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Effects of Tracked-Vehicle Training Activity on Gopher Tortoise (*Gopherus polyphemus*) Behavior at Fort Benning, GA

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ABSTRACT: This research examined the influence of tracked-vehicle use on gopher tortoises (*Gopherus polyphemus*) on Fort Benning, GA. Did tortoises on sites with heavy tracked-vehicle use differ from those in areas with limited tracked-vehicle use in: number of burrows used during the active season; rates at which female tortoises receive visitors; and number of males that visit each female? Data from an undisturbed off-post site with characteristics of old-growth longleaf pine forest were used for comparison. Similar numbers of burrows were used by both sexes in both the heavily disturbed and less-disturbed sites on Fort Benning, but more burrows per animal were used at the undisturbed comparison site. Significantly fewer total social visits were received by females in the more highly disturbed sites. In both the less-disturbed areas and the off-post site, many more different males visited each female. One conclusion drawn is that females on sites impacted by tracked-vehicle activities seem to have more limited options for mate choice and, therefore, are susceptible to problems associated with inbreeding and restricted gene flow. These susceptibilities are not desirable for population viability.

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Preface

This study was conducted for the Army Environmental Quality research program (PE 62720A896) under project number 005Z0L, "TES Mission Impact Studies," and project number 0079X3, "Maneuver Disturbance Extrapolated to User Primary Species." The technical monitor was William Woodson at the Army Chief of Staff for Installation Management.

The work was completed under the direction of the Ecological Process Branch (CN-N) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator and contract monitor was Dr. Harold Balbach. The field work and preliminary report preparation was performed by the Department of Biological Sciences, Auburn University, Auburn, AL. Dr. Craig Guyer was the Auburn University Principal Investigator, and Roger Birkhead was a graduate assistant in the department. The work was completed under Purchase Request No. W81EWF-0216-9636. Patricia M. Kirby, Colorado State University contractor, coordinated preparation of the final report. Alan B. Anderson is Chief, CN-N, and Dr. John T. Bandy is Chief, CN. The associated Technical Director was Dr. William D. Severinghaus. The Acting Director of CERL is Dr. Ilker Adiguzel.

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1 Introduction

Background

Domestic Army installations and installations of other U.S. military services cover more than 25 million acres (about 10 million hectares) of land. This land area includes significant parcels where training intensity is low enough, or infrequent enough, to allow the continuation of populations of species which, though originally common to the area, are now much less common outside the installation than within it (Fatz 2003; NatureServe 2005). Some of these species are designated as endangered or threatened under the Endangered Species Act of 1973 (PL 93-205; 16 USC 1531 et seq., as amended) (ESA). Others are not yet so designated, but are considered locally or regionally threatened or of special concern (NatureServe 2005). Army installation managers are regularly called upon to accommodate the needs of such species to the greatest degree possible without compromising the essential mission activities of the base.

The gopher tortoise (*Gopherus polyphemus*) is a large, land-dwelling turtle which is or was found in parts of six southeastern states. Populations are declining throughout their range. One report (Auffenburg and Franz 1982) estimated that, in the last 100 years, gopher tortoise populations have declined by 80 percent. This significant decline resulted in the species being listed by the Fish and Wildlife Service (FWS) as "Threatened" in Louisiana, Mississippi, and west of the Tombigbee and Mobile Rivers in Alabama (*Federal Register*, July 7, 1987). Within this Federal listing area lies Camp Shelby, MS, the only Army installation reporting (Bak et al. 2002; Rubinoff et al. 2004) the gopher tortoise on its property. The tortoise is being studied as a part of the Army Threatened and Endangered Species (TES) Research Program due to the potential for training conflicts at locations within the nonlisted (eastern) population were the tortoise to be listed, as was recommended by an advisory group in January 2003 (Smith et al. 2005). Eighteen military bases are known to have gopher tortoises (Wilson et al. 1997), including Fort Rucker, AL, and several outlying landing fields; Forts Benning, Gordon, and Stewart, GA; Camp Blanding and Eglin Air Force Base, FL; and at least eleven other Navy, Marine Corps, and Air Force installations in Florida and Georgia. Forts Benning and Stewart, GA, especially, are major training installations where large populations of the tortoise survive. The installations manage the tortoise at its current, state-level designation as a "species of concern"; however, the potential exists for significant

additional management burden and for further impact on mission should the species proceed to listing under the ESA. This potential is the basis for studying the species at locations where it is not now listed. Studying the species at locations where ESA requirements for work with the animal are not yet required also has the advantage of not requiring permits from the U.S. Fish and Wildlife Service, although state requirements must be followed.

Historically, gopher tortoise populations occurred in relatively open longleaf pine stands that were maintained by wildfire. Throughout their range, exclusion of fire has transformed suitable open upland habitat into dense mixed hardwood forests that are no longer suitable for gopher tortoises. Gopher tortoises now often inhabit ruderal areas that are cleared and maintained as some mix of grasses and forbs, usually through mowing. On military bases, gopher tortoises often place their burrows in areas that are maintained for training (e.g., firing points, ranges, and airstrips). At Camp Shelby Training Site, the highest densities of tortoises are found in training areas (Epperson and Heise 2001). The presence of gopher tortoises in these areas limits training and is potentially detrimental to gopher tortoise populations. The presence of gopher tortoises on Camp Shelby influences military training since military personnel have to keep vehicles 25 feet away from burrows. These cleared training areas may be acting as sinks for gopher tortoise populations by attracting them to these areas but simultaneously threatening their successful reproduction and survivorship.

Objectives

The major objective of this study was to determine the general effects of tracked vehicle and other off-road training activities on important aspects of the life and behavior of gopher tortoises. Three specific questions were asked:

1. Do tortoises on sites with heavier tracked-vehicle use differ from areas with limited tracked-vehicle use or from off-installation sites with characteristics of old-growth longleaf pine in the number of burrows used during the active season?
2. Do the rates at which female tortoises receive visitors on sites affected by heavy tracked-vehicle use differ from those with limited tracked-vehicle activity or from off-installation sites with characteristics of old-growth longleaf pine? and
3. Does the number of males that visit females on sites with heavy tracked-vehicle use differ from sites with limited tracked-vehicle use or from off-installation sites with characteristics of old-growth longleaf pine forest?

This study was designed to supplement knowledge of how tracked-vehicle use influences behavior of individual gopher tortoises (*Gopherus polyphemus*) on Fort Ben-

ning. The study was specifically designed to duplicate insofar as possible the objectives, locations, and methodology of a 1994 study by Guyer (Guyer et al. 1996). Knowledge of such effects is important because gopher tortoise population density has been reduced throughout the geographic range of the species, causing the western populations to be protected under the ESA. Therefore, management activities implemented now to protect tortoises might preclude the need for more stringent activities in the future. Additionally, tortoise burrows are used as refuges for a wide variety of animals and because these burrows may affect understory vegetation in ways that may affect plant species richness, *Gopherus polyphemus* is thought to be a keystone species within the longleaf pine forest ecosystem. Thus, conservation efforts geared toward protecting tortoises pay dividends in that additional taxa are likely to be protected as well.

Scope

This study was limited to the daily observation of ca 30 tortoises as found in 6 different training compartments on Fort Benning, GA. Four compartments were considered impacted by heavy tracked-vehicle use (D12, D17, F1, O11) and two compartments were considered to have limited impacts by tracked vehicles (K20, O14). An additional study site was Green Grove, an area on the Jones Ecological Research Center, Newton, GA that retains characteristics of old-growth longleaf pine forests (open canopy, large trees, growing season fires). Data acquired at Green Grove were expected to be representative of tortoise populations that experience essentially no vehicle or equipment activity, and may be considered a form of control for this study.

Approach

At each of the study locations, all burrows were located, marked with numbered metal tags, measured for entrance width and height, and the location determined in Universal Transverse Mercator (UTM) coordinates via a global positioning system. At each location, burrows showing active use were examined with video camera scoping equipment and a trap was placed at the mouth of those burrows where a tortoise was confirmed to be present. Traps were examined twice daily until the animal was trapped. Tortoises were measured, weighed, sexed, marked, an identity number painted on the carapace, and a radio transmitter affixed. The locations of

all individuals were verified daily* from the date of release until mid-October using their unique radio frequency, and the burrow occupied by each tortoise was recorded. Digital cameras were placed at the burrow entrance of each adult female to record activity patterns of females as well as visitation rates of other tortoises to those females.

Method of Technology Transfer

The information included in this report is one portion of the materials prepared by the Engineer Research and Development Center (ERDC) to assist installation natural resources and TES program managers. The primary means of communicating the tortoise behavior information will be through publication in the scientific literature, as well as through the availability of this report. The specific data presented are intended to be used in the preparation of biological opinions related to planned Army actions where the gopher tortoise is present. The data will also be used for endangered species management plans (ESMPs), integrated natural resources management plans (INRMPs), and in the preparation of ecological risk assessments involving training and other land disturbing activities where the tortoise is present.

This report will be made accessible through the World Wide Web (WWW) at URL:
http://www.cecer.army.mil

* Following the 11 September 2001 attacks on the United States, the installation was closed to the study team for 4 days, and locations were not recorded for these days.

2 Methodology

This study was performed on six sites on Fort Benning. Four sites were in training compartments impacted by heavy tracked-vehicle use (D12, D17, F1, O11) and two sites were in compartments with limited impacts by tracked vehicles (K20, O14). Green Grove, an area on the J. W. Jones Ecological Research Center, Newton County, GA, was an additional study site that retains characteristics of old-growth longleaf pine forests (open canopy, large trees, growing season fires). On each site, all burrows were located, marked with numbered metal tags, measured for entrance width and height, and mapped via GPS technology. All burrows were examined with a video camera, and a trap was placed at each burrow known to contain a tortoise. Traps were covered with burlap, to provide shade (Figure 1), and were examined twice daily until the animal was trapped.

Figure 1. Tortoise in live trap, showing burlap provided for shade.

All individuals were measured to the nearest millimeter (carapace length, plastron length, shell width, shell height, circumference, and plastron concavity; Figure 2), weighed to the nearest gram, sexed (ratio of plastron length to plastron concavity), marked (v-shaped file marks on edge of marginal scutes), painted with a number on

the carapace (nontoxic paint sticks), and affixed with a radio transmitter (Figure 3). Juveniles and adult males were released into the burrow from which they were captured. Adult females were taken to a veterinary clinic in Columbus (Fort Benning animals) or Albany (Jones Center animals), GA, and were x-rayed to determine whether shelled eggs were present in the uterine tract. Females were then released into the burrow from which they were captured (typically the next day).

Figure 2. Measuring carapace length and recording health data.

Figure 3. Tortoise with attached locator transmitter and antenna.

Locations of all individuals were verified daily via a telemetry receiver (Figure 4), and the burrow occupied by each tortoise was recorded. Digital cameras were placed at the entrance of each burrow occupied by an adult female. The cameras were triggered by pressure-sensitive switches, so photographs recorded activity of tortoises at burrow entrances (Figure 5). The time and date of each photograph were recorded with each shot. Because social activities take place at entrances of female-occupied burrows, this procedure recorded activity patterns of females as well as visitation rates of other tortoises to those females. Because marked individuals had carapaces with painted numbers, the identity of most visitors was known from the photographic evidence. Because each female had a radio transmitter, the camera was moved to follow that female when she moved to a new burrow.

Figure 4. Radio-tracking tortoise daily to burrow.

Figure 5. Tortoise 72, a female, triggers the camera by stepping on a pressure-sensitive pad.

Totals of 16 males, 11 females, and 6 juveniles were captured and released on Fort Benning during the 2001 field season (see appendix). Of these totals, 10 (30 percent) were recaptures from a 1994 study in the same area (Guyer et al. 1996). Recaptures were made on both impacted and unimpacted sites, but these recaptures were too few to determine statistically whether they were more likely to occur on unimpacted vs. impacted sites. Data from Fort Benning animals were compared with similar data collected over the same time period from 37 male, 46 female, and 11 juvenile tortoises from Green Grove.

3 Results and Discussion

First Question

The question that prompted the study originally was "*Do tortoises on sites with heavy tracked-vehicle use differ from areas with limited tracked-vehicle use or from sites with characteristics of old-growth longleaf pine in the number of burrows used during the active season?*"

Results

The number of burrows used by tortoises during the active season differed among the three sites (heavy tracked-vehicle, limited tracked-vehicle, old-growth; $F = 14.0$, $p < 0.0001$) and between the two sexes ($F = 13.8$, $p < 0.0007$). Additionally, the interaction term between these two main effects was significant ($F = 3.9$, $p < 0.03$). The differences among sites resulted from a far greater number of burrows used per tortoise on Green Grove than on Fort Benning. No significant difference in numbers of burrows used was found for tortoises on sites with heavy tracked-vehicle use compared with sites with limited tracked-vehicle activity (Figure 6). The differences between sexes resulted from an increased number of burrows used by males compared with females; however, the magnitude of this difference depended on the site (Figure 6). On Green Grove and on sites with limited tracked-vehicle activity, females used approximately half the number of burrows used by males. On sites with heavy tracked-vehicle use, males and females used approximately the same number of burrows.

Discussion

Two major conclusions can be drawn from these results. First, tracked-vehicle activities do not alter the average number of burrows used by male tortoises, but may increase the number of burrows used by females. This finding may indicate that females within conservation areas near sites altered by tracked vehicles are forced to wander more widely, either because of a rapidly changing landscape or because adequate forage is lacking. Second, tortoises throughout Fort Benning occupy fewer burrows than they might occupy if land management practices there more closely approached the characteristics of old-growth longleaf pine forests. Based on tortoise samples from the Jones Center and other sites throughout the northern portion of

its range, it must be concluded that Fort Benning has not received management practices associated with restoration of old-growth features (thinning and use of growing-season fires) for a time sufficiently long enough to affect tortoise movements and, therefore, social structure (see discussion under second question).

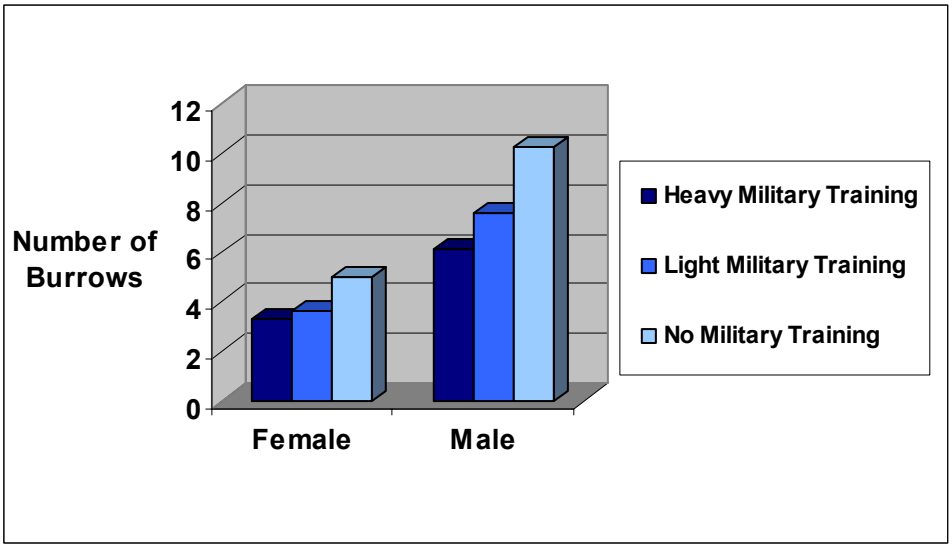

Figure 6. Mean number of burrows used by adult male and female tortoises on sites impacted by heavy tracked-vehicle activity on Fort Benning, sites with limited tracked-vehicle activity on Fort Benning, and on Green Grove (Jones Center), where no military training takes place.

Second Question

Do the rates at which female tortoises receive visitors on sites affected by heavy tracked-vehicle use differ from those with limited tracked-vehicle activity or from sites with characteristics of old-growth longleaf pine?

Results

A significant difference in visitation rates among sites was documented in this study ($F = 5.3$, $p < .009$). This difference resulted from a significant reduction in the rate at which other tortoises visited resident female tortoises on sites affected by heavy tracked-vehicle activity compared with sites with limited tracked-vehicle activity (Figure 2). Additionally, the rate at which visitations took place on Fort Benning was 30 to 90 percent less than that experienced by tortoises on Green Grove (Figure 7).

Discussion

These findings further document altered social structure of tortoises due both to direct military activity and to past land management practices. Nearly all visitors to females on all sites were males, and most of these appeared to court females or were known to mount them. Thus, the reduced visitation rates are likely to be of great significance to mating opportunities for females. If so, viability of small isolated populations could be reduced in areas that are heavily impacted by tracked-vehicle training. Reduced rates may result partly because females move more widely on these sites (see discussion under first question). Further, because tracked-vehicle activity has already been shown (Guyer et al. 1996) to reduce the amount of time during which tortoises are active and to shift activities to midday periods during which tortoises typically bask rather than engage in social activities, heavy military activities appear to reduce the ability of females to find mates. Even in the best areas on Fort Benning, the ability of females to gain mates is restricted relative to that expected of animals on old-growth sites.

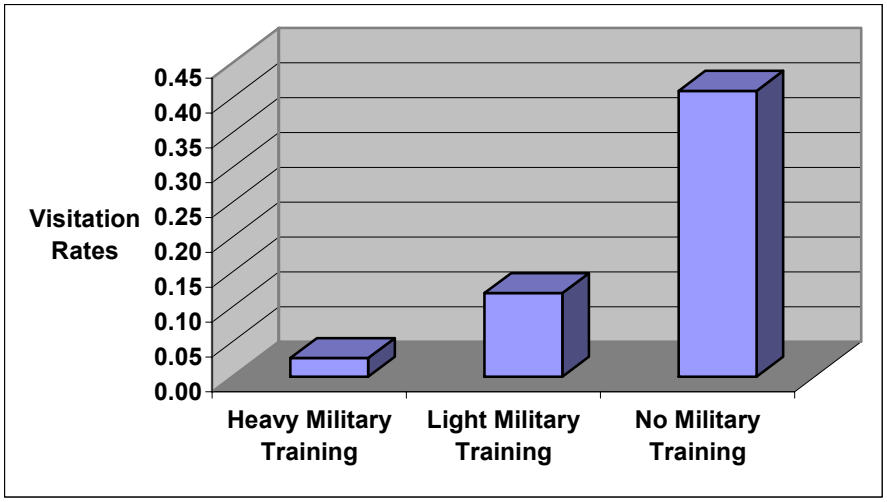

Figure 7. Mean visitation rates (tortoises per day) of tortoises to resident females on sites impacted by heavy tracked-vehicle activity on Fort Benning (impacted), sites with limited tracked-vehicle activity on Fort Benning (unimpacted), and Green Grove (Jones Center).

Third Question

Does the number of males that visit females on sites with heavy tracked-vehicle use differ from sites with limited tracked-vehicle use or from sites with characteristics of old-growth longleaf pine forest?

Results

The number of males known to visit females was marginally significantly different among the three sites ($F = 2.8$, $p < .08$). This number was similar between sites with limited tracked-vehicle activity and Green Grove. Females at sites affected by heavy tracked-vehicle activities typically interacted with only one male whereas females at the other two sites experienced visits from three or four males during the active season (Figure 8).

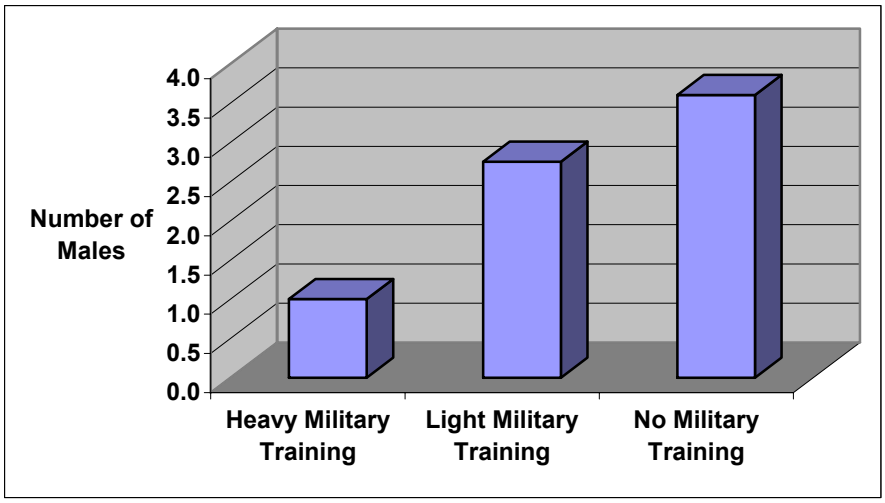

Figure 8. Mean number of male visitors to resident females on sites impacted by heavy tracked-vehicle activity on Fort Benning (impacted), sites with limited tracked-vehicle activity on Fort Benning (unimpacted), and Green Grove (Jones Center).

Discussion

These results further suggest that tracked-vehicle activities alter the social structure of groups of tortoises. These results predict that patterns of paternity of tortoises are restricted on such sites. Although female turtles are capable of storing sperm for up to 4 years, females on sites impacted by tracked-vehicle activities seem to have limited options for mate choice and are susceptible, therefore, to problems associated with inbreeding and restricted gene flow.

4 Conclusions and Recommendations

Several roughly concurrent studies at other sites unimpacted by military use have served to establish what may be called "normal" patterns of movement and interaction (Eubanks et al. 2003; Boglioli et al. 2003). Based on these studies and others, it may be concluded that, while the gopher tortoise meta-populations on Fort Benning are surviving even in areas with off-road vehicle training activity, they may not actually be viable in the long term due to reduced freedom of movement.

The study presented here represents a relatively small number of individuals from one general vicinity; however, some overall conclusions may be drawn that are general enough to likely apply to most or all on-base populations of gopher tortoise. Remembering that this is a follow-up study where 7 years intervened between field surveys, the following characteristics* have now been documented for sites with heavy tracked-vehicle activities:

1. Reduced numbers of juveniles
2. Restriction of activities to midday
3. Reduced number of minutes of daily activity
4. Increased number of burrows used by females during activity season
5. Reduced visitation rates of tortoises to resident females
6. Reduced number of potential mates to resident females.

These features indicate that clusters of tortoises currently protected by signs at sites used for intense military activities are unlikely to be viable. Both the small number of individuals in such clusters and their altered social structure suggest that reproduction is insufficient to replace loss due to mortality and emigration. A better conservation strategy for these clusters appears to be to move the tortoises to management areas where they might participate in viable populations. Because substantial areas on Fort Benning currently are being managed to enhance the

* Characteristics 2 and 3 were described in Guyer et al. 1996; characteristics 1, 4–6 were described in both that study and the present one.

habitat for red-cockaded woodpeckers and because these birds require landscape features that characterize old-growth longleaf pine forests, the simplest conservation strategy would be to move tortoises to areas managed for woodpeckers. Currently, most such areas lack tortoises but appear to be suitable for them. Such relocations may have the added benefit of creating tortoise populations on Fort Benning that are more similar to those on sites like Green Grove. Current data suggest that, even on the best sites, tortoises on Fort Benning do not exhibit the types of social organization expected of animals on old-growth sites. If this is caused by a reduced availability of high quality habitat on Fort Benning, then monitoring of tortoises moved to areas managed for red-cockaded woodpeckers should reveal improved social organization and could be used to measure the success of relocation projects.

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Appendix: Data for Fort Benning Tortoises Tracked in 2001

Table A.1. Selected data on each tortoise tracked for the study at Fort Benning, May to October 2001.

Site	Tortoise ID	Sex	Date	Burrow ID	Weight	Age	Carapace Length	Plastron Length	Total Length	Circumference
Area D12										
D12	22	Unknown	15-Jul-01	316	4003	22	303	302	315	605
D12	50	Male	15-Jul-01	313	5150	?	297	289	309	612
D12	86a	Female	13-Jul-01	374	5215	30	302	314	321	608
D12	87	Male	14-Jul-01	306	3163	25	255	237	259	562
Area D17										
D17	41	Male	31-Aug-01	413	5400	19	313	310	323	660
D17	88	Female	31-Aug-01	413	4172	20	277	273	277	600
D17	89	Juvenile	31-Aug-01	415	175	5	101	100	103	
Area F1										
F1	72a	Male	26-Jun-01	594	4696	17	316	303	324	610
F1	75	Female	26-Jun-01	4	3600	18	270	265	285	553
F1	85	Male	26-Jun-01	8	4246	25	280	290	300	508
F1	86	Male	26-Jun-01	3	3917	24	270	270	280	590
Area K20										
K20	36	Female	23-Jun-01	502	4175	28	289	277	298	572
K20	48	Male	07-Jul-01	573	4960	33	299	290	319	611
K20	49	Male	23-Jun-01	558	6259	28	322	323	340	630
K20	52	Male	11-Jul-01	198	4988	24	293	292	305	600

Site	Tortoise ID	Sex	Date	Burrow ID	Weight	Age	Carapace Length	Plastron Length	Total Length	Circumference
K20	6	Female	02-Jul-01	516	4211	19	306	296	318	602
K20	63	Juvenile	30-May-01	504	28	0	48	50	52	105
K20	82	Female	10-Jun-01	571	1916		225	213	224	427
K20	84	Male	23-Jun-01	563	3875	19	281	277	286	564
Area O11										
O11	110	Male	25-Jun-01	599	3277	18	261	268	276	520
O11	15	Male	30-May-01	578	4905	22	298	313	326	598
O11	65	Juvenile	31-May-01	501	80	3	76	74	76	165
O11	77	Female	01-Jun-01	586	5093	?	315	315	329	628
O11	90	Juvenile	07-Sep-01	586	35	0	52	51	54	
Area O14										
O14	61	Female	30-May-01	56	5101	22	313	299	316	605
O14	64	Juvenile	30-May-01	61	82	3	74	73	75	160
O14	66	Female	31-May-01	42	4700	26	315	312	324	608
O14	67	Male	31-May-01	47	6308	23	320	311	332	630
O14	68	Female	31-May-01	63	5530	27	319	321	331	620
O14	69	Male	03-Jun-01	59	4049	23	286	298	302	574
O14	71	Male	03-Jun-01	54	5136	24	303	310	318	604
O14	72	Female	17-Jun-01	129	6735	?	351	343	361	680
O14	74	Male	30-May-01	125	4680	29	302	301	312	581

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14. ABSTRACT

This research examined the influence of tracked-vehicle use on gopher tortoises (*Gopherus polyphemus*) on Fort Benning, GA. Did tortoises on sites with heavy tracked-vehicle use differ from those in areas with limited tracked-vehicle use in: number of burrows used during the active season; rates at which female tortoises receive visitors; and number of males that visit each female? Data from an undisturbed off-post site with characteristics of old-growth longleaf pine forest were used for comparison. Similar numbers of burrows were used by both sexes in both the heavily disturbed and less-disturbed sites on Fort Benning, but more burrows per animal were used at the undisturbed comparison site. Significantly fewer total social visits were received by females in the more highly disturbed sites. In both the less-disturbed areas and the off-post site, many more different males visited each female. One conclusion drawn is that females on sites impacted by tracked-vehicle activities seem to have more limited options for mate choice and, therefore, are susceptible to problems associated with inbreeding and restricted gene flow. These susceptibilities are not desirable for population viability.

15. SUBJECT TERMS
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