

Florida Gopher Tortoise Relocation: Overview and Case Study

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ABSTRACT

Gopher tortoise *Gopherus polyphemus* populations are greatly reduced from former numbers. Relocation is one technique currently being used to protect tortoises on land being developed. Previous relocations have generally been poorly documented and the usefulness of relocation for tortoise conservation is unclear.

In this study, 85 tortoises were relocated from a development site to a county park 25 km away where tortoises had been extirpated. Two years after release, 35 tortoises remained in the park, an apparently stable population. The presence of hatchlings demonstrated that successful reproduction was occurring. This study showed that it is possible to relocate and reintroduce gopher tortoises fairly successfully. It does not support the suggestions of previous workers that social structure determinants such as sex and size, gravidity, or on-site penning before release, may influence the success rate.

INTRODUCTION

Gopher tortoises *Gopherus polyphemus* formerly ranged throughout much of the southeastern United States, primarily in longleaf pine *Pinus palustris* forests (Auffenberg & Franz, 1982). These forests once covered over 28 million ha and were the dominant habitat type of the Coastal Plain, but now exist on fewer than 4 million ha—a loss of approximately 86% (Means &

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Grow, 1985). Auffenberg & Franz (1982) estimated that by the year 2025 only scattered populations on fully protected land will remain.

These reductions in tortoise habitat and numbers are especially ominous because of the tortoise's vital community role as a keystone species (*sensu* Paine, 1969). Jackson & Milstrey (1989) have documented commensal use of the gopher burrow by 332 vertebrate and invertebrate species.

The conspicuous burrow, as well as recent improvements in public awareness of the ecological importance, docile nature, and uncertain future of the gopher tortoise, have made it the prominent species conflicting with development plans in Florida (FGFWFC, 1988). Traditionally, the vast majority of gopher tortoises on lands being altered for human use have very likely been unnoticed or ignored, and have either abandoned the site or been killed. However, relocation of tortoises is increasingly suggested as a viable conservation measure and mitigative technique, especially for the large, high profile developments that undergo extensive government review. Although relocation of the associated commensal species has received little attention, the history of gopher tortoise relocations has been reviewed by Diemer (1987, 1989). In 1984, the Florida Game and Fresh Water Fish Commission (FGFWFC) formulated a policy specifically regulating the relocation and release of tortoises, refined and expanded in 1985 into an Interim Gopher Tortoise Relocation Protocol. Since September 1984, more than 90 gopher tortoise relocation permits have been issued by the FGFWFC (D. Wood, pers. comm.).

Although an unknown but certainly large number of relocations have taken place, follow-up studies, analysis, and dissemination of results have been generally poor. The objective of many relocations is to save the lives of a small number of tortoises; poor documentation is largely due to lack of funds or scientific interest. Most relocation studies that have involved follow-up have simply resurveyed the release site to look for increased numbers of tortoise burrows. It has not always been clear that the new burrows were established and maintained by the released tortoises, or that a viable, reproducing population had been established. Those results that have been reported are inconclusive and, in some cases, contradictory. The main objectives of this study were to determine: (1) if a reasonable percentage of tortoises and any vertebrate commensals captured on the donor site and relocated to a new site would remain at the release site; (2) if relocated tortoises could establish a viable population; and (3) what factors, particularly penning, influence whether tortoises remain on the release site (site adoption).

Various relocation methodologies have been suggested by previous workers. Lohofener & Lohmeier (1986) found that penning relocated gopher tortoises before release improved site adoption in their southern

Mississippi experiments. As a result, the FGFWFC required penning as a part of the Interim Gopher Tortoise Relocation Procedures (FGFWFC, 1986). I tested the usefulness of the penning procedure and attempted to determine the optimal penning duration by varying the number of days tortoises were penned.

Landers (1981) and Berry (1986) suggested that gopher social structure and behaviour may influence the success of relocations. *Gopherus* social hierarchies are largely, if not completely, based on body size and gender (Douglass, 1976; McRae *et al.*, 1981*b*; Berry, 1986) and may also be influenced by age. I analyzed data on body size, age, sex, and gravidity to determine whether any of these variables were correlated with site adoption.

METHODS

The donor and release sites

In this study, literature values were used to estimate the amount of land needed by the tortoises. The generalized correction factor determined by Auffenberg & Franz (1982) was used to estimate that 75 tortoises occupied the donor site, based on the 122 active and inactive burrows found during a preliminary survey. Next, reported densities (Auffenberg & Iverson, 1979) of gopher tortoises in similar habitat types were used to estimate that 10.8 to 24.1 ha was needed to support the relocated tortoises. Time constraints prevented study of their activities on the donor site before relocation, which may have provided a better estimate.

I chose Okeehetee County Park (OK) as the best available release site. It is geographically close to the donor site, and contains 40 ha of appropriate habitat with restricted public access. Palm Beach County has a legal commitment to preserve the natural components of the park in perpetuity. The natural area of the park is divided into three approximately equal sections that are control-burned in the winter on a 3- to 5-year rotation, which somewhat duplicates natural conditions. Although gopher tortoises previously occupied the park (J. Street, pers. comm.), they were hunted extensively and none were present when I began this study.

Tortoises were moved 25 km from the Regional Development Center (RDC) site in Palm Beach Gardens (to become a large business and residential complex) to Okeehetee County Park. Both sites were primarily cabbage palm flatwoods habitat type (SCS, 1987), although they were probably wet prairies before the region was extensively modified by the installation of drainage canals in the 1940s (Richardson, 1977). They were composed of widely scattered trees, dispersed clumps of shrubs, and grassy

ground cover with patches of bare sand. Dominant tree species were slash pine *Pinus elliottii*, live oak *Quercus virginiana* and cabbage palm *Sabal palmetto*; shrubs were mostly saw palmetto *Serenoa repens*. Ground vegetation species included chalky bluestem *Andropogon calliipes*, wiregrass *Aristida stricta*, low panicums *Panicum* sp., muscadine grape *Vitis rotundifolia*, and prickly-pear cactus *Opuntia* sp. No detailed vegetative analysis was done on either site.

Survey, capture and release

In 1985 and 1986, both sites were thoroughly surveyed for active tortoise burrows; in 1987 OK was surveyed to determine relocation success. Occupants of each burrow were captured and measured. Although most tortoises were captured by bucket trapping, others were caught opportunistically, and some were lured from burrows (Burke & Cox, 1989). Seven tortoises died accidentally from overheating while in the bucket traps; thereafter all exposed traps were shaded with palmetto fronds. All tortoises were relocated to pens at OK within 6 h of capture at RDC.

Each tortoise was marked with a unique pattern of holes drilled in the marginal scutes. Plastron and carapace length were recorded, and each tortoise was classified as male, female or juvenile, according to methods described by McRae *et al.* (1981a), although the applicability of their techniques to tortoises in this part of the range is untested. Where possible age was estimated by counting growth annuli on three scutes and averaging results as described by Stubbs *et al.* (1984). All adult female tortoises captured in 1985, and three recaptured in 1987 were X-rayed (Turner *et al.*, 1986) to evaluate gravidity and clutch size.

Four square holding pens, each 56.25 m² in area, were placed in widely separate areas at OK. Five starter burrows were dug in each pen, and shade was provided by palmetto fronds piled in the middle. Each tortoise captured at RDC in 1985 was randomly assigned to one of the four pens and randomly assigned the number of days it was to remain penned. Penning duration ranged from 0 to 15 days, and tortoises were released immediately outside the pen after their designated penning time was completed.

Analysis

Statistical analysis was performed using the Statistical Analysis System (SAS). Data on carapace length, sex, age, pen location, and penning duration were tested using PROC LOGIST (SUGI, 1983) to determine if any of these variables were useful in predicting the probability of relocation success. PROC LOGIST uses multiple logistic regression to classify individuals into

one of two possible populations based on relocation success ('recaptured in 1987' or 'not recaptured in 1987') and to determine which, if any, of the independent variables are significantly correlated with the success (Adler & Wilson, 1985).

RESULTS

In 1985, 82 gopher tortoises were caught on RDC. Seven died during trapping, and the remaining 75 tortoises were penned and released at OK. While in pens and after release, tortoises engaged in numerous social interactions. These typically involved large adult male tortoises chasing and ramming small males and adult females.

The 1986 and 1987 survey and trapping efforts at OK were very thorough and I am confident that few, if any, tortoises on the site were not recaptured. In 1986, 31 were recaptured at OK, an overall recapture rate of 41.3% (31/75). Status of those which left the park is unknown. Ten additional tortoises were captured at RDC in 1986; these were measured, marked and released without penning at OK, raising the total number of releases to 85. These additional animals were not included in the statistical analysis.

In 1987, 35 tortoises were recaptured, an overall success rate of 41.2% (35/85). Of these, 32 were 1985 releases; therefore the two-year recapture rate was 42.6% (32/75). All 31 tortoises captured at OK in 1986 were recaptured in 1987.

One of three females X-rayed in 1987 was gravid and three young tortoises in the 1 year age class were found at OK. Carapace and plastron measurements of the RDC population and recaptures documented growth in most recaptured individuals. The largest proportional increases were seen in smaller size classes.

Logistic regression analysis indicated that sex, size, age, penning duration, and release site did not significantly influence recapture probability (all p values > 0.23). Further, visual comparison of the size class structures of the original RDC population, the 1986 OK population, and the 1987 OK population (Fig. 1) does not suggest important differences between these populations.

Comparison of recapture rate versus penning duration (Fig. 2) shows extreme day-to-day variation, indicating that penning does not have a predictable influence on site adoption. Neither smoothing the data (Chambers *et al.*, 1983), using F values of 0.33, 0.50 and 0.66, nor plotting the resulting residuals helped elucidate any possible relationship between site adoption and penning length.

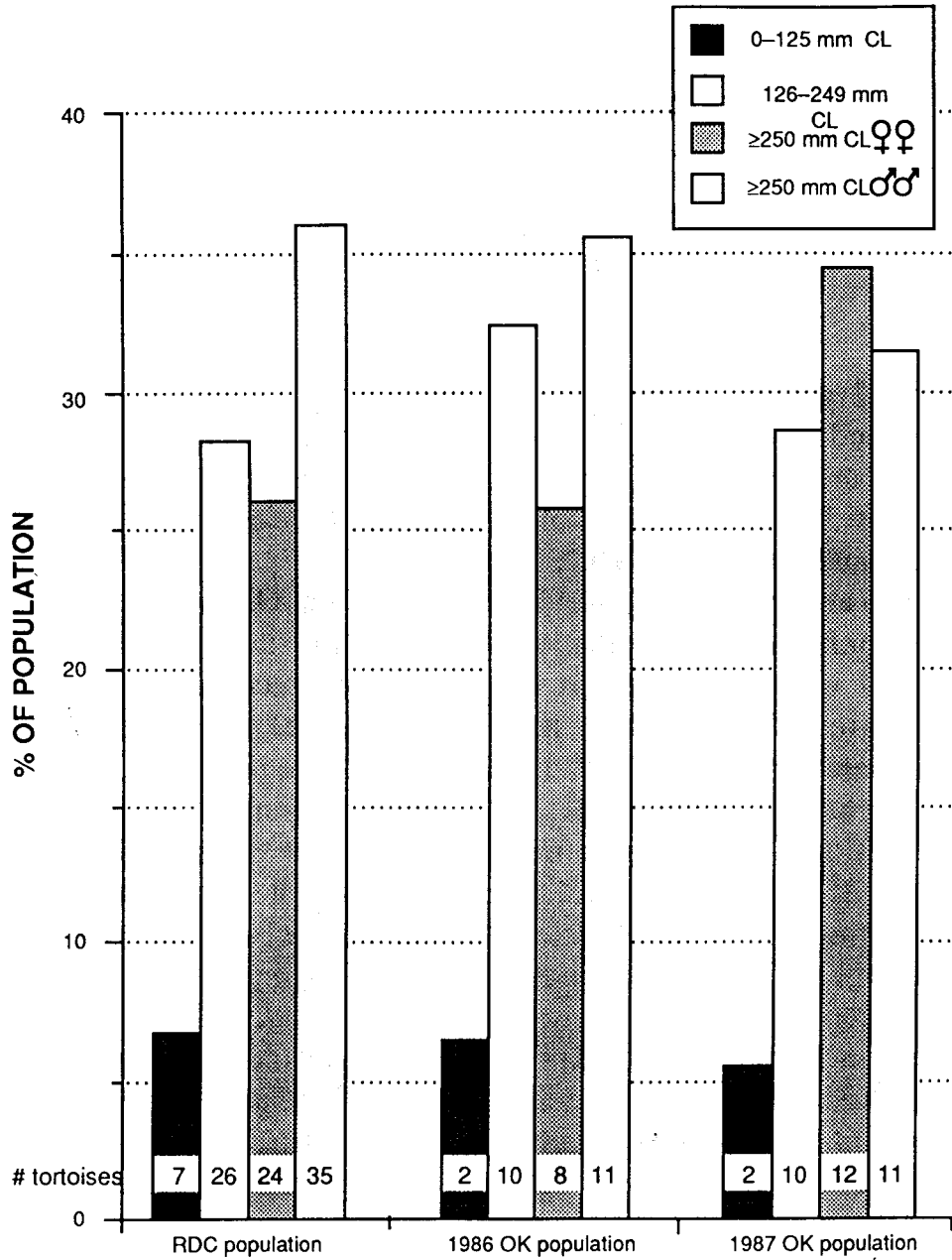


Fig. 1. Comparison of population structures.

DISCUSSION

Choosing a release site

The choice of a release site was based on initial characterization of an 'ideal' site (see Stoddart *et al.*, 1982). First, it had to contain sufficient quantities of appropriate habitat—gopher tortoises apparently respond more to a small

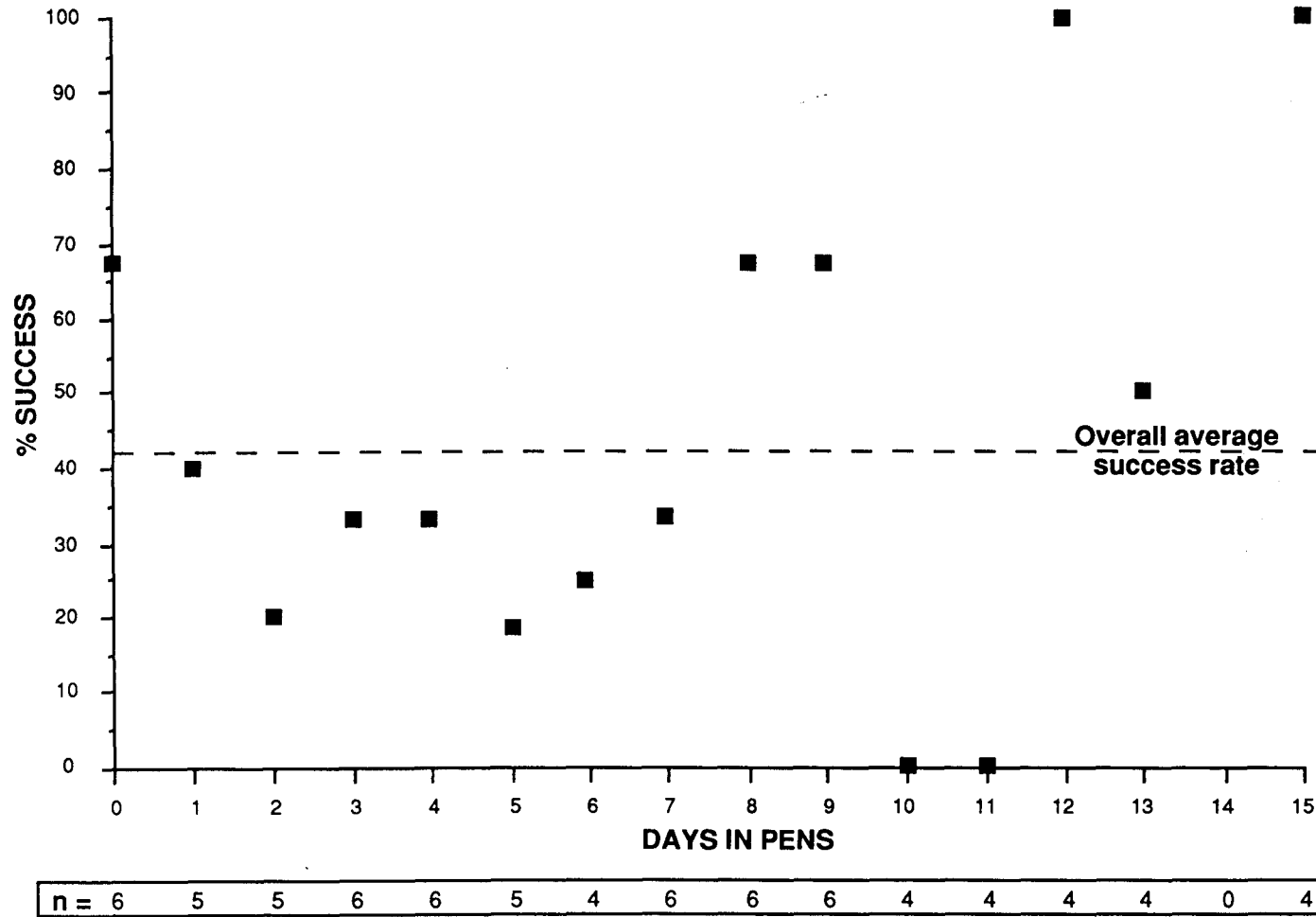


Fig. 2. Penning duration versus site adoption.

suite of physical characteristics of the habitat than to specific plant associations (Campbell & Christman, 1982). Therefore, the required habitat can be loosely described as relatively open, allowing sunlight to reach the ground and support both ground level herbaceous food plants and egg incubation (Landers & Speake, 1980). Also, soils should be well-drained and sandy, although gopher tortoises do occupy seasonally flooded organic soils in some regions (personal observations).

The best indication that a habitat is suitable for a species is that it already supports a stable population. In fact, some gopher tortoise relocations have been to sites that are already occupied, but with 'reduced' densities (Diemer *et al.*, 1989). There are few data available to determine the carrying capacity for gopher tortoises in any habitat type, although densities in some types have been measured (Cox *et al.*, 1987).

However, as pointed out by FGFWFC (1988) and Greig (1979), relocation to sites already containing resident conspecifics has many potential negative impacts, including possible disruption of the social system and local genetic adaptation, disease transmission, and overuse of resources. This may be especially true for long-lived social species, and short-term studies may be insufficient to document the effects fully. In situations where tortoise densities have been reduced, the resident individuals are the natural source for recolonization. Therefore, the ideal site should have appropriate habitat, but very few or no resident tortoises.

In Florida there is land available from several sources that, in some circumstances, fits these requirements. The Florida citrus industry has experienced major setbacks due to severe weather, and some abandoned groves are becoming available for re-establishment of native wildlife (Humphrey *et al.*, 1985). Also, much of the forested southeastern United States has suffered from active fire-suppression programs, allowing habitat changes intolerable to gopher tortoises (Landers & Speake, 1980). Tortoises that abandon these areas often move to sites where they experience much higher mortality (Landers & Buckner, 1981). Currently, increasing numbers of land owners and managers regularly control-burn their properties, making large tracts of land available for tortoise recolonization. Suitable habitat has also been created (particularly in South Florida) when hydric and mesic regions are drained (see Richardson, 1977). Finally, some of the large tracts of reclaimed mining land in Florida may be suitable release sites (Diemer, 1986).

The ideal release site should be close to the donor site because populations may be adapted, genetically and/or behaviorally, to local conditions (Templeton *et al.*, 1986). Although the importance of local adaptation in gopher tortoises is unknown, there is considerable geographic variation in size at sexual maturity, duration of winter dormancy, colour, adult size, and

clutch size (Douglass & Layne, 1978; Iverson, 1980; Landers, 1981; Landers *et al.*, 1982). The genetic basis of these traits is unknown. However, Lamb *et al.*'s (1989) mitochondrial DNA analysis of desert tortoise populations suggests that significant dispersal barriers are necessary for important genetic intraspecific differences to develop in tortoises. In Florida, these might be limited to the Saint Johns and Apalachicola Rivers.

Finally, it should be possible to arrange legally binding long-term management and protection commitments for the release site. Diemer (1987) described a gopher tortoise relocation to a site that is now slated for development. While publicly owned land may appear to be the only suitable option, large tracts of private land may be available that have some advantages, such as restriction of public access (D. Speake, pers. comm.).

Social structure determinants

Previous studies (Douglass, 1976; Douglass & Layne, 1978; Auffenberg & Iverson, 1979; McRae *et al.*, 1981*b*) have shown that the activity levels, outcome of social interactions, movement patterns, and burrow locations of gopher tortoises are strongly influenced by the factors of sex and size, which apparently determine status in a loose dominance hierarchy. Larger males dominate preferred burrow sites near adult females and may exclude subordinate males from breeding altogether by preventing access to the adult females: 'a dominance hierarchy based on body size exists in males of *G. polyphemus* and is most expressed in breeding colonies, where population densities are high and social interaction more frequent' (McRae *et al.*, 1981*b*, 177). Juveniles apparently do not interact with older tortoises; however, subadults are actively excluded from inner-colony burrows and often move long distances during the breeding season (McRae *et al.*, 1981*b*; J. E. Diemer, pers. comm.).

Because home range size and movements are strongly influenced by sex and size, previous workers have postulated that these factors influence the activity of relocated tortoises. Landers (1981) suggested that reintroduction success rate might be increased by first establishing a group of female tortoises and later releasing males during the breeding season. Berry (1986, 122) postulates that:

'Some tortoises may have greater chances of successfully relocating than others. Hatchlings and juveniles may have the highest potential for assimilation into the resident population and the lowest potential for disturbing the existing social structure. Adult females probably are next and adult males last. Adult males appear to be more aggressive, active, and wide ranging than females or juveniles. They may also disperse greater distances.'

Many social interactions between tortoises of all size and age classes were observed during this study, so it is clear that the stress of the relocation and penning does not completely interrupt normal behaviour. However, analysis of the results does not show any correlation between gender, size, or age with site adoption.

In addition, Landers (1981) reported that gravid female tortoises relocated in southern Georgia were more likely to remain on site than females released after the ovipositing season. In contrast, in this study, which took place early in the summer when some females had already oviposited, only one of three gravid females was recaptured. Although low sample size makes comparison tentative, the success rate for gravid females is lower than the overall population average.

Penning

The large differences in site adoption associated with small differences in penning duration implies that the individual tortoise's response to relocation may depend on factors other than those examined here. Moskovits & Kiester (1987) have postulated that the combination of low metabolic requirements, benign environment and low predation risk has permitted tortoises in general to express an unusually wide range of behaviour patterns relative to other ectotherms. As was demonstrated in this study, much of the behavioural variation they observed was on the level of individual animals, except for patterns directly related to reproductive activities.

Although two other researchers (Doonan, 1986; Lohoefener & Lohmeier, 1986) have reported penning studies, comparison is difficult. Without standardization of recapture technique, results are as much a function of retrapping effort as site adoption. Therefore, each study must provide adequate control populations for comparison. However, these results agree with those of Doonan (1986), who confined 28 relocated adult gopher tortoises individually in 4.5 m² pens. Juvenile tortoises were kept in group pens, seven in a 22.5 m² pen and four larger juveniles in a 40.25 m². Each pen enclosed food plants and either abandoned gopher burrows, or human excavated substitutes. Pens were left up for between 3 and 77 days, and he found little correlation between enclosure period and time until the burrows were abandoned. Doonan did not retrap to determine the level of site adoption, but none of the 39 relocated tortoises used these burrows after release. He believed that pens did not aid in site adoption.

In contrast, Lohoefener & Lohmeier (1986) tested the effects of penning in a series of relocations in which forty tortoises were released at five release areas in southern Mississippi. They were able to recapture only 1 of 19

unpenned tortoises, but 17 of 21 that had been penned. They confined five of their tortoises in 12.5 m² individual pens, and sixteen in groups of two and three in 38.5 m² pens. Pens were left up for two to four weeks. Interpretation of their results is difficult, not only because their study animals came from a variety of sources, including a zoo, but also because relatively few were released at each of five habitat types and their resurveys and recaptures were never more than one 'season' after release.

In some situations penning has proven to be detrimental because the tortoises were stolen (S. Godley, pers. comm.). Holding animals in unnaturally high densities may promote injury, disease and parasite transmission. Gopher tortoises normally spend the majority of their lives underground (McRae *et al.*, 1981b) where humidity and atmospheric gas levels are quite different than above ground (Ultsch & Anderson, 1986).

Although the presumed function of penning is unclear, Berry (1986) has suggested that it may disrupt homing ability. While Diemer (1987), McRae *et al.* (1981b), Burke (unpublished field notes) and others (see Chelazzi & Delfino, 1986) have documented homing ability by gopher tortoises, this has not been demonstrated in any relocation studies (Diemer *et al.*, 1989). Chelazzi & Delfino (1986) showed the importance of olfaction in homing Hermann's tortoises *Testudo hermanni*. Distance, perhaps associated with disruption of visual or olfactory clues, may be more important than penning. For example, analysis of numerous relocations of black bears *Ursus americanus* has shown that relocations beyond a certain distance, apparently associated with familiar territory, have a significantly higher success rate than short distance relocations (Rogers, 1987). A procedure known as 'phase-shifting', in which the circadian cycle is altered in a controlled situation, has also been suggested as a technique to disrupt tortoise homing behaviour (G. Adest, pers. comm.).

Viability of small populations

When this study was concluded, OK was occupied by at least 35 tortoises, including 13 adult females and 11 adult males. Growth of tortoises was documented, and the presence of hatchlings in 1987 demonstrates that successful reproduction took place. Although no field-tested information is available on the long-term survival prospects of small protected populations of gopher tortoises, Cox (1989) used stochastic and deterministic computer simulations to examine the 200-year persistence patterns of gopher tortoise populations. He concluded that populations initially composed of at least 20 individuals have a good likelihood of long-term survival. He points out, however, that his models are based on life history characteristics of stable, undisturbed populations, and therefore do not

compensate for the stress and reactions associated with relocated populations. Of course, small relocated populations are as vulnerable to adverse stochastic and genetic events as are fragmented populations. Cox *et al.* (1987) described management techniques that can greatly enhance survival probabilities for gopher tortoises. These include prescribed burning, public education, and predator control.

Previous reintroductions of other tortoise species have also had generally positive results. McFarland *et al.* (1974) released 20 captive-raised five-year-old Galapagos tortoises *Geochelone elephantopus* at an isolated island site where densities had been drastically reduced by human predators. Ten months later, all released tortoises were found close to the release site. Not only were their daily activity ranges much smaller than those of similar sized wild tortoises, but they had grown considerably faster than a similar group in captivity. This was attributed to the abundant food available at the release site. More captive-raised Galapagos tortoises were released subsequently. In 1978 and 1979, 173 Aldabra tortoises *Geochelone gigantea* were reintroduced to the island of Curieuse in the Seychelles (Stoddart *et al.*, 1982). Poachers have evidently removed many of the tortoises, but growth and reproduction have been documented (Stoddart *et al.*, 1982; Samour *et al.*, 1987).

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