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CONSERVATION STATUS OF THE TEXAS TORTOISE *GOPHERUS BERLANDIERI*

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North American tortoises (genus *Gopherus*) are paradigms of long-lived species. These tortoises live for 40 years or more, require a decade or longer to reach sexual maturity, and have low recruitment rates related to high mortality of eggs and young (Bury, 1982). The survival of these tortoises is threatened by habitat reduction and adverse impacts to populations due to a variety of human activities (Bury, 1982; Bury and Germano, 1994). Conservation plans are sorely needed if viable populations of these species are to be sustained.

Conservation plans for species require detailed life history information, assessment of past and current impacts, assessment of the efficacy of current management practices, identification of problem areas, and identification of gaps in current knowledge. Usually, information on these topics is distributed through a variety of published and unpublished sources and is largely unavailable to resource managers. Herein, we provide information on the conservation status of the Texas tortoise, *Gopherus berlandieri*, in an effort to assemble, in one place, information needed to help develop a conservation plan for this protected species.

Gopherus berlandieri is the smallest and most sexually dimorphic of the four extant species of *Gopherus* (Rose and Judd, 1982). Maximum size of males is about 220 mm (carapace length) and some individuals become sexually mature at 105 mm. The head is small and narrow, and the snout is more pointed than in the other three species. Carapace width (relative to length), as well as depth, is greater than in other *Gopherus* (Rose and Judd, 1989). In Texas, *G. berlandieri* occurs generally south of a line connecting Del Rio, San Antonio, and Rockport. In Mexico, the range extends southward from the Rio Grande through eastern Coahuila and Nuevo Leon into San Luis Potosi (Rose and Judd, 1982, 1989).

The habitat of *G. berlandieri* is best described as semidesert scrub, although the tortoise probably inhabits several barrier islands. Substrates range from sand to clay to caliche. In Mexico, the tortoise occurs from sea level to an elevation of 884 m in Coahuila.

HISTORICAL AND LEGAL STATUS

The low reproductive rate and the exploitation of Texas tortoises by pet suppliers prompted the Texas Legislature in 1967 to establish a law protecting *Gopherus berlandieri* from being injured, killed, collected, or possessed for "sale, barter or commercial exploitation" (Rose and Judd, 1982). In 1973, the U SA endorsed the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Article IV of the Convention affirmed the policy of requiring foreign government export permits before permitting importation of endangered taxa. The Convention placed all species of *Gopherus* in Appendix II of the List of Endangered Species (Morafka, 1982). This appendix included all species, which although not then necessarily threatened with extinction, might become so unless trade in specimens of these species was subject to strict regulation. Protected nongame species regulations were adopted by the Texas Legislature in 1977 that prohibit persons from taking, possessing, transporting, exporting, selling or offering for sale, or shipping 81 species of Texas vertebrates, including *G. berlandieri* (Rose and Judd, 1982). These prohibitions apply equally to goods made from the tortoise. Permitted exceptions to these regulations are based on scientific or rehabilatory justifications.

Despite these legislative enactments, Texas enforcement agencies do little to protect the species. Indeed, not all enforcement officers are aware of the laws or are able to identify all the species included in the prohibitions. *Gopherus berlandieri* is now listed as "threatened" by the State of Texas, but the federal government does not list it. Apparently, the rationale is that because the tortoise occurs only in Texas in the United States, Texas laws are sufficient to ensure protection. The law may be sufficient, but lack of enforcement makes the reality of protection a sham.

Little is known of the status and demography of this tortoise in Mexico. Most of the information garnered for *G. berlandieri* there is anecdotal or relegated to a few locality records, mostly unpublished.

ANTHROPOGENIC THREATS TO CURRENT POPULATIONS

Human Predation.—There is little evidence to suggest that Indians used the Texas tortoise as food. The Coahuiltecans occupied the inland areas of Texas in the range of *G. berlandieri*. Newcomb (1980) states that the Coahuiltecans ate reptiles, but he does not mention tortoises. However, it is likely that the Coahuiltecans ate tortoises because Newcomb (1980) states, "There seems to be little that Coahuiltecans failed to eat which could be used by the human digestive apparatus." This includes re-ingestion of seeds harvested from animal scat.

The coastal areas in the range of *G. berlandieri* in Texas were occupied by the Karankawas, Malaquites, and Borrados (Newcomb, 1980). None of these groups has been reported to have used tortoises as food. Salinas (1990) reported on the Indians of the Rio Grande Delta of southern Texas and northeastern Mexico. He pointed out that in documents written by Europeans, very few kinds of animals hunted by Indians were identified. He stated, "No European ever bothered to list the names of all animals, large or small, that were hunted by a particular Indian group, or by various Indian groups associated with some specific area." He cited nine sources for the table of animals hunted that he presented. Snakes (unspecified) were the only reptiles identified as food.

Newcomb (1980) stated that Tonkawas hunted "land tortoises" for food, but Tonkawas were residents of the Edwards Plateau, an area now north of the range of *G. berlandieri* (Rose and Judd, 1982). It is not clear if "land tortoise" referred to *G. berlandieri* or *Terrapene ornata*.

There are no reports of middens containing tortoise shells. The Texas tortoise would have been an important, and easily captured, source of protein for Coahuiltecans. Even these nomadic hunters and gatherers could have accumulated sizable mounds of shells at their encampments, but no such mounds have been reported. Perhaps there were taboos against eating tortoises. Alternatively, absence of shells might be related to the method of cooking. If tortoises were cooked by placing an animal on its back in a bed of coals, the shell might have been largely destroyed in the process, i.e., the bones of the carapace and plastron would become disarticulated and the heating process would favor disintegration once the elements were scattered. The skeletal elements of the shell of *G. berlandieri* are quite thin and possibly weathering and gnawing by rodents account for their apparent absence.

In Mexican tourist markets, the tortoises are sold after they have been killed, dried, and varnished. Rose and Judd (1982) reported that a survey of shops in border cities from Ciudad Acuna to Matamoras showed that of 346 such chelonian products, *G. berlandieri* accounted for 11.3%, *Chrysemys* (= *Trachemys*) 20.5%, *Kinosternon* 67.1%, and *Terrapene* 1.1%. They stated that it was likely that the tortoises being sold were of Mexican origin, but collection of tortoises north of the Rio Grande and their transport to Mexico for commercial exploitation was considered a strong possibility.

Rose and Judd (1982) reported that for years it was rumored that the Texas tortoise was being collected in vast numbers and rendered for its high-quality fat, which was used in cosmetics. They assayed tortoises found dead on roads for total fat content. Mean percentage fat of the dry weight was 3.5 (range, 2.5 – 4.6%). In contrast, the mean percentage of fat for *Kinosternon flavescens* was 31.2 (range, 19.0 – 38.9%) (Rose and Judd, 1982). They concluded that the low level of fat exhibited by the Texas tortoise would make commercial exploitation for fat infeasible.

The most bizarre use we found for the tortoise was to scare deer from agricultural fields, especially garden plots (Rose and Judd, 1982). A tortoise was placed in a metal tub from which it would try to escape; the constant scraping and scratching sound apparently deterred deer from entering the fields. When a tortoise died or became too weak to scratch, it was replaced. Ernst and Barbour (1972) stated that some ranchers kill tortoises because of a mistaken belief that they eat quail eggs.

During movements and foraging, tortoises cross roads where they may be killed by passing vehicles or collected by people. Nicholson (1978) found that paved roads were a major factor contributing to the reduction of desert tortoise (*G. agassizii*) populations. No similar study exists for *G. berlandieri*, but observations suggest that vehicles cause significant mortality in Texas tortoise populations.

Habitat Alteration.—In certain areas, notably in the lower Rio Grande Valley of Texas (LRGV), northeastern Tamaulipas, Mexico, and around Zapata and Laredo, Texas, habitat alteration has markedly affected the distribution and abundance of tortoises. Here the land is either reclaimed for agricultural purposes or modified to improve grazing conditions. In the LRGV, less than five percent of the native communities remain (Jahrsdoerfer and Leslie, 1988).

In the early 1900's, land managers began large-scale removal of brush in southern Texas (Inglis et al., 1986). In the 1910's and 1920's, trees were killed one at a time by chopping or application of kerosene. In the 1930's, brush removal was made markedly more efficient by using tractors or caterpillars to pull a steel cable or heavy anchor chain between two such machines. Trees, shrubs, and prickly pear were literally gouged from the earth and left to die or raked into rows and burned. Subsequently, the land was root-plowed and then converted to row crops or improved pasture. As a result of brush clearing of this sort, tortoises are adversely affected immediately by a loss of shade cover, by direct physical damage, and by the terrain being intersected with deep furrows and mounds (Rose and Judd, 1982).

In the early 1960's, chemical growth stimulants and poisons were used to kill woody species of plants (Inglis et al., 1986). In the early 1970's, new herbicides that could destroy many of the common woody species in southern Texas mixed-brush communities were developed and applied (Beasom and Scifres, 1977; Mutz et al., 1978). We do not know what direct effects, either immediate or long-term, these chemicals may have had on tortoises, but they all resulted in reduced shade cover for the tortoises.

It is questionable if there are long-term agricultural benefits from brush control efforts. Grass production benefits are short-lived and appear to be largely the result of release of nutrients from the dead stems and roots (Jahrsdoerfer and Leslie, 1988). Retreatment is necessary within two years after chaining and within 15 years after root-plowing. Indeed, Fulbright and Beasom (1987) found that density of mesquite was three to four times greater 25 years after treatment in root-plowed areas than in untreated areas.

Bury and Smith (1986) stated that controlled burns might improve habitat for tortoises at Laguna Atascosa National Wildlife Refuge (Cameron County, Texas) because the shrub and tall grassland conditions were too dense for tortoise movements and seemed to provide little food. They suggested that these conditions might have forced tortoises to use roadways and edges for basking and foraging and thereby increased exposure to vehicular mortality. They reasoned that controlled burns of some of the lomas might provide openings in the vegetation and attract tortoises away from roads. Because intense, large fires are known to be hazardous to tortoises (Cheylan, 1984; Stubbs et al., 1985), they have recommended several small, controlled burns (<1 ha) as experiments.

Naturally occurring wildfires are uncommon in the LRGV (Jahrsdoerfer and Leslie, 1988). Most of the vegetative associations now present in the area are not fire-dependent, but shrubs here exhibit fire-tolerant adaptations (Jahrsdoerfer and Leslie, 1988). On Welder Wildlife Refuge (Sinton, Texas), 95% of the upland shrubs sprouted from the root crown when the top was removed by fire (Hanselka, 1980).

Increased hunting for trophy antler deer (*Odocoileus virginianus*) in south Texas has had a deleterious impact on *G. berlandieri*. In order to regulate the ratio of bucks to does, and antler size (resulting in higher prices to the hunter), vast areas are fenced. Thirty-two kms of fencing, perimeter and internal divisions, is common. These so-called "deer proof fences" are a barrier to moderate and larger sized tortoises, but because of the opening size, many tortoises become embedded in the fence and die. The initial number of tortoise deaths can be staggering, but for some unknown reason, after several months, deaths due to fencing become minimal. These fences, however, might impact local body size distributions of tortoises.

Fragmentation of Habitat/Populations.—In coastal areas, *G. berlandieri* occurs principally on lomas (clay dunes or ridges) that are habitat islands surrounded by salt flats and marshes (Auffenberg and Weaver, 1969; Rose and Judd, 1975; Judd and Rose, 1983; Bury and Smith, 1986). There is probably limited gene exchange between these tortoise populations and there may be differences in their population ecology on nearby lomas (Auffenberg and Weaver, 1969; Judd and Rose, 1983). Brush clearing has also created habitat islands in the LRGV and many of the remnant brush tracts in the area are small (<40 ha) and scattered (Jahrsdoerfer and Leslie, 1988). The size of these natural areas, the degree of fragmentation, and their relative proximity to each other influence recruitment and extinction relationships. Larger areas, or small areas with close neighbors provide increased diversity, dispersal potential, and lower extinction rates (Harris, 1984).

Diseases.—Little is known about diseases or parasites of *G. berlandieri*. We have observed few ectoparasites other than the chigger, *Eutrombicula alfreddugesi* (Goff and Judd, 1981). Danny Pence (pers. comm.), who necropsied about 20 *G. berlandieri* from near Cotulla, LaSalle County, Texas, found only a few unidentified pin worms; blood smears were negative. Immature pin worms appear to be common in fresh scats of *G. berlandieri* on the Chaparral Wildlife Management Area and tortoises there are frequently observed eating mammal scats (J. Rutledge and D. Synatzske, pers. comm.), a behavior first reported by Mares (1971).

Many adults show evidence of lamella infection that is manifested as whitish, irregular patches that appear "chalky". The posterior carapace is frequently involved, especially the marginals. The infection doesn't appear to be life threatening and progression is slow but it can destroy the lamella. In a few old individuals, the disease spreads to all lamellae and they appear to be replaced by a thin, horny covering lacking growth rings. The new layer appears to be generated as a response to injury and there is no underlying bone involvement. The causative organism was identified as *Fusarium semitectum* (Rose, unpubl.), a keratinophilic fungus found in south Texas. This organism was implicated in corneal infections of several patients seen at the University of Texas Health Sciences Center in San Antonio (Ms. Deanna Sutton, Fungus Testing Laboratory). The health impact to humans having contact with *G. berlandieri* infected with this organism has not been evaluated; however, individuals with compromised immune systems might be at risk.

Bowen (1977) reported that *G. berlandieri* tested positive for equine encephalites virus (EEV). These results were obtained when personnel from the Center for Disease Control were testing for reservoirs of the virus during an outbreak in south Texas.

Captive *G. berlandieri* tested (ELISA test for *Mycoplasma agassizii*) positive for *Mycoplasma* infection (Rose, unpubl.). General symptoms of Upper Respiratory Tract Disease (URTD) include watery exudate from the nares, often as bubbles, lethargy, and swollen eyelids frequently fused closed with exudate. Infected individuals fail to thrive but respond temporarily to several antibiotic drugs only to express symptoms shortly after drug treatment. Confirmation of this disease in captive *G. berlandieri* does not bode well for this species because of the frequency that captive individuals are released. One infected female produced two clutches of three and two eggs each in 1995. The previous year she produced three eggs (according to her captor), and all were infertile. Of the five eggs produced in 1995, one was viable; thus, the female was not infertile, but it is not known if her egg inviability was related to her disease. Two males, both of which now exhibit symptoms of UTRD, courted her vigorously in July and August of 1995. She succumbed to the disease in June 1999.

Anecdotal accounts from veterinarians practicing in south Texas who report seeing increasing numbers of Texas tortoises exhibiting URTD symptoms is alarming. State officials should begin immediately to verify and monitor this situation. Smith et al. (1998) reported that URTD exposure, as determined by antibody assay, of populations of *Gopherus polyphemus* in southern Mississippi and east Florida were high (60-100%). Such a study of *G. berlandieri* populations is recommended.

Pet Trade.—Luckenbach (1982) reported that many *G. berlandieri* were imported into California for the pet trade, mostly from northeast Mexico through New Mexico to avoid Texas laws (Brame and Peerson, 1969). Auffenberg and Weaver (1969) reported that 4,000 *G. berlandieri* were collected for one shipment. Luckenbach (1982) cited personal communication with Glen R. Stewart in 1974, who reported a shipment of 8,000 animals transported in two vans. Stewart estimated that some 40,000 *G. berlandieri* were being imported to California each year. While we believe the numbers of Texas tortoises exported to be high, figures of 4,000 to 40,000 are unrealistic.

Tortoises are often collected by individuals and kept as pets at their residences. We have frequently learned about some of these when a person contacts one of us after seeing a newspaper account of our studies or rehabilitative efforts with the Texas tortoise. Often the persons live in cities far to the north (Lubbock) or east (Houston) of the geographic range of the tortoise. These individuals usually state that they first learned about the protected status of the tortoise from a newspaper account. Follow up of one such call revealed that 72 tortoises were being kept in a residential backyard.

The tremendous upsurge in the reptilian and amphibian pet trades in recent years will eventually impact *G. berlandieri*. While illegal to possess, the numbers maintained in captivity must be staggering. Of 32 telephone calls received in 1994-95 from individuals requesting information on this tortoise, the average number being maintained was 15 (1-72). Many of those maintaining *G. berlandieri* also maintain box turtles and exotic tortoises. Sick, injured, or predator-attacked tortoises are expensive to treat and the task is often time consuming. Frequently, it is more expedient to release the tortoise than to maintain its care. Tortoises maintained in confined captivity for several years do not exhibit normal escape behavior nor do they select relatively safe resting areas. For example, captive individuals received by us and maintained in a ¼ acre fenced enclosure approximating natural conditions that are frequently found exposed at night as though no site selection was involved. After several months they adopt more traditional behavior and seek shelter in cavities or under brush, but in the intervening periods they were vulnerable to predators. All seven individuals killed by predators (raccoons and foxes) in this enclosure were long-term captives, recently released into the enclosure.

Subsidized Predation.—The southern plains woodrat, *Neotoma micropus*, might be the most active egg predator (Auffenberg and Weaver, 1969) because of its close proximity to nesting sites. Skunks, coyotes, and foxes probably consume eggs. Small tortoises are susceptible to predation from numerous organisms including snakes (indigo and western diamondbacks), birds, woodrats, skunks, foxes, raccoons, opossums, coyotes, bobcats, badgers, feral cats, and dogs. Collared peccaries and feral hogs should be suspect predators. The population levels of feral hogs in south Texas are high and the negative effects of this relatively recently introduced predator on native species is a concern, but difficult to measure without having solid baseline data. Auffenberg and Weaver (1969) reported finding an adult female in November 1963 which had been dragged from its pallet, killed, and partially eaten the previous night. In 1995, we received a report of an opossum killing and eating three captive juveniles.

Urbanization into tortoise habitat not only fosters habitat destruction but also brings with it increased domestic predators, and an increased number of wild predators such as raccoons, opossums, and skunks, that exploit urbanization. Coyotes and raccoons and probably badgers readily kill adult tortoises. The decrease in the fur trade and the low price of hides has released human hunting pressure on many carnivores resulting in higher densities, with devastating results. In addition, many people living in rural areas feed wild animals, further enhancing their survival. However, no known predator has equal densities throughout the tortoise's range.

Woodrats gnaw at the shells and feet of tortoises during winter inactivity. It is conceivable that young tortoises are killed during these episodes and adults might suffer serious enough injury to be killed.

The role of the introduced fire ant (*Solinopsis invicta*) as a nest predator on hatching *G. berlandieri* is unstudied. Although fire ants do not co-inhabit with *G. berlandieri* over most of the latter's range, they are sympatric along the southeastern border. The hard egg shell (Rose and Judd, 1991) extending the pipping stage, and close proximity of the eggs to the soil surface, favor fire ant predation where the two co-occur. The geographical range of fire ants in the United States is projected (Vinson and Sorensen, 1986) to encompass the range of the Texas tortoise.

INTEGRITY OF THE TAXON

Evidence of Genetic Divergence.—There is no evidence of genetic divergence among populations of *G. berlandieri*. There are notable size differences associated with geography and the degree of sexual dimorphism in size is not expressed uniformly. Size and the degree of sexual dimorphism decreases with increasing distance from the Gulf of Mexico. Whether these size differences are related to genetics, age differences, or nutrition is unknown.

In captivity, hybrids between *G. berlandieri* and *G. agassizii* are known (Woodbury, 1952), as are hybrids between *G. polyphemus* and *G. flavomarginatus* (Judd and Rose, unpubl.). It is unlikely that *G. berlandieri* will hybridize with *G. polyphemus* or *G. flavomarginatus*. There is no evidence regarding the reproductive status of either the hybrids reported by Woodbury (1952) or the hybrids reported here.

Evidence of Genetic Decline.—Because there has been no systematic study of the genetics of this species, it is impossible to know if there has been genetic decline. However, we feel that the geographical range is sufficiently large to rule out any form of genetic decline. Also, there is mixing of populations by well-meaning, but misguided individuals, who pick up tortoises on the road, transport them considerable distances, and release them after they expel their fecal and urinary products in typical tortoise fashion. According to US Customs officials along the US-Mexico border, confiscated tortoises entered through Mexico are frequently released on the US side of the Rio Grande.

Populations restricted to lomas or habitat islands created by development or agricultural activities undoubtedly have reduced opportunity for genetic mixing, but the significance of this is unknown. Demography differs between lomas (Judd and Rose, 1983), but a tortoise marked on one loma was found on another, over 1.6 km distance. A single tortoise trail in a maintenance road on the Chaparral Wildlife Management Area was followed for well over 1.2 km and was undoubtedly a single movement. Some tortoises, then, are capable of making sustained movements if the intervening terrain is adequate. Unfortunately, much land modified for development is inhospitable to tortoises.

SECURITY OF EXISTING POPULATIONS

Protected and Unprotected Populations, With Estimates of Numbers.—All of the information on population density of the Texas tortoise has come from study areas in Cameron County, Texas. Auffenberg and Weaver (1969) reported densities for three vegetative communities occurring on lomas. Judd and Rose (1983) estimated density annually over a five-year period (1972-76) on a loma supporting grass, prickly pear, and scattered shrubs. Bury and Smith (1986) provided information (not estimates) on density at Laguna Atascosa National Wildlife Refuge (LANWR). There are no other published reports of *G. berlandieri* density.

Auffenberg and Weaver (1969) estimated tortoise density at 122 per ha in a brush community, 33 per ha in a *Baccharis* community, and eight per ha in a grass and cactus community. Judd and Rose (1983) found that estimates varied depending on the method used to estimate density and among years. Mean estimates ranged from 10.0 to 22.9 tortoises per ha (Judd and Rose, 1983). They suggested that a maximum density of 16 tortoises per ha was likely. Bury and Smith (1986) did not estimate density, but they reported locating 107 tortoises on about three ha of dirt roads and adjacent areas.

The population at LANWR is protected, but there are no estimates of the density there (Bury and Smith, 1986). The population on the Yturria Ranch (Judd and Rose, 1983) is likewise secure from the public behind a locked and guarded gate where entry is closely monitored and limited. Populations on most of the lomas studied by Auffenberg and Weaver (1969) are unprotected and they have experienced a variety of disturbances by humans. These include hunting, National Guard maneuvers, and clearing for residential development.

Conflicts of Protection of Other Species.—There are no conflicts that we know of related to the protection of other species. Quite the contrary, protection provided to habitats supporting ocelots and jagarundi also support tortoises, although this makes up a small portion of the tortoise's range.

Conflicts with Cattle, Sheep, and Other Agricultural Interests.—The loss of habitat to agriculture along the US-Mexico border has fragmented the range of the tortoise and eliminated much prime habitat (Rose and Judd, 1982). Clearing of land to increase rangeland has a devastating effect initially, killing many tortoises. For those surviving the land disruption, however, habitat quality might be enhanced (Auffenberg and Weaver, 1969). The more open short-grass associations interspersed with clumps of cactus and shrubs seem highly favorable to tortoises. In general, the number of cattle per ha is small and injury risk from cattle and horses appears small.

Conflicts with Other Human Interests, e.g., Recreation and Housing.—Southernmost Texas, specifically the LRGV, is one of the fastest-growing areas in the United States, and this trend is expected to continue into the 21st century. Urbanization is rapidly claiming significant amounts of land. However, most of this urbanization follows a progression; the land is cleared first for agriculture and subsequently, the agricultural land is converted to urban use. Relatively little of the native shrubland supporting tortoises is cleared initially for residential development. Lands that are claimed in this way are associated with aquatic habitats. They are on the margins of a lake (such as Falcon Lake), the Rio Grande, Arroyo Colorado, a resaca, or the Laguna Madre. The cleared lots either have water frontage or water is nearby. Thus, they are at sites affording access to recreational opportunities associated with the aquatic habitats.

MANAGEMENT OF POPULATIONS

Monitoring Procedures.—Populations of *G. berlandieri* are not systematically monitored. Our data generated on the Yturria and Reed ranches in Cameron County, Texas, indicate a drastic decrease in the number of individuals inhabiting our study grids over a 20-year period. In addition, sites frequently visited in Cameron County have lower numbers of tortoises than they did in the early 1970's. The only other long-term study that we are aware of is being conducted on the Chaparral Wildlife Management Area in LaSalle and Dimmit counties, Texas.

We suggest that three to five sites representing differing habitat types should be selected for study. Baseline data generated would allow personnel from the Texas Parks and Wildlife Department to continuously monitor population dynamics to detect systematic negative trends in population numbers. *Gopherus berlandieri* is known to live for over 70 years (Judd and McQueen, 1982) and it is reasonable to assume that a life span of 30-50 years is common. Long-lived individuals producing only a few (1-4) eggs per year (Judd and Rose, 1989) with high nest and young mortalities, might be severely impacted by a single new, or enhanced, lethal insult.

Species Management.—There are no studies purporting to manage populations of *G. berlandieri*. At this stage, there is not even a life table, and whereas such a table is needed before management might be effective, we suggest that life tables should be developed for several populations in different habitats. We selected the lomas along the coastal areas of Texas to study because of suggested high densities of tortoises there. Inland tortoise densities are much lower and the rewards of finding tortoises through intensive searching are not great. Therefore, areas need to be selected that have personnel on site.

Habitat/Ecosystem Management.—We are unaware of any habitat management programs designed specifically for *G. berlandieri*. Bury and Smith (1986), however, made recommendations for improving tortoise habitat at LANWR. The principal recommendation was the use of prescribed burns to reduce the height of grasses and the density of trees and shrubs to provide a mosaic of open patches in the shrublands of the refuge. Locating tilled and grazed areas away from lomas was also recommended (Bury and Smith, 1986). Auffenberg and Weaver (1969) suggested that brush control and cattle grazing might be beneficial for tortoises by creating open, grassy habitats where the height of grasses is low, facilitating tortoise movements. The clearing of habitat might well enhance a predator's chances of finding a tortoise, especially smaller ones. Therefore, we recommend caution if habitat is to be modified such that predator search techniques also might be enhanced.

Apparently most federal, state, and private refuge managers assume that preservation of the lands in their care constitutes sufficient habitat and ecosystem management. Studies incorporating appropriate controls are needed to assess the effects of fire and grazing on *G. berlandieri* density. Management options for managers at refuges within the geographic range of *G. berlandieri* should consider maximizing Texas tortoise density.

Exotic Plant/Animal Problems.—There are no exotic animals that constitute competitors, predators, parasites, or disease organisms for *G. berlandieri* at any stage of the tortoise's life cycle. Conversely, the introduced buffel grass, *Cenchurus ciliaris*, has had a significant detrimental effect on tortoise populations. Large expanses of native shrub-grassland in southern Texas and northeastern Mexico have been cleared of brush, root-plowed, and planted in buffel grass to create "improved" pasture. Buffel grass is tall compared to the native, dominant buffalo grass (*Buchloe dactyloides*), and pastures with thick stands of buffel grass impede the vision and movements of tortoises. Consequently, pastures with thick stands of buffel grass constitute inappropriate habitat for *G. berlandieri* and the large scale planting of buffel grass has resulted in death and displacement of the Texas tortoise. Death comes from injury during clearing and root-plowing of brushlands and displacement results as stands of buffel grass become dominant.

Translocation, Restocking, and Captive Propagation.—There is no state-sanctioned activity supportive of translocation, restocking, or captive propagation. The finding of *Mycoplasma* infections in captive *G. berlandieri* will further inhibit release of captive animals. It is not known if *Mycoplasma* is transmitted through the eggs, but there is some suggestion (Dr. Isabella Schumacher, pers. comm.) that this might be true for *Gopherus polyphemus*. Hatchlings reared by us that were derived from infected females show no symptoms of the disease. The restocking of tortoises in areas where they were once deemed to be more abundant without understanding the cause of the perceived decline is unwarranted. The low natality of *G. berlandieri* coupled with predator vulnerability during juvenile and adult stages will hamper efforts to propogate and release. Nonetheless, a pilot program should be started and individuals of varying ages monitored for success after release.

LOCAL, STATE, AND FEDERAL CONSERVATION PLANNING

Gopherus berlandieri is not a federally protected species and there is no federal recovery plan. The Texas Parks and Wildlife Department considers the tortoise a threatened species, but there is no conservation plan for the species. We are unaware of any county or local conservation plans for the Texas tortoise. It would be useful if *G. berlandieri* was recognized as a threatened species by the federal government for it would increase awareness of the species' status and help with the enforcement of laws.

CHALLENGES

Primary Deficits In Our Knowledge.—The distribution of *G. berlandieri* in Mexico is poorly known and we have no information on other aspects of the biology of the Texas tortoise in this large portion (over half) of its geographic range (Rose and Judd, 1982; Rose and Judd, 1989; Germano and Bury, 1994). Basic life history information on tortoise populations in Mexico is sorely needed for the planning and implementation of conservation measures. Information on Mexican populations is especially important because rangelands there are rapidly being converted to agricultural fields. For example, in 1953-54, the total area of Tamaulipas, Mexico, devoted to agricultural production was 243,800 ha; in 1980-81, it was 1,310,000 ha (Jahrsdoerfer and Leslie, 1988).

Because all studies of population ecology of *G. berlandieri* were conducted in Cameron County, Texas, parallel studies in inland sites in Texas and Mexico are needed to assess geographic variation (Germano and Bury, 1994). It is important to know how variation in climatic factors, soil, and plant communities affect parameters such as density, egg production, growth, and survivorship. Data on survivorship to various ages is the missing key to the establishment of a life table for the Cameron County, Texas, populations (Judd and Rose, 1989) and this information will be crucial in assessing the status of all populations.

A conservation plan for *G. berlandieri* is needed, but it will be difficult to accomplish this goal until crucial life history and distribution information is available. Efforts should focus on providing information on density, sex ratios, age structure, fecundity, longevity, and survivorship of populations from different major plant communities within the geographic range of the species. Life tables should be constructed for each of these populations. As a beginning, long-term demographic studies could be initiated on each state and federal wildlife preserve within the species' geographic range to provide the data on geographic and year-to-year variability needed to construct life tables.

Directions for Successful Protection.—Perhaps *G. berlandieri* has suffered the least of all members of the genus regarding human impacts. The large blocks of ranch land, virtually off limits to the public, provide safe haven for many populations. Although many individuals are killed on public roadways, large numbers are also killed on ranch roads, which the tortoises use frequently. There is little that can be done to protect tortoises from vehicular traffic. We suggest that roadside signs be strategically placed to warn motorists of tortoises and that possession of tortoises is unlawful.

On the surface, the Texas tortoise appears to be adequately protected because of its state "threatened" status. Sadly, few enforcement officers know of the protected status and those that know the regulations are not prone to take action. We have been working with Texas Parks and Wildlife Department personnel for about a year to make enforcement personnel and the public more aware of the problem but much more needs to be done. An enforcement officer confiscating a tortoise is faced with a dilemma: he/she cannot release the animal and he/she has no place to send it. Zoological parks generally have more Texas tortoises than they wish to have and not knowing the history of a captive tortoise, *Mycoplasma* transmission is now thought likely. There appears to be no solution as to what to do with captive individuals and because of this, enforcement officers generally fail to confiscate tortoises. Continual and vigorous education of the public to the plight of this animal is a must.

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It was through the efforts of Horn Professor J Knox Jones, as director of Academic Publications, that Texas Tech University initiated several publications series including the Occasional Papers of the Museum. This and future editions in the series are a memorial to his dedication to excellence in academic publications. Professor Jones enjoyed editing scientific publications and served the scientific community as an editor for the Journal of Mammalogy, Evolution, The Texas Journal of Science, Occasional Papers of the Museum, and Special Publications of the Museum. It is with special fondness that we remember Dr. J Knox Jones.

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