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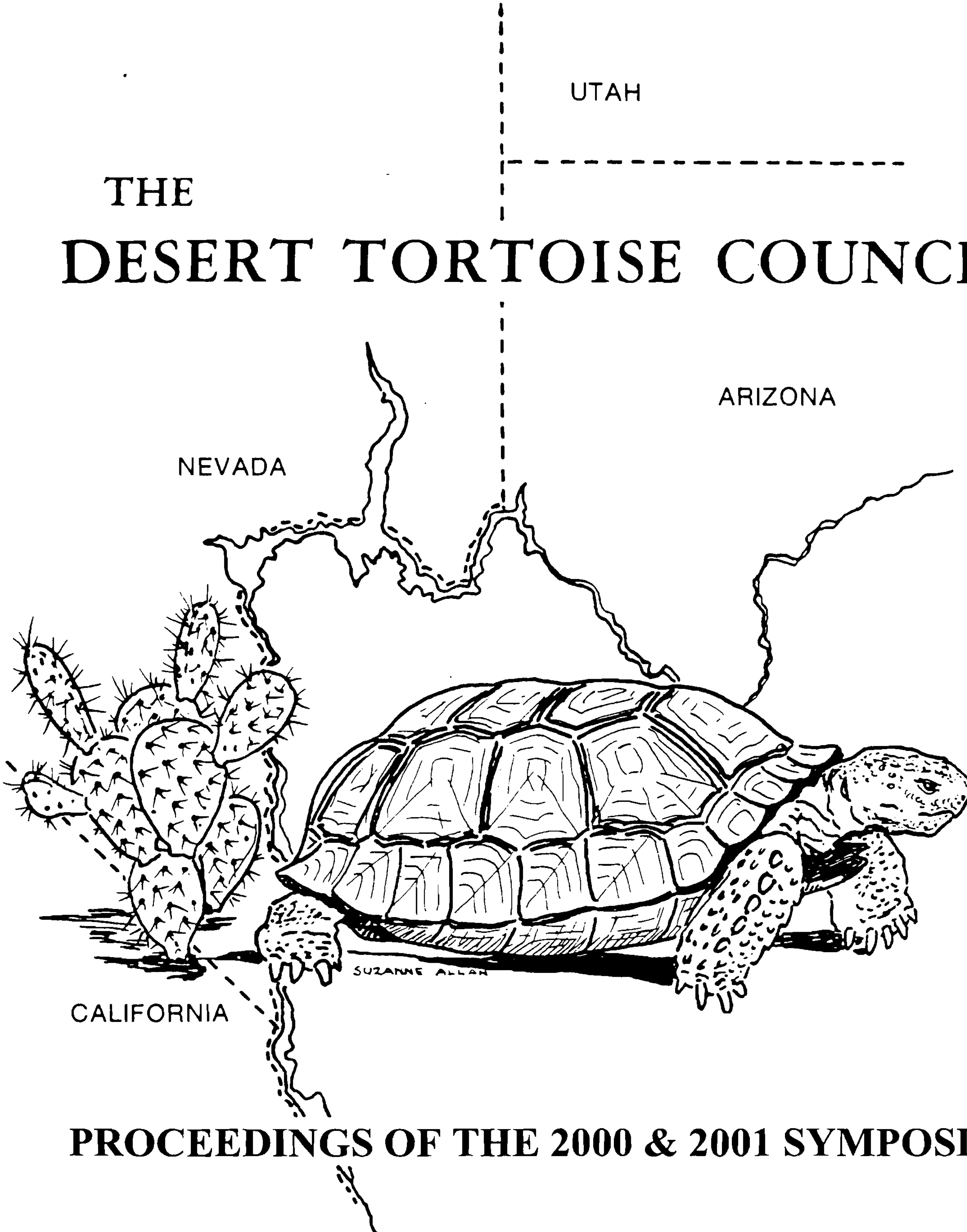

PROCEEDINGS OF THE 2000 & 2001 SYMPOSIA

Desert Tortoise Council

Proceedings of the 2000 & 2001 Symposia

A compilation of reports and papers presented at the
twenty-fifth and twenty-sixth annual symposia of the Desert Tortoise Council
April 20-23, 2000, in Las Vegas, Nevada and March 16-19, 2001, in Tucson, Arizona

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ISSN 0191-3875

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ABSTRACTS AND PAPERS FROM THE

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REPRODUCTION IN SONORAN DESERT TORTOISES

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We studied reproduction in desert tortoises for four years (1993, 1997-99) at a site in the northeastern Sonoran Desert. Environmental conditions varied greatly between years. Summer rainfall (July - October) in 1992 and 1996-1998 ranged from 6.9 to 22.1 cm, and winter rainfall (November - February) ranged from 7.2 to 36.7 cm; long-term means for the area were 12.8 and 13.8 cm, respectively. Tortoises experienced particularly favorable conditions for reproduction in 1993 (during which 80% of the females laid eggs) with maximum seasonal rainfall observed during the study occurring during the previous summer and winter. With the exception of winter 1997-1998, seasonal rainfall was below average during the remainder of the study, with 36 to 67% of the females laying eggs. Tortoises laid a maximum of one clutch each year. Oviposition occurred later on average during each year of the study, from 27 June in 1993 to 25 July in 1999, not including two probable cases of egg retention through hibernation. Preliminary analyses indicate that the proportion of females reproducing was positively correlated with winter rainfall. Mean annual clutch size ranged from 3.8 to 5.7 eggs per reproductive female and was not correlated with seasonal rainfall, but variation in clutch size (SD ranged from 1.26 to 2.43) was positively correlated with summer rainfall. The smallest tortoise observed to lay eggs was a 220 mm MCL female in 1993; minimum size reproducing each year was negatively correlated with winter rainfall.

EFFECTS OF UPPER RESPIRATORY TRACT DISEASE ON GOPHER TORTOISE POPULATIONS

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Within the last decade, research has revealed an upper respiratory tract disease (URTD) in wild gopher tortoises (*Gopherus polyphemus*) in Florida. One causal agent of URTD is *Mycoplasma agassizii*. A blood test has been developed to detect antibodies to *M. agassizii*. Blood samples collected at various Florida sites have indicated exposed gopher tortoise populations in 24 of Florida's 67 counties. In 1998, the Florida Fish and Wildlife Conservation Commission initiated a radiotelemetry study to investigate the effects of URTD on tortoise populations on public lands. A total of 61 tortoises were fitted with radio transmitters on three URTD study sites and a control site. Because the current blood test only indicates exposure to mycoplasma, nasal lavages were

also taken to detect presence of mycoplasma. A different mycoplasma was detected on each of the three URTD study sites: *Mycoplasma agassizii* on Gold Head Branch State Park, a genetically distinct mycoplasma on Cecil Field Naval Air Station, and an undescribed mycoplasma on Oldenburg Mitigation Park. No seropositive or diseased tortoises have been found to date on the control site. Recapture efforts in 1999 revealed that two of 15 radioed tortoises at Oldenburg had died outside their burrows. A third, severely symptomatic tortoise was euthanized, necropsied, and found to have nasal lesions associated with mycoplasma infection. Over 120 dead gopher tortoises were found at Oldenburg during 1998-1999. One of 15 radioed tortoises at Cecil Field was found dead in its burrow. Continued monitoring will document mortality rates and changes in serology over time.

MAJOR SCIENTIFIC CONTRIBUTIONS FROM THE DESERT TORTOISE RESEARCH NATURAL AREA: 1973-1999

***Kristin H. Berry*[1] *and Michael Connor*[2]**

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The Desert Tortoise Research Natural Area (DTRNA) has provided critical information for understanding desert tortoise (*Gopherus agassizii*) ecology, physiology, health, and behavior. Since 1973, research projects conducted at the DTRNA have played an important role in identifying major issues for the desert tortoise such as: tracking population dynamics and catastrophic declines; discovery of upper respiratory tract disease; quantifying physiological and reproductive adaptations to drought and abundant precipitation; establishing plasma and biochemical reference ranges; developing protocols for field handling techniques; identifying forage patterns and preferences; documenting the impacts of raven predation on juvenile tortoises; and describing the protective effects of preserve fencing in regards to livestock grazing and off-road vehicles. For the past 26 years, the approach has been for integrative scientific research with each project drawing on the others.

The DTRNA has provided biologists and land managers with valuable lessons for design and management of reserves for the recovery of tortoise populations in the Mojave and Colorado deserts. Management issues such as disease, raven predation, invasion and establishment of alien plant species and encroaching urban interfaces are at a landscape scale. The existing hogwire fencing and management do not effectively protect tortoises as individuals or as a population because of landscape-scale problems. Therefore management issues must be addressed at a landscape scale for recovery to be successful. During the next century, the DTRNA, as well as many other parks and reserves, will face challenges of disease, predators, alien species, and urban, recreational, and industrial developments.

EFFECTS OF GEOLOGY AND COVER SITE CHOICE ON DESERT TORTOISE POPULATIONS AT THE TIEFORT MOUNTAINS, CALIFORNIA

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We studied use of above and below ground cover sites by desert tortoises in the Tiefort Mountains, National Training Center, Fort Irwin (Central Mojave Desert) between 1997 and 1999. The study site is in a military training area. Desert tortoises used four types of below-ground cover sites (natural caves, rock shelters, burrows in soil, and pallets), and when above ground, were under shrubs or in the open. The locations of the different cover site types varied according to geology. Natural caves and rock shelters were in old (Jurassic to Pleistocene) geologic formations, whereas burrows were common in both recent (Holocene) alluvium and old geologic formations. Selection of cover site type differed by size and sex of the tortoise. Adult females were more often found in burrows than in other types of cover sites, whereas adult males were more often found in natural caves ($P<0.0001$). Adult female choice of below-ground cover sites differed significantly by season ($P<0.01$) and may be related to nesting sites. Juvenile and immature tortoises were found primarily in soil burrows and rock shelters ($P< 0.0165$). Soil burrows and pallets were more vulnerable to collapse from natural and anthropogenic changes in the environment than were the natural caves. During the study, none of the natural caves ($N = 85$) and rock shelters ($N = 22$) collapsed, whereas 30% of burrows collapsed or were damaged. Differences in vulnerability to collapse were also related to age and type of geologic formation and topography. Because adult female tortoises spent more time in burrows, they may have been more vulnerable to injuries and early mortality. These findings have implications for research designs on sampling different types of habitats on local and landscape scales. They also have management applications for both military training and recreation vehicle use areas. The Department of the Army funded the research.

DESERT TORTOISE SURVIVORSHIP: ABSENCE OF EVIDENCE DOES NOT MEAN EVIDENCE OF ABSENCE

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The desert tortoise has been an important symbol to the peoples of the arid Southwest for centuries. In 1990, this long-lived herbivore was designated as a federally threatened species. One of the driving forces for listing was an apparent scarcity of young animals, even in areas of high adult abundance. Two explanations are probable; either young tortoises suffer from high mortality, or their cryptic coloration and limited activity schedule prevent detection. We addressed this issue for a population of desert tortoises at the Marine Corps Air Ground Combat Center, Twentynine Palms, California. From 1997 to 1999, we monitored the survival of tortoise nests, eggs, and dispersing young. Contrary to previous belief, survival during these stages was quite high: 70% of nests survived incubation; 68% of eggs in surviving nests developed and produced healthy hatchlings; and 88% of dispersing young survived until winter hibernation. We conclude that absence of evidence does not mean evidence of absence. Nests and hatchling tortoises may be abundant in natural areas, but simply not observed by the casual observer. While it is well documented that juvenile tortoises are susceptible to predation for the first year of life, studies that quantify mortality rate over these early years are vital to interpreting current age class distribution of tortoise populations and allowing a scientific data based underpinning for their management.

DETECTION OF ANTIBODY TO *MYCOPLASMA AGASSIZII* IN TORTOISE SPECIES

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Over the past five years we have screened over 7,000 sera from a wide variety of tortoise and turtle species for the presence of antibody to *Mycoplasma agassizii*, the etiologic agent of upper respiratory tract disease (URTD). While the majority of these samples were obtained from either gopher or desert tortoises, a large number of samples representing tortoises from private collections and zoological collections have been screened. Samples were obtained from 19 different states and represented 30 different tortoise or turtle species. For the purposes of this report, results are reported only for species which had at least 10 animals sampled. Specific antibody to *M. agassizii* was detected in the African spur thighed (32% seropositive), Aldabra (27% seropositive), French (26% seropositive), Galapagos (8% seropositive), radiated (22% seropositive),

star (75% seropositive) and leopard (73% seropositive) tortoises. Box (23% seropositive) and bog (16% seropositive) turtles also tested positive. No seropositive animals were detected in spider tortoises. During the same time period, positive tests were found for 21% of desert and 36% of gopher tortoises tested. The results of these surveys suggest that *M. agassizii* is capable of colonizing and perhaps infecting many of the tortoise species commonly kept in private collections and zoological collections. Although clinical history was not available on all of these animals, at least some had documented clinical signs compatible with URTD. Therefore it is important that individuals or zoological collections exercise caution and practice good management and quarantine procedures to prevent spread of disease among captive species.

CURRENT ISSUES ASSOCIATED WITH URTD: GAPS IN KNOWLEDGE AND FUTURE DIRECTIONS

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Since the identification of *Mycoplasma agassizii* as the etiologic agent of upper respiratory tract disease (URTD), the focus of research has been on the development of diagnostic tests, determination of the seroprevalence in natural populations, and the description of clinical signs and lesions associated with the disease. With both the diagnostic tools and the basic knowledge of the clinical picture of the disease in place, current gaps in knowledge and areas to target for future research efforts should be addressed. Several key issues to be discussed include the impact of URTD on population parameters such as reproduction, survival, population dynamics, and behavior/nutrition. Little is known regarding the virulence potential of mycoplasmal strains, the pathogenic mechanisms by which they cause disease, or the relationships among mycoplasmal strains present, seroprevalence, and clinical disease expression. Possible approaches to control URTD as well as the effect of URTD on management decisions will be addressed.

EXPLOITATION OF ASIAN TORTOISES AND FRESHWATER TURTLES AND THE NEED FOR IMMEDIATE AND MULTI-PRONGED CONSERVATION TACTICS

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All species of Asian tortoises and freshwater turtles are unquestionably threatened with extinction, some within the next two to five years. Participants at the recent Workshop on Trade in Tortoises and Freshwater Turtles in Asia determined that IUCN Red Listings of the 89 recognized species should be classified as follows: 1 Extinct; 18 Critically Imperiled (CR); 23 Endangered (EN); 21 Vulnerable (VU); 15 Lower Risk (LR); 6 Data Deficient (DD); and 5 could not be evaluated (NE). Eight species of tortoises were recognized and evaluated: *Geochelone elegans* (LR), *G. platynota* (CR), *Indotestudo elongata* (VU), *I. forstenii* (EN), *I. travancorica* (VU), *Manouria emys* (EN), *M. impressa* (VU), and *Testudo horsfieldi* (VU, NE).

The overriding causes of declines in Asian chelonians are attributed to consumption for food and use in traditional medicine. The trade and exploitation of chelonians begins in southern Asian countries (Cambodia, Vietnam, Indonesia, Malaysia, Bangladesh, and others) where most species are collected by local villagers and sold to traders. Chelonians are shipped by truck, ship, and airlines and the majority are eventually sold in Chinese markets. Turtles are also consumed in their native countries and collected for the international pet trade. A WWF-TRAFFIC report documented 25 tons of live turtles per week leaving the port of Medan, Sumatra and several hundred tons of live turtles have been flown from Indonesia to China in one day in 1997. In 1996, 2.7 million kg (2970 tons) of live turtles were documented as imported into Hong Kong, whereas 389 tons were documented in 1992. The value of the 1997 Hong Kong turtle trade was estimated at 38.7 million U.S. dollars.

Recommendations from the Workshop included strengthening and enforcing existing regulations and treaties (i.e., CITES), listing all Asian freshwater turtle and tortoise species on Appendix II of CITES, continuing field and market surveys of turtles, investigating the potential to establish sustainable turtle farming operations, developing outreach and education programs, establishing in-country nature reserves with turtle conservation programs, conducting ecological studies of turtle habitats and life histories, and establishing ex-situ conservation programs.

The situation currently faced by Asian tortoises and freshwater turtles is extremely critical and requires immediate, collaborative, and multi-pronged conservation efforts. Preventing the extinction of several species *in the wild* may be impossible; commercial extinction is a probability for many others. Perhaps the most immediate conservation response should be the establishment of insurance colonies that can maintain the genetic diversity for all threatened Asian turtle species. Progress towards this goal have been made, but efforts are small, scattered, and need to become better coordinated and expanded. However, reestablishing populations of Asian turtles in their appropriate, native habitats is the long-term goal, not maintaining turtles in captive or semi-captive conditions. Therefore, coordinated efforts must continue to address the Recommendations outlined by the Workshop, including the establishment of insurance colonies.

THE ROLE OF THE PRIVATE CITIZEN IN PUBLIC AGENCY DECISIONS

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The private citizen often feels powerless to improve the natural resource decisions of sometimes unresponsive public agencies. But actually, the well informed citizen is the beneficiary of several important laws that vest much power in the public and compel land managing agencies to abandon defective courses of action in favor of actions that better serve the public interest. Such tools include the Administrative Procedures Act, the Federal Advisory Committee Act, the National Environmental Policy Act, the Freedom of Information Act and the agency's own statutes, regulations and written procedures. Most powerful among these tools is the Endangered Species Act. Even with such tools, making headway is grueling work when confronting land managing agencies like the National Park Service and Bureau of Land Management. Two case studies from the Mojave National Preserve in California help illustrate the tools in the citizen's arsenal, the difficulty of gaining success and the sometimes limited nature of the gains. Those examples both involve the desert tortoise.

IMPLEMENTATION OF LONG-TERM MONITORING OF DESERT TORTOISE POPULATIONS USING LINE DISTANCE SAMPLING METHODS

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Substantial funds are being spent on desert tortoise recovery actions yet there has not been a comprehensive program in place to determine if these actions are improving the status of desert tortoise populations or whether recovery goals are being achieved. In recognition of this need, several workshops were held to evaluate various methods to monitor tortoise populations. In 1998, the Desert Tortoise Management Oversight Group (MOG) chose line distance sampling as the appropriate method to determine rangewide desert tortoise population densities and trends. Through successful rangewide monitoring, managers will be able to evaluate the overall effectiveness of recovery actions and population responses to these actions, thus guiding recovery of the Mojave desert tortoise. Furthermore, monitoring must show that population trends are stable or increasing for a period of 20 years before delisting may be considered. Following delisting, section 4(g) of the Endangered Species Act requires the Fish and Wildlife Service (Service) to monitor the status of all recovered and delisted species for a minimum of five years.

The Service is in the process of hiring a rangewide desert tortoise coordinator with primary responsibility to oversee implementation of desert tortoise population monitoring activities. Because a consistent approach to monitoring is essential, a monitoring plan or set of field protocols will be developed to standardize methods. Transects established and read as part of pilot studies will continue, which should provide important data to further define the monitoring strategy required to produce reliable density estimates. After five years of having the recovery plan in place, we have made little progress at implementing rangewide monitoring, largely due to lack of funding. In response to this need, the technical advisory committee of the MOG recommends establishing recovery implementation teams representing each of the recovery units. These teams will develop budget requests and prioritize research needs in cooperation with the coordinator which will be submitted to the MOG for approval and action.

TORTOISE HEALTH AND ELEMENTAL CHEMISTRY OF FORAGE PLANTS FROM DESERT TORTOISE HABITAT BETWEEN THE RAND MINING DISTRICT AND THE DESERT TORTOISE NATURAL AREA, CALIFORNIA

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The chemistry of plants, including any surficial dust coatings on the above ground parts, generally reflects the chemistry of the immediate area where a given plant grows. The desert tortoise (*Gopherus agassizii*), a threatened species, relies mostly on annual and herbaceous perennial plants and cacti for nourishment. Necropsies of ill, dying, or recently dead tortoises have revealed elevated levels of one or more potentially toxic elements (As, Ba, Cd, Cr, Hg, Ni, Pb, or V) in the kidneys or livers as compared with control animals (Jacobson et al. 1991, Homer et al. 1994, Homer et al. 1996). Ingestion of plants with unusually high concentrations of these and possibly other elements may thus influence tortoise health.

During 1998 and 1999, we collected one or more samples of the above-ground parts of 32 different plant species known to be key desert tortoise forage. These samples were from 31 sites along a transect between the Rand mining district and the Desert Tortoise Research Natural Area (DTNA), in the western part of the Mojave Desert of southeastern California. These plants included native herbaceous species, perennial grasses, annual herbs, and cacti, as well as samples of alien annual grasses and forbs. The samples were from relatively pristine areas, as well as from areas contaminated by mine waste and dust derived from this waste, both of which may contain elevated concentrations of elements such as As, Sb, and W. Inasmuch as tortoises eat material in its natural condition, the samples were prepared without washing, and the dried plant material was analyzed for as many as 35 elements (Ag, As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, Hg, Ir, K, La, Lu, Mo, Na, Nd, Ni, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, U, W, Yb, and Zn) by neutron activation analysis. To provide a context to the plant analyses, we also collected and analyzed samples of rock (20 sites), soil (52 sites), and unconsolidated stream alluvium (19 sites) from the same area.

Both physical and chemical environments in tortoise habitats can influence plant chemistry. Physical environments include areas of rock outcrop, outwash pediment surfaces and their soils, and washes with active sediment and near surface groundwater. In areas without mineral deposits, the local chemical differences between these three physical environments are generally minor. However, in mineralized areas, the chemical differences between these environments may vary more widely. As an example, a comparison of analyses of soil and sediment samples from the study area suggests that some elements (As, Au, Pb, Sb) tend to be slightly more concentrated in active wash sediment and some (Cd, Hg) more concentrated in soil. Others (Cu, Cr, Fe, La, Mn, Mo, Zn) show no obvious chemical differences between these two environments. Additionally, near surface water (and its chemical content) tends to be more available in washes and therefore to plants growing in washes. Thus, the physical environments in habitats may have an effect on element concentrations in plants by tortoises.

Chemical environments are largely influenced by local geology (rock chemistry). Each rock type has a characteristic but variable chemical content. The chemistry of different rock units is commonly reflected in the chemistry of the overlying soils and often of the plants growing in these soils. Unusually high but localized chemical concentrations in rocks may constitute a mineral deposit. In the Rand district, the deposits are enriched in elements such as Ag, As, Au, Sb, and W. Anthropogenic activity related to mining of the mineral deposits may additionally increase the concentrations of the elements in nearby soils and sediments. Anomalous distributions of these elements in the study area clearly delineate the natural and anthropogenic effects of the mineral deposits on soils and plants.

Wind borne dust is another factor that may affect the chemical content of plants consumed by tortoises. By comparing the relative distribution and concentration levels of various elements, particularly in samples of soils and plants, we were able to determine which plant samples were probably contaminated by this process. The distributions of anomalous deposit related elements in soil and plants, especially those of As, show an area of contamination associated with the Rand mining district that extends to the southwest as much as 18 km from the center of the district, to within about 7 km of the northern boundary of the Desert Tortoise Research Natural Area. The extent of the contamination in other directions was not completely defined. The anomaly for As in plants is more extensive than that seen for As in soils, emphasizing the effects of wind borne contamination.

All plants have normal nutritional chemical needs for their proper growth. However, for reasons not clearly understood, some plant species tend to accumulate specific elements to concentration levels well above what is needed for normal growth. This process could have important consequences for tortoise health. Examples of accumulator plants found in arid areas include *Stanley pinnata*, which accumulates Se, and various species of legumes, such as *Astragalus*, which may accumulate As, Mo, Se, Zn, and possibly other elements. Our evaluation of the plant analyses indicates that most high concentrations of potentially toxic elements in plants are related either to relatively high uptake from a contaminated substrate or, more commonly, to surface contaminated resulting from wind borne dust. Most high concentrations are thus not the result of natural accumulation in an uncontaminated area.

Two ill adult tortoises were salvaged from the Rand district and necropsied. One of the two contained the highest level of As (15 mg/kg wet weight) in keratin (scute) recorded to date in necropsied tortoises. The ingestion by tortoises of plants from these mineralized or contaminated areas may thus represent a potential threat to their health and longevity.

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PROXIMATE CONSTRAINTS AFFECTING THE REPRODUCTIVE OUTPUT AND MORTALITY OF DESERT TORTOISES

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Understanding the affects of resource availability on reproduction is critical to the study of life history and demography of animal populations. The desert tortoise (*Gopherus agassizii*), a long-lived species with delayed sexual maturity, is dependent on stored nutrients and water to minimize fluctuations in reproductive output. Tortoise populations are subject to lower fecundity and higher mortality in unpredictable desert ecosystems following extended periods of decreased resource availability. In an ongoing study, we measured the reproductive output of female tortoises from a population at Ivanpah Valley, California, located within the Mojave National Preserve, from 1997 - 1999. We measured egg and clutch size, and clutch frequency in 42 female tortoises using a portable x-ray unit. Eleven rain gauges were used to monitor monthly precipitation across three study sites within Ivanpah valley to measure variance in rainfall. Perennial plant cover and annual plant biomass were also measured. Precipitation was significantly greater at higher elevations across a 10 km distance characterized by a 400 m increase in elevation. Availability of food plants increased with higher elevation as well. Tortoise reproductive output was greater and recent mortality was lower, at the higher elevation along this short elevational and rainfall gradient. Resource variability is a defining feature of desert ecosystems, yet the importance of micro-geographic variation of these resources to desert tortoise populations has not been previously determined. Our study shows that micrographic differences in rainfall and primary productivity of annual vegetation can result in significant differences in survivorship and mortality of the threatened desert tortoise. These findings have important implications to designing reserves, managing public lands, and other conservation issues relevant to the desert tortoise.

THE DESERT TORTOISE PRESERVE COMMITTEE: A QUARTER CENTURY OF PROGRESS

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Since 1974, the nonprofit Desert Tortoise Preserve Committee has been driven by its mission to protect the welfare of the desert tortoise in its native wild state. Starting from a small group of volunteers working to build and protect a preserve in the Fremont Valley-Rand Mountain area, the Committee has developed into a highly effective force for the conservation of the tortoise and associated species throughout the West Mojave Desert. Examples of the Committee's many accomplishments from the last twenty-five years that have significantly benefited tortoise conservation include: development of creative strategies to acquire significant numbers of privately held small land parcels within the Desert Tortoise Research Natural Area, implementation of fencing mitigation commitments along Harper Lake Road, long-term protective management and recovery at the Pilot Knob grazing allotment, and the development and use of innovative educational programs. The Committee's success in meeting these challenges reflects its relative freedom from bureaucratic and political constraints, its flexibility to adaptively manage to make the most of opportunities that arise, and its ability to complement the work of state and federal government agencies to further its mission.

TRANSLOCATION AS A TOOL FOR CONSERVATION OF THE DESERT TORTOISE: CAN PET TORTOISES BE REPATRIATED?

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Desert tortoises with pet and wild backgrounds were experimentally translocated to the Large-Scale Translocation Study (LSTS) site near Jean, Nevada in the spring of 1998. These tortoises received identical treatment upon translocation allowing comparison of the successes of translocating tortoises from pet or wild backgrounds. All experimental tortoises spent time at the Desert Tortoise Conservation Center (DTCC) in Las Vegas, Nevada before being translocated. Tortoises with wild backgrounds were collected from new urban development sites and were placed in holding pens at the DTCC in 1997. Unwanted pet tortoises also were taken to the DTCC. Thirteen wild adults, two wild juveniles, 17 pet adults and eight pet juveniles were equipped with radio transmitters and translocated in April 1998. The tortoises were monitored for 14 months. During that time, movements, changes in body mass, changes in carapace length, and a qualitative assessment of general condition were measured. Pet and wild tortoises had no adult mortality. Two of the eight pet juveniles died during 1998. Neither movements nor changes in body mass following release differed statistically for pet and wild tortoises of either sex. Based upon our short-term results, it appears that pet and wild tortoises can be repatriated to the wild without adverse negative consequences. However, the spring of our experiment (1998) had abundant rainfall and much forage. Although unfavorable weather conditions may produce different results, we found no evidence that formerly pet desert tortoises are inept at survival in the wild.

TRACE ELEMENT SYSTEMATICS OF DESERT TORTOISE SHELL

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Among the suspected causes of accelerated morbidity and mortality of the federally threatened desert tortoise (*Gopherus agassizii*) is elemental toxicity related to several heavy metals and metalloids. We and several colleagues are evaluating this hypothesis by investigating the biogeochemical pathways that link rock, soil, vegetation, and tortoises; comparing trace element concentrations in the shells and internal organs of healthy and diseased tortoises; and studying

the chemical effects of geological environment and various human activities and products on tortoise health.

Here we report data that establish for the first time the basic trace element patterns that characterize the two major components of desert tortoise shell, bone and scute. Shell materials from six apparently healthy tortoises (accidentally traumatically injured or killed by vehicles) and from 14 diseased tortoises were analyzed by instrumental neutron activation analysis (INAA). Powdered samples were irradiated by thermal neutrons in the USGS research reactor in Denver. Five gamma ray counts were performed: < 1 hour; and 5, 7, 14, and 60 days after irradiation. Approximately 18 elements were determined with satisfactory accuracy and precision in tortoise bone, scute, or both; and six additional elements could be determined at moderate to high concentrations. As the measured abundances span more than seven orders of magnitude, from major (structural) elements such as Ca in bone ($\approx$ 23 percent) to trace elements such as Sc or Sb ($\approx$ 10 - 40 ng/g (ppb)), presentation of the data is facilitated by normalization to the average composition of upper continental crust (UCC) (Fig.).

Despite the contrast in bulk composition between bone (apatite-like) and scute (composed of keratin, an insoluble protein), the normalized trace element patterns of bone and scute from healthy tortoises are rather similar, differing by no more than one half an order of magnitude for most elements (Fig.). The higher Ca and Na content of bone is to be expected. These basic trace element patterns evidently are determined primarily by biologic processes rather than by geologic factors, as the analyzed tortoises lived on diverse geologic substrates in widely separated areas of the Mojave and Colorado Deserts, southern California. Local geologic factors may influence details of the patterns.

The trace element spectra comprise three segments: alkali and alkali earth elements on the left side, transition metals (Sc-Ni) in the middle, and chalcophile ("sulfur-loving") metals and metalloids (Zn-Se) on the right (Fig.). The transition metals plotted either are trace nutrients (Cr, Fe, Co, Ni) or are of little or no biological significance at parts-per-billion levels (Sc, La - Lu, Th, Ta). Zinc, Se, and probably As are essential trace nutrients, although all are toxic at high concentrations; Sb and Au have no known natural biological role. In both bone and scute, the transition metals, except Cr and Ni, are effectively "diluted" to $\sim 10^{-2}$ times their upper-crustal abundances. In contrast, the chalcophile elements Zn, As, Sb, and Se, along with Au, have markedly higher normalized abundances. This relative enrichment of the chalcophile elements in both bone and scute suggests that sulfur may be important in controlling these trace element patterns.

Desert tortoises spend six to nine months of the year underground in their burrows, in close contact with soil. Scute (the outer layer of the shell) is not appreciably enriched relative to bone in lithophile trace elements such as Le, Ce, Th, or Ta nor in potentially labile elements such as As and Se, suggesting minimal elemental input to the shell through contact with soil, at least in healthy tortoises.

Our trace element data also reveal several interesting and possibly important differences between healthy and diseased tortoises. Scute from diseased tortoises is strongly enriched, relative to scute from healthy tortoises, in several trace metals, most notably Au and W (!). The significance of this anomaly is unclear. Three diseased tortoises have much higher scute As and slightly lower scute Se than the other healthy and diseased tortoises. In tortoise bone, As and Sb are particularly informative. These two trace elements evidently are incorporated into tortoise bone in approximately the same ratio as they occur in UCC: As/Sb ≈7.5. Two diseased tortoises have highly elevated bone As and Sb, with somewhat low As/Sb ratio. These pronounced anomalies in the chalcophile trace elements As, Se, and Sb in several diseased tortoises suggest some perturbation in the concentration, siting, chemical state, or utilization of sulfur within the organism. Whether such a disturbance is more likely a cause of disease or a result of disease remains to be determined. We shall continue to evaluate these ideas as we acquire data for more tortoises and for additional potentially toxic chalcophile elements such as Cd, Hg, and Pb.

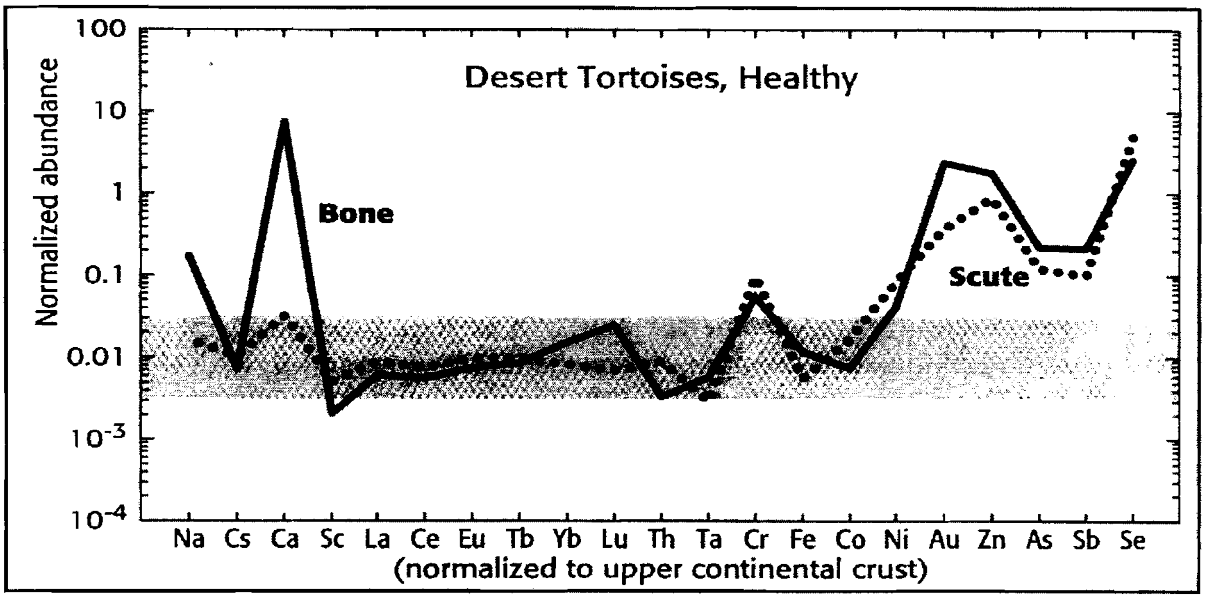

Figure. The normalized trace element patterns of bone and scute from healthy tortoises. The trace element spectra is comprised of three segments: alkali and alkali earth elements on the left side (Na-Ca), transition metals (Sc-Ni) in the middle, and chalcophile ("sulfur-loving") metals and metalloids (Zn-Se) on the right.

EGG FOLLICLES AND YOLKS OF SONORAN DESERT TORTOISES (*GOPHERUS AGASSIZII*)

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There are many differences between desert tortoises of the Mojave and Sonoran Deserts, including aspects of tortoises reproductive biology. To develop a better mechanistic understanding of these reproductive differences, we used ultrasonography to measure the number and size of vitellogenic and atretic follicles, plus egg yolk width, in wild, female Sonoran tortoises during May, July, August and October 1999. As typified by desert tortoises, there was extreme individual and temporal variation in all of these measures. Vitellogenic follicles were large during May and July but appeared to be small and numerous in October. Atretic follicles were not detected until after the peak periods of oviposition (July) but then they were abundant. Egg yolks and shelled or oviductal eggs were most numerous in July. Body size effects were weak, having mild effects upon the size of vitellogenic follicles prior to and during peak oviposition times (May and July) but not affecting atretic follicle size or number. Although some relatively small females (<239 mm MCL) had vitellogenic follicles, these females did not produce shelled eggs. Smaller tortoises of the Sonoran and Mojave Deserts can produce eggs, so the smaller females may have had insufficient nutrients available (as body reserves and fresh food) in 1999 to convert their follicles into eggs.

RESOURCE ACQUISITION AND ALLOCATION BY DESERT TORTOISES(*GOPHERUS AGASSIZII*): TRANSDUCING UNPREDICTABLE RESOURCES INTO POPULATION PARAMETERS

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Deserts are defined by their paucity of rainfall and characterized by low primary productivity. For long-lived desert animals, the availability of resources like water and food varies profoundly.

Desert tortoises use opportunistic and conservative patterns in their physiology and behavior to prevail in these extreme environmental conditions. When rain falls, desert tortoises seek and imbibe pooled water to eliminate wastes and to replenish their body water reserves. Similarly, when new annual plants become available, desert tortoises selectively consume them, helping to replenish their body nutrient reserves (e.g., water, protein, and lipids). These reserves facilitate egg production, help tortoises overwinter and help tortoises endure seasonal, annual, and multi-annual droughts when water and quality forage are scarce. Under drought conditions, desert tortoises become conservative, reducing losses of body nutrient reserves by reducing allocations of water, energy and other nutrients to reproduction and other functions. The opportunistic acquisition and storage of resources, and conservative allocation of resources, helps explain how population level parameters (e.g., fecundity and survivorship) of desert tortoises are affected by extreme variations in rainfall and food availability. Female body reserves, which are developed when resources are available, enable female tortoises to produce eggs and temper fluctuations in fecundity relative to the fluctuations in environmental resource availability. Similarly, fluctuations in survivorship may be moderated by the conservative use of body reserves and high tolerances to dehydration and starvation.

PAST AND FUTURE CLIMATE VARIATION IN THE MOJAVE DESERT: SURFACE PROCESSES AND LAND MANAGEMENT ISSUES

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As part of the USGS Mojave Desert Ecosystem Science Program, we are studying historical climate variation and its affects on the desert landscape. Two components of landscape change amenable to study are sediment yield and the frequency of surface runoff. These should vary jointly with precipitation. Generally, sediment yield (work done cooperatively with R.H. Webb, USGS, WRD-NRP, Tucson) and runoff frequency increase during wet climate episodes and decrease during dry episodes. The problem is whether the magnitude of past climate variation was sufficient to effect hillside runoff and landscape change. Although preliminary and subject to revision, results suggest that runoff frequency and sediment yield have varied with climate. Runoff in over 50 percent of the cases was more frequent in roughly the first half of the 20th century when climate was relatively wet but was less frequent during the latter half when climate was dryer or when precipitation was less intense. Information presently available suggests that runoff frequency did not increase substantially during the present wet climatic regime, probably because of a concurrent long-term decrease of rainfall intensity. Thus, the physical landscape, the substrate of the desert ecosystem, was affected by the precipitation patterns of past and present climatic regimes.

Climate variation caused by the Pacific decadal oscillation is a high visibility topic of recent climatological research. This global climate phenomenon is caused by subtle but important changes of sea surface temperature (SST) and atmospheric pressure in the eastern Pacific Ocean. These changes, which trigger a sharp transition from one climatic regime to another, alter the climate of North America for periods of 25–35 years (Fig.). The weather, SST, and surface pressure patterns of the past one to two years suggest to climatologists that the transition to another regime is underway. If so, the present relatively wet climatic regime in the Mojave Desert should become dryer in the near future.

The climate in the near future may resemble that of the 1940's to mid-1970's, an era of generally cool SST and increased atmospheric pressure linked to drought in the Mojave Desert and Southwest in general. Precipitation from the 1940's to mid-1970's was generally below the long-term normal, whereas it was mostly above normal from 1976–1998, when SST was warm and atmospheric pressure was low, conditions that enhance precipitation in the Southwest (Fig. 2).

This anticipated change to drier and possibly warmer conditions will likely affect the biological and physical environments of the Mojave Desert. Persistent dry conditions stress the flora and fauna of the region, decrease surface runoff and replenishment of shallow aquifers, and increase recovery times from human disturbances. Restoration projects, investigations of landscape recovery, and studies of floral and faunal population dynamics undertaken in the previous 20–25 years were done when conditions were usually favorable. Researchers and land management agencies should consider the potential influence of this new, relatively dry climatic regime when planning restoration projects and monitoring biological components of the ecosystem.

ADDITIONAL INFORMATION

Climate History Web Site: *www-wmc.wr.usgs.gov/mojave/climate-history/*

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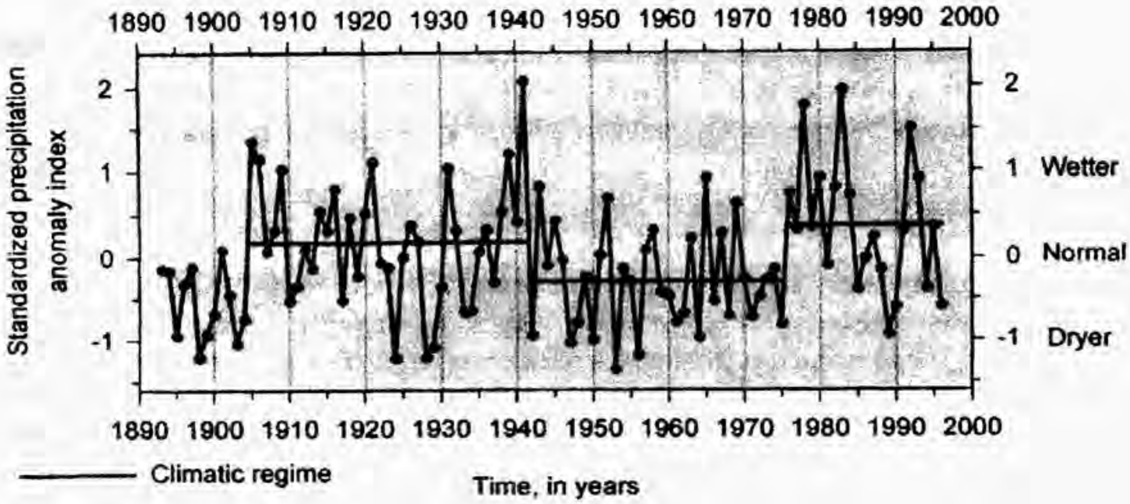

Figure. Annual precipitation of the Mojave Desert region, 1893-1996, based on analysis of daily rainfall at 48 long-term weather stations. Climatic regimes are distinctive periods of relatively wet or dry conditions linked to the Pacific decadal oscillation.

DESERT TORTOISES AS SENTINELS OF ENVIRONMENTAL TOXICANTS

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Animals exposed to environmental toxicants often suffer health effects similar to those in humans. Data collected from studies of these animals may play a vital role in the risk assessments of toxicants on the environment and on human health. For instance, because of their exquisite sensitivity to carbon monoxide, canaries were carried into mines to monitor air quality. Recognition of other animal sentinels has been more fortuitous. Epidemiologic studies of epizootic liver cancer in fish have shown a strong correlation with the presence of carcinogens in the aquatic environment. For an animal species to be a suitable sentinel for a hazardous environmental agent, members of the species must exhibit the following traits: 1) a long life span; 2) a large enough size to yield adequate tissue samples for analysis; 3) non-migratory behavior; 4) territorial behavior; 5) easy apprehension; 6) a sufficient population size and density to be enumerated; 7) inhabit the area to be monitored; 8) accumulate the toxicant without being killed; 9) a correlation between the concentration of the toxicant in tissues with that in the environment; 10) express a measurable response to the toxicant; and 11) respond to the toxicant analogously to humans. For the most part, the desert tortoise fits the profile (traits 1-7) of a desirable sentinel species.

As part of a study of 49 ill, dying or dead desert tortoises from the Mojave and Colorado deserts of California, the concentrations of up to 22 trace elements were determined in fresh sections of liver, kidney and scute. Toxic or potentially toxic metals assayed included cadmium, lead, mercury, nickel, chromium, selenium, zinc, copper, and molybdenum, the concentrations of which appeared to be elevated in liver, kidney and scute of one or more tortoises from multiple study sites (trait 8). Haxel, Knight, Chaffee and Berry are investigating uptake of metals in plants and biogeochemical pathways of metals as a means of correlating concentrations of metals in tissues with that in the environment (trait 9).

We have not detected a consistently measurable response of tortoises to exposure to toxic metals, although we suspect that elevated concentrations of toxic metals have contributed to tortoise morbidity and mortality (trait 10). Thus, we have initiated a study to determine if the presence of the metal-binding protein metallothionein (MT) in tissues and fluid samples in free-ranging desert tortoises can be used as an indicator of environmental toxic metal exposure. Certain metals, including cadmium, nickel and mercury, can induce synthesis of MT in vertebrates. We propose to induce MT synthesis in juvenile desert tortoises by administering multiple injections of cadmium chloride. Low molecular weight proteins, including metallothionein isoforms, will be isolated from liver of these tortoises by molecular weight gel-filtration column chromatography. Metallothioneins will be further purified by anion exchange high performance liquid chromatography (HPLC). Purified metallothioneins will be injected into rabbits to induce anti-MT antibody formation. Rabbit polyclonal MT antibodies will be utilized to develop a competitive enzyme-linked immunosorbent assay (ELISA) for desert tortoise MT in tissues (particularly liver and kidney), serum and urine. The MT-ELISA test will ultimately serve as a simple and sensitive assay for MT content in desert tortoise tissue and fluid specimens, and should provide correlative information about which metals induce synthesis of MT in desert tortoises, and whether elevated concentrations of MT correlate with elevated concentrations of toxic metals in desert tortoises. If we determine that MT occurs in plasma or urine of metal-exposed tortoises, then it may be possible to develop a non-invasive laboratory and/or field test to assess exposure to heavy metals in live desert tortoises. Polyclonal antibodies will also be utilized for immunohistochemical (IHC) detection and localization of MT in paraffin-embedded liver, kidney, and other tissues of tortoises that were submitted for complete necropsy and for which metal analyses have been conducted. Like the ELISA test, the IHC studies should help address which metals induce MT in desert tortoises and whether the presence and sites of localization of MT in tissue are useful indicators of metal exposure.

CAUSES OF MORTALITY AND DISEASES IN TORTOISES: A REVIEW

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Most of the 40 species of tortoises are experiencing populations declines. Of the various causes of mortality in wild populations of tortoises, the interactions of disease and population dynamics are least understood. While habitat degradation is considered the most significant threat to wild populations of tortoises, disease is being observed more frequently in certain populations. An upper respiratory tract disease has been seen in populations of desert tortoise, *Gopherus agassizii*, in the Mojave Desert and certain populations of the gopher tortoise, *Gopherus polyphemus*, in Florida. In both species, *Mycoplasma agassizii*, has surfaced as the causative agent. Compared to wild tortoises, much more information is available on diseases of captive tortoises. Of infectious diseases, viral, bacterial, mycotic and parasitic diseases have all been reported. Herpesvirus has been incriminated as the causative agent of stomatitis, glossitis, conjuctivitis, and rhinitis is in the European tortoises, *Testudo graeca* and *T. hermanni*. An intranuclear coccidial protozona has been associated in deaths of several species of exotic tortoises imported into the United States. Noninfectious diseases identified in tortoises include various nutritional diseases, hypothyroidism, and neoplasia. Virtually nothing is known about the effects of pollutants/toxicants in individual or populations of tortoises.

THEORY, APPLICATIONS, AND CONTROVERSIES OF DISTANCE SAMPLING

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Line and strip transects have been used for almost a century to estimate abundances of both animal and plant populations. In actuality, square, rectangular, and circular quadrats are merely specialized geometries of transects. From the earliest use of transects for biological surveys, surveyors appreciated that corrections had to be applied in order to "adjust" for the logical consequence of visually missing objects that were located farther out from the surveyor's line of travel. A large number of simple to complex functions have been implemented over the years.

Distance sampling (DS) was developed and refined over several decades by David Anderson and Ken Burnham to estimate densities of biological organisms in the field, and software was available in 1993. DS software fits user selected analytical functions and series expansion terms to actual field survey data to optimally model and quantify the decreasing visibility of objects at increasing distances from the surveyor's transect line. We applied DS to surveying desert tortoises and their sign at Edwards Air Force Base in 1994 (DTC 1995) and at Marine Corps Air Ground Combat Center and Joshua Tree National Park in 1995 (DTC 1997).

A number of problems and controversies have arisen in the application of DS for wildlife surveys, particularly when estimating desert tortoise distribution and density patterns. Important issues include: assumptions inherent in the application of DS methodology, the relevance of tortoise fossorial behavior, the relevance of tortoise sign, the relevance of g_0, and the nature of the experimental design to incorporate distance sampling transects. These issues are discussed along with the theory of DS and its relationship to strip transects, advantages of DS, and application of DS for surveying desert tortoises.

PERSPECTIVES ON INITIATIVES AND ACCOMPLISHMENTS OF THE DESERT TORTOISE MANAGEMENT OVERSIGHT GROUP: A PANEL DISCUSSION BY AGENCY COOPERATORS

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The cooperating agencies of the Desert Tortoise Management Oversight Group (Tortoise MOG) have coordinated on numerous tortoise conservation and recovery actions in the past 12 years. The primary mission of the Tortoise MOG is to coordinate agency planning and management activities involving the desert tortoise and its habitat so as to ensure the survival of this species in the wild. The Tortoise MOG includes representatives of the Bureau of Land Management, Fish and Wildlife Service, U.S. Geological Survey, National Park Service, Department of Defense, and State wildlife management agencies from Arizona, California, Nevada, and Utah. Perspectives on the accomplishments by, and challenges confronting, cooperating agencies are given by representatives of BLM, Fish and Wildlife Service, National Park Service, Department of Defense, and Utah Division of Wildlife Resources.

THE RED CLIFFS DESERT RESERVE IN UTAH: SUCCESS AND LESSONS LEARNED

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The Washington County Habitat Conservation Plan (HCP) for the threatened desert tortoise in southwestern Utah, now managed under the Red Cliffs Desert Reserve (RCDC), has enjoyed early success for a multitude of reasons. The principle reason has been Washington County's ability to build a successful partnership with seven local cities, the BLM, Utah Division of Natural Resources, Utah State Parks Department, the USFWS, and Utah State Institutional Trust Lands Administration. This approach has also given the local community, which is paying for the Reserve by way of impact fees, the opportunity to actively participate and therefore take pride in the Reserve. The end result is a broadly supported initiative that enhances tortoise viability while also permitting restricted recreational uses. It has been our experience that initiatives such as ours to save endangered species are most successful when the impacted community is largely behind it. This is especially so when thousands of acres of private property are directly affected and the habitat in question is immediately adjacent to metropolitan areas.

1999 Baseline Desert Tortoise Density and Abundance in the Upper Virgin River Recovery Unit

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Comprehensive and accurate desert tortoise density estimates are recognized as critical in both the Washington County Habitat Conservation Plan and the Desert Tortoise (Mojave Population) Recovery Plan. Distance sampling monitoring was implemented within the Red Cliffs Desert Reserve, Washington County, Utah, to gather baseline regional population densities of desert tortoises. In 1997, a pilot study was completed to standardize field techniques, to provide preliminary estimates of encounter rates and the detection probability, and to determine the field effort necessary to achieve precise regional density estimates within the Red Cliffs Desert Reserve (Reserve). In 1998, 201.42 km (103) transects) of distance sampling was completed within Management Zone 3 of the Reserve.

In the spring of 1999, 306.5 km (158 transects) of distance sampling was completed within Management Zones 2, 3, and 5 of the Reserve. Two hundred and twenty-eight tortoises were encountered during the spring sampling period between March 30 to June 10, 1999. A total of 187 reproductive tortoises ($\geq$ 180 mm) were observed with an encounter rate of 0.61 tortoises per km (range = 0.46 to 0.81) and a coefficient of variation (cv(D)) of 14.45%. The density of reproductive tortoises within the Reserve was estimated at 0.23 tortoises per hectare with a 95% confidence interval from 0.17 to 0.32 and a cv(D) of 16.21%. The abundance of reproductive tortoises was estimated at 5,036 tortoises per area sampled (11,457 ha) within Zone 2, 3, and 5 of the Reserve with a 95% confidence interval from 3,666 to 6,920 and a cv(A) of 16.21%. Density and abundance estimates calculated for reproductive tortoises in 1999 within Management Zone 3 are within the 95% confidence interval of 1998 estimates (0.23 tortoises/ha, 2,361 tortoises per area sampled). The precision level of measured estimates (i.e., $\hat{P}_w$, $\hat{g}_0$, $\hat{D}$, $\hat{A}$) will be refined as additional years of monitoring data are collected. Baseline regional density and abundance estimates can be compared to future estimates to reveal regional trends within the Reserve.

IS *GOPHERUS AGASSIZII* A DESERT ADAPTED TORTOISE OR AN EXAPTIVE OPPORTUNIST? IMPLICATIONS FOR TORTOISE NUTRITION

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While the desert tortoise (*Gopherus agassizii*) traditionally has been viewed as an archetypal desert adapted vertebrate, evidence from historical ecology and phylogenetics, anatomy and physiology, and biogeography qualifies this view significantly. Ancestors of *G. agassizii* achieved a modern and stable morphology some 18 million years ago (mya) ago, perhaps 12 mya before the formation of major regional deserts in North America. Some physiological mechanisms for avoiding or accommodating desert stressors may be symplesiomorphies, primitive character states common to most ectothermic amniotes, such as slow metabolic rates and high tolerances for osmotic flux in body fluids. Other functional characteristics for accommodating aridity were either exaptations shared with forest dwelling batigurid and manourine antecedents. Large brittle shelled eggs, herbivory, and a generalized and expansive digestive tract may all be among these synapomorphies. Other anatomical and behavioral features are associated with a fossorial life style which apparently developed in sandy habitats within grasslands and along forest edges, where microclimates were semiarid, but major landforms had not yet experienced desert levels of aridity. Modern climatic and vegetational settings typical for contemporary populations of *G. agassizii* have only developed episodically over the last 1% of its history.

Biogeographically, neither the testudinids, nor the species *G. agassizii* are confined to deserts. Both track more reliably with warm temperate to tropical climates, and appear to be excluded from the extremely arid zones with less than 50-80 mm mean annual precipitation, such as the deserts of the Baja California Peninsula, Sahara, Atacama, and Arabia. Both extant and fossil *G. agassizii* range well beyond the limits of deserts ecologically into thornscrub, woodland, and grassland habitats.

Ecologically gopher tortoises generally, and *G. agassizii*, in particular, exploit a wide variety of food resources. Preponderant components of the diet are succulent, herbaceous vegetation ranging from cacti fruit to a variety of grasses and forbs. Even carrion and insects can constitute a small portion of the diet. Sclerophyll vegetation, so characteristic of extreme desert habitats, is largely absent from the diet.

The desert tortoise functions well in modern but natural desert landscapes. Its survival is contingent upon a combination of ancient exaptations and contemporary adaptions which resist drought and locally dry microclimates, but evolved long before deserts themselves. Nutritionally it is an opportunistic generalist, shuttling through temporally and spatially patchy forage. When anthropogenic desertification of a preexisting desert impoverishes the landscape floristically and depletes forage, the opportunities for continued tortoise survival and recruitment may be compromised significantly.

TRANSLOCATION AS A TOOL FOR CONSERVATION OF THE DESERT TORTOISE: NEVADA STUDIES

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ABSTRACT

Large numbers of tortoises are being displaced by the expansion of metropolitan areas in the Mojave Desert. Translocation is the only outlet for large numbers of displaced tortoises that is biologically and socioeconomically acceptable in Nevada. We translocated long-term captive tortoises to a site southwest of Las Vegas, NV (1997, 1998), and to a low elevation site near Overton, NV (1998), to evaluate the effectiveness of translocation to more inimical habitat (i.e. hotter, fewer shade resources, less food). At each site, we monitored wild tortoises (residents) as well as translocated animals. We measured survival, reproduction, movement distances, home ranges, social interactions and burrow selection in both translocated and resident animals. Survival for all years of our study was the same for translocated and resident animals within and among sites. Above average rainfall, and forage were available in 1998, and in that year we observed greater survival for both groups compared to 1997. Translocated animals had more variable movement initially than did resident tortoises, but translocated tortoises had similar patterns of movement and habitat use in the activity season following their first winter of hibernation. No difference in reproduction was measured between translocated and resident animals, however tortoises at the more inimical site produced roughly half the number of eggs per female tortoise. Our data suggest that translocation can be effectively used as a conservation tool for the desert tortoise.

From the spring of 1996 to the fall of 1999, we conducted an experiment to evaluate the efficacy of translocation as a conservation tool for the desert tortoise (*Gopherus agassizii*) in Clark County, NV. Translocation is becoming increasingly important as urban areas expand, consume and fragment tortoise habitat. The human population of Clark County, has grown from a few thousand people in the 1940's to greater than 1.6 million as of 1996, and is currently growing at a rate of four to six thousand persons per month (U.S. Census Bureau). In this region, where economic growth and conservation are in conflict, habitat conservation plans (HCP's) are used to reach a compromise. The Las Vegas Valley consists of important tortoise habitat that has been relinquished in a compromise, leaving two options for the tortoises in the path of urban development: 1) Kill tortoises in the way of urban development by taking no action or 2) remove tortoises from harm's way into areas where they can survive and reproduce naturally.

In Clark County, NV, tortoises removed from the path of urban development are taken to the Desert Tortoise Conservation Center (DTCC) in Las Vegas, NV. At the DTCC several options for the deposition of tortoises are available including: adoption, use in research projects at the DTCC, or transfer to other institutions for research projects. As these activities become saturated, the DTCC quickly fills to capacity. Translocation or returning animals to the wild is still another option. Translocated tortoises could be used to bolster populations that have lower than normal population numbers (Fish and Wildlife Service, 1994). However, the efficacy of any translocation program must follow from sound science to tell us what to expect for translocated animals and the influence they may have (if any) on resident populations (Berry 1986).

Some important criteria by which to judge the success or failure of translocation in this species are: (a) survival - whether translocated animals die in large numbers; (b) reproduction - whether translocated animals are likely to contribute to the recovery of populations that have suffered large die-offs and (c) movement - an index of behavior that may be especially important to land managers. Knowledge about tortoise movements can be used for appropriate planning for the design of reserve areas (i.e., location, fencing, etc) or the size designated for translocation release areas. Success or failure of translocation can be measured by comparing wild resident and translocated animals in the same habitat and environmental conditions. These comparisons have enabled us to understand, for example, if deaths of translocated animals are due to additional stress associated with translocation, or to the habitat and environmental conditions of the translocation site. The goal of our experiment has been to evaluate the efficacy of translocation to diminish the loss of tortoises in areas where construction occurs by moving them to other locations. Specifically we were interested in the extent to which translocation affects several ecological processes and properties including: 1) survival, 2) reproductive output, 3) movement patterns and 4) growth, among others.

In 1996, we began monitoring resident animals in Bird Spring Valley (BSV), which is southwest of Las Vegas, NV. Tortoise densities there are approximately 30 animals per square kilometer. The habitat in BSV is characterized by Mojave Desert scrub (Turner 1994) dominated by the shrubs *Larrea tridentata* and *Ambrosia dumosa* with *Yucca schidigera* and *Y. brevifolia* sparsely distributed. The valley is an extensive bajada ranging from 900 m to 1,300 m and is of relatively uniform terrain. Mountainous peaks to the east and west border BSV.

In 1997, we translocated 60 long-term captive tortoises to the BSV site. In 1998, we translocated 30 tortoises to a low elevation site at Lake Mead (LM) to evaluate the effectiveness of translocation in habitat considered to be inhospitable for tortoises. The LM site is at the northern end (Overton arm) of the Lake Mead National Recreation Area, near Overton, Nevada, which is 105.8 km northwest of the BSV site. The site is 550 m lower in elevation, and is characterized by a hotter and drier climate than BSV with less abundant forage for tortoises (Nussear et al. unpublished data).

Vegetation is Mojave Desert scrub (Turner 1994) dominated by *Larrea tridentata, Psorothamnus fremontii,* and *Ambrosia dumosa* with *Atriplex spp.* and patches of *Tetradymia spinosa*. *Yucca* spp. are absent at this site. The LM site is surrounded by water on three sides and has varying terrain. There are mountainous cliffs to the north and cliffs with a few beaches to the south.

In 1998, we added an additional 13 individuals to BSV as a temporal control to match the 1998 release at LM. We were surprised to find that tortoises are present at the LM site, but are in low densities (approximately six animals per sq km) relative to BSV. Resident animals were marked and monitored as encountered.

SURVIVAL

Survival for all years has been the same for translocated and resident animals at each site. In 1996 (the second year of a three year drought), two of 33 resident tortoises monitored at BSV died. In 1997, eight of 53 resident animals in BSV died and seven of 48 translocated animals died. There was higher rainfall and food availability in 1998 (an El Niño year), and we observed greater survival for both translocated and resident animals compared to 1996 and 1997. At BSV in 1998, none of the 55 monitored resident animals died, two (out of 53 tortoises released in 1997) translocated individuals died, and none of the 13 tortoises in the 1998 release group died. Mortality at BSV appears to be largely due to predation, with only one death of a resident animal that was likely due to URTD. In 1999, two of 47 resident animals died while none of the 47 translocated animals died.

At LM in 1998, one resident died (likely predation) and two translocated animals died (one became inverted in the sun, and the other was possibly exposed to lethally cold conditions). There was no tortoise mortality in 1999 at LM.

MOVEMENT

Translocated animals had more variable movement patterns after release than did resident tortoises, but they adopted similar patterns of movement and habitat use in their second year. We measured movement using several different methods. We measured: 1) straight line distance from the point of release (or the hibernation burrow for second year translocatees and residents) to the hibernation burrow for the next winter (Table), 2) straight line distance from the point of release (or hibernation) to the farthest distance traveled, and 3) the cumulative distance moved for the year as measured by summing each line segment between successive relocations. We also measured home range size using the minimum convex polygon technique. We do not report home ranges for translocated animals, as they do not exhibit characteristic home ranges, as defined by Burt (1943).

The differences in activity patterns were great between resident and translocated animals. Resident animals typically have tightly grouped movement patterns, and a characteristic home range, while translocated animals in their first season tend to move in straight lines, covering a greater distance. Translocated animals, during their first season in the field, move much further from their initial location than do resident animals. This is consistent for all releases, but by the second season after release, translocated animals ceased moving great distances, and they had movement patterns that are more similar to resident animals.

REPRODUCTION

We took x-radiographs at biweekly intervals to count the number of eggs and how many clutches of eggs were laid annually for each female. The average number of eggs per female in 1997 was about three, and did not differ between resident animals and translocated animals. In BSV during 1998 (an El Niño year), the average number of eggs per female doubled to about six, and there were not differences between translocated or resident animals or between translocated animals released in different years. In 1999, BSV females produced an average of four eggs per year, and again the number of eggs produced did not differ among translocated and resident groups of animals. Overall, there was no effect of translocation on reproduction, however there was a significant correlation in the number of eggs produced with the amount of rainfall per year.

In 1998 (an El Niño year) at the LM site, female animals produced an average of three eggs. This average not differ between resident animals and translocated animals and was equivalent to the number of eggs produced in BSV during the second year of drought conditions. This is probably due to the different environmental conditions at LM which is lower in elevation, higher in temperature and had less available forage. However, even though BSV and LM differ in habitat characteristics, survival, egg production and movement were the same at both sites for the resident and translocated animals.

To summarize our findings to date, (a) translocated animals had about the same level of mortality as did resident animals, (b) translocated animals oviposited the same number of eggs per year, (c) translocated animals moved further during their first season after translocation and (d) by the second season the translocated tortoises had similar movement patterns to those of the resident animals. We recognize this was a short-term study; nevertheless, we were unable to find differences between resident and translocated animals after their first year back in the wild. This pattern was consistent across several years and six study sites ranging from Jean, Nevada, near the Nevada/Californian border, to the southeastern corner of Utah, a linear distance of about 145 miles in the eastern Mojave. Our sites also ranged from about 500 to 1,400 m in elevation (the extremes in which desert tortoises are normally found). We designed this study to evaluate translocation under a range of conditions and environmental stresses. In our opinion, we have captured not only a significant part of the eastern Mojave in our study, but also a very wide range of environmental conditions as well, and thus we have results that ultimately can be generalized to other portions of the Mojave with considerable confidence. Finally, we can think of no long-term response that would not be confounded with the variability occurring naturally due to year to year differences in environmental conditions. Thus, while longer-term studies may be used to assess the long-term demographics of augmented populations, the labor-intensive approach that we used is unlikely to reveal any additional information.

Our data suggest that translocation can be used as a conservation tool for the desert tortoise. This technique provides a positive use for tortoises displaced due to large-scale habitat loss due to increasing human populations. Ultimately, this research should provide managers with information about the best times of release, as well as sites and conditions for successful translocation programs.

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Table. Maximum distance moved by tortoises from the point of release or hibernation burrow.

Treatment	Year	N	Average Distance (m)	Standard Deviation
Bird Spring Valley				
Resident	1997	46	558	387
Translocated in 1997	1997	50	1867	1288
Resident	1998	50	613	295
Translocated in 1997	1998	38	955	988
Translocated in 1998	1998	13	2354	1703
Resident	1999	47	561	434
Translocated in 1997	1999	36	533	432
Translocated in 1998	1999	11	551	43
Lake Mead				
Resident	1998	15	594	476
Translocated in 1998	1998	30	1189	1101
Resident	1999	16	491	320
Translocated in 1998	1999	28	502	950

JUVENILE DESERT TORTOISES ENHANCE NUTRITIONAL STATUS BY FORAGING CHOICE: DATA FROM THE 1998 EL NIÑO AT THE FORT IRWIN STUDY SITE

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Potassium has a profound impact on the water and nitrogen (N) economies of tortoises because absorbed potassium (K) must be excreted either in fluid urine or as potassium urates. This provides a strong incentive for tortoises to select foods low in K and/or high in water and N (as protein). In captivity, well hydrated tortoises avoid dietary K in food choice trails but do not favor dietary N. It is not known if tortoises exhibit similar choices in the wild. A two week observational study was initiated in April 1998 to monitor foraging behavior of juvenile tortoises (carapace length 68-98 mm, body mass 73-211 g; n = 15) in a predator resistant enclosure at the U.S. Army National Training Center, Fort Irwin, CA. Following fall and winter precipitation of 14.7 cm, 27 species of annual plants were observed in the enclosure. Samples of these species were collected adjacent to the enclosure. Of the plant species selected by juveniles, eaten parts and uneaten parts were collected separately. Samples were frozen, dried to constant weight at 50°C to determine water content, analyzed for N in a CHN elemental analyzer, and assayed for K by atomic absorption spectroscopy following acid digestion.

Individual tortoises were followed for a total of 33.2 hours during which time more than 5,000 bites were observed and recorded by plant species and part. Tortoises took bites from 10% of the individual plants encountered (defined as those passed within one body width on either side, excluding *Schismus barbatus* which was too abundant to count). The primary species ingested were *Camissonia claviformis* (46.2% of bites), *Plantago ovata* (20.4%), *Erodium cicutarium* (18.7%), *Malacothrix glabrata* (5.0%), *Cryptantha angustifolia* (4.8%), *Schismus barbatus* (2.2%), and *Chaenactis fremontii* (1.2%); other species collectively accounted for 1.5% of bites. Leaves were the primary part ingested of all species except *Schismus*. Reproductive structures that included immature fruit and/or flowers were the primary eaten part of *Schismus*, and a major eaten part of *Plantago*, *Erodium* and *Cryptantha*.

The plants encountered contained on average (weighted for abundance and mass) about 66% water and 7.6 % crude protein (CP = N x 6.25; dry matter [DM] basis, and 1.5% K (DM basis). The average potassium excretion potential (PEP; an index of the relative amounts of water and protein compared to potassium) was rather low (about 5 g/kg DM). However, the diet as consumed was very different, containing a PEP of 15 even though the highest whole plant PEP was only 13 (*Camissonia*). This was attributable to the propensity of tortoises to select high PEP plant parts. For example, *Camissonia* leaves, which accounted for 42% of all bites, had a PEP of 20. The ingested diet contained on average 72% water, 11% CP and 1.4% K; tortoises did not need to avoid K to achieve high PEP. We conclude that juvenile tortoises are able to enhance their nutritional status

by dietary selection, at least in a wet year when a wide variety of annual plants germinate and grow, including high PEP species.

THE EFFECT OF CATTLE GRAZING ON DESERT TORTOISE (*GOPHERUS AGASSIZII*) ABUNDANCE AND HABITAT IN THE NORTHEASTERN MOJAVE DESERT

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When the desert tortoise (*Gopherus agassizii*) was listed as threatened, livestock grazing was one of the factors identified as threatening long-term survival. We did an analysis of some of the factors and determined that effects of livestock grazing, particularly that by cattle, had not been scientifically evaluated. Thus, in 1992, we initiated research to evaluate the effects of cattle grazing on tortoises and their habitat in southern Nevada and southeastern California. In many evaluations of cattle grazing, exclosures are used to evaluate grazed versus not grazed; however, in the Mojave, there are not many sizable exclosures that have been in place long enough to approximate a non-grazed state. Because cattle are dependent on water and graze near water, we sampled at 11 water sources in southern Nevada and southeastern California. This approach, using a water device as a center of a study, has been used in Australia and published as a piosphere. For our design, we used five lines radiating out 4,800 to 6,400 m from a water source. We avoided major highways, other water, and other factors that may have influenced cattle or tortoise distribution. We sampled one hectare plots at 10 distances from water starting at 200 meters and ending at 6,400 meters in 1993 and 4,800 meters in 1994 and 1995. We have made the assumption that cattle impacts are less at those distances from water than they are nearer water. We hypothesized that abundance data would fit a logistic curve with distance from water as the horizontal axis. That is, for perennial grass density as an example, density would increase further from water if livestock grazing was indeed affecting perennial grass abundance. We recognize that during cooler seasons, cattle wander further from water but we believed that 50-100 years of grazing would result in the patterns hypothesized.

Within each one ha plot, we sampled desert tortoise and active burrow density by the removal method. Woody plant abundance was sampled with line intercept and quadrat methods. None of the methodology we used adequately described abundance of perennial grasses, because they occurred so rarely. Thus, using rare plant sampling theory, we tested several quadrat sizes for estimating density of perennial grasses and selected two by 100 m quadrats as providing the best estimate of grass abundance. We identified 22 plots at each of the 11 locations that occurred in a single soil type to sample soils and perennial grasses.

We clustered the soils data into seven soil types based on minerals, texture, and elevation. Analyses of tortoise, active burrow, *Larrea tridentata*, *Ambrosia dumosa*, and perennial grass abundance were performed in the most common soil type to reduce any effects due to soil differences. Sixty-five one ha plots occurred in this soil type in Piute, Fenner, and Ivanpah valleys. We tested the logistic hypothesis by trying to fit each of the above variables to a curve with the distance from water as the horizontal axis. We first tested logistic, then polynomial regressions, with no success. Finally we ran straight line regressions with the following results. For each variable tested, $R^2 < 0.08$, the intercept value was significantly ($P<0.05$) different from 0, and the slope was not significantly ($P>0.10$) different from 0. This means that the overall mean of the variable was a good estimate of that variable at any distance from water; we could not detect any impact due to grazing.

INVESTIGATION OF HERPESVIRUS INFECTION IN CHELONIANS

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Beginning in the mid 1970's, herpesviruses have been reported as pathogens associated with different diseases in several species of chelonians (Cox et al. 1980, Drury et al. 1998/1999, Frye et al. 1977, Harper et al. 1982, Heldstab and Bestetti 1989, Jacobson et al. 1982/1985/1986/1991, Kabish and Frost 1994, Marschang et al. 1997/1998/1999, Muro et al. 1998, Rebel et al. 1975). More recently herpesvirus infection has been identified as a significant health problem in Mediterranean tortoises (*Testudo graeca* and *hermanni*; Drury et al. 1998/1999, Heldstab and Bestetti 1989, Kabish and Frost 1994, Marschang et al. 1997/1998/1999, Muro et al. 1998). Several herpesvirus strains have been isolated from pet Mediterranean tortoises in Europe and in the U.S., showing a worldwide distribution of these viruses. Two isolates have been recently purified in our laboratory. A variety of clinical signs, including stomatitis rhinitis, conjunctivitis, pneumonia and signs of central nervous system disease can be observed in ill tortoises (Heldstab and Bestetti 1989). Glossitis can be severe and diphteritic plaques on the tongue as well on the hard palate of the tortoises in the advanced stages of the disease are a common finding. The disease seems to target more aggressively the upper respiratory tract of the tortoise, but involvement of the lower respiratory tract has also been reported. Using light microscopy, intranuclear eosinophilic inclusions have been detected in multiple epithelial tissues and in the brain. Electron microscopy has shown inclusions to consist of virions that are morphologically compatible with herpesvirus.

The transmission route is totally unknown in the wild. Captive tortoises are commonly exchanged between different collectors, resulting in spreading of the disease. A six month quarantine is necessary to reduce the risk of transmission of the pathogen from infectious to naive tortoises. In naive collections the mortality can be as high as the 100% (Drury et al. 1998).

No specific therapy is currently available. An in vitro study with acyclovir and gancyclovir has shown the ability of these chemotherapeutics in reducing viral replication (Marschang et al. 1997). An early diagnosis is the most effective preventive measure for reducing the risk of infection. The most definitive diagnostic test for herpesvirus infection in Mediterranean tortoises is virus isolation. Unfortunately, virus isolation is not always achievable. In tortoises, relatively little or no virus at all is shed in early stages of the disease.

Of serological tests serum-neutralization is considered the "gold standard" for detection of exposure to herpesvirus in tortoises. This test detects the presence of serum-neutralizing antibodies and 11-14 days are needed for a diagnosis to be made (Frost and Shmidt 1997).

A new enzyme-linked immunosorbent assay (ELISA) has been recently developed at the University of Florida (Origgi and Jacobson 1999). Preliminary unpublished data shows a high sensitivity and specificity of the test compared to SNT. In a survey conducted on 175 plasma samples obtained from Mediterranean tortoises in a rehabilitation facility in France, 35 samples were positive for the presence of SN antibodies while 38 were positive using the ELISA test. All the samples positive by SN were positive also by ELISA. This assay is currently been validated through a transmission study conducted on Mediterranean tortoises. Furthermore, we are currently screening a total of 31 recombinant DNA fragments obtained from the cloning of an American herpesvirus isolate (HV1976). Partial sequencing of several recombinants has already been accomplished. Sequencing information could allow the development of several new diagnostic tests that could complement the serological assays described above. These tests will allow rapid screening of tortoises in wild, private, breeding and zoo populations.

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DIGESTIBLE ENERGY IN FOODS OF JUVENILE DESERT TORTOISES

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The digestible dry matter and energy in two dietary grasses, *Achnatherum hymenoides* and *Schismus barbatus*, were measured in feeding trials on one to two year old desert tortoises. *A. hymenoides* (Indian ricegrass) is native to the Mojave Desert whereas *S. barbatus* (Mediterranean grass) is introduced. We offered weighed amounts of chopped dry grass of both species *ad libitum* to the tortoises (n = 10 for animals who ate *A. hymenoides*, and n = 6 for animals who ate *S. barbatus*), and collected uneaten food and feces daily for several weeks. Dry matter retained (food consumed minus feces produced) was used to estimate apparent dry matter digestibility. Energy content measurements of food and feces from microbomb calorimetry were combined with dry matter measurements to calculate apparent energy digestibility. Preliminary results suggest that energy digestibility is slightly lower than dry matter digestibility because feces have a slightly higher energy content (per gram) than food (probably due to bacteria in feces). Dry matter and energy digestibilities in juvenile *Gopherus agassizii* were roughly comparable to those determined in previous studies on adult desert tortoises (Meienberger et al. 1993, Nagy et al. 1998).

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TRANSLOCATION AS A TOOL FOR CONSERVATION OF THE DESERT TORTOISE: IS TRANSLOCATION A REASONABLE STRATEGY FOR DESERT TORTOISES DISPLACED BY URBAN EXPANSION?

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Translocation may be the only biologically and socioeconomically acceptable strategy for dealing with tortoises displaced by urban expansion. Since 1997, we have translocated literally thousands of captive and displaced desert tortoises to several sites in Nevada and Utah. Some of these sites were thought to be good tortoise habitat, and some of the sites were considered to be different from that thought to be good tortoise habitat. At each site, we measured survivorship, reproduction, movements, distances, home ranges, social interactions, burrow selection, and habitat selection. Tortoises translocated to habitats thought to be not tortoise habitat, tended to move greater distances in the first year after translocation than did resident wild tortoises and tortoises translocated to good tortoise habitat. However, all tortoises translocated to good tortoise habitat, including long-time pet tortoises, eventually were found to not be statistically different from wild tortoises in all of the dependent variables that we measured. Our data suggest that translocation can be a humane way to deal with tortoises whose habitat has been destroyed. Additionally, our results suggests that translocation may be a strategy for supplementing depauperate populations of desert tortoise as part of plan to recover this species. However, this latter use of translocation is controversial, and likely needs further research, if only to convince the most conservative of those who manage this biological resource that translocation is efficacious.

THE CLARK COUNTY DESERT CONSERVATION PROGRAM: A REVIEW OF CONSERVATION ACCOMPLISHMENTS

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With the emergency listing of the desert tortoise under Endangered Species Act provisions in 1989, Clark County became the potential battleground for conflicts between the goals of economic prosperity and environmental integrity. Within a year of the formal listing of the desert tortoise as threatened, a vast array of stakeholders joined together to hammer out what has become one of the nation's most significant public habitat conservation plans, which is soon to become the nation's third largest Multiple Species Habitat Conservation Plan. As part of the Desert Tortoise Council's panel on habitat conservation plans, this talk will address the short and long-term accomplishments of the Clark County Desert Conservation Plan including attention to issues of public consensus building, conservation infrastructure development, an overview of significant research findings, as well as a discussion of an array of mitigation efforts currently underway.

PROPOSED CONSERVATION PLAN FOR A SMALL, ISOLATED GOPHER TORTOISE POPULATION ON A SOUTH CAROLINA STATE NATURAL PRESERVE

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The gopher tortoise is a state endangered species in South Carolina and is probably the state's most endangered reptile. In addition, the northernmost population of gopher tortoises occurs in Aiken County, SC and is believed to be in serious decline. Therefore, this population is significant due to the rarity of the species and its location. Compelling anecdotal evidence suggests that there are few adult tortoises to be found at this colony site. South Carolina Department of Natural Resource's Heritage Trust program has acquired 1,395 acres at this site and is managing to restore the longleaf pine-wiregrass habitat required by the tortoise on the preserve. We believe that, despite the efforts to restore habitat, the tortoise population will likely continue to decline unless conservation measures, including population manipulation to recover the population, are not implemented. As an important step towards developing a site-specific recovery plan for gopher tortoises on the Aiken County preserve, we will evaluate and present the potential conservation options for review and comment.

TRANSLOCATION AS A TOOL FOR CONSERVATION OF THE DESERT TORTOISE: UTAH STUDIES

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Management and conservation plans for the desert tortoise often involve the removal of individuals from areas of disturbance. Displaced tortoises are temporarily held in tortoise holding facilities until their fate is determined. Translocation of tortoises is often advocated in areas of rapid development, however, few studies have yet to demonstrate the effectiveness of translocating tortoises. Using radio telemetry, we tracked translocated tortoises at three study sites (Pahcoon, Shivwits, Sandstone) near St. George, Utah. These three sites differ from each other in several habitat characteristics (e.g., elevation, vegetation). The habitat at the Pahcoon and Shivwits sites is not considered "typical" desert tortoise habitat in that it does not contain the characteristic shrub species (e.g., creosote bush, ambrosia) normally associated with desert tortoise populations. Additionally, the Pahcoon site is at a higher elevation (1350 m) than that where desert tortoises are found in Utah. On the other hand, the habitat and elevation at the Sandstone site is composed of the characteristics typical of tortoise habitat. Here, we compare movements of tortoises translocated to these three study sites. We found that tortoises released at the Pahcoon and Shivwits sites moved longer straight line distances and greater cumulative distances than did tortoises released at the Sandstone site. Many of the tortoises released at the Pahcoon and Shivwits sites moved several kilometers from their initial release sites and are currently located in more characteristic tortoise habitat. Only one of the 18 tortoises released at the Sandstone site moved far enough to have moved off the study site.

RESULTS OF LINE DISTANCE TRANSECTS CONDUCTED ON THE CHOCOLATE MOUNTAINS AERIAL GUNNERY RANGE, RIVERSIDE COUNTY, CALIFORNIA

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The approximately 387,200 acre Chocolate Mountain Aerial Gunnery Range (CMAGR) is located in the central portion of the Colorado Desert, in Riverside County, California. It is a live-fire air to ground and air to air range. Most of the base is a buffer for approximately 30 target sites that

are on the CMAGR. The target sites range from 200 to 1,000 acres, are heavily impacted, and portions of many are virtually denuded. The surrounding habitat is impacted very little, if at all. Only two ground based activities occur on the base: a Navy SEAL training area is on the west edge, and EOD clears the target areas of unexploded ordinance. Two utility corridors traverse the CMAGR: a Gas Company natural gas pipeline and an electrical transmission line.

That portion of the CMAGR north and east of the Chocolate Mountains is within the Chuckwalla Bench Desert Wildlife Management Area (DWMA) and within Critical Habitat (the boundaries for both the DWMA and Critical Habitat are the same). Two strata were determined to be on the CMAGR, the Chuckwalla Bench Strata on the north end and the Milpitas Wash strata in the eastern portion. It was estimated that approximately half of the Chuckwalla Bench strata is on the CMAGR and that approximately 15% of the Milpitas Wash strata is on the CMAGR.

In 1997, forty-one line distance transects were established within Critical Habitat on the CMAGR. The transects are four kilometers long, one kilometer on a side, and in the shape of a square or diamond. Thirty-one transects were placed in the Chuckwalla Bench strata and 10 transects were placed in the Milpitas habitat. The locations were not randomly selected but were spaced throughout the two strata.

The transects were first read between April 21 and May 6, 1999. Three person crews were used to read each transect. The center person stayed within one meter of the actual line and two flankers roamed from 0 to 10 meters from the line, one on each side. Desert tortoises, fitted with transmitters, were relocated daily during distance sampling to estimate the number of visible tortoises and the probability of detection (g_0). The Milpitas habitat type is in a range that cannot be accessed prior to the spring sampling period, thus, all tortoises used for g_0 were in the Chuckwalla Bench strata. Unfortunately, only one tortoise was transmittered on the first day of distance sampling and the tenth tortoise was not fitted with a transmitter until the fourth day of distance sampling. All of the tortoises fitted with transmitters were adults, seven males and three females. During the sampling period the number of visible tortoises, g_0, was 0.68 (n=10; SE=0.11).

Thirty-one desert tortoises were observed on the 41 transects, 25 on the Bench and six on the Milpitas. The encounter rate was 0.21 tortoises per km in the Chuckwalla Bench and 0.12 tortoises per km in the Milpitas strata. Nine of the 31 tortoises were above ground and the other 22 were visible in burrows. Twenty-four of the tortoises were adults (7 male, 10 female, 7 unknown), four were subadults (1 male, 1 female, 2 unknown), and three were immatures. None of the eight tortoises we were able to inspect had signs of upper respiratory tract disease. We could not inspect the plastrons of the tortoises observed, but three of the eight tortoises whose carapaces were inspected had shell lesions indicative of cutaneous dyskeratosis. The density for both strata was 0.17 tortoises per hectare with a 95% confidence interval from 0.08 to 0.27 and a cv(D) 30.02%. This project was funded by Marine Corps Air Station, Yuma via Contract No. N68711-97-M-8808. Ron Pearce (MCAS, Yuma) and Bill Fisher (Southwest Division, Naval Facilities Engineering Command) provided invaluable assistance.

DISTRIBUTION AND RELATIVE ABUNDANCE OF DESERT TORTOISES ON THE MARINE CORPS AIR GROUND COMBAT CENTER, TWENTYNINE PALMS, CALIFORNIA

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In 1997 and 1999, surveys for the desert tortoise (*Gopherus agassizii*) were conducted on the Marine Corps Air Ground Combat Center (MCAGCC), Twentynine Palms, San Bernardino County, California. The survey encompassed approximately 595,860 acres and was conducted in the summer and fall of 1997 and the summer and winter of 1999.

A two-pronged approach was used to estimate the distribution and relative abundance of desert tortoises on the training areas. Two previously established one km^2 plots, Emerson and Sand Hill 2, were surveyed, for 28 days each, to provide reliable data on abundance, demographic parameters, and health of tortoises at these two locations. A total of 920 relative abundance transects were conducted on the 22 training areas in order to estimate distribution and relative abundance of desert tortoises throughout the MCAGCC. Data were also collected on human impacts on the training areas, including the number of vehicle tracks, roads, expended ordnance, and other range residue.

The Emerson Lake plot is located approximately one km east of the western boundary of MCAGCC. Fourteen live tortoises were found on the plot. Three tortoises were immature and the remainder were adults. Five of the adults were male and six were female. Tortoise abundance was estimated at 39 tortoises per mi^2. Carcasses of 16 tortoises were found. Nine tortoises were estimated to have died within four years, but of the nine only three carcasses were of adults. Tortoise densities appeared to be stable. No tortoises had signs of upper respiratory tract disease (URTD) but three tortoises had minor amounts of peeling scute laminae. However, six tortoises (43%) had various amounts of trauma to the shell and forelimbs. We believe that this trauma was due to dogs (*Canis familiaris*).

The Sand Hill 2 plot is located in the southwestern portion of the MCAGCC. Thirteen live desert tortoises were found on the plot. Except for one subadult male, all of the tortoises were adults. Six tortoises were male and seven were female. Tortoise abundance was estimated at 77 tortoises/mi^2. Carcasses of 16 tortoises were found. Eleven tortoises were estimated to have died within four years, but of the 11, seven were juvenile or immature and four were adults. No tortoises had signs of URTD but the plastrons of two adult males were affected by cutaneous dyskeratosis. However, 11 (85%) tortoises had varying amounts of trauma to the shell and forelimbs. As at the Emerson plot, we believe this trauma to be due to dogs.

The relative abundance transects indicated that tortoises were present on all 22 training areas. Only three areas were estimated to have an abundance greater than 50 tortoise per mi^2. These areas were the south end of the Bullion Training Area, the western edge of the Emerson Lake Training Area, and the southern portion of the Sand Hill Training Area. These areas account for approximately 10,899 acres of habitat. Approximately 56,345 acres of habitat had an estimated abundance of 21-50 tortoise/mi^2 and approximately 111,398 acres had an estimated abundance of six to 20 tortoises per mi^2. Tortoise sign was not found in the northeastern portion of the MCAGCC in the Black Top, Lead Mountain and Lava Training Areas. This may be due to low elevations in the area as well as the large substrate that is typical of the area.

Forty-six live desert tortoises were observed on the 920 transects. Of the 46 live tortoises, 29 were visually inspected for signs of URTD and cutaneous dyskeratosis. One subadult male tortoise had conjunctivitis, a sign of URTD. This tortoise also had severe cutaneous dyskeratosis, peeling scute laminae, and was missing his right rear leg. No other tortoises had signs of URTD. Three other tortoises, all adult males, had cutaneous dyskeratosis, none of which were severe.

The carcasses of 125 tortoises were found on the transects. The size class structure of the carcasses was 92 adults, 25 immatures, and 8 juveniles. Sixty-seven (53.6%) of the carcasses were of tortoises that had died more than four years previously. The cause of death for 95 (76%) tortoises is unknown. The cause of death for 17 (13.6%) was believed to be predation, 16 of which were juvenile or immature. All six juveniles and one small immature were probably killed by common ravens (*Corvus corax*) and the remainder were believed killed by canids, probably coyotes (*Canis latrans*). Vehicles were thought to be the cause of death for 23 (18.4%) of the dead tortoises. Several other carcasses were found that had been crushed, but due to the type of bone fractures, they were probably dead when crushed.

Because of its mission as a training facility, the MCAGCC is impacted by a variety of human uses including off-road vehicle travel, target practice with various sizes and types of ordnance, camping, and trash. The most prevalent impacts are associated with vehicular travel, both on and off roads, and ordnance. Impacts are heaviest in the corridors used for travel to and from mainside to the training areas. These corridors are generally in the valley bottoms and gently sloping bajadas. The hills and mountainous areas tend to be less impacted and many of these areas have not been impacted by military training activities.

More than 700 vehicle tracks were found on 10 (1.1%) of the 920 transects. Three hundred and fifteen (34.2%) transects had fewer than 25 vehicle tracks counted, 118 of which had no vehicle tracks. Expended ordnance was found on 824 (89.6%) of the transects. More than 700 pieces were found on four transects, all of which were in target areas.

These surveys were funded by MCAGCC via contracts DACW05-95-d-003 with Jones & Stokes, Inc. and N68711-99-M-6629. Sharon Jones and Rhys Evans from MCAGCC and Bill Fisher from Southwest Division, Naval Facilities Engineering Command provided invaluable assistance. John Westermeir, Jones & Stokes, was the Project Manager and Richard Rust was the GIS specialist.

ABSTRACTS AND PAPERS FROM THE

26TH ANNUAL SYMPOSIUM,

TUCSON, ARIZONA, MARCH 16-19, 2001

STATUS OF THE SONORAN POPULATION OF THE DESERT TORTOISE IN ARIZONA: ARIZONA INTERAGENCY DESERT TORTOISE TEAM

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The Arizona Interagency Desert Tortoise Team recently completed an update of the 1990 report, *Status Summary for the Desert Tortoise in the Sonoran Desert* (Barrett and Johnson 1990), to provide a 10-year update on the adequacy of current management to conserve viable populations of Sonoran desert tortoises statewide (AIDTT 2000). This analysis could be used by land managers and others to better manage for desert tortoises across agency boundaries and to identify multi-jurisdictional Sonoran Desert Management Areas as recommended by the AIDTT's 1996 management plan. The following discussion is taken directly from the revised status report. See the report for more detailed information, tables, figures, and maps.

The Bureau of Land Management has management authority for the greatest proportion of habitat within the range of the Sonoran desert tortoise in Arizona and actively works to conserve tortoise populations and habitat, especially through its compensation policy and habitat categorization. Substantial tortoise habitat also occurs on Areas of Critical Environmental Concern and wilderness managed by BLM. Several other agencies take a more passive approach to desert tortoise management (at least as an individual taxonomic unit), but it is no less effective due to their particular missions. Most national wildlife refuges on which desert tortoises occur are managed as wilderness, effectively minimizing many of the threats identified in other areas. The same is true of national parks, and restricted access on the Yuma Proving Ground and Barry M. Goldwater Range affords near-wilderness status to tortoise habitat on those lands.

Most of the central and south-southeastern portion of the tortoise's range (Maricopa, Pinal, and Pima counties) occurs on relatively unprotected Arizona State and forest service lands, although restricted access and cultural importance on the Tohono O'odham Nation may afford some protection there. The southwest portion of the tortoise's range in Arizona (i.e., Yuma County and the western portion of Pima County) appears to be well covered by "wilderness" level protection, but most of this area is characterized by low density, sparsely distributed tortoise populations. The northwestern portion of the range also contains a significant amount of more actively managed tortoise habitat (wilderness and ACECs), but large gaps remain. Most of the wilderness areas in the central to southeastern part of the state lie above the tortoise's elevational limits.

Important gaps in desert tortoise habitat protection occur near the metropolitan areas of Phoenix, Tucson, and to some extent Kingman, as well as intervening lands between these areas. These areas are under immediate pressure as more and more public land is being accessed for recreation by Arizona's growing urban population. Increasing recreational use results in increased opportunities for tortoises or habitat to be lost to roads (including trails illegally created by OHV enthusiasts), collection, and vandalism. Genetic contamination and introduced disease from relased captives also pose increasing risks near metropolitan areas. Proposed actions in Pima County's Sonoran Desert Conservation Plan would reduce pressures of urbanization on tortoise habitat within the eastern portion of that county (Pima County 2000).

We identified an important need to update comprehensive management plans to address increasing demands and impacts on BLM lands, but this could be applied to other public lands, as well. In addition, even though wilderness-level status may offer some protection against urbanization (at least the effects of direct habitat loss), roads and OHV activity, and grazing and mining (in some cases), land managers must realize that other threats, especially exotic plant invasion and fire, are not constrained by artificial boundaries. Wilderness and other areas may also be affected by the unknown long term effects of habitat fragmentation by urban and agricultural development, roads, and canals. Even though market conditions are not particularly good for gold and other hard rock minerals at present, mining claims are numerous throughout the range of the desert tortoise. Protection is somewhat limited on many federal lands by the 1872 Mining Law, unless areas such as wilderness, national parks, and refuges are withdrawn from mineral entry. Resources are desperately needed to adequately implement existing policies and enforce existing regulations on many public lands.

Given the information currently available, tortoise populations appear to be stable within the Sonoran Desert in Arizona. However, trend data are currently insufficient to draw secure conclusions about population trajectories (Averill-Murray 2000), especially with the increasing threats related to urban growth and habitat fragmentation. The ability to detect trends is negligible if populations are only surveyed 2 or 3 times, thus requiring a long term commitment to population monitoring in order to detect anything other than a catastrophic decline (Averill-Murray 1999). With the exception of 1990-94 when 3 plots were surveyed annually, monitoring efforts have been haphazard. Several plots have been surveyed across long time intervals or have yet to be resurveyed at all. Inconsistent funding will result in an increased period of time before trend estimation is possible for each plot. Long survey intervals could result in gradual declines over several years not being detected until a significant absolute decline in abundance has already occurred. Catastrophic declines (such as that at the Maricopa Mountains; Shields et al. 1990) might not be recognized as such, reducing the ability to identify and correct the cause of the decline (Averill-Murray 1999). Finally, little more than general distribution data exist for tortoise populations on lands managed by the Department of Defense, U.S. Forest Service, national wildlife refuges, and the Tohono O'odham and other Native American nations.

The unknown significance of currently low incidence of URTD symptoms but high incidence of cutaneous dyskeratosis within tortoise populations poses another concern; apparently healthy populations in the Mojave Desert have suffered dramatic declines in the presence of these diseases. Continued monitoring across the range is essential to better quantify population status and trends. Individual and cooperative efforts by land and wildlife management agencies must continue to ensure that sufficient habitat area and quality remain for the survival of tortoise populations. Finally, additional research should be conducted to answer questions about population dynamics, habitat impacts (especially fire and invasion of exotic grasses), and disease, so managers can better direct their conservation efforts (AIDTT 1996).

ACKNOWLEDGEMENTS

The following people contributed to the preparation of the revised status report: Scott Bailey, Loren Billerbeck, Mike Boyles, Bill Burger, Neva Connolly, Ted Cordery, Gene Dahlem, Micheal Demlong, Julia Fonseca, Bob Hall, Amy Heuslein, Dave Hoerath, Jeff Howland, Jack Johnson, John Kennedy, Junior Kerns, Natasha Kline, Chris Klug, Diane Laush, Chip Lewis, Elroy Masters, Aimee McIlroy, John Morgart, Bruce Palmer, John Regan, Jim Rorabaugh, Tom Skinner, Don Swann, Tim Tibbits, Selso Villegas, Stephen Williams, Betsy Wirt, and Lori Young.

The preparation of the report and this manuscript was partially funded by the Arizona Game and Fish Department's Heritage Fund and U.S. Fish and Wildlife Service Partnerships For Wildlife Project, Job 01, administered by the National Fish and Wildlife Foundation. The U.S. Army Yuma Proving Ground funded the printing of the status report.

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Program Mark Survival Analysis of Tortoises Voiding their Bladders During Handling

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At the 1998 Symposium, I presented data that indicated that desert tortoises that voided their bladders during handling were less likely to be captured in subsequent years than those that did not void their bladders. This indirectly suggested that tortoises that void their bladders during handling have lower survival than those that do not void. A more conclusive analysis would measure survival directly. I accomplished this in an analysis using Program MARK. Data were taken from three monitoring plots (Eagletails, Granite Hills, and Little Shipp) and broken into three groups each: adult males, adult females, and juveniles (<180 mm MCL). Individual covariates included MCL at first capture and a binary voiding covariate for each year, 1990-94. About half the tortoises at Little Shipp voided their bladders at least once when handled, with lesser proportions at the other two plots. The most parsimonious model in the original candidate set of 21 models analyzed with Program MARK was one in which survival varied by MCL, plot, and voiding. Subsequent inclusion of an exploratory model that lacked the plot effect resulted in 49% greater support for the reduced model. Tortoises that voided their bladders during handling had significantly lower average annual survival (0.81-0.88) than those that did not void (0.96). Therefore, as suggested in 1998, researchers studying desert tortoises should develop well-defined study objectives that minimize handling time as much as possible in an effort to prevent tortoises from voiding their bladders.

Activity and Behavior of Desert Tortoises in a Northeast Sonoran Desert Population

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Desert tortoises were monitored weekly with radio telemetery from 1996 through 1999 at a Sonoran Desert site on the Tonto National Forest, northeast of Phoenix, Arizona. Peak tortoise activity occurred during the summer monsoon season, but spring and winter activity increased with increasing rainfall during those seasons. Spring foraging appears to be important, especially for females, since ovarian follicles mature during spring. Males also appeared to be more active during spring than previously thought. Average annual home range areas ranged up to about six ha, but some individuals made long-distance movements outside their "normal" home ranges.

Some of these movements represent temporary excursions to specific resource sites, such as nesting burrows. Others are more difficult to explain, but some may represent dispersal.

SONORAN DESERT TORTOISE POPULATION MONITORING, 1987-2000

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To date, 17 Sonoran desert tortoise population plots have been surveyed under funding from the Arizona Game and Fish Department, Bureau of Land Management, and Fish and Wildlife Service (several others have been surveyed by other agencies). Tortoise densities within local populations vary widely, ranging from 15 to more than 100 adults per square mile, and density is apparently related to habitat features providing burrow sites. Sex ratios are typically balanced between males and females. Symptoms of upper respiratory tract disease have occasionally been observed on plots, and cutaneous dyskeratosis is present in virtually all populations. However, disease has not impacted Sonoran populations as it recently has in the Mojave Desert. Notable human related impacts to some populations include predation by feral dogs, burrows trampled by cattle, tortoises trapped in a mining pit, adjacent development, and shot and vandalized tortoises (or a released pet). Only one documented population crash has occurred in the Sonoran Desert in Arizona during the last 13 years, and it appears to have been related to drought rather than disease, although substantial numbers of carcasses have been found at a few other sites. Other populations appear to be stable, based on the current data.

SONORAN DESERT CONSERVATION PLAN: HISTORY, PROCESS, AND DISCUSSION

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Pima County's Sonoran Desert Conservation Plan (SDCP) addresses not only conservation and growth issues but also cultural and historical resources, open space, and ranch conservation. The

SDCP covers all of Pima County (Tucson), except native American lands. This presentation will give an overview of the SDCP and its inception and general goals. Dr. Shaw is the chair of the Science Technical Advisory Team, and will discuss the role of science in the Plan. Sherry Barrett will address the USFWS perspective and involvement and compare this Habitat Conservation Plan to other HCP's. Time will be available for questions and discussion.

PREDATION AND SURVIVAL DURING EARLY LIFE STAGES OF THE DESERT TORTOISE IN THE SOUTH-CENTRAL MOJAVE DESERT

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Despite extensive research on desert tortoise population trends, very little is currently known about survival during early life stages and the impacts of native and introduced predators. To address this issue, I monitored tortoise nests, eggs, and young for survival while simultaneously surveying predator communities at the Sand Hill Training Area (Sand Hill) of the Marine Corps Air Ground Combat Center, Twentynine Palms, California (1997-1999). I used x-radiography and thread-trailing devices to locate 42 tortoise nests. I fenced nests at the end of incubation to capture neonate tortoises, 32 of which I radio-tagged to monitor movements and survival during fall dispersal. Mortality during each life stage was quite low: 74% of nests survived incubation; 69% of 132 eggs in those nests developed and produced healthy hatchlings; and 88% of dispersing young survived until winter hibernation in late October. However, these three stages account for less than one year, or approximately 3% of the life of a tortoise that reaches 35 years or older before senescence. I estimate that less than half of the eggs produced by Sand Hill females successfully hibernated as neonates and therefore conclude that desert tortoises underwent high mortality early in life, as suggested by life history data for other chelonian species. I recorded kit fox visitation to scent stations throughout the training area and found fox tracks at many depredated nests. Raven abundance was considerably lower at Sand Hill than in surrounding residential areas and few tortoise carcasses were found beneath raven perch and nest sites, suggesting that ravens were not important local predators. I encountered 31 free-ranging dogs in 11 packs, witnessed dog harassment of a tortoise, had numerous radiotransmitters forcibly removed from study females, and believe that dogs may have been responsible for the high frequency (47%) of nonlethal shell damage to the 76 adult and immature tortoises examined during the study period.

THE DYNAMIC GEOGRAPHY OF EXTINCTION

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Predictions based on macroecological patterns and island biogeography theory have suggested that the final population of a declining species should be located near the center of the species' historical range. In previous research, I have found that this pattern of range contraction was not realized. Range remnants and final populations were found in the periphery of the historical range significantly more often than near the center. This peripheral bias held true for species from most regions and taxonomic groups. These previous analyses of range contraction have been limited, as I have only looked at historical and current distributions. In this research, I link these two stages with a trajectory of predicted decline based on the peripheral bias and its hypothesized cause. An analysis of these decline trajectories provides a counterintuitive result that has important implications for the development of conservation priorities.

CLINICAL DISEASE AND LABORATORY ABNORMALITIES IN FREE-RANGING DESERT TORTOISES (*GOPHERUS AGASSIZII*) IN CALIFORNIA (1990-1995)

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Desert tortoise (*Gopherus agassizii*) populations have experienced precipitous declines resulting from the cumulative impact of habitat loss, and human and disease related mortality. Diagnosis of disease in live, free-ranging tortoises is facilitated by evaluation of clinical signs and laboratory test results but may be complicated by seasonal and environmental effects. The goals of this study were: to document and monitor clinical signs of disease in adult, free-ranging desert tortoises at three sites in the Mojave Desert of California between October 1990 and October 1995; to determine the association of clinical signs with hematological, biochemical, serological and microbiological test results; to characterize disease patterns by site, season, and sex; and to assess the utility of diagnostic tests in predicting morbidity and mortality. Venous blood samples were obtained four times per year from tortoises of both sexes at the Desert Tortoise Research Natural Area (DTNA), Goffs, and Ivanpah Valley. Tortoises were given a complete physical examination, and clinical abnormalities were graded by type and severity. Of 108 tortoises, 68.5% had clinical signs of upper respiratory disease consistent with mycoplasmosis, and 85.4% had shell lesions

consistent with cutaneous dyskeratosis. Oral ulcers were noted in 23% of tortoises at Goffs and in two Ivanpah tortoises. Tortoises with ulcers were significantly more likely to have positive nasal cultures for *Mycoplasma agassizii* ($P<.0001$). Six tortoises had marked azotemia (BUN > 100 mg/dl); of these, three died, and two had necropsy confirmation of urinary tract disease. Tortoises at Goffs were significantly more likely to have moderate to severe shell disease, positive nasal cultures for *Mycoplasma agassizii*, heteropenia, and increased serum AST activity than tortoises at other sites. Tortoises at DTNA were significantly more likely to be seropositive for *M. agassizii* and to have lymphocytosis or heterophilia. Ivanpah tortoises were more likely to have moderate to heavy *Pasteurella testudinis* growth in nasal cultures, heterophilia, and hypophosphatemia. Specific laboratory or clinical abnormalities were poorly predictive of morbidity and mortality. The severe disease abnormalities in Goffs tortoises have likely contributed to the population decline that occurred during and subsequent to this study.

"PLANNING" TO SAVE THE TORTOISE IN THE CALIFORNIA DESERT

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Management of *Gopherus agassizii* in the California desert has been a major component of federal planning efforts since long before the tortoise's emergency listing under the Endangered Species Act in 1989. The 1976 Federal Land Policy and Management Act established the 25 million acre California Desert Conservation Area (CDCA), directed the Bureau of Land Management to develop a plan to manage it, and marked the start of a 25 year planning odyssey by the Bureau that continues today. In 1994, the USFWS published a Recovery Plan for the Desert Tortoise (Mojave Population) that laid out a series of recommended actions to achieve the long-term goal of delisting the tortoise through recovery. The nonprofit Desert Tortoise Council, Desert Tortoise Preserve Committee, and California Turtle and Tortoise Club are committed to ensuring that the Recovery Plan is implemented in the California deserts, and to this effect designated the author to represent them in the bioregional planning efforts that are underway. This presentation will evaluate the ongoing tortoise planning efforts for adherence to Recovery Plan recommendations.

Preparation of tortoise specific management plans has been a slow process. A management plan on the Desert Tortoise Natural Area was signed in 1988. This plan was drafted for the BLM by the Desert Tortoise Preserve Committee and, while adequate at the time, predated the listing of the tortoise and is now in need of substantial revision. The 1994 Rand Mountains Fremont Valley Management Area plan included 88 management actions, the vast majority of which have never been implemented. This plan too predates the publication of the Recovery Plan and needs to be updated.

The three bioregional planning efforts that are expected to carry tortoise recovery in California have yet to bear fruit. The West Mojave Plan has been over 10 years in the making but recent Congressional action related to the proposed expansion of Fort Irwin has added new purpose and urgency. A draft of the NECO plan was released February 26, 2001 after an eight year effort. The National Park Service component of the NEMO plan has been released in the draft General Management Plan for Mojave National Preserve, and a draft of the BLM component is expected by summer. Each of these plans claims to be scientifically driven and compatible with the Recovery Plan. However, political considerations have assured that none aspire to fully implement the Recovery Plan's recommendations but tend instead to enshrine current management practice within a DWMA framework. Continuing declines in tortoise numbers documented at the permanent study plots throughout the region and increasing calls from biologists for its listing under the Federal Endangered Species Act to be upgraded from threatened to endangered belie the compatibility of current management with tortoise recovery.

Management Plan/Action	**Onset[1]**	**Approval[2]**
CDCA Plan	March 1977	December 1980
Desert Tortoise Natural Area	November 1986	December 1988
State listing	August 1987	June 1989
Federal listing	September 1984	August 1989
Rand Mountains Fremont Valley	August 1988	February 1994
Critical Habitat Designation	January 1993	February 1994
Desert Tortoise (Mojave Population) Recovery Plan	September 1990	June 1994
West Mojave Plan	March 1991	
NECO	March 1993	
NEMO	July 1995	

[1]Date of establishment of a Technical Review Team or first public scoping.
[2]Date of publication, signing or Record of Decision.

Purification of Desert Tortoise (*Gopherus agassizii*) Metallothionein, A Potential Biomarker of Heavy Metal Exposure

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Identified causes of desert tortoise morbidity and mortality include upper respiratory tract disease, cutaneous dyskeratosis, shell necrosis, liver and kidney degeneration, and urolithiasis (Homer et al. 1998). Postmortem examinations of several tortoises have revealed suspected elevated concentrations of heavy metals, including cadmium, mercury, lead, molybdenum, arsenic, selenium, chromium, and nickel, in the liver and kidney of ill tortoises (Homer et al.1996, unpublished data). Free-ranging tortoises that showed evidence of liver and kidney degeneration have contained elevated mercury, cadmium, or lead concentrations (Homer et al. 1996). Elevated concentrations of these metals may contribute to tortoise morbidity and mortality.

The overall objective of this research is to determine if the presence of tissue, plasma, or urine metallothionein (MT), a metal binding protein with a molecular weight of approximately 7,000 daltons, is a useful indicator of environmental toxic metal exposure in free-ranging desert tortoises. We hypothesized that accumulation of toxic metals correlates with elevated concentrations, and hence, increased deposition of MT in tissues. Fourteen juvenile desert tortoises were injected daily with 1 mg/kg BW cadmium chloride intra chemically for five days to induce MT synthesis. Low molecular weight proteins, including Cd-MT complexes, were isolated from tortoise liver cytosol by molecular weight gel-filtration on a Sephadex G-75 column. Atomic absorption spectrophotometry (AAS) confirmed low molecular weight fractions containing Cd. Gel electrophoresis (SDS-PAGE) of gel-filtration fractions confirmed the presence of doublet protein bands at approximately 6,500 and 7,000 daltons, typically indicative of the isoforms MT-1 and MT-2, and at 14,000 daltons, a possible polymer or an additional MT protein. Metallothionein isoforms were further purified by anion exchange column chromatography. Two distinct Cd peaks were detected via AAS. Gel electrophoresis of purified peaks confirmed, thus far, the presence of three protein bands that possibly correspond to MT isoforms. Protein fractions from peak 1 (MT-1) and peak 2 (MT-2) displayed bands at approximately 6,500 and 7,000 daltons, respectively. A band at 14,000 daltons was present in fractions from peak 1. Thus far, amino acid sequencing has identified the presence of ubiquitin, a 7,000 dalton protein involved in nonlysosomal degradation of damaged intracellular proteins during stressful conditions. Results from further amino acid composition analyses and sequencing of the other bands are forthcoming. Liver samples from treated and control tortoises were analyzed for Cd content on a dry weight basis. The mean Cd concentration in livers from treated tortoises was 44.8 ppm; the median was 27.7 ppm. In control livers, the mean Cd concentration was 0.26 ppm; the median was 0.25 ppm.

All livers and kidneys were submitted for histologic staining. Microscopic changes, if any, were minimal and included mild renal tubular dilatation and proteinosis.

Reverse-phase high performance liquid chromatography will further confirm the presence of MT isoforms. Purified MTs will be injected into rabbits to induce anti-MT antibody formation. A sandwich enzyme-linked immunosorbent assay (ELISA) will be developed utilizing the MT antibodies. The ELISA will be useful in determining MT concentrations in tissues and body fluids, including plasma and urine, of the desert tortoise. If it is determined that MT occurs in plasma or urine of metal exposed tortoises, then it may be possible to develop a laboratory and/or field test to determine exposure to heavy metals in live desert tortoises. Polyclonal antibodies will also be utilized for immunohistochemical detection of MT in paraffin-embedded tissues of archived specimens. This test will be valuable in investigating the localization of MT in the liver, kidneys, and other tissues. A noninvasive technique for determining exposure to metals would be valuable when determining causes of illness in tortoises, or if tortoises were to serve as sentinels of environmental metal references.

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THE WESTERN RANGE REVISITED: REMOVING LIVESTOCK FROM PUBLIC LANDS TO CONSERVE NATIVE BIODIVERSITY

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The continued use of 270 million acres of federal public land for domestic livestock production is endangering species and disrupting ecosystems at unprecedented rates. Impacts are greatest on arid and semiarid lands and in riparian areas. In these areas, livestock and "improvements" undertaken for their benefit or management, (1) introduce and spread nonnative plant species and disease; (2) compete with native species for habitat; (3) destroy sensitive native plants, (4) contribute to soil compaction, drying, and excessive erosion; (5) disrupt aquatic systems; and (6) alter hydrological patterns. This paper (based on the book by the same title) concludes that eliminating livestock would be the single most effective strategy for conserving native biodiversity on arid public lands, and it outlines an interdisciplinary rationale for making this policy choice.

Several writers have suggested that "livestock grazing may be the major factor negatively affecting wildlife in the 11 western states" (Ohmart and Anderson 1986; Fleischner 1994). The U.S. Forest Service concluded that livestock grazing is the number one cause of species endangerment in arid regions of the West, such as the Colorado Plateau and Arizona Basin (Flather et al. 1994). Agriculture (which includes grazing) is the chief source of water quality impairment of rivers nationwide (EPA 1996); grazing was identified as the number one cause of nonpoint source pollution of surface waters in the western states (Western States Water Council 1989). The impacts of livestock in western riparian areas, and the high values of these areas as native species habitats and for clean water, are well documented (Belsky et al. 1999; Fleischner 1996; USDA Forest Service 1992; Platts 1991; Ohmart 1996; Horning 1994).

Only relatively recently have range ecologists come to understand that traditional theories of vegetative succession do not apply on arid and semiarid lands, and that livestock grazing in these areas can have irreversible ecological impacts (Westoby et al. 1989; Friedel 1991; Laycock 1991, NRC 1994). Indeed, livestock grazing has been the principal cause of desertification in North America (Sheridan 1981). Once disturbance factors (usually livestock grazing) cause vegetation and soil conditions to exceed certain threshold conditions, pre-disturbance conditions cannot feasibly be reestablished. (For purposes of the author's proposal, "arid or semiarid" denotes those areas receiving 12 inches or less average annual precipitation (see Noss and Cooperrider 1994; Department of Interior 1994; NRC 1994; Sheridan 1981; Sanders 1994).

The bulk of BLM rangelands qualify as arid or semiarid. The condition of areas that receive less than 12 inches annual precipitation has not improved under BLM management, and BLM riparian areas are in their worst condition ever. According to the agency, "watershed and water quality would improve to their maximum potential" if livestock were removed from public lands (Department of Interior 1994).

Congress was well aware in 1934 that western ranges were widely and severely degraded by overgrazing and that many desert lands were simply unsuited to livestock use. Thus, in the Taylor Grazing Act, Congress authorized the Interior Secretary to establish grazing districts on lands "chiefly valuable for grazing or raising forage crops," or, as the legislative history reveals, lands *not more valuable* for other uses. While grazing continues to be allowed on 170 million BLM acres, the Interior Department has never determined which of its lands are "chiefly valuable" for grazing.

Since 1976 federal law has required that BLM lands be managed for the sustained yield of multiple resources, including grazing, wildlife, watershed, and recreation, without impairment of the land's productivity. The Federal Land Policy and Management Act (FLPMA), 43 U.S.C. §§ 1701-1784, the BLM's principal statute, further directs the BLM to weigh long-term benefits to the public when it allocates lands for use, and to consider the "relative scarcity of values" and the availability of alternate means and sites for realizing those values. Most important, FLPMA charges the BLM with managing the public lands to prevent any "unnecessary or undue degradation." The agency has not justified livestock grazing using any of these criteria. Instead, it rationalizes grazing as a means of sustaining small communities and preserving an important western way of life and culture (Department of Interior 1994).

These justifications are belied by the facts. There has never been a single, identifiable ranching "way of life." Federal grazing permit holders include banks, other large corporations, grazing associations, wealthy individuals, and small family operations. Only a minority of permittees have been in the business for more than a generation. For some, the ranch is a hobby or a tax write-off. The majority are small operators, who depend on other, non-ranch income to support themselves. (Department of Interior 1994, GAO 1992). Nor does public land grazing support western communities. On the contrary, the services and employment opportunities afforded by small towns help sustain public land ranchers (Power 1996; Smith and Martin 1972; Department of Interior 1994).

Furthermore, the BLM has no statutory authority, much less a mandate, to promote local economic or lifestyle concerns. FLPMA directs the agency to consider the *national interest*. Nowhere does it suggest that the agency give priority to the short-term economic interests of any subset of public land users. Producing livestock on public lands, despite the ecological damage and conflicts with other multiple uses, thus violates the letter and spirit of both FLPMA and the Taylor Grazing Act and is contrary to national policy in the Clean Water Act and Endangered Species Act.

Public land livestock grazing continues largely because the federal agencies are reluctant to buck politically powerful western livestock interests. Permittees, though few in number, are disproportionately represented in state legislatures, county commissions, and the U.S. Senate. Their allies are also found in governors' mansions, the federal land management agencies, extension offices, and land grant colleges. The organization of BLM field offices along state lines renders the agency more susceptible to political pressure applied by governors' offices or congressional delegations. And a grazing advisory board system established in the Taylor Act led to a grazing regime dominated by grazing permittees (Clawson 1983; Calef 1960; Foss 1960).

Much of the range science literature and agency publications (EISs, land use plans, and educational materials) consists of promotion or apology, rather than sound science or management advice. That "rangelands" *will* be used for livestock production has been an implicit premise of range research and management decisions. Only rarely have investigators or managers considered whether livestock grazing is an appropriate or sustainable land use. Grazing apologists have exaggerated the importance of public lands for livestock production and demonstrated an uncritical devotion to the mythical "Old West" (Power 1996; Noss and Cooperrider 1994).

Public land livestock grazing is challenged based on its ecological impacts and interference with other public land uses. Permittees, agency officials, and even some conservation organizations have countered these challenges with sociocultural arguments. Notably, they claim that public land grazing is key to preserving the ranching "way of life" and valuable open space (Department of Interior 1994; *Natural Resources v. Hodel*, D. Nevada 1985; Sindelar et al. 1995). They predict that small communities would disappear and private land open space would be lost to development if public range privileges were rescinded (Quigley and Bartlett 1990, Department of Interior 1994, Cotton and Cotton, n.d., Senate Bill 852 1995, Senate Bill 1459 1996).

In fact, few, if any, western communities are dependent economically on public land grazing. Agriculture as a whole comprises a small fraction of the economies of most western states and livestock production, a smaller part. Fewer than 23,000 livestock producers (of 1 million nationwide) possess federal grazing permits. Seventy percent of western cattle producers own all the land they operate. Although livestock grazing is the most widespread commercial use of public lands, it is by far the least valuable. Federal grazing fee revenues (assessed at the rate of $1.35 per AUM) are swamped by the costs of administering the program. Average returns to ranchers range from negative to two to four percent. Other regions and private land operators could easily replace the two percent of U.S. livestock products attributable to public lands, and the 18,000 low wage jobs directly related to federal land grazing could be replaced in a matter of days by normal job and income growth in the national economy (Department of Interior 1994, Power 1996).

Similarly, public land grazing has no demonstrable role in maintaining private land open space. Private ranch land comprises a tiny fraction of the West's land area and an even smaller fraction enjoys federal grazing privileges. Absent state or local land use restrictions, nothing prevents ranchers from subdividing or developing their private lands. Moreover, the loss of federal grazing privileges would not lead most federal grazing permittees to sell or develop their lands. When surveyed, they indicated that they would find some other way to stay in the ranching business: downsize, find off-ranch income, diversify ranch operations, etc. (Smith and Martin 1972; Department of Interior 1994). The appropriate mechanisms for preventing the subdivision of ecologically important private lands are regulation (such as zoning) or public incentives (such as tax breaks). Incentives should not perpetuate an ecologically unsustainable use of public lands. In ecological terms, open space filled with the nonnative species which grazing fosters might as well be empty space.

Under FLPMA, grazing permits may be canceled to devote the lands to another public purpose. Cancellation requires two years notice; less, if an emergency exists. Emergency action could be justified in areas approaching an ecological threshold, i.e., where continued grazing will bring about irreversible changes in soil or vegetative conditions. Livestock should be removed even where ecological thresholds have been exceeded and restoration might not be feasible (e.g., on cheatgrass dominated areas). Otherwise, land degradation will continue, and the resulting grazing induced communities will be even less desirable for native species and ecosystem functioning. Surveys indicate that the public is educable on this issue; the chief impediment to reforming public land grazing policy is a lack of political will (Brunson and Steel 1994; Evans 1988).

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GENETIC VARIABILITY AMONG AND WITHIN SONORAN POPULATIONS OF THE DESERT TORTOISE: ATTEMPTS TO IDENTIFY INFORMATIVE MICROSATELLITE DNA MARKERS

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In this study we are attempting to gather information on the population genetics of the desert tortoise (*Gopherus agassizii*) in southern Arizona to assess potential long-term effects of habitat fragmentation due to valley bottom development, such as roads, canals, and agriculture. Using microsatellite markers, we will estimate gene flow and compare genetic distance with geographic distance between desert tortoises in different mountain ranges to determine extent of relatedness and degree of genetic isolation. In addition, we will examine genetic relatedness of individuals within a seemingly continuous population in Saguaro National Park while simultaneously gathering movement data with radiotelemetry. We will relate genetic distances among these individuals to geographic distances between them to determine if behavior or habitat features influence gene flow within the population. Our goal is to recommend management strategies such as reserve design coupled with translocation for maintaining genetic integrity of desert tortoises in the Sonoran population in Arizona.

During summer 2000, we collected blood samples from 117 tortoises in 11 sites around the Tucson Basin. We are currently constructing a microsatellite-enhanced genomic library using biotin-labeled repeat oligos and streptavidin beads. Inserts containing tandem repeat arrays will be sequenced and flanking primers will be designed for amplification of microsatellites. Identification of informative microsatellite markers in the desert tortoise genome may have applications in other *Gopherus* species in the United States and Mexico. Project completion is scheduled for 2002. This project is funded by the Arizona Game and Fish Department Heritage Grant Program.

FREE-ROAMING DOG ISSUES AT THE UNITED STATES MARINE CORPS AIR GROUND COMBAT CENTER, TWENTYNINE PALMS, CALIFORNIA

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ABSTRACT

Extensive research at the Marine Corps Air Ground Combat Center has shown that free-roaming dogs have a significant impact on all age classes of desert tortoises (*Gopherus agassizii*), in the forms of direct mortality, injury and harassment. After a comprehensive public education program was initiated, a limited live trap control program was conducted. Trapping was unsuccessful. By-catch was minimal, and no nontarget species were injured or killed. Potential control methods and future direction are discussed.

The nearly 250,000 hectare Marine Corps Air Ground Combat Center (Center) is located in south central San Bernardino County, California. The purpose of the Center is to support live-fire military training, most often in the form of the Combined Arms Exercise, in which nearly 30,000 Marines and other military personnel participate annually. Desert tortoises (*Gopherus agassizii*) are found throughout the Center, however predominantly in densities of less than five animals per square mile.

Extensive desert tortoise and other environmental research has been conducted for more than twenty years, long before the desert tortoise was listed under the Endangered Species Act. Readers are encouraged to contact the author for a detailed bibliography.

One relatively small area of the Center borders several small desert communities. Unfortunately, many local residents allow domestic dogs to run free. We believe that all or most of the free-roaming dogs depend upon anthropogenic food and water sources, and it is known that dogs cause mortality, injury and harassment to desert tortoises. We have little evidence of direct mortality caused by dogs, but significant "circumstantial evidence" exists. Woodman (unpublished data) estimated that more than 75% of tortoises in the southwest corner of the Center have been harassed. Additionally, several researchers and other personnel have directly witnessed harassment. Dogs have also displayed aggressive behavior to humans. In one case, two researchers had to swing a radio antenna to suppress a dog attack.

The most commonly seen forms of trauma include: broken gular, missing scutes, peeling marginal and nuchal scutes, and missing claws and/or scales. Several radio transmitters have been removed from study animals. Some of these transmitters were located afterward, bearing canine tooth marks.

Prior to the initiation of any control activities, we distributed a series of three newspaper articles to the local media. The articles were independently adapted by a local radio station and broadcast. Nearby Joshua Tree National Park provided several weekly Public Service Announcements mentioning dog issues, some with Marine Corps input.

We very quickly ruled out leghold traps and poisoning, primarily due to the impacts those activities would have on by-catch animals. Fencing is not a viable option because we have a 280 km perimeter. The costs of fence construction and maintenance would be prohibitive. Additionally, a fence would likely impede natural dispersal patterns of tortoises and other wildlife.

Though a brief literature review (Endangered Species Recovery Council, unpublished data) indicated that live trapping would likely be unsuccessful, that method was chosen in order to fully consider options under the National Environmental Policy Act and due to the "known controversy" of lethal control. With more than 150 trap availability periods, only one target animal was captured, resulting in 0.7% trap success. Though we did experience limited by-catch (six kit foxes and one coyote), no injuries to these animals occurred.

THE DESERT TORTOISE IN NORTHWEST ARIZONA AND A ROAD MORE TRAVELED

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In order to accommodate increased traffic flow and to facilitate greater public safety, the Arizona Department of Transportation is currently expanding two existing highways in northwest Arizona (US 93 and State Route 68) from two lanes to four lanes. The highway expansion crosses Bureau of Land Management administered public lands in Mohave County managed by the Kingman Field Office. Wildlife biologists identified impacts, mitigation, and compensation for impacts to desert tortoises and their habitat. This paper will explore the identified impacts to Sonoran desert tortoise habitat in northwest Arizona resulting from highway construction, mitigation, and compensation actions that were successfully implemented.

COMPARATIVE DISPERSION OF JUVENILE AND NEONATE DESERT TORTOISES: A PRELIMINARY ASSESSMENT OF AGE EFFECTS

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Dispersal by young tortoises released from seminatural hatcheries could be affected by the age of the tortoise or the length of time spent within the hatchery before release. Older animals might be expected to remain closer to familiar territory than newly hatched animals. To test this, juvenile (6-8 years old) and neonate (< 2 months old) desert tortoises (12 per group) were fitted with radiotransmitters and released from the hatchery at the Fort Irwin Study Site (National Training Center, Fort Irwin, CA) in October 1999, and their movements tracked until all stopped moving (presumably hibernating) and no activity was observed, 34 days later. Juveniles and most neonates were hatched and grew up in FISS Pen 1, but all animals were released from around Pen 3, about 75 m west of Pen 1. In the first 34 days after release, neonates generally moved to the northwest, uphill and away from the release point, while juveniles moved northeast, in the direction of Pen 1. Total distance traveled and final linear distance from the release site did not differ between age groups. Neonates moved less frequently and settled into hibernation locations sooner than juveniles. All 12 juveniles and 11 of 12 neonates were still alive when transmitters were removed in the early spring; one neonate lost its transmitter shortly after release and its status could not be determined. Future releases from different locations around the pens will help determine whether differences between juveniles and neonates are due to philopatry of juveniles, which could have implications for proposed headstart programs.

Calcium and Phosphorus Availability in Native and Exotic Food Plants Eaten By Juvenile Desert Tortoises

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Exotic plants can comprise a major component of the diet for some desert tortoises (*Gopherus agassizii*) in the Mojave Desert. Introduced plants may not be as nutritious as native plants. Nutrient availability in a native grass (*Achnatherum hymenoides*), an introduced grass (*Schismus barbatus*), a native forb (*Malacothrix glabrata*) and an introduced forb (*Erodium cicutarium*) were measured in one to two year old juvenile desert tortoises. We fed tortoises measured amounts of chopped foods daily for ~130 days (dry grass) or ~90 days (fresh or thawed forb). Orts and feces were collected daily and dried to constant mass, and calcium and phosphorus content of food and feces were measured.

Calcium digestibilities did not differ significantly among diets. Because the grasses were lower in calcium content, calcium availability (mg obtained/g dry food) was significantly lower for grasses than forbs, and did not differ between grasses or between forbs. Phosphorus digestibility was relatively high for the forbs, but was negative for both grasses. Tortoises lost phosphorus while feeding on the grasses, but gained phosphorus while eating forbs. Calcium and phosphorus availability are better explained by the type of food (forb vs. grass) than by its geographic origin (native vs. exotic); however, if exotic grasses are replacing native forbs rather than native grasses, the nutritional quality of the tortoises' diet could be decreasing.

Serologic and PCR Findings on Captive Desert Tortoises in the Greater Barstow Community, California for Exposure to *Mycoplasma* and Herpesvirus

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Mycoplasma agassizii and herpesvirus are known to cause respiratory disease in tortoises. Clinical signs of both diseases may be similar, including nasal discharge and conjunctivitis. Escaped or released infected captive desert tortoises (*Gopherus agassizii*) pose a potential threat of disease introduction to healthy wild populations. One hundred sixty two captive desert tortoises from

Barstow, California and surrounding towns were tested for evidence of previous exposure to these two infectious agents. Access to these captives was facilitated by the local (High Desert) chapter, members of the California Turtle and Tortoise Clubs (CTTC), and the cooperation of a local veterinarian (Dr. T. R. Rao) who made his hospital available for our examinations. Blood samples were collected from July 19 through August 17, 2000, for enzyme linked immunosorbent assay (ELISA) testing to detect antibodies specific for exposure to *M. agassizii* and herpesvirus. At the same time, nasal flush samples were collected from 69 tortoises for PCR testing to detect *M. agassizii* antigen. The results showed that, of the 162 ELISA assays, 130 were positive for *M. agassizii* antibodies, 10 were suspect, and 22 were negative. All 69 PCR assays for *M. agassizii* antigen were negative, of which 53 were positive on ELISA assay, 1 was suspect, and 15 were negative. Of 40 ELISA's performed to detect herpesvirus antibody, 12 were positive. Further work is needed to determine the risk of release of seropositive tortoises into susceptible wild populations.

2000 HEALTH SURVEY OF SONORAN DESERT TORTOISES

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Blood samples were drawn from 36 tortoises at three different study sites in the fall of 2000. The sites included Sugarloaf Mountain (26 tortoises), Florence Military Reservation (FMR; 8 tortoises), and Ragged Top Mountain (2 tortoises). Samples were submitted for mycoplasma ELISA, herpes ELISA, Packed Cell Volume (PCV), plasma chemistries, and bile acids. All tortoises tested negative for mycoplasma antibodies. Fifteen (42%) tortoises tested positive for herpes antibodies: 10 from Sugarloaf, 5 from FMR, and none at Ragged Top. PCV's, plasma chemistries, and bile acids appear to be similar to previously reported values, however, they have not been completely evaluated yet.

The significance of the herpes positive tortoises is unknown. Awareness of herpes virus in tortoises has increased over the past decade. The majority of reported cases are in *Testudo* spp., however cases of clinical disease have been reported in *Gopherus* spp. The ELISA test for herpes virus was validated for *Testudo* spp., and it is unknown if the validity holds true for other tortoise species. Clinical signs of herpes virus include stomatitis, rhinitis, conjunctivitis, pneumonia, and central nervous system disease. None of the tortoises sampled showed any signs of disease. Future plans are to increase study size and locations for prevalence of ELISA positive tortoises in central and southern Arizona. Samples will be submitted for PCR's on all ELISA positive tortoises identified.

STRESS, CORTICOSTERONE AND TESTOSTERONE IN MALE DESERT TORTOISES

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Stress in male lizards, snakes and alligators results in an immediate rise in plasma corticosterone, and a rapid decrease in plasma testosterone. The elevated corticosterone is believed to inhibit the secretion of gonadotropin and thus shut down gonadal secretion of steroids. In male turtles and tortoises, however, there is a paradoxical rise in testosterone in response to stress. Corticosterone does increase as in other reptiles, but no decrease in testosterone is seen until about 24 hours after the onset of stress, when corticosterone has also returned to prestress levels. In unstressed adult male tortoises, plasma corticosterone and testosterone show an identical seasonal pattern: when testosterone declines in mid summer, corticosterone declines. Regression analysis of the seasonal data for the two steroids gave a value of $P<0.001$. To test this relationship between the two hormones, we injected adult male tortoises with ACTH (adrenocorticotropic hormone) and measured testosterone and corticosterone. Again both steroids increased in response to the ACTH injection. The reason for this linkage of corticosterone and testosterone secretion is not known, but the close anatomical relationship of the two tissues may play a role. Possible reasons for this unusual phenomenon will be discussed.

DESERT GRASSLAND AND TROPICAL DECIDUOUS FOREST: PERIPHERAL OR EXTRALIMITAL DESERT TORTOISE HABITATS?

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Desert grassland (USA and Mexico) and tropical deciduous forest (Mexico), delimit respectively the eastern and southern margins of the desert tortoises' distribution. Literature records document desert tortoises in these habitats, but they are biogeographical communities where the species has received little attention. Are these continuous border entrant populations from immediately adjacent principle centers of distribution, i.e., Sonoran desertscrub and foothills thornscrub, or extralimital outliers? What prevents the species from further spreading into desert grassland and tropical deciduous forest? Topography is similar, and food and precipitation are perceptively greater than in those contiguous communities that are the principle population centers. Recent studies and observations of desert tortoises in desert grassland and tropical deciduous forest are

discussed to help determine limiting factors controlling desert tortoise presence and abundance in these seemingly hospitable habitats.

RECREATING EVOLUTION: PLEISTOCENE PARKS

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Those who yearn for recovery of wilderness, dream of the restoration of large animals on the range. The problem lies in what kinds of large animals should be restored. For two centuries the answer has seemed obvious, bring back bison and whatever other large mammals existed historically. But 13,000 years ago the North American megafauna (large mammals >45 kg in mass) suffered massive impoverishment. In evolutionary time, North America would have supported upwards of 33 genera and 50 species as large or larger than a pronghorn, three times the number of large species known in ecological time. Prior to 13,000 years ago, the most common fossils were proboscideans, equids, camelids, and bovids. For millions of years these groups evolved in North America.

Whether human colonization forced the extinctions or whether the agent was climatic change, or both, nothing in the Cenozoic record matches the elimination of American mammals of large size at the end of the Pleistocene. In the face of a radical depletion in America's prehistoric megafauna, a new approach to restoration ecology is needed. Native bovids, wild horses and asses, and domestic camelids are currently available for a Pleistocene park. Missing are the ultimate keystone species in late Cenozoic ecology, the elephants represented by mammoths, mastodonts, and gomphotheres. Also crucial in designing Pleistocene Parks are large carnivores, not excluding the African lion, a close relative of the extinct American lion. Parks stocked with surrogates for the lineages of the lost megafauna are essential both to demonstrate the evolutionary potential of this continent and to restart its evolution.

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DISTANCE SAMPLING IN THE RED CLIFFS DESERT RESERVE: 1998-2000 PROGRESS REPORT

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Comprehensive and accurate desert tortoise density estimates are recognized as critical in both the Washington County Habitat Conservation Plan and the Desert Tortoise (Mojave Population) Recovery Plan. Distance sampling monitoring was implemented within the Red Cliffs Desert Reserve (Reserve), Washington County, Utah, to gather baseline regional population densities of desert tortoises. In 1997, a pilot study was completed to standardize field techniques, to provide preliminary estimates of encounter rates and the detection probability, and to determine the field effort necessary to achieve precise regional density estimates within the Reserve. In 1998, 201.42 km (103) transects of distance sampling was completed within Management Zone 3 of the Reserve. In 1999, 306.5 km (158 transects) of distance sampling was completed within Management Zones 2, 3, and 5 of the Reserve. Two hundred and twenty-eight tortoises were encountered during the spring sampling period between March 30 to June 10, 1999. A total of 187 reproductive tortoises ($\geq$ 180 mm) were observed with an encounter rate of 0.61 tortoises per km (range = 0.46 to 0.81) and a coefficient of variation of 14.45%. The density of reproductive tortoises within the Reserve was estimated at 0.23 tortoises per hectare with a 95% confidence interval from 0.17 to 0.32 and a cv(D) of 16.21%. The abundance of reproductive tortoises was estimated at 5,036 tortoises per area sampled (11,457 ha) within Zone 2, 3, and 5 of the Reserve with a 95% confidence interval from 3,666 to 6,920 and a cv(A) of 16.21%.

In 2000, 301.95 km (153 transects) of distance sampling was completed within Management Zones 2,3, and 5 of the Reserve. Two hundred and twenty tortoises were encountered during the spring sampling period between April 5 to June 9, 2000. A total of 190 reproductive tortoises ($\geq$ 180 mm) were observed with an encounter rate of 0.62 tortoises per km (range = 0.45 to 0.80). Density and abundance estimates calculated for reproductive tortoises in 2000 within Management Zone 3 are within the 95% confidence interval of 1999 and 1998 estimates.

DESERT TORTOISE RECOVERY EFFORTS IN THE RED CLIFFS DESERT RESERVE

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On April 2, 1990, the Mojave desert tortoise population was listed as threatened under the Endangered Species Act. Declines of Mojave populations rangewide are associated with habitat degradation, disease, predation, and human-related mortality. The Desert Tortoise Recovery Plan identifies the Upper Virgin River population (managed as the Red Cliffs Desert Reserve (Reserve)) as one of six distinct recovery units. Due to its proximity to urban growth and considerably smaller size than other recovery units, it is classified as having a high degree of threat.

In an effort to resolve conflicts between urban development and desert tortoise conservation, the habitat conservation planning process was initiated in Washington County, Utah in 1991. In February 1996, Washington County received an incidental take permit for 1,169 tortoises, 12,264 acres of desert tortoise habitat, and 31,282 acres of potential habitat. The HCP offers measures to minimize and mitigate take by establishing a 61,022 acre Reserve. A primary goal of the Reserve is to maintain tortoise viability in perpetuity by implementation of the recovery measures outlined in the Recovery Plan.

One of the primary mitigation efforts has been federal land acquisition. BLM is spearheading land exchanges and purchases based on fair market value. A cooperative law enforcement program has been established with officers from federal, state, and local agencies to control illegal OHV activity, wildlife collection, as well as maintaining signing and fencing. Fencing around the perimeter of the Reserve has been established to control vehicle access and prevent tortoises from moving into adjacent developments. A public use plan is in process to control human use impacts in the Reserve. Since 1997, DWR has gathered baseline information on desert tortoise densities and abundances. The primary reason that so many recovery measures are being implemented in the Reserve is the broad based cooperation and communication between local, state, and federal agencies.

IMPLEMENTATION OF LINE DISTANCE SAMPLING THROUGHOUT THE MOJAVE DESERT

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A series of implementation meetings were held during the fall of 2000 within each Recovery Unit. At the Management Oversight Group Technical Advisory Committee (MOG/TAC) meeting in January 2001 the plans for this next field season were discussed. Line Distance Sampling shall be initiated rangewide throughout the Mojave Desert (listed population) of the desert tortoise. A workshop was held for managers and staff personnel in January 2001, and a second workshop shall be held in mid-March of this year for field crews to be trained in the Line Distance sampling. All field personnel should attend this four day workshop which will cover an introductory presentation by Paul Lukacs of Colorado State University, and 3 days of field trials practicing Line Distance Sampling and subsequent evaluations.

Line Distance Sampling will be conducted within each Mojave Desert Tortoise Recovery Unit, and most of the Desert Wildlife Management Areas (DWMAs) within Critical Habitat. It is estimated that approximately 2,400 kilometers will be sampled in California, at least 700 to 750 km in Nevada, 300 km in Utah, and 240 km in Arizona. Sampling will be initiated approximately April 1, 2001 and continue until about June 15, 2001, depending upon environmental factors. In the light of limited funding in 2001, we anticipate being able to determine more accurately the encounter rate and, subsequently, the number of transects needed to obtain the necessary sample size (80-100 tortoises) per designated area, i.e. Recovery Unit, DWMA, or stratum.

LOW RAINFALL AFFECTS THE NUTRITIVE QUALITY AS WELL AS THE TOTAL QUANTITY OF FOOD AVAILABLE TO THE DESERT TORTOISE

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Each year, desert plants germinate and grow in response to the onset and intensity of rainfall. The numbers of species that germinate, the numbers of individual plants that survive, and the average mass of individual plants vary greatly from year to year, leading to tremendous annual variation in biomass production and in species diversity. This well-known variation in quantity of potential tortoise food is also coupled to variation in plant nutritive quality.

Desert tortoises are influenced by the relative amounts of water, nitrogen (protein), and potassium in their foods, and tend to choose foods with favorable ratios among these constituents, as indicated by the Potassium Excretion Potential (PEP) index. The water, nitrogen and potassium concentrations of plants may change substantially over the course of early growth, flowering, seed set, and senescence, but the direction and timing of these phenological changes vary from species to species. Thus, tortoises are confronted not only with an array of species of differing PEP indices, but the overall pattern is continually changing as different species go through phenological changes at different times and rates. In at least some situations, tortoises alter food choice to take advantage of high PEP plants when they are available.

Annual variation in rates of precipitation and evapotranspiration further complicate the picture. If rains cease early and are succeeded by high temperatures, desert plants may be forced to adapt to dropping soil moisture and hence low soil water potential. This includes a reduction in tissue water and changes in relative proportions of nitrogen and potassium, so that the PEP index may be greatly reduced. Analytical data from both the western Mojave (Desert Tortoise Natural Area, Kern Co., CA) and the eastern Mojave (Piute Valley, Mormon Mesa, Clark Co., NV) demonstrate that most plant species with moderate and high PEP values in a wet year (1995, 1998) have low or negative PEP values in a dry year (1994, 1997). Thus, the nutritional challenge facing desert tortoises in a dry year is exacerbated by the physiological responses of food plants to drought conditions.

TRANSMISSION STUDY WITH A TORTOISE HERPESVIRUS (THV) IN GREEK TORTOISES

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Two different strains of a pathogenic herpesvirus previously isolated from two captive Hermanís tortoises (*Testudo hermanni*; Marschang et al., 1997) were used in a transmission study in Greek tortoises (*Testudo graeca*; n=5). Plasma samples were collected before and after a first challenge with 15,000 TCID50 viral suspension (either Intranasally or Intramuscularly). Antibody titers of the tortoises were measured using a new Enzyme-linked Immunosorbent Assay (ELISA; Origgi et al., 2001) and a Serum Neutralization (SN) test (Marschang et al. 1997). Seroconversion was detected four to nine weeks following challenge. Mild clinical signs consistent with those described in the literature for herpesvirus infection of tortoises (Drury et al 1998/1999; Heldstab and Bestetti, 1989; Jacobson et al.,1985; Kabish and Frost 1994; Marschang et al., 1997/1998/1999; Muro et al., 1998) were observed in challenged tortoises. At 11 months following the first challenge, the tortoises in this study were challenged for a second time using a viral dose 10 times higher (150,000 TCID50) than the first challenge dose. Severe clinical signs consisting of stomatis and glossitis were observed in the challenged tortoises. Diphtheritic plaques were observed in areas of the oral mucosa overlying salivary glands. The distribution of the lesions was independent of the route of challenge or strain of virus used. Two of the four challenged animals showed only mild clinical signs. The unchallenged (control) tortoise never developed any clinical signs of herpesvirus infection.

At one month following the second challenge all tortoises were euthanized and necropsied. Tissue samples from all major systems were collected and processed for histopathology and DNA/RNA isolation. Using polymerase chain reaction (PCR) analysis all four challenged tortoises were positive for presence of herpesvirus nucleotide sequences and negative for the control tortoise. The number of positive tissues varied between two (tortoise #1) and 17 (tortoise #3). PCR evaluation of tissues indicated a specific tropism of the herpesvirus for the central nervous system (CNS), where half of the total number of positive samples was detected. This represents the first transmission study attempted with tortoise herpesvirus and it will serve as a model in investigating the role of herpesvirus in desert tortoises (*Gopherus agassizzii)*, a species known to be infected with herpesvirus (Harper et al., 1982, Pettan Brewer et al., 1996)

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CDCA Lawsuit Against BLM: Protecting the Desert Tortoise and 23 Other Species on 11 Million Acres Through E.S.A. Legal Action and Negotiated Settlement for on the Ground Recovery Actions Desert Wide

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In 1976, Congress designated a 25 million acre swath of Sonoran, Mojave and Great Basin deserts, stretching from the Mexican border north to Death Valley and the eastern Sierra Nevada Mountains, as the California Desert Conservation Area (CDCA). The CDCA includes some of the most scenic and biologically important areas in Imperial, San Diego, Los Angeles, Riverside, San Bernardino, Kern, Inyo and Mono counties. This Virginia sized expanse was entrusted to Bureau of Land Management (BLM) to be forever protected for wildlife, open space, sustainable use and human enjoyment.

BLM's 11 million acre share of the CDCA contains 3.4 million acres of habitat designated critical to the survival and recovery of the threatened desert tortoise (*Gopherus agassizii*).[1] The CDCA also harbors 23 other federally protected threatened or endangered species including Peninsular Ranges bighorn sheep, Inyo California towhee, desert pupfish, Coachella Valley fringe-toed lizard

[1]U.S. Fish & Wildlife Service, final rule (59-582), *Federal Register*, 2/8/94.

and rare plants such as Cushenberry oxytheca, Amargosa niterwort and Peirson's milkvetch. These 24 species and the entire ecological health of the CDCA are jeopardized by the historic status quo favored by BLM management of mining, livestock grazing, road building, utility projects, and off-road vehicles. Imperiled species, such as the desert tortoise in the west Mojave, have nose-dived toward extinction while planning efforts to protect and restore habitat were repeatedly delayed by politics.

In March 2000, The Center for Biological Diversity (CBD), Public Employees for Environmental Responsibility (PEER) and the Sierra Club sued BLM over its failure to consult, as required under Section 7 of the Endangered Species Act, with USFWS over the 1980 CDCA Plan. BLM admitted liability in the case on August 25 and the plaintiffs and off-road group interveners negotiated a settlement in which BLM agreed to: prohibit mining expansions or new mines on all designated or occupied T& E species habitat within the CDCA; reduce or prohibit livestock on 1.9 million acres; conduct public education campaigns about environmental protection; prohibit ORV's on 550,000 acres of sensitive habitat areas, including 49,310 acres of the Algodones Sand Dunes; designate routes, this year, on over 874,000 acres closing an anticipated 4,500 miles of routes; complete desert wide route designation by 2004; raptor proof power lines; use of wildlife safe engine coolant; and increase wildlife surveying, monitoring, and conservation plans.[2]

BLM has just released a new draft of its Northern and Eastern Colorado Desert Plan, but it falls far short of species and habitat recovery needs. With the Ft. Irwin expansion lurking, and a new anti-environmental Interior Secretary, the CDCA agreement is a minimum shield for recovery of the California desert. The agreement is promising and has BLM taking on the ground action in the right direction, but as a result of a negotiated compromise, it does not require all the actions needed to recover species. Disturbingly, BLM is already missing deadlines, including grazing, and may be waffling in its commitment toward implementation. USFWS, CDFG, and perhaps the court, will play a critical role in plan reviews.

The CDCA settlement has revolutionized desert wildlife protection within California BLM, but the long-term results will come from better planning, consultations, public scrutiny and conservation demand.

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[2]Center for Biological Diversity, Legal Settlement Protects 24 Endangered Species on 11 Million Acres, *www.biologicaldiversity.org/swcbd/goldenstate/cdca/settlement.html*

SIX YEARS OF DESERT TORTOISE RESEARCH AND THE FUTURE EXPANSION OF THE NATIONAL TRAINING CENTER AND FORT IRWIN

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During the past six years, the National Training Center (NTC) and Fort Irwin have funded several major research projects designed to provide baseline information about the desert tortoise and its environment in the Mojave Desert. These research programs included the hatchling research headed up by Dr. David Morafka, several research projects on the upper respiratory tract disease conducted by the University of Florida, and Dr. Berry's Behavior Studies. In addition to current research projects, the NTC and Fort Irwin will be funding line distance sampling in two Desert Wildlife Management Areas.

Congress approved and President Clinton signed the legislation that starts the process for the NTC and Fort Irwin 's proposed Land Expansion. The timetable for the expansion will be discussed, as well as the potential affect on threatened and endangered species.

MANAGING FOR RECOVERY IN THE RED CLIFFS DESERT RESERVE

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The Red Cliffs Desert Reserve (RCDR) is a 61,000 acre scenic desert north of St. George, Utah, dedicated to the protection of the desert tortoise and other species of plants and wildlife. Following the tortoise's designation as a threatened species, it became obvious that development in Washington County was occurring in tortoise habitat, and that tortoises were being "taken" as defined by the Endangered Species Act. In February 1996, Washington County received an incidental take permit from the U.S. Fish and Wildlife Service for an estimated 1,169 tortoises and 12,264 acres of privately owned habitat based on an approved Habitat Conservation Plan (HCP).

The central element and primary mitigation measure in Washington County's HCP is the establishment and management of the 61,000 acre Red Cliffs Desert Reserve (whose boundaries closely coincide with the proposed Upper Virgin River Desert Wildlife Management Area, the only DWMA in the Upper Virgin River Recovery Unit). The plan also identified specific actions designed to achieve the objectives of the Recovery Plan, and established a 20 year funding mechanism to pay many of the costs associated with recovery and monitoring.

The County administers the HCP, and works closely with the BLM's St. George Field Office and the State of Utah Division of Parks and Recreation to manage the Reserve.

UNIQUE CONDITIONS

Several conditions in the Upper Virgin River Recovery Unit are unique: 1) it is the smallest of the recovery units, with only one 61,000 acre DWMA, well below the recommended minimum size and population; 2) it is located at the northern most extent of the species' range in southern Utah; 3) it contains one of the most dense population of desert tortoises across the species' range; 4) incidence of URTD appears to be stable at a low percentage of the population; and 5) local, state and federal partners work cooperatively to achieve shared objectives with an emphasis on measurable, on the ground successes.

One condition is not unique: the DWMA is located in an area of rapid change. Loss of habitat and habitat fragmentation due to urban development have threatened the population of tortoises in the recovery unit. The Recovery Plan identified three actions needed to accomplish recovery: 1) establish DWMA's and implement recovery unit management plans; 2) inform the public about the status of the desert tortoise and regulations within DWMAs through environmental education; and 3) research activities necessary to monitor and guide the recovery effort. Washington County contracts with the Utah Division of Wildlife Resources for annual monitoring of tortoise populations within the Reserve. The County, working closely with the BLM, focuses on securing habitat inside of the Reserve, reducing controllable threats to tortoises to enable recovery, and achieving environmental education objectives.

MANAGING FOR RECOVERY IN THE RED CLIFFS DESERT RESERVE

The First Five Years

Once the HCP was approved, there were several critical actions that needed to occur to arrest the process of habitat degradation inside of the Reserve and to reduce tortoise mortality. Top priority was given to land acquisition, fencing, the purchase of grazing rights, adopting protective ordinances, and law enforcement. Simultaneously, a monitoring program was designed and implemented to build baseline data on tortoise populations within the Reserve, and research was conducted to learn more about the potential for successful translocation of displaced tortoises from incidental take areas.

The key to the strategy for recovery, as summarized in the Recovery Plan, is the establishment of DWMAs and implementation of reserve level protection within them. Highlights of on the ground actions implemented to date by Washington County and our partners include:

- supported land acquisition initiatives of the BLM and Utah State Parks to acquire title to private lands inside of Reserve boundaries: to date, over 4,800 acres of private land has been acquired;
- coordinated and/or installed over 30 miles of fencing along the Reserve boundary and along highway corridors, and funded a part time person dedicated to building and repairing fences;
- passed numerous ordinances and inter-local agreements that directly or indirectly help tortoises, ranging from restricting off-road vehicles inside the Reserve to limiting the shooting of firearms;
- purchased over 99% of grazing rights within the Reserve on a willing-seller basis;
- funded a BLM law enforcement position at $65,000 a year to patrol the Reserve;
- improved the Reserve configuration by strategically purchasing habitat acres not originally designated inside of the Reserve: to date, over 335 acres have been purchased for riparian and upland habitat protection consistent with the HCP;
- worked with USFWS and University of Nevada Reno to increase understanding of tortoise translocation and potential for success;
- removed over 130 tortoises from take areas prior to development and relocated healthy animals, in a manner consistent with research findings, to an area of the Reserve dedicated to translocation;
- sent ELISA positive tortoises to a Colorado State University in support of URTD research;
- developed a multi-jurisdictional Public Use Plan which details management prescriptions for recreation and other public uses within the Reserve;
- removed over twenty tons of trash from the Reserve and reclaimed an old dump site inside the Reserve;
- started re-seeding old roads in the Reserve; and
- presented over 40 classes to over 1,700 school kids and civic groups on tortoises and other wildlife in the Reserve, built an education kiosk immediately adjacent to the Reserve in a prominent city park, and incorporated large herbariums into its main office with sensitive reptiles, including a tortoise, so visitors can learn first hand about some of the unique wildlife inside the Reserve.

Current Initiatives: Implementing the Red Cliffs Desert Reserve Public Use Plan

The County invested two years to develop a collaborative management plan for the Reserve which balanced the responsibility to protect habitat and tortoises with the public's right to access and utilize resources inside of the Reserve as allowed in the HCP. Team members represented a diversity of interests, including the U.S. Fish and Wildlife Service, BLM, Utah Division of Wildlife Resources, Washington County, Utah's congressional delegation, municipal planning, economic development, mountain biking, equestrian use, hiking, rock climbing, and hunting.

The planning process encouraged extensive public involvement and a final draft of the proposed Public Use Plan (PUP) was adopted by the Washington County Commission in June 2000. Currently, the BLM and U.S. Fish and Wildlife Service are considering the plan through the NEPA review process. An environmental assessment (EA) has been completed and public comment on the EA closed in early March. The County is hopeful that the plan will survive the review intact and that implementation can begin within a few months. The HCP generally limited recreational activities to designated trails and designated areas. The County and its partners are anxious to sign designated trails and to close and revegetate redundant routes.

Implementation will be the joint responsibility of Washington County and BLM working with the cooperation and assistance of other local, state, and federal partners. While the plan is intended to comprehensively address human activities within the RCDR, it acknowledges that new information will become available, regulations or policies evolve, and other changes occur that make some flexibility necessary if this plan is to continue to be a workable, "living" document. The adaptive management protocol would be used to refine management prescriptions in response to information revealed through monitoring and other sources.

To minimize disturbance to wildlife, trails generally: 1) are located along the Reserve boundary; 2) provide the opportunity to traverse the Reserve east-to-west and north-to-south; 3) follow existing roads or utility rights of way; 4) allow continued use of the most popular loops; and 5) avoid the most sensitive habitat areas. No trails traverse the densely populated City Creek area.

Other provisions of the Public Use Plan include:

- Off-trail use is prohibited, except within the Upland Zone. Upland/Lowland Zone boundaries are depicted on the Reserve map. The Upland Zone accommodates recreational users who desire the freedom to responsibly travel off-trail. Hikers and equestrians are free to travel across country where the terrain permits, or to utilize the trails within the zone that access the most popular areas. Camping and campfires are also allowed, with some limitations, in the Upland Zone. The Lowland Zone protects sensitive species and their habitat by restricting travel to designated trails and by limiting camping and campfires to designated campgrounds.
- Persons who are licensed or permitted under state, county, or federal law and regulation are permitted to go off trail east of the Cottonwood Road

where necessary to accomplish the purposes for which the license or permit was issued (researchers, educators, hunters, etc.). Persons who must travel off-trail in the performance of their official duties are permitted to travel off-trail in the Reserve as necessary.

- The plan anticipates the need to establish trailheads with adequate vehicle parking, including the parking of trucks with horse trailers. Proposed locations for access points and parking areas are included in the plan.
- Parking is allowed in designated staging areas only and staging areas would be carefully located. Overnight parking is permitted in established staging areas only. No camping is permitted in the staging areas. Whenever possible, parking areas located within the Reserve would be restricted to previously disturbed areas, located on a developed boundary, or would otherwise not result in a reduction of habitat.
- Damaging practices such as removing, chipping rock or destroying vegetation would be prohibited. Reserve managers may need to minimally alter rock surfaces and vegetation in order to maintain trails or to install signs; in both of these instances, such action is intended to reduce overall impacts to the Reserve. Marking trails would be accomplished in the least obtrusive way possible to achieve the desired result.
- Snow Canyon State Park is almost entirely within the boundaries of the Reserve, and generally Reserve management prescriptions apply inside the Park. Recreational uses within the Park are restricted to designated trails, to slickrock areas, or to designated rock climbing areas, and the same concerns for impacts to desert tortoise and their habitat apply. Camping at the Park is limited to the campground. Additional Utah State Parks and Recreation regulations may also apply, including required entrance fees that can be paid at the ranger station.
- Pioneer Park is a municipal park operated by the City of St. George within the boundaries of the Reserve. For the purpose of this plan, the park is bounded on the north by the Pioneer Rim Trail, on the west by Turtle Road, on the south by Skyline Drive and on the east by municipal government facilities. Existing uses within the developed area may continue, such as picnicking, hiking, rock scrambling, and rappelling. The park's master plan, adopted in 1977, identifies park roads and facilities. The park would continue to be managed by the City of St. George, while proposed changes in use or new development would be coordinated through the HCP Administration and the Habitat Conservation Advisory Committee.
- Maximum use numbers could be established in the future to protect the Reserve. No new limits are proposed at this time. Except for commercial activities or authorized competitive events, no fees to access the Reserve are required at this time, outside of Snow Canyon State Park.
- Motorized vehicles would be permitted in the Reserve on designated roads only. Motorized vehicle use on surfaces other than designated roads is prohibited. A comprehensive list of all designated roads within the Reserve

can be found in the Washington County Public Use Plan, Final Draft, Appendix A. Buggies, wagons, or other animal drawn vehicles are limited to travel on designated roads, and are prohibited from single-track trails where their passage would create new surface disturbance.

- Motorized speed events are prohibited. Additional regulations apply to any non-speed vehicle events (or non-speed portions of speed events) requiring permitting by the BLM.
- Amenities such as picnic tables, restrooms, trash receptacles, bridges over riparian areas, and hitching posts may be necessary additions to contain, concentrate, and reduce user impacts. Each facility shall be approved by Reserve management and placed strategically in areas of popular use, such as trailheads and along specific trails.
- At all trailheads, Washington County would install or coordinate the installation of signs that inform users of their responsibilities and provide information on route locations and distances. Signs may be installed at trail junctions. Interpretive signing may be developed for trails and at locations in the Reserve as recommended by the HCP Administrator and/or BLM. Signs would be installed at rock climbing areas and in other activity concentration areas to provide information and reinforce restrictions.
- The Reserve provides educational opportunities for a broad range of age groups. Scientific field studies can provide Reserve managers with valuable data that could expand our understanding of the Reserve's ecology and help manage recreational impacts. Examples of the potential components of an educational program include: experiential field opportunities for primary, secondary, and high school students; on-site classrooms; outreach; volunteer opportunities (naturalists, docents, etc.); publications; interpretive signing; guided nature hikes; and elder hostel programs.
- Educational and research uses of the Reserve may require, on occasion, special access so individuals or groups can visit sensitive areas of the Reserve. Special access permits would be arranged with the County HCP Administration and coordinated with other Reserve managers as necessary.

ON THE HORIZON: UPCOMING CHALLENGES

Management issues looming ahead include recreation management, utility development, revegetation and weed control. In addition, the County is currently investigating the design of a regional nature education program, for which the County has set aside $250,000 in a dedicated fund.

SUMMARY: MAKING A DIFFERENCE ON THE GROUND WHERE IT COUNTS

All the partners associated with the Red Cliffs Desert Reserve take pride in seeing that we are truly making a difference on the ground. These achievements are more meaningful because they have been accomplished by a highly effective, collaborative partnership that takes the responsibility to protect tortoise habitat seriously, operates out in the open, finds solutions and get things done with minimal bureaucracy. If there is any single lesson learned by the success of the Red Cliffs Desert Reserve, it is that you must give the local community the opportunity to be a meaningful part of the process. Success resides in fairness, a joint sense of ownership, and local citizen's ability to take pride in, and get credit for, the outcome.

REPRODUCTION AND URTD IN THE DESERT TORTOISE (*GOPHERUS POLYPHEMUS*): AN EIGHT YEAR FOLLOW-UP

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In 1992, an outbreak of upper respiratory tract disease (URTD) was observed in our research animals maintained at the Desert Tortoise Conservation Center (DTCC). Our initial results showed that tortoises that had antibodies to the mycoplasma and had mild signs of URTD were able to reproduce, but that mycoplasma positive animals that had severe signs had lower hormone levels than healthy animals and failed to reproduce.

Today, eight years later, 28 of the original 30 female tortoises and 16 of the original 20 male tortoises are surviving at the DTCC. Equal numbers of URTD positive and negative animals have died or disappeared over the past eight years. Of these 28 animals, 18 are mycoplasma antibody positive (URTD positive) and 10 are mycoplasma antibody negative (URTD negative). This is the identical ratio of positive to negative animals verified in May 1993 (following the outbreak in 1992). During the summer of 2000, 16 of the 18 URTD positive and nine of the 10 URTD negative females produced eggs. Furthermore, nine of the 18 URTD positive females and six of the 10 URTD negative females produced second clutches of eggs. Several females that had stopped reproducing during the outbreak of the disease have now recovered and are reproducing again. Many (70%) of the URTD positive animals never showed signs of URTD or exhibited signs only upon initial emergence from hibernation. Many URTD positive tortoises could not be distinguished from URTD negative tortoises based on signs during late summer and fall 2000. This may indicate an increased immune response as indicated by seasonally increased white blood cell numbers that correlate with increased hormone levels. This increase in hormone levels occurs during the late summer and fall as fall mating season approaches. Hatching success (>90%) was similar for eggs produced by URTD positive and negative females. Hatchling size was also similar for hatchlings produced from eggs or URTD positive and negative females.

These data support our conclusions that (1) tortoises with persistent titers to *Mycoplasma agassizii* are capable of reproduction over extended time periods, (2) that URTD positive tortoises maintained with adequate nutrition can produce similar size clutches to free-ranging tortoises and to captive tortoises that have not been exposed to the mycoplasma, and (3) that URTD positive tortoises produce hatchlings that are free of signs of the disease and are indistinguishable from hatchlings from URTD negative animals. Given these results from captive tortoises, understanding how URTD impacts wild populations is critical.

TORTOISE RESEARCH IN THE SONORAN DESERT

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Federal listing of the Mojave population of the desert tortoise as threatened in 1990 created a stir among managers and conservationists and spurred much research on that population. The subsequent determination by the U.S. Fish and Wildlife Service that listing of the Sonoran population was not warranted has resulted in a disparity of funding for tortoise research and management between the two deserts. However, using a variety of state and federal funding sources in the 1990's, researchers learned much about the basic ecology of the Sonoran tortoise with regards to diet, health profiles, activity patterns, and reproductive effort. Despite this effort, we still do not understand some of the most important questions about limits to distributions and population growth, and the effects of roads and other dispersal barriers on populations. I will give a brief overview of the important findings from this past decade of research and discuss ongoing and new research on the Sonoran desert tortoise.

SMALL-SCALE APPLICATION OF DISTANCE SAMPLING IN A SONORAN DESERT TORTOISE POPULATION

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We used line transects and distance sampling in combination with radio telemetry to estimate desert tortoise density in Saguaro National Park and the adjacent Rocking K Ranch near Tucson, Arizona, as part of a long-term study evaluating the impact of urban development on tortoises. In 2000, 34 one km transects were each sampled twice on the 368.5 ha Rocking K Ranch study area. Forty-six adult ($\geq$150 mm) and seven juvenile tortoises were observed. Encounter rate for adults was 0.63 tortoise per km with a percent coefficient of variation (CV) of 17.76 and a 95% confidence interval (CI) of 0.44-0.91. The mean number of observable adults during radio telemetry was 82% with one standard error (SE) of 0.115. Corrected mean density of adults based on line transects and radio telemetry was 0.52 tortoises/ha (CV=25.37, C.I.=0.28-0.77). Distance sampling appears to be a feasible method of estimating density of Sonoran Desert populations of the desert tortoise, at least in small-scale applications.

ECOSYSTEM-BASED MULTIPLE SPECIES CONSERVATION PLANNING: FROM THE DESERT TORTOISE PLAN TO PROACTIVE CONSERVATION PLANNING IN CLARK COUNTY, NEVADA

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Building upon the once contentious Desert Conservation Plan for the desert tortoise, the highly successful public consensus based Clark County Desert Conservation Plan has grown into the nation's largest Multiple Species Habitat Conservation Plan (MSHCP). We will discuss the role of consensus building and public habitat conservation planning in laying the foundation for the growth of the Clark County HCP to its current status as the nation's newest Multiple Species Plan while also considering the benefits and responsibilities which accompany national innovation in habitat conservation planning through multiple species conservation planning. We will consider the opportunities for proactive conservation facilitated by the MSHCP as well as discuss the centrality of desert tortoise conservation management activities under the new Plan. Finally, we

will review the Plan's nascent Adaptive Management component as well as some of the challenges posed by collaborative management initiatives on public lands included in the Adaptive Management Program.

REFINEMENT OF THE *MYCOPLASMA AGASSIZII* ELISA: FROM RATIO TO TITER

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Current diagnostic methods available for upper respiratory tract disease (URTD) include culture, polymerase chain reaction (PCR), and enzyme-linked immunosorbent assay (ELISA) serology. Of these, the detection of specific antibody is the method of choice for determination of exposure to *Mycoplasma agassizii*. The ELISA for the detection of antibodies to *M. agasszii* in desert and gopher tortoises was developed in 1992. Since that time, we have analyzed over 10,000 samples from at least 32 different chelonian species. With the extensive database now available to us, we have further refined the existing ELISA.

The results are currently being reported as an enzyme immunoassay (EIA) ratio (the optical density at 405 nm [OD_{405}] of the sample/OD_{405} of the negative control). Although this method of reporting is not uncommon for many ELISA assays, it is not as familiar for many veterinarians and wildlife disease researchers who are more comfortable with the concept of titers. In most situations, either a fourfold increase in titer over time or a single high titer result is considered clinically significant. The large number of samples tested over the past few years has allowed us to get an accurate picture of the distribution of antibody levels in gopher and desert tortoises. This has allowed us to refine the test, to include more stringent quality control measures, and to report results as a titer that will make the assay more consistent with other serologic tests.

The OD_{405} of sera from over 1,000 gopher and desert tortoises was plotted to identify natural points of inflection within the data to evaluate current positive and negative cutoff points. A subset of these sera was used to determine end point titer and construct a standard curve. A linear relationship between end point titer and the absorbance value for these samples was established. From this graph, the equation of the line can be utilized to calculate sample titer. This also provides an internal standard for quality assurance between and within assays. The relationship between titer and OD_{405} was validated using sera from known positive and negative control tortoises from prior transmission studies.

This refinement does not invalidate previous results obtained with the EIA ratio method. The titer system does, however, have numerous benefits. Under the new protocol, samples are assessed at a higher dilution that decreases the chance of false-positive results due to nonspecific cross-reactions. A smaller volume of serum is needed to run the analysis, which conserves serum for other diagnostic tests. The standard curve provides a mechanism for more closely monitoring inter- and intra- assay variance for improved quality assurance. Further, it provides a more clinically relevant system for monitoring antibody changes in individual animals over time.

PROGRESS REPORT ON DESERT TORTOISE RECOVERY EFFORTS IN NEVADA

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Desert tortoise recovery efforts are moving forward in Nevada following completion of land use plans for all desert tortoise habitat under Bureau of Land Management (BLM) management in Nevada. In August 2000, the U.S. Fish and Wildlife Service (Service) hired a Desert Tortoise Coordinator to facilitate desert tortoise population monitoring using line distance sampling methods and recovery tasks across the range of the desert tortoise. In November 2000, the existing Clark County, Nevada habitat conservation plan for desert tortoise was superseded by a multiple species habitat conservation plan (MSHCP). The incidental take permit issued in association the MSHCP will allow the incidental take of two listed species, the desert tortoise and southwestern willow flycatcher, and 76 unlisted species should they become listed in the future. As mitigation under the MSHCP, the County and land managers will implement desert tortoise conservation and recovery tasks approved by the Service, including the Clark County desert tortoise translocation program. Under the translocation program, researchers and contractors have successfully translocated over 2,000 desert tortoises during the past three years.

Desert tortoise recovery issues that Service staff are addressing include the potential need to formally review the Desert Tortoise Recovery Plan which was finalized in 1994. Before undertaking such a review, workshops would be held to assess the current level of knowledge on effects to desert tortoises from livestock grazing, disease, and predation from ravens as well as other important desert tortoise predators. The unidentified cause of significant desert tortoise mortality at sites such as Goffs and local desert tortoise extinctions are problematic for recovery efforts. Other priority issues include the invasion of nonnative vegetation into desert tortoise habitat and its effects on the Mojave Desert ecology and tortoise nutrition and health. Inadequate funding continues to limit our abilities to fully implement recovery tasks recommended in the Recovery Plan, including rangewide population monitoring. However, the Service, with support from the Desert Managers Group and other partners, continues to seek appropriations and funding for these tasks with limited success.

USING GIS TO MODEL DESERT TORTOISE HABITAT IN SOUTHWESTERN ARIZONA

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Southwestern Arizona has large parcels of land managed by a variety of federal agencies with few natural resource management personnel. Limited time and resources for agency biologists are common complaints. Having a realistic model of desert tortoise habitat provides a valuable reference for protecting desert tortoises while also planning new projects and prioritizing management activities. Using GIS, we developed a model of tortoise habitat in Organ Pipe Cactus National Monument and the Barry M. Goldwater Range in southwestern Arizona. Data layers for the model include vegetation (paloverde-cacti-mixed scrub series), elevation (greater than 300 m and less than 1067 m) and slope (less than 70 %). Potential tortoise habitat required all three qualifiers be met, otherwise the area was considered non-potential tortoise habitat. Potential habitat areas were further divided into high quality and low quality tortoise habitat by trying to capture potential sheltersite areas. Buffering 20 meters on washes from the USGS 7.5' hydrography theme created an estimator for caliche cavities, creating the potential sheltersites qualifier.

We attempted to test the model using frequency of tortoise sign locations found during field surveys that intersected with the habitat model. Observations were identified within the high, low, or unsuitable habitat model classes. The transect data applied to the model shows that it captured most of the habitat appropriately. The model is not perfect and further validation is appropriate, however, it is a realistic estimate of desert tortoise habitat in this region.

RESULTS OF LINE DISTANCE TRANSECTS CONDUCTED AT TWO MARINE CORPS RANGES: CHOCOLATE MOUNTAINS AERIAL GUNNERY RANGE AND MARINE CORPS AIR GROUND TASK FORCE TRAINING COMMAND, CALIFORNIA

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In 2000, line distance transects were conducted at two U.S. Marine Corps Ranges in the California Deserts: Chocolate Mountains Aerial Gunnery Range (CMAGR) in Riverside and Imperial Counties and the Marine Corps Air Ground Task Force Training Command (MCAGTFTC), Twentynine Palms, San Bernardino County, California.

All of the transects were walked with three personnel. One individual (team leader) remained on the centerline at all times and was responsible for searching a belt one meter on either side of the centerline, thus they walked on or within one m of the transect line at all times. The other two individuals flanked the team leader, one on each side of the line. The two flankers generally walked a straight line, three to five m from the transect centerline. Approximately half of their search time was spent searching from their position and looking towards the centerline and the other half looking out from their position. If an object of interest was seen then the field worker would walk out too investigate, then walk back to the position they left before resuming their coverage of the transect. A transect took approximately two hours to walk.

Approximately half of the transects were read using a Trimble Pro XRS GPS system with real time accuracy of one to five meters. The other half of the transects were read by using a 10 foot length of PVC pipe placed over each rebar for visibility so that the transect centerline could be determined at all times. In those areas where a minimum of two PVC poles could not be seen, surveyors flagging was placed on shrubs on the transect centerline so that the centerline was known at all times. The PVC poles were placed on the rebar the afternoon prior to their being read, generally the following morning. The PVC poles were collected as the transect was being searched. A set of 12 adult tortoises (6 male, 6 female) were fitted with AVM transmitters at both sites in order to calculate g_0 (the percentage of tortoises available to be observed). Generally, a set of 10 tortoises (5 male and 5 female) were located as many times as possible during the period of time that transects were walked, typically between 0700 and 1200 hours. Each tortoise could generally be found twice during the morning. The objective was to revisit each tortoise as many times as possible while transects were being walked.

CHOCOLATE MOUNTAIN AERIAL GUNNERY RANGE

The approximately 387,200 acre Chocolate Mountain Aerial Gunnery Range is located in the central portion of the Colorado Desert, in Riverside County, California. It is a live-fire air to ground and air to air range. Most of the base is a buffer for approximately 30 target sites that are on the CMAGR. The target sites range from 200 to 1000 acres, are heavily impacted, and portions of many are virtually denuded. The surrounding habitat is impacted very little, if at all. Only two ground based activities occur on the base: a Navy SEAL training area is on the west edge, and EOD clears the target areas of unexploded ordnance. Two utility corridors traverse the CMAGR: a Gas Company natural gas pipeline and an electrical transmission line.

That portion of the CMAGR, north and east of the Chocolate Mountains, is within the Chuckwalla Bench Desert Wildlife Management Area (DWMA) and within Critical Habitat (the boundaries for both the DWMA and Critical Habitat are the same). Two strata were determined to be on the CMAGR, the Chuckwalla Bench Strata on the north end and the Milpitas Wash strata in the eastern portion. It was estimated that approximately half of the Chuckwalla Bench strata is on the CMAGR and that approximately 15% of the Milpitas Wash strata is on the CMAGR.

In 1997, forty-one line distance transects were established within Critical Habitat on the CMAGR. The transects are four kilometers long, one kilometer on a side, and in the shape of a square or diamond. Thirty transects are in the Chuckwalla Bench strata and 11 transects are in the Milpitas habitat. The locations were not randomly selected but were spaced throughout the two strata.

The transects at the CMAGR have now been read twice: 1999 and 2000. In 2000, the transects were read between 26 April to 4 May, 2000. A total of 40 live desert tortoises were detected on 20 of the 41 transects (164 km walked) that were read in 2000. Thirty-four (85.0%) of the tortoises were in the Chuckwalla Bench and six (15.0%) were in the Milpitas Wash stratum. The encounter rate was 0.25 tortoises per km on the Bench and 0.09 tortoises per km on the Milpitas stratum. When the data are pooled for both strata, and all tortoises are included, the encounter rate was 0.24 tortoises per km. The encounter rate was slightly higher in 2000 on the Bench (from 0.21 to 0.25) and slightly lower on the Milpitas (0.12 to .09). The pooled encounter rate increased from 0.21 in 1999 to 0.24 in 2000.

The density, when data for both strata are pooled, was 0.23 tortoises per hectare, a CV of 25.63%, with a 95% confidence interval from 0.14 to 0.37. Approximately 72,843 hectares of Critical Habitat were surveyed on the CMAGR. Thus, these data indicate an estimate of 16,754 tortoises with a range of 10,198 to 26952 at 95% confidence.

We found 178 tortoise carcasses on the 41 transects. Several tortoises were found that had died in 2000, thus it appears that the high mortality rates that began in the mid-1980's still continue. Two hundred twenty-five carcasses were found in 1999, many more than were found in 2000. The reason for the fewer carcasses may be that we were concentrating our search more at the centerline and not searching as wide a transect as we were in 1999, thus, we did not find as many carcasses.

This project was funded by Marine Corps Air Station, Yuma via Contract No. N68711-97-M-8808. Ron Pearce and Bob Riley (MCAS, Yuma) and Patricia Cutler (Southwest Division, Naval Facilities Engineering Command) provided invaluable assistance.

MARINE CORP AIR GROUND TASK FORCE TRAINING COMMAND

MCAGTFTC is a 600,000 acre facility located within the Mojave Desert near the City of Twentynine Palms, San Bernardino County, California. MCAGCC is broken down into 22 Training Areas, functional units that allow different types of training to occur without jeopardizing safety. The primary mission of MCAGTFTC is to develop, conduct, administer, and evaluate the Marine Corp's Combined Armed Exercise (CAX) Training Program. It allows infantry troops, artillery and armored battalions, fixed-wing aircraft, and attack helicopters to work closely together in various maneuvers and exercises in a live-fire environment, allowing commanders to practice combat command control in a realistic setting. The MCAGTFTC provides training for approximately one third of the Marine Corps on an annual basis.

The MCAGTFTC is in the southeastern portion of the Western Mojave Recovery Unit as delineated in the Recovery Plan. The MCAGCC is not within a DWMA, the northwest corner of the MCAGCC (Sunshine Peak Training Area) is adjacent to the east edge of the Ord-Rodman

DWMA. The north edge of the Joshua Tree DWMA is 15 to 20 miles south of the MCAGTFTC. The 62 transects were read between 14 to 20 April and 7 to 18 May, 2000. A total of 29 live desert tortoises were detected on 19 of the 62 transects. Eight (27.6%) of the tortoises were on the surface when they were detected and 21 (72.4%) were visible in burrows. The encounter rate was 0.12 tortoises per kilometer. The estimate of density was 0.048 tortoises per hectare with a CV 28.33%. At 95% confidence the range was 0.027 to 0.083 tortoises per hectare. Approximately 114,330 hectares were sampled, thus the estimate of density is 5488 tortoises, with a range of 3087 to 9489 tortoises, at 95% confidence. The high CV and broad estimate indicate that a much greater sample size needs to be obtained. This can be accomplished by walking more transects, finding more tortoises on the established transects, or by pooling the data from several consecutive years and calculating an estimate of density with the pooled data.

We found 66 tortoise carcasses on 36 of the 62 transects. We did not collect data for the carcasses due to our time constraint of walking transects during the morning or evening activity period. Thus, nothing can be said regarding the time since death, size classes, signs of disease, sex ratio, or cause of death. Several tortoises were found that had died in within the past year.

This survey was funded by Marine Corps Air Ground Combat Center, Twentynine Palms through Contract No. N68711-99-M-6629. Rhys Evans and Carolyn Martus of MCAGCC provided logistical support. Rhys Evans (MCAGCC) and Patricia Cutler of Southwest Division provided technical support.