Turtles at the beginning of Age Class 2 are easily aged because 10 scute rings, presumed to be annual, are present and can be counted accurately. But it is sometimes difficult to know exactly when a turtle leaves Age Class 2 and becomes Age Class 3 because the transition is gradual (due to wear of the shell and fading of the color), and growth and aging may be variable even within a single population.

During this 35-year study, five turtles moved from Age Class 1 through Age Class 2 into Age Class 3 but, because of some gaps in surveys at the beginning or ending of the years they spent in Age Class 2, the precise time in this age class cannot always be known. Turtles Nos. 168 and 594, both males, spent 21 known years out of a possible 22 and 30 years, respectively, in Age Class 2; No. 2006, a female, spent 26 known years out of a possible 28 years; No. 248, a female, and No. 514, a male, each spent 29 known years out of a possible 30. An additional 14 turtles spent from 21 through 28 known years in Age Class 2. These data suggest that the duration of Age Class 2 is between 21 and 29 years, and thus turtles in Age Class 2 are from 10 through a probable 30–38 years old.

The duration of Age Class 3 is known to be as long as 35 years because 8 turtles, originally Age Class 3 when marked in 1965, were captured throughout the entire 35-year study period. Eleven other turtles were captured in Age Class 3 for 21 through 31 years.

Using the duration of the above age-classes, the oldest turtles were a minimum of 65 years old at their last collection in 1999 and could be as much as 73 years of age. This longevity in *T. c. triunguis* is comparable to that of *T. c. carolina* in which subspecies some individuals are known to have survived >70 years (Hall et al., 1999).

Recent Threats. — This turtle population was relatively undisturbed for many years before the present study began and it has continued to be a healthy, natural one. However, drastic changes are occurring in the habitat. In 1998 the northern half of the study area, along with adjacent lands, was annexed into the city limits of Jefferson City, Missouri, and a housing development was started on it immediately; in 1999, the property along the western border was staked for development. This present study is providing a baseline for monitoring the potential detrimental aspects of these disturbances.

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A Translocation Strategy for Confiscated Pancake Tortoises

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Re-establishing or founding new populations of threatened or endangered species has become a popular method of conservation for a wide range of species. Translocations have been used in recent years as a conservation technique for multiple species of reptiles (Dodd and Seigel, 1991). Despite the popularity of translocations, their validity as a conservation technique continues to be questioned by a number of authors (Berry, 1986; Kleiman, 1989; Dodd and Seigel, 1991). Although translocation programs are often highly visible in the media, their methodologies and decision-making protocols are rarely published and reviewed in the scientific literature. A widespread lack of follow-up research has made it extremely difficult to gauge the success of past efforts (Dodd and Seigel, 1991; Burke, 1991).

Despite such concerns, translocation can be both successful and ecologically beneficial if performed under a specific suite of circumstances. Knowledge of ecological and social factors important to the continued survival of a population is essential before any animals are moved to a new habitat. Vital preliminary information includes knowledge of the reasons for the decline of the species in other areas, understanding of the biological and habitat constraints for the species, consideration of population and demographic factors in the released population, presence of conspecifics in the release area, and knowledge of prevention of disease transmission both within the release population and between released and wild populations (Dodd and Seigel, 1991). Addressing all of these concerns through detailed preliminary research can greatly improve the chances of a translocation's success and warn of potentially deleterious effects of the translocation.

The pancake tortoise, *Malacochersus tornieri*, has been characterized as the most divergent member of the Testudinidae (Ernst and Barbour, 1989). It is a small tortoise (maximum carapace length 177 mm) with a soft, flattened shell (Loveridge and Williams, 1957), which enables it to exploit a specific niche in crevice-rich outcroppings and kopjes in the Somalia-Maasai floristic region in Kenya and Tanzania (Broadley, 1989; Moll and Klemens, 1996; Wood and MacKay, 1997). Pancake tortoises spend most of their time in narrow crevices, emerging only to forage and mate (Moll and Klemens, 1996). When encountered inside a crevice, the tortoises retreat to narrow, remote areas of the crevice and wedge themselves tightly between the floor and ceiling. They are extremely difficult to dislodge in this state (Moll and Klemens, 1996). Crevices occupied by pancake tortoises can vary greatly in physical characteristics, although most have rock floors and entrances relatively free of obstructions, and all narrow at some point to ≤ 5 cm in height (Moll and Klemens, 1996). Although pancake tortoises have been known to move between crevices, the extent of dispersal and distances traveled have not been studied. Long-distance dispersal is most likely limited due to the vulnerability of tortoises while outside of their crevices.

Pancake tortoises are currently listed in Appendix II of CITES, and have been identified by the IUCN as a "known threatened species in need of specific conservation measures" (IUCN/SSC Tortoise and Freshwater Turtle Specialist Group, 1991). Their status has been caused by the popularity of the pancake tortoise in the international pet trade. Systems of local collectors supplying village middlemen, who in turn supply large-scale international dealers, have made Tanzania the leading source of pancake tortoises in American, Asian, and European markets (Klemens and Moll, 1995). A zero-export quota system was imposed by the Tanzanian government in 1992 (Klemens and Moll, 1995), but smuggling still occurs (USFWS, in litt.). In 1991, a shipment of hundreds of tortoises being illegally exported from Tanzania was intercepted and impounded at Schiphol Airport in Amsterdam (Klemens, 1995; Luiijf, 1997).

In a high-publicity effort by the Dutch government (Klemens, 1995), 216 confiscated tortoises (Luiijf, 1997) were brought to Mweka College of African Wildlife Management, Tanzania, with the intent to eventually release them into the wild. These tortoises currently reside in a 10 x 15 m holding pen on the Mweka campus, where significant mortality in the past five years decreased their numbers to around 100 as of May 1997 (R. Mwaya, *pers. comm.*). The tortoises have not yet been released due to the complex nature of translocation and a desire to maximize the success of a potential translocation effort. The major limiting factors in this process have been the health status of these tortoises (Karesh et al., 1993) and the inability to locate a site for release that would not contaminate other tortoises. Recently, Saanane Island Game Reserve in Lake Victoria has been suggested as a potential release site for the tortoises due to its distinctive, crevice-rich habitat, protected status, and isolation from mainland tortoise populations.

The purpose of this study was to evaluate the suitability of Saanane Island Game Reserve as a potential release site for the Mweka population of pancake tortoises or other confiscated pancake tortoises that may be obtained in the future. A preliminary assessment of the suitability of the island in terms of the unique ecological needs of this tortoise is necessary to determine if such translocations should take place and how they should be conducted to maximize their chances of success. The initial objective of the study was to determine the current and historical presence or absence of a population of pancake tortoises on Saanane Island. The ecological characteristics of the island, including availability of suitable crevice microhabitat and vegetational and soil composition, were also evaluated in light of the specific ecological needs of pancake tortoises. These objectives were undertaken to provide baseline data for evaluating the potential outcome of a translocation of this highly threatened species of tortoise.

Study Site. — Saanane is a small island (area = 0.5 km^2) in Lake Victoria southwest of Mwanza, Tanzania, approximately 2 km from shore. It is characterized by large, extremely rocky hills which peak at 70 m above shore level and areas of scattered tall grassland interrupted by large boulders. The landscape is typical of the Mwanza region, which is known for its distinctive, rocky terrain. The region averages 100–130 cm of rain per year, mainly during the short (November–December) and long (March–April) rainy seasons, with daily high temperatures averaging 18–31°C (Berry, 1971). The island was used for agriculture prior to 1964, at which time it was partially developed by Frankfurt Zoological Society to serve as a holding station for exotic animals due to be translocated to Rubondo Island, an island then being established as a game reserve. Saanane Island has since been classified as a game reserve and developed into a small zoological park where animals are kept on a more or less permanent basis (Jonathan et al., undated). Daily transport is available to the island from Mwanza, and the reserve receives frequent visitors. Today, most of the island is relatively undisturbed and there are areas of natural habitat. Along with several caged animals, the island is home to a herd of free-ranging impala, a wildebeest, and a hartebeest. Saanane Island is also home to a diverse array of reptile and bird fauna. Most prevalent of the reptiles are agama lizards (*Agama agama*). Also resident are Nile monitor lizards (*Varanus niloticus*) and a diversity of skinks and geckos. Along the shores of the island are crocodiles

(*Crocodylus niloticus*). Leopard tortoises (*Geochelone pardalis*) have been introduced into a grassy area on the east side of the island, and are still limited to this small area. A previous study has reported a population of pancake tortoises on the island based on the evidence of two dead animals found there in 1992 (Klemens and Moll, 1995).

Methodology. — Saanane Island was first explored for the presence of pancake tortoises. Areas containing crevice-rich rock outcroppings were identified as suitable habitat for the species (Ernst and Barbour, 1989; Moll and Klemens, 1996) and searched on foot. A small proportion of the crevice-rich area of the island was unable to be searched due to the steepness of the rocky hills. The area was surveyed for suitable crevices, which were then examined thoroughly with a flashlight. Suitable crevices were defined as those crevices with a maximum entrance height >2 cm to allow tortoise entry and tapering at some point to <5 cm high to allow tortoise wedging (Moll and Klemens, 1996). Because the identified areas were searched on foot in a wandering fashion, it is possible that some crevices in each area were missed. However, the small size of the island ensured that most crevices were located and examined.

A proportion of suitable crevices was evaluated for comparison with data on crevices inhabited by wild pancake tortoises in natural populations. Measurements taken included entrance length, entrance height (floor to ceiling, widest point), and distance to ground (Moll and Klemens, 1996). All measurements were taken using a string marked at 1 cm intervals. Additionally, average height of the crevice interior and depth to the back of the crevice were estimated. Slope from the crevice to the ground was subjectively classified as being flat, moderate, or steep, with flat being a slope of <10° and steep being a slope >45°. Crevice orientation was classified as horizontal, vertical, or downward-facing; oblique crevices were rare due to rock formations.

The vegetation in the vicinity of crevices was classified according to the five communities on Saanane Island identified in a previous study: (A) upper hill rocky forest patches, (B) upper rocky-hill thickets, (C) rocky hill thickets on steep ground, (D) lowland open-tall grassland, and (E) scattered tree grassland on hillside (Mushy and Ludanga, undated). More detailed vegetation analysis was conducted for 12 crevices, 3 each in vegetation communities B–E. Two areas were sampled for each crevice using a metal ring of 0.47 m diameter, and vegetation within these areas was analyzed. The first area sampled for each crevice was taken on the ground near the widest point of the entrance to the crevice. If there were no soil or plants in this area, the sample was taken in the nearest area with soil or plants. The second area was sampled at a distance of 1 m from the first, measured perpendicularly out from the crevice entrance. After placement of the marker at each sample location, the total number of plant species within it was determined. Specimens of each species found were retained until the end of the study to obtain a total species count for each community. Each species was classified as an herb, sedge, forb, grass, or tree/shrub. Plants too young to classify in this way were lumped together as "shoots." The percent cover for each species for the area sampled was estimated by visually dividing the marker into quarters and estimating the percent of its area covered by the species as viewed from above. Other components of the sampled area, such as bare rocks or decaying vegetation, were noted as well, and their percent covers estimated. Soil samples were also obtained from vegetation communities B–E and were classified according to Brewer and McCann (1982).

Informal interviews were conducted with several staff members who had been working on the island for a number of years. Interviews were conducted in Swahili and English, and pertained to the history of pancake tortoises on the island, any past translocations, and pancake tortoise sightings made in the area.

Results. — A total of 282 crevices was examined over the course of the study. No pancake tortoises were found. Crevices were searched for tortoises in 13 areas on the island. Of the 282 crevices examined, 93 were measured and classified, and mean measurements calculated. The mean entrance width was 122 cm (range: 20–500 cm) while mean entrance height was 11 cm (2–40 cm). The mean height of crevice interior was 6 cm (2–20 cm) and the mean depth to back wall was 74 cm (10–300 cm). The mean distance from crevice to the ground was 48 cm (0–200 cm). Of the 93 measured crevices, 45 were oriented horizontally, 34 vertically, and the remaining 14 were downward facing. The slope from the entrance to the ground was flat for 59, moderate for 19, and steep for 15 measured crevices.

Suitable crevices were distributed throughout all of the predominant vegetational zones on Saanane Island. Crevices were located and searched from all vegetation communities (A–E). Only one crevice from community A was searched due to the fact that this community constitutes a very small and relatively inaccessible portion of the island's area; of the crevices measured, 16 were in community B, 16 in C, 22 in D, and 38 in community E. Detailed vegetation analysis was completed on 3 crevices each from communities B–E. Total numbers of distinct species observed for each plant type were counted for each community, and average percent cover for each plant type in each vegetation community was calculated (Table 1). Vegetation analysis revealed

Table 1. Total number of plant species counted (and mean percent cover) in sampled areas around crevices located in the four readily accessible vegetation communities (B–E) on Saanane Island.

	Grasses	Trees/ Shrubs	Sedges	Forbs	Herbs	Shoots	Decaying Veg.	Rocks
B	1	1	2	0	4	2	–	–
	(16.7)	(2.5)	(7.5)	(0)	(44.2)	(2.5)	(13.3)	(13.3)
C	0	0	0	1	7	0	–	–
	(0)	(0)	(0)	(24.2)	(55.8)	(0)	(7.5)	(12.5)
D	6	1	0	0	3	2	–	–
	(49.2)	(1.7)	(0)	(0)	(23.3)	(1.7)	(18.3)	(5.8)
E	2	3	0	2	3	1	–	–
	(57.5)	(12.5)	(0)	(4.2)	(5.0)	(1.7)	(19.2)	(0)

that the dominant plant type in communities D and E were grasses. These communities both exhibited a significant proportion of shoots and short grasses. Communities B and C had herbs as the dominant plant type. Community B had the highest proportion of decaying vegetation and rocks, but also a significant number of small plants and shoots. Soil samples from communities B, C, and E were all found to be sandy loam, while soil from community D was classified as loamy sand.

Informal interviews with island staff revealed that there was an introduction of an unknown number of pancake tortoises onto Saanane Island sometime in 1992. Estimates of the number released varied, but all estimates were <10 individuals. However, no written records of this translocation could be found. The tortoises were reportedly obtained from Mwanza Airport along with a group of leopard tortoises, quarantined for some time, and then released in the meadow near the eastern shore of Saanane Island. No information about the history of pancake tortoises on the island before this translocation was uncovered. B. Foya, the project manager at the island, stated that there were probably no pancake tortoises on Saanane Island before 1992. Several employees reported seeing pancake tortoises on the island, but these sightings were described as infrequent, of only one tortoise, during the rainy season, and taking place near the water.

Discussion. — The current presence of a substantial population of pancake tortoises on Saanane Island seems unlikely. A significant proportion of suitable habitat and a large number of crevices were searched without finding any pancake tortoises. It is possible, however, that a small population could exist in one of the inaccessible regions of the island, or that a few tortoises live in crevices missed by the search. Because crevices were examined from almost all parts of the island, and search areas were covered thoroughly, it seems unlikely that an undiscovered population, should it exist, could be substantial.

The history of pancake tortoises on the island remains unclear due to lack of documentation. No information was found concerning pancake tortoises or any other reptile on the island before 1992. The reported translocation attempt in 1992 is an example of a translocation project from which no records survive. It seems from the available information that the tortoises were probably from a population confiscated on the way to Zaire that same year (B. Foya, *pers. comm.*). A small number of pancake tortoises and a larger number of leopard tortoises were released into the meadow on the east side of the island, an area almost completely free of crevices. A small group of leopard tortoises currently inhabiting this area is presumably from this release group. As this area is approximately 100–200 m to suitable crevices, and since pancake tortoises are quite vulnerable when outside of crevices, it is likely that the pancake tortoises did not reach these crevices. This information probably also accounts for the previous record of pancake tortoise shells found on Saanane Island in March 1992 (Klemens and Moll, 1995).

Reported sightings of pancake tortoises by island staff suggest that there might be, or were, pancake tortoises living on Saanane Island. This interpretation is complicated by the presence of a number of flattened aquatic terrapins native to Lake Victoria (*Pelusios* spp. or *Pelomedusa subrufa*) that could be confused with a pancake tortoise by a casual observer (R. Mwaya, *pers. comm.*). Because all sightings were reported near the water and far from any crevices, the possibility that they were actually terrapins seems quite high. Overall, no sightings of pancake tortoises on the island could be verified.

Crevice microhabitat on Saanane Island seems to be suitable for pancake tortoises. All measurements taken on the crevices were highly variable, consistent with measurements taken on inhabited crevices elsewhere (Moll and Klemens, 1996). Furthermore, entrance height and length and distance to the ground were within the range of values found for crevices inhabited by pancake tortoises (Moll and Klemens, 1996). Means for measurements in both studies were roughly similar, although extreme variability in measured values complicates a direct statistical comparison. Measurement variability for inhabited crevices may indicate that tortoises do not consider these factors when choosing a crevice and that ample space for retreating and wedging is more important (Moll and Klemens, 1996). Wedging space was available in all searched crevices, and the range of depths available for retreat was greater than the retreating distance of turtles in natural populations (Moll and Klemens, 1996). Most crevices were oriented horizontally and were separated from the ground by a flat area. However, tortoises can occupy vertically oriented crevices and climb (Broadley, 1989; Moll and Klemens, 1996), so crevices from all orientation and slope categories might be suitable. Thus, the crevices on Saanane Island may provide suitable microhabitat for pancake tortoises.

Although the exact feeding preferences of pancake tortoises are presently poorly known, they are known to eat a variety of shoots, small grasses, herbs, forbs, and sedges (Moll and Klemens, 1996). This description is consistent with the observed feeding habits of captive tortoises at Mweka (R. Mwaya, *pers. comm.*). Therefore, an adequate supply of food seems to be present near suitable crevices in all four vegetation communities analyzed. Still, the vegetation analysis was conducted during the long rainy season, so the availability of vegetation during the dry season remains to be determined.

No information is available concerning the nesting habitat requirements of pancake tortoises in nature. Sandy and loamy soil, however, is a suitable nesting substrate for other species of tortoises (e.g., Luckenbach, 1982). There is no information available to suggest that pancake tortoises would be unable to utilize the soil types found on Saanane Island for nesting purposes.

Climatic data indicate that Saanane Island receives more rain than other areas of the pancake tortoise's known range. Tarangire National Park, known to contain significant populations of pancake tortoises (Klemens and Moll, 1995), averages <60 cm of rainfall annually (Berry, 1971). Pancake tortoises have adapted to the long dry season in these areas, and are able to inhabit crevices with no accessible sources of water nearby (Moll and Klemens, 1996). It seems likely, therefore, that they could survive the dry season on Saanane Island. The habitat and climate on the island are very similar to those at Busisi, a region on the shore of Lake Victoria 40 km west of Mwanza, where a native population of *M. tornieri* is said to exist (Broadley, 1989).

The objective of this study was to evaluate the suitability of Saanane Island as a potential release site for the Mweka population of pancake tortoises or for any groups of confiscated pancake tortoises that might be obtained in the future. This preliminary research indicated that Saanane Island contains habitat which is suitable for pancake tortoises. Crevice characteristics, vegetation, and climate appear to be compatible with what is known about the ecological needs of pancake tortoises. Because the island is a well-patrolled, protected game reserve, exposure of the tortoises to poachers would be minimized, unlike in other areas where collecting is the primary cause of their decline or demise (Klemens and Moll, 1995). Additionally, the island is within the range of the species as suggested by past research and is near a reported population at Busisi (Broadley, 1989).

Major concerns still remain if a translocation is to be attempted. The main concern regarding the Mweka tortoises is their health. It is likely that some of them are infected with *Mycoplasma*, a bacterial pathogen causing upper respiratory disease syndrome (URDS), along with other diseases (Karesh et al., 1993; Klemens, 1995). The tortoises experienced significant mortality during their first five years at Mweka (R. Mwaya, *pers. comm.*). If these tortoises were released into the wild, URDS could be transmitted to natural tortoise populations in the area, which could result in an epidemic similar to that experienced by *Gopherus agassizii* in the United States (Jacobson et al., 1991). Alternatively, releasing the confiscated tortoises onto an island uninhabitated by native pancake tortoises minimizes that risk.

A second major concern regards the high numbers of potential predators on pancake tortoise eggs and hatchlings. The island contains many *Agama agama* and *Varanus niloticus*, which are known to dig up tortoise nests for food. These lizards could present a threat to establishing a breeding population of tortoises. The island is also inhabited by Black Kites and other large predatory birds that could prey on the hatchling tortoises. Nonetheless, *M. tornieri* is sympatric with these species throughout its distribution, suggesting that these predators should not prevent establishment of a stable population of tortoises.

The future of the Mweka pancake tortoises must be considered in light of the above concerns. The tortoises are currently being held at an extremely unsuitable site high on the slope of Mt. Kilimanjaro. This location is most likely detrimental to the health of these tortoises and may have contributed to the documented mortality. A possible solution to this dilemma is to construct an enclosed exhibit for the pancake tortoises on Saanane Island. This exhibit would include an appropriate area of natural, crevice-rich habitat (i.e., vegetation zones B–E) that could serve as an experimental "halfway house" for the tortoises. Several partially-enclosed exhibits are currently unused on the island and could be readily adapted for this purpose. Tortoises should be marked individually, checked thoroughly for signs of disease before release, and prevented from leaving the enclosure. Furthermore, other reptile species on the island should be monitored for signs of disease. Such a "halfway house" would thus provide the following benefits:

1) Relocation of the tortoises to a site that is ecologically suitable,

2) Prevention of disease transmission to wild tortoise populations,

3) Education of visitors to the island about this unique, imperiled species, and

4) Controlled experimentation to evaluate the suitability of Saanane Island as a potential release site for future groups of confiscated pancake tortoises.

Such a controlled translocation experiment, if monitored over several years, could provide the Tanzanian government with data regarding the management of confiscated pancake tortoises. These data could therefore be valuable for the inevitable subsequent incidents of smuggling involving this species. Translocation projects involving preliminary research followed by careful, controlled execution and long-term follow-up could result in crucial knowledge for better tortoise management practices in the future.

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Aquatic Home Ranges of Female Western Pond Turtles, *Clemmys marmorata*, at Two Sites in Southern California

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Movements within animal populations are critical to many life history and ecological processes (Gibbons et al., 1990). Movement and home range data have been reported for the western pond turtle, *Clemmys marmorata*, at different locations throughout its range (Storer, 1930; Bury, 1972, 1979; Rathbun et al., 1992; Holland, 1994; Ernst et al., 1994; Reese, 1996; Holland and Bury, in press). However, no studies have described their range of movements in southern California. Here we compare linear and total aquatic home ranges and pre-nesting movements of western pond turtles, *C. marmorata*, at two locations in southern California.

Methods. — Turtles were captured and marked from 1992–94 as part of a long-term study in the Chino Hills State Park (CHSP), San Bernardino County, California, USA, and the West Fork of the San Gabriel River (WFSGR), Los Angeles County, California, USA. Turtles were individually marked with small (3–4 mm) triangular notches in their marginal shields with a number system devised by Holland (1994). Total carapace length (mm), weight (g), sex, and reproductive status were recorded.

Small (4.1 x 1.8 x 0.8 cm, 16 g) radio transmitters (Telonics®, Mesa, Arizona) were epoxied to the third vertebral shield of 20 adult female turtles (CL >110 mm; Holland, 1994): 9 in the CHSP and 11 in the WFSGR. All turtles were located two to four times monthly with the exception of gravid animals, which were located daily until nesting occurred.

Linear aquatic home ranges were determined from the range of upstream and downstream movements for each turtle. Total aquatic home range was calculated by multiplying the linear aquatic home range of each turtle by the mean stream width within each turtle's linear home range. Pre-nesting movements are defined as the distance traveled by gravid females within the watercourse from their capture site to the approximate location where they moved away from the watercourse to nest. Terrestrial (nesting) excursions (Schubauer et al., 1990) were excluded from this analysis. Means and standard deviations were calculated for each population and two-sample t-tests were used to compare differences.