
Map 4. Movements and burrows occupied by indigenous female tortoise 8009, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.2
0
0.2 Kilometers
N
E
S
W
5/27
6/1
5/31
6/25
8/1
7/4
7/28
10/21
7/10
7/22
8/13
9/7
9/24
10/24
8/16
8/31
8/28
5/28
6/19
7/1
7/19
6/14
9/21
6/4

Map 5. Movements and burrows occupied by relocated female tortoise 3001, released with relocated tortoises only, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


6/11
0.2
0
0.2 Kilometers
N
E
S
W

Map 6. Movements and burrows occupied by relocated female tortoise 3002, released with relocated tortoises only, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.2 Kilometers
0
0.2
N
E
S
W
5/30
1
9/21
9/27
4
7/1
7/30
9/24
10/4
1
10/18
1
1
7/22
1
7/28

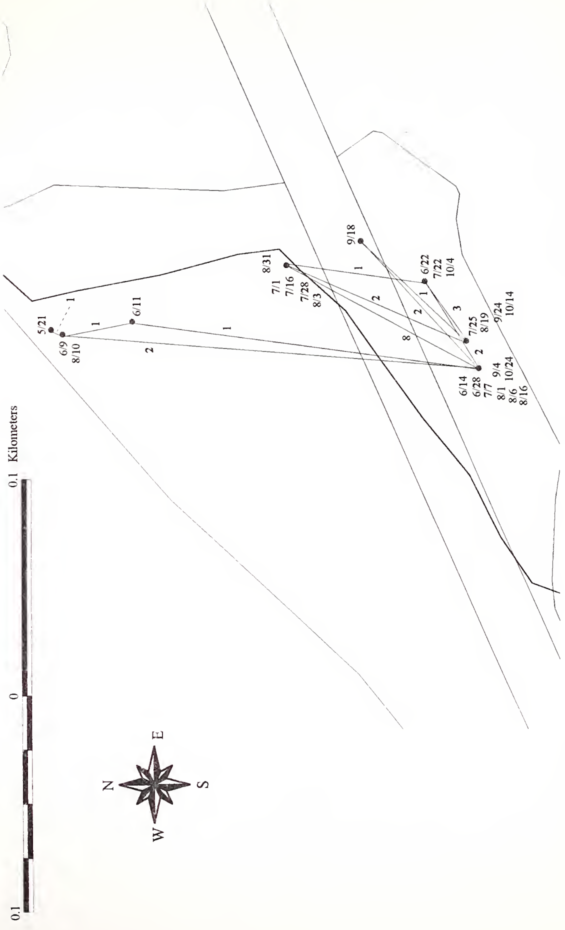
Map 7. Movements and burrows occupied by relocated female tortoise 4001, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


10/4
1
5/30
0.1 Kilometers
0
0.1
N
E
S
W

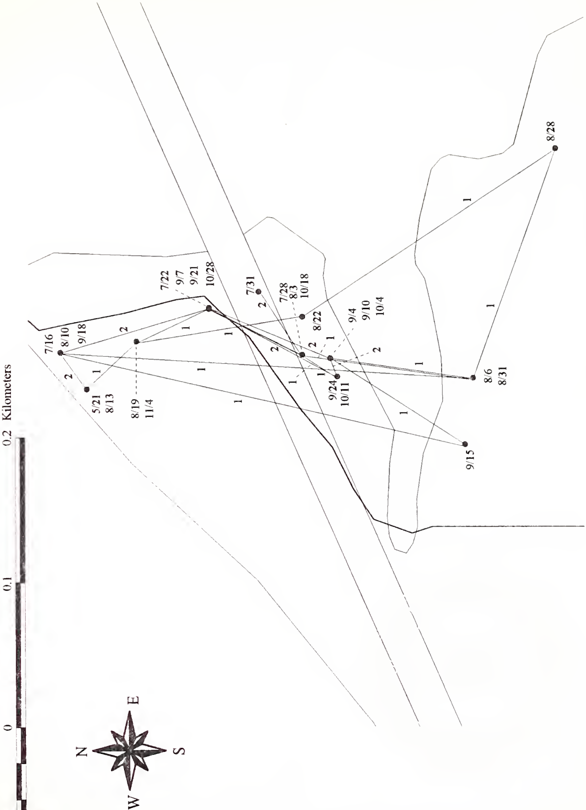
Map 8. Movements and burrows occupied by relocated female tortoise 1012, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


7/28
2
5/30
8/28
0.1
0
0.1 Kilometers
N
E
S
W

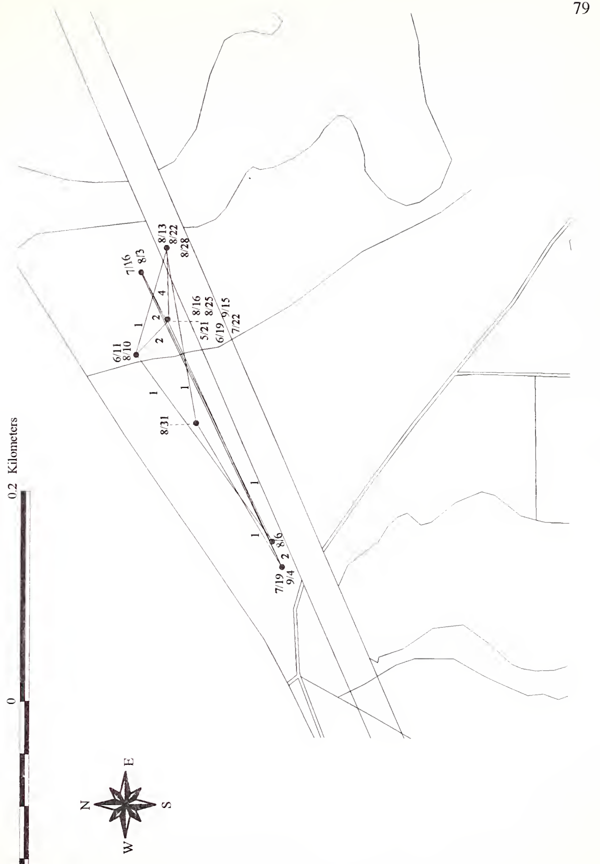
Map 9. Movements and burrows occupied by indigenous male tortoise 5002, released with indigenous tortoises only, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.1 Kilometers
0
0.1
N
E
S
W
5/21
6/9
8/10
6/11
8/31
7/1
7/16
7/28
8/3
9/18
6/22
7/22
10/4
7/25
8/19
9/24
10/14
6/14
6/28
7/7
8/1
8/6
8/16
9/4
10/24

Map 10. Movements and burrows occupied by indigenous male tortoise 5005, released with indigenous tortoises only, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.1
0
0.1
0.2 Kilometers
N
E
S
W
7/16
8/10
9/18
5/21
8/13
8/19
11/4
7/22
9/7
9/21
10/28
7/31
7/28
8/3
10/18
8/22
9/4
9/10
10/4
9/24
10/11
8/6
8/31
9/15
8/28

Map 11. Movements and burrows occupied by indigenous male tortoise 1011, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.2
0
0.2 Kilometers
N
E
S
W
7/16
8/3
8/13
8/22
8/28
6/11
8/10
8/16
8/25
9/15
5/21
6/19
7/22
8/31
8/6
7/19
9/4

Map 12. Movements and burrows occupied by indigenous male tortoise 4004, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

5/21
1
5/23
2
5/22
6/2
8/3
2
6/11
7/19
3
7/10
10/28
0.2 Kilometers
0
0.2
N
E
S
W

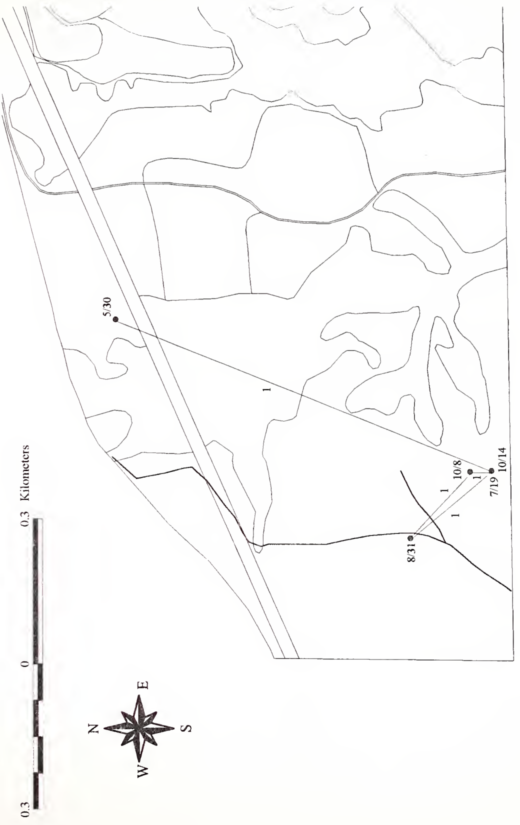
Map 13. Movements and burrows occupied by indigenous male tortoise 4005, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.2
0
0.2 Kilometers
N
E
S
W
5/21
6/5
8/6
6/22
8/22
7/19
9/4
10/28
8/19
8/3
6/19
7/7
8/1
8/16
9/27
8/28
9/24
8/31
10/14
1
2
3
4

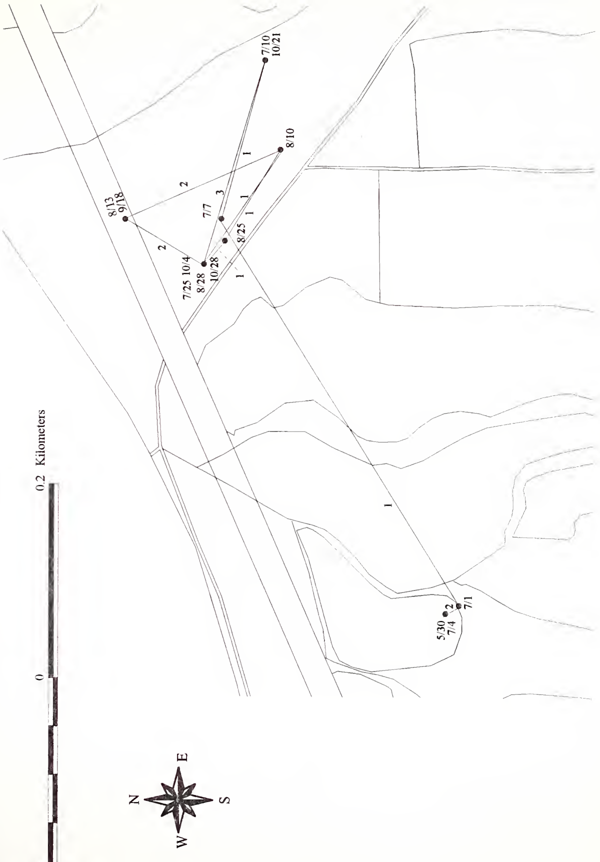
Map 14. Movements and burrows occupied by relocated male tortoise 3004, released with relocated tortoises only, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.

0.3 Kilometers
0
0.3
N
E
S
W
8/31
5/30
8/22
9/4
8/19
7/16
8/13
7/22
7/28
8/16
7/25
8/3
7/10
6/16
7/13

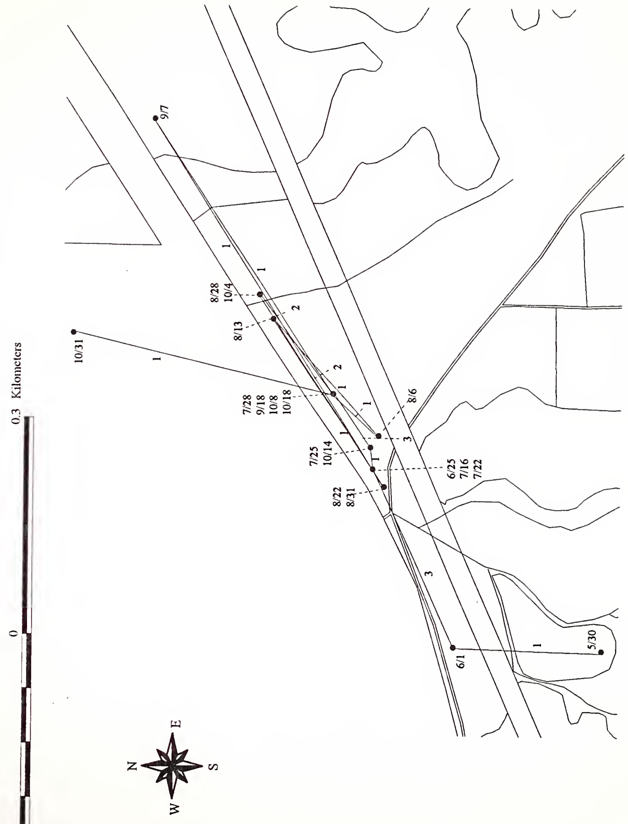
Map 15. Movements and burrows occupied by relocated male tortoise 3005, released with relocated tortoises only, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.3 Kilometers
0
0.3
N
E
S
W
5/30
1
10/8
10/14
7/19
1
1
1
8/31

Map 16. Movements and burrows occupied by relocated male tortoise 8006, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.2 Kilometers
0
0.2
N
E
S
W
7/10
10/21
8/10
8/13
9/18
7/7
7/25 10/4
8/28
10/28
8/25
5/30
7/4
7/1
1
2
3

Map 17. Movements and burrows occupied by relocated male tortoise 8008, released with indigenous and relocated tortoises, on a 336 ha tract, 3.2 km east of Geneva, Talbot County, Georgia.


0.3
0
0.3 Kilometers
N
E
S
W
9/7
8/28
10/4
8/13
10/31
7/28
9/18
10/8
10/18
8/6
7/25
10/14
6/25
7/16
7/22
8/22
8/31
6/1
5/30
1
2
3