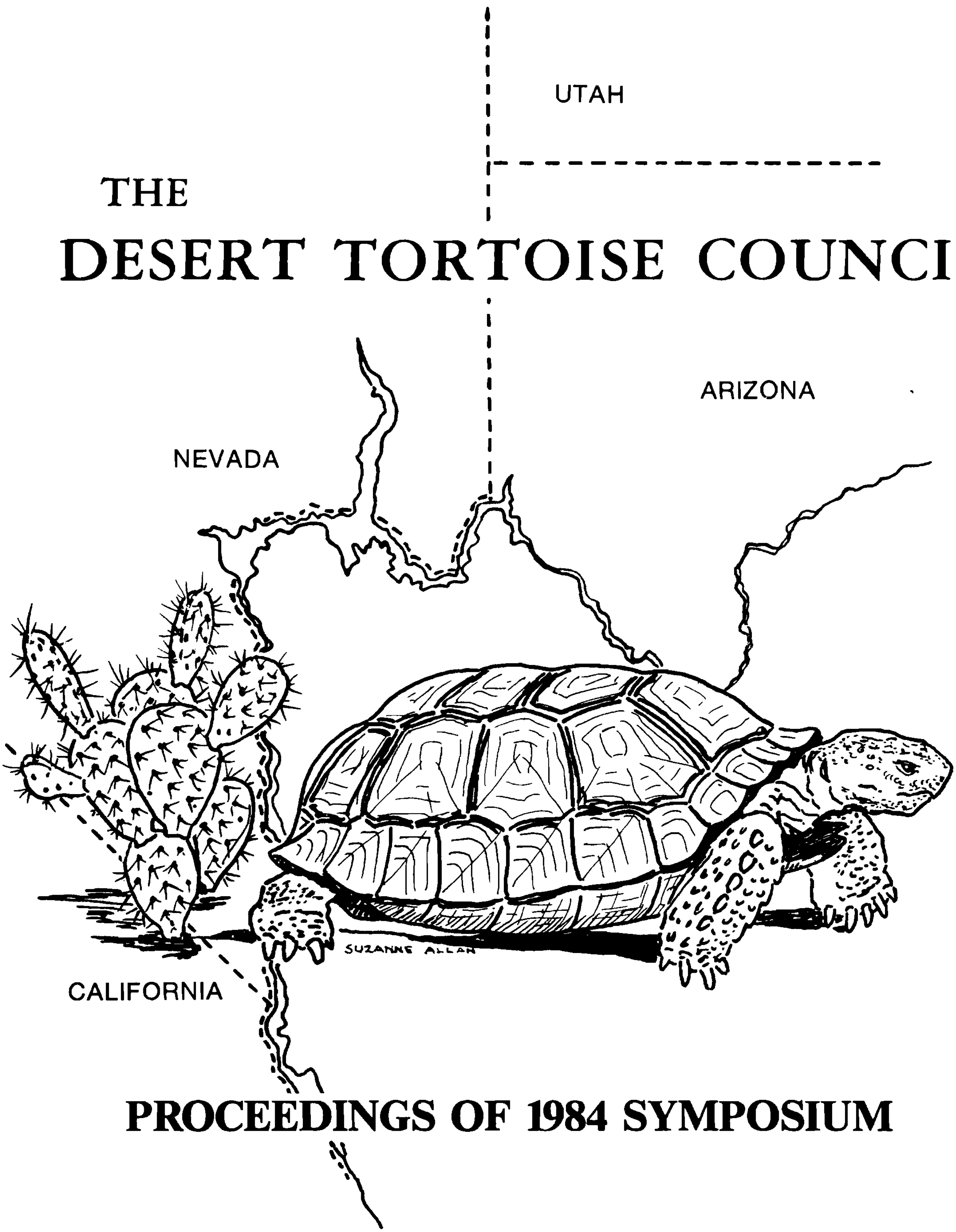
THE DESERT TORTOISE COUNCIL



PROCEEDINGS OF 1984 SYMPOSIUM

DESERT TORTOISE COUNCIL

PROCEEDINGS OF 1984 SYMPOSIUM

A compilation of reports and papers presented
at the ninth annual symposium of the
Desert Tortoise Council,
March 31 - April 2, 1984,
in Lake Havasu City, Arizona

Publications of the Desert Tortoise Council, Inc.

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DESERT TORTOISE COUNCIL

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Desert Tortoise (*Gopherus agassizii*) *Photo by Beverly F. Steveson*

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DESERT TORTOISE COUNCIL

Executive Committee

In 1974, members of the Prohibited and Protected Fishes, Amphibians and Reptiles Committee of the Colorado River Wildlife Council created an interim Four States' Recovery Team to lend a helping hand to the desert tortoise, *Gopherus agassizii*. Interest and concern for the tortoise soon outgrew the scope of the Team; subsequently, on 21 April 1975, its members formally originated the Desert Tortoise Council.

The Council continues to advance toward its goal of assuring the maintenance of viable populations of the desert tortoise throughout the tortoise's range in California, Arizona, Nevada, and Utah. To this end, the Council has effectively combined efforts of state and federal agencies, academic institutions, museums, zoos, turtle and tortoise clubs, and concerned citizens.

Each year, starting in 1976, the Council has held an annual symposium within the Southwest. Each of the symposium proceedings has been published, and more than 200 copies have been mailed gratuitously to select libraries throughout the United States. The reports and scientific papers contained in these publications are a testimonial to the Council's success in carrying out its intended functions, as well as a reminder that much remains to be done.

The goal of the Desert Tortoise Council is to assure the continued survival of viable populations of the desert tortoise, *Gopherus agassizii*, throughout its existing range.

The objectives of the Council are:

1. To serve in a professional advisory manner, where appropriate, on matters involving management, conservation and protection of desert tortoises.
2. To support such measures as shall work to insure the continued survival of desert tortoises and the maintenance of their habitat in a natural state.
3. To stimulate and encourage studies on the status and on all phases of life history, biology, physiology, management and protection of desert tortoises, including studies of native and exotic species that may affect desert tortoise populations.
4. To provide a clearinghouse of information among all agencies, organizations and individuals engaged in work on desert tortoises.
5. To disseminate current information by publishing proceedings of meetings and other papers as deemed useful.
6. To maintain an active public information and conservation education program.
7. To commend outstanding action and dedication by individuals and organizations fostering the objectives of the Council.

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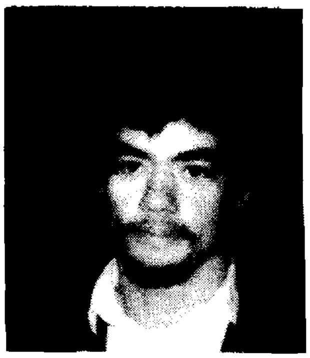
Ninth Annual Meeting Dedicated to the Memory of PAUL B. SCHNEIDER (1955-1983)

Paul Schneider was born in Lima, Ohio, fourth in a line of five boys, the son of Lloyd and Virginia Schneider. He lived in Birmingham, Michigan; Berlin, Wisconsin; and Decatur, Illinois, graduating from Decatur High School with awards in biology in 1969. His mother told me that as a boy he kept a variety of pets, especially birds (crow, barn owl, and red-tailed hawk). He collected specimens at every chance and on family outings no road-kill went unexamined or collected and prepared. He played piano, tuba, and flute — beautifully — and juggled very well.



Paul Schneider

In the fall of 1973 he entered Prescott College (with a hawk and six live pigeons). There he met Dr. Lyndon Hargrave, a well-known ethnobiologist and ornithologist. Lyn became Paul's mentor and urged him never to lose his enthusiasm for studying and learning — he never did. Lyn was a good mentor for Paul and used to grumble about Paul's lack of settling down, but I think that Lyn always understood that Paul was basically feral and that he was the sort of person who worked on his own time and with his own sense of purpose.

Paul explored the deserts of the Southwest with a burro named Amos, studied at Prescott College and Evergreen State College, and received a B.A. in Biology from Evergreen in 1977. Dr. Amadeo Rea, formerly of Prescott College and currently Curator of Birds and Mammals at the Natural History Museum in San Diego, has written: "We all know that Paul was a tough field man and could get a job done under trying circumstances where almost everyone else would fail — and he'd probably get it done better. Paul was both intelligent and had intellectual curiosity (which don't always go together). He didn't want to be known as a this-ologist or a that-ologist. He had the amazing intuitive facility with bird bone identification. He perceived morphological similarities and differences perhaps quicker than anyone else I have ever worked with."

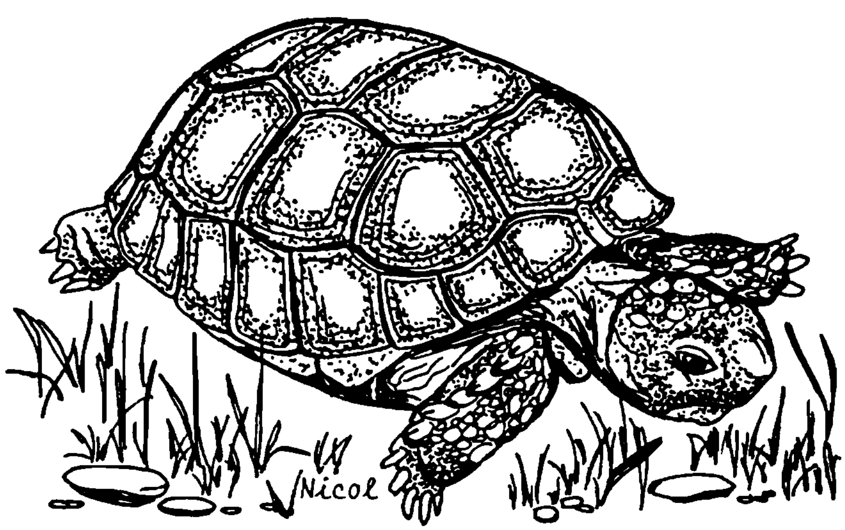
In 1979, when I was fortunate to have the BLM contract for the Chemehuevi Valley, I asked Paul to do fieldwork with me. I enjoyed working with Paul. We would have the most wonderful, table-banging discussions over tortoise demographic data and how to interpret them. Even from far away Paul would call periodically and we would go at it. He was a very valued colleague, and working with him in the desert was particularly rewarding. He had the keenest eye-brain relationship I've ever seen, and he loved the desert in the whole way he lived with it. (Pack rats make good breakfasts.)

He went from that study to do more work on the tortoise at Chemehuevi, and in Arizona and Nevada, and gave a few papers at Desert Tortoise Council meetings. He was on his way to his site in Nevada when an accident took his life.

In 1982 he was accepted at the University of California-Riverside in graduate school. He enjoyed the college scene after being away from it for five years, and it gave him the chance to learn about and use computers. In one of his earlier letters to his mother, he said ". . . so far, it's not a bore, rather a strain, and the lack of aesthetics is taking its toll on my spirit. I'm learning shitloads — more than they would ever guess or hope for." In another letter ". . . I don't know a significant percentage of what I want to learn — and quite frankly I think if I could learn 1% of what I wonder about before I die I'll consider my life an incredible success. I doubt I'll be that successful. As some sort of minimum goal I'd like to establish a peace of mind . . . I'm close to a peace of mind now . . . it will be great to get out to the field this spring [1983]. I'm quite excited about it. It looks like it's going to be an incredibly beautiful spring."

At the meetings we closed the dedication by asking each person to sit quietly for a moment and bring into his/her mind a favorite, beautiful and serene place in the desert. Some of us remembered places we had been with Paul. Those of us who work in and for the desert, and with and for desert creatures, will always remember him and miss his presence. But we will be more than satisfied with what he has given us already.

—*Margaret H. Fusari*



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MAJOR ACTIVITIES OF THE DESERT TORTOISE COUNCIL 1983-1984

GEORGE P. SHEPPARD
Senior Co-chairperson

Since the 1983 Annual Meeting and Symposium, the Desert Tortoise Council (DTC) has been involved with several major developments in tortoise management and conservation. Our accomplishments have contributed toward fulfilling the obejctives described in our bylaws, as well as solidifying the Council as a respected, professional organization in the southwestern United States. The following are highlights of major activities during the last 12 months.

Issues and Concerns

We prepared a package to support listing of the desert tortoise as a California state-listed rare species. The package was supported by the California Department of Fish and Game but has not yet been placed on the Fish and Game Commission agenda for discussion.

We sent a letter to the Arizona Game and Fish Department concerning proposed changes in the state reptile and amphibian regulations and the functions of the recently developed nongame branch.

We provided recommendations to the Nevada Division of Wildlife concerning high mortality of desert tortoises on a Bureau of Land Management (BLM) allotment in Piute Valley.

We held a joint meeting with the Desert Tortoise Preserve Committee to discuss problems of land acquisition within and around the Desert Tortoise Natural Area, as well as problems with the current management by the BLM.

Two resolutions were passed by the Board: one concerned relocation of desert tortoises as a mitigation measure, and a second regarded sale or exchange of public lands in desert tortoise range.

The DTC was directly involved with the BLM's Coordinated Resource Management Planning effort in the Las Vegas District. Grazing management and off-road vehicle events were discussed in a series of public meetings, and the Council presented its viewpoints.

Although the DTC and other organizations raised strong objections, the Los Angeles Federal Court approved resumption of the Barstow-Vegas off-road vehicle (ORV) event. Because of this decision, tortoises along the race course will once again receive impacts and their habitat will be fragmented by this activity. Betty Burge is to be commended for documentation of ORV impacts in Nevada.

The BLM released a draft recreation management plan for the Western Rand Area of Critical Environmental Concern (ACEC). The draft plan allows for continued intensive ORV use in the area and offers no mitigation measures to protect the tortoise. The DTC provided comments to the BLM.

The DTC also provided comments to the U.S. Fish and Wildlife Service on the Draft Recovery Plan for the federally-listed threatened population of tortoises on Beaver Dam Slope, Utah.

Reports and Contracts

The Council's contract with the U.S. Navy was fulfilled by preparing two reports on the Chocolate Mountains Aerial Gunnery Range. One report, prepared by Brian McGurty, was an inventory of reptiles. The second was on the distribution and abundance of tortoises (*see* Berry et al., pages 47 to 65 in the Proceedings of the Desert Tortoise Council 1983 Symposium). The 838-page report, entitled, "The status of the desert tortoise (*Gopherus agassizii*) in the United States" (edited by K. H. Berry), was completed and submitted by the DTC to the U.S. Fish and Wildlife Service in Sacramento.

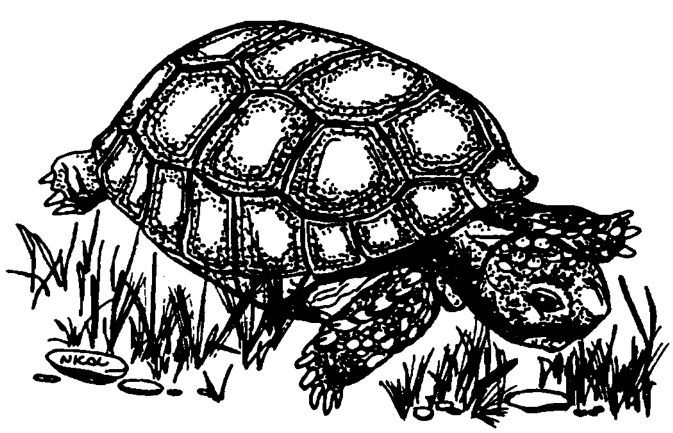
Organizational Business

After appropriate changes in its bylaws, the DTC became a "nonprofit corporation." We received corporate status in 1983 and provisional nonprofit status in January 1984.

Working relations with the state wildlife agencies, particularly in Arizona and Nevada, were enhanced following meetings and workshops conducted in these states.

The DTC pursued formation of a conservation coalition by initiating coordination with organizations that have similar conservation philosophies and ethics.

The Board recognized the need for a regular newsletter, and we will soon be printing our first issue.



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1984 ANNUAL BUSINESS MEETING OF THE DESERT TORTOISE COUNCIL

The following resolution was passed by unanimous vote at the 1984 Annual Business Meeting of the Desert Tortoise Council:

RESOLUTION ON PUBLIC LAND SALES AND EXCHANGES

WHEREAS the desert tortoise is a rare, long-lived reptile of low reproductive potential with a scattered distribution in the Southwest requiring large continuous areas of land to sustain wild, viable populations, and

WHEREAS the desert tortoise is listed or otherwise protected as Rare of Threatened in every state in which it occurs, due to many deleterious impacts, including habitat loss, and

WHEREAS the U.S. Fish and Wildlife Service is reviewing the status of the desert tortoise for possible listing under the Endangered Species Act of 1973, as amended, and

WHEREAS most of the desert tortoise habitat in the United States occurs on land administered by the Bureau of Land Management (BLM), an agency committed to multiple use and sustained yield of resources (including wildlife and Threatened and Endangered species) under the Federal Land Policy and Management Act of 1976, and

WHEREAS the BLM is selling or exchanging tracts of public land (known as FLPMA sales or Assessment Management) cumulatively totalling large acreages, some of which include desert tortoise habitat needed for survival and perpetuation of the tortoise in the wild, and

WHEREAS the Desert Tortoise Council, a private, nonprofit organization, is dedicated to the conservation and perpetuation of the desert tortoise in the wild,

NOW, THEREFORE, BE IT RESOLVED that the Desert Tortoise Council demands the BLM cease and desist sales or exchanges of public land occupied by identified populations of the desert tortoise until such a time as BLM can prove each individual tract of land and cumulative acreages of habitat will not lead to further decline of the species.

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1984 FIELD TRIP TO SITES NEAR GOFFS AND NEAR ESSEX, CALIFORNIA

We had a double field trip this year, for which we thank Dr. Howard Wilshire of the U.S. Geological Survey, and Dr. Frederick Turner and Page Hayden of the University of California at Los Angeles.

We began near the town of Goffs in California with a visit to tortoise territory. We found some sign but noticed that there was very little in the way of annual forage, so little in fact that the Bureau of Land Management did not issue sheep grazing permits this year. Either because of this or because it was a little early in the season, we did not see any tortoises.

As we were returning to the road with Dr. Turner, Page Hayden arrived with his wonderful research-equipped car. He explained to us about the use of telemetry to locate tortoises and the use of the portable X-ray machine to determine how many eggs were inside each female and how far along in development the eggs were. With this information, to be collected over several years' time, biologists will be able to understand more about the reproduction of tortoises, especially how tortoise populations respond to environmental factors.

After the demonstration, we returned to Essex to meet Dr. Wilshire and his crew from the U.S. Geological Survey. They were studying recovery of desert vegetation from the effects of two army maneuvers. The earlier impact took place in the days of General Patton in the 1940s, and lasted for two years. The second, referred to as Desert Strike, occurred during a two-week period in 1964. We were shown how one can tell the two sets of tank tracks apart by their size and distance apart. The tracks made by the M3 tanks of the Patton maneuvers have treads 16½ inches wide with an internal separation of 65 inches. By contrast, the tracks of the Desert Strike force tanks are 23-27 inches wide with a separation of 86-88 inches. The Patton site was awesome. His forces worked on 12 sites with an average of 10,000 men camped per site. The total set of maneuvers covered over 17,000 square miles. The site we visited had been built once and then rebuilt because of flooding. It was five miles long and a mile wide. By the rows of rocks set up along the paths one can see, on the ground and from the air, where each tent was located. The creosote scrub has returned but Dr. Wilshire and his colleagues are not sure if it has been by root sprouting or by reseeding. We were shown, in a trench dug by the researchers, that the upper vesicular layer of soil had recovered BUT that the lower layers, where the shrub roots must grow, was still noticeably compacted. How little we really know about our own effects on the land!

For more information about the effects of vehicles on the desert surface you can refer to a book edited by Robert Webb and Dr. Wilshire. Some data from that work were presented at a previous Desert Tortoise Council symposium. The book is: Webb, R. H., and H. G. Wilshire (eds). 1982. Environmental Effects of Off-Road Vehicles. Springer-Verlag, New York. 534 pp.

I think we all had a good trip this year, but, then, it's always good to be in the desert.

— *Margaret H. Fusari*

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1984 ANNUAL AWARD: PROFILE OF RECIPIENT, BETTY L. BURGE

Our 1984 annual award goes to Betty L. Burge, who has contributed significantly to the conservation of the desert tortoise and the growth of the Desert Tortoise Council since its formation in 1976. Betty has a broad educational background. She received a diploma from the Albany Medical Center of Nursing in New York in 1951 and a bachelor's degree in music (voice) from the Eastman School of Music at the University of Rochester in 1956. Between 1962 and 1972, she worked at the Youth Science Institute in San Jose, California, primarily as curator of live animals and collections. During this time she became aware of the challenge of maintaining captive desert tortoises and was impressed with the paucity of literature on wild tortoises. In 1967 Betty was awarded a Bachelor of Arts in Conservation at San Jose State University.

Betty L. Burge

Betty Burge began a new phase of her life in 1973, when she moved to Las Vegas, Nevada, to work on a Master of Science degree at the University of Las Vegas under Dr. W. G. Bradley. She established a study area south of Las Vegas at Arden, where she gathered data on population attributes, behavior, and movements of 127 marked tortoises for 17 months. Her master's thesis, "Movements and Behavior of the Desert Tortoise, *Gopherus agassizii*," was completed in 1977 and is the first substantive work on a population in Nevada.

Between 1977 and 1980 Betty worked for the U.S. Bureau of Land Management (BLM) in California and Arizona. In California she surveyed permanent study plots in Ivanpah Valley and at Goffs, helping to establish techniques for 30- and 60-day censuses. In Arizona she walked 1,119 miles of strip transects to sample approximately 15,000 square miles, as part of surveys to determine distribution and relative abundance of the desert tortoise. Her findings indicate that tortoises in the Sonoran Desert of Arizona are confined primarily to granitic and volcanic slopes in palo verde-saguaro cactus vegetation.

Betty also worked on contracts for Southern California Edison Company and EG&G, and currently is employed as a temporary employee of the University of California, Los Angeles. In all cases, Betty has set high standards and has been very productive. She is respected throughout the Southwest for her outstanding fieldwork. For example, she participated in a project in Ivanpah Valley at the site of a proposed power plant and trained personnel to estimate tortoise distribution and abundance at Yucca Mountain on the Nevada Test Site. She now is an important part of the field team for a major research project funded by Southern California Edison and involving the University of California at Los Angeles and the BLM in Riverside. The team is gathering data to develop a population model for the desert tortoise in eastern California.

For the Desert Tortoise Council, Betty undertook a number of difficult and time-consuming tasks. For 13 months she represented the Council on the BLM's Coordinated Resource Management Planning Group for off-road vehicle (ORV) use in Clark County. She sought to inform members of the public and the Coordinated Resource Management Planning Group about habitat and behavioral requirements of the tortoise and the need for its protection. Her concern about the impacts of ORV use on important tortoise habitat grew considerably during this period. In 1982 she quantified and photographed impacts of a major new ORV race, the Frontier 500. The race course traversed 12 miles of crucial desert tortoise habitat in the Las Vegas area. She presented her findings to the BLM, personnel of the Frontier Hotel who sponsored the race, the State Multiple Use Advisory Committee on Federal Lands, and the Desert Tortoise Council. Betty made a number of recommendations to the Bureau to protect tortoise habitat during future races. In 1983 she met with Bureau officials in the field, and reported to the BLM that recreationists were violating stipulations designed to protect desert tortoise habitat even before the race was underway. During the race, she recorded numerous infractions and photographed impacts at several sites along the course. She presented convincing evidence to the BLM that stipulations and mitigations were insufficient to ensure habitat protection.

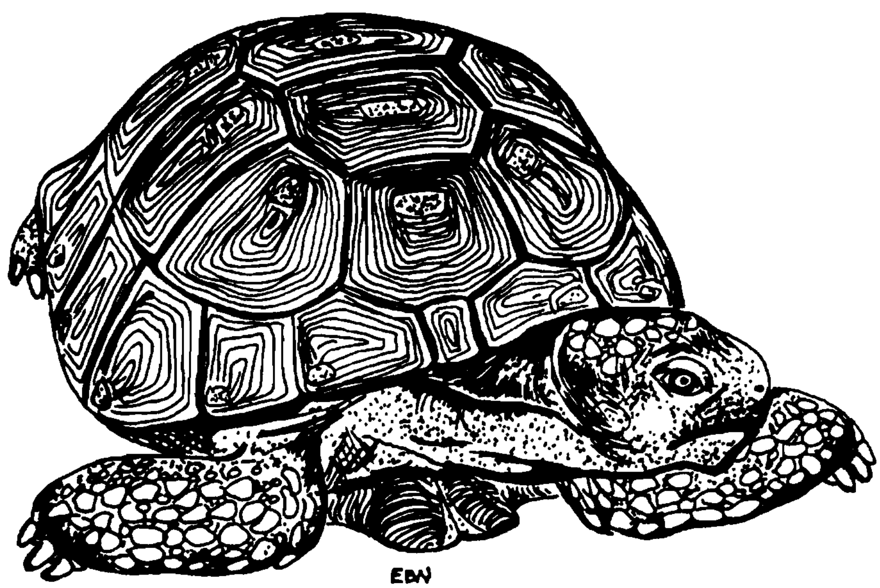
Between 1982 and 1984, Betty made significant contributions to the Desert Tortoise Council by assisting with analysis of impacts to desert tortoise habitat in Nevada for the report "The Status of the Desert Tortoise (*Gopherus agassizii*) in the United States." She also assisted with a study of the distribution and abundance of the desert tortoise on the Chocolate Mountains Gunnery Range, as part of a Council contract with the Department of the Navy.

A major facet of Betty's conservation efforts is her work with the Nevada Department of Wildlife (NDOW), which began in 1973. Betty approached the Department with several goals in mind: (1) to discourage the release of captives by Department personnel; (2) to change Nevada laws and legalize the possession of thousands of captive tortoises; (3) to publicize proper husbandry techniques; and (4) to offer her yard as a holding facility for the hundreds of captives turned into the Department annually. Her dialogue with NDOW continued for several years.

In 1981 Betty, with four other persons, began the TORT-Group, The Organization for Protection of Nevada's Resident Tortoises. Betty and others in the group worked closely with Department representatives to develop new legislation. When the Department proposed statute revisions in 1982, members of TORT-Group were prepared to assist with adoptions of abandoned captives and to publicize the plight of Nevada's wild tortoises. Under pressure from Betty, the Department agreed to allow TORT-Group to build a special enclosure at the Department's headquarters for captive tortoises. The enclosure protects the tortoises from heat stress until a TORT-Group member collects them for adoption. Betty coauthored "care sheets," the TORT-Group brochure, and wrote several information sheets of value to captive tortoise owners. The care sheet alone has an average distribution of about 10,000 per year. She has solicited funds to cover costs of printing TORT-Group brochures and informational materials. She distributes educational materials to local veterinarians, libraries, museums, animal shelters, and public agencies; presents slide shows to interested groups; and continues to work with adoption of captives.

During the past decade, Betty Burge's life has centered around improving the status of captive tortoises and protecting wild populations. Her methods are those of a dedicated professional. She has made major contributions to the well-being of tortoise populations and habitat. Congratulations, Betty, for years of outstanding work!

—Kristin H. Berry



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THIS WEEK -- FOR RELEASE ON RECEIPT

DESERT RESOURCES GROUPS DRAW PRAISE

The work of ad hoc citizen groups in protecting the desert resources of the Southwest was praised today by the director of the California Department of Fish and Game, Don Carper.

Carper said the 9th annual meeting of the Desert Tortoise Council March 31-April 2 in Lake Havasu City, Arizona and the 28th annual meeting of the Desert Bighorn Council April 5-7 in Bullhead City, Arizona was an appropriate time to recognize the valuable contributions of these organizations in preserving desert habitat.

Carper noted that these organizations include a wide representation from various public agencies both in the United States and in Mexico and from universities and the general public. He was pleased that DFG personnel participated in the work of these groups on a volunteer basis.

Carper noted that it was a policy of the California Fish and Game Commission and the department "to cooperate with local, state and federal agencies and with all interested persons, groups or organizations in every way feasible to further the aims and purposes of fish and game conservation, preservation, propagation, protection, management and administration."

"We are pleased to cooperate with organizations such as the Desert Bighorn Council, the Desert Tortoise Council and the Desert Fishes Council in our mutual efforts to protect and conserve the unique and fragile fish and wildlife resources of the southwestern desert," Carper said.

(Editor's note: The above California Fish and Game Department press release was issued the first day of the Council's 1984 Annual Meeting and Symposium.)

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ATTENDEES - NINTH ANNUAL MEETING AND SYMPOSIUM*

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STATE REPORT - NEVADA

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Abstract.—Legislation regarding protection of the desert tortoise was addressed and approved by the Nevada Board of Wildlife Commissioners. The legislation dealt with the legal possession of captive tortoises and the exploitation of wildlife for financial gain. The Piute Valley permanent study plot was surveyed this year to compare recent data with data collected from a 1979 study on that site. A new sampling method was developed to determine relative densities of tortoises based on total adjusted sign. A pamphlet dealing with the life history, distribution and management of the desert tortoise in Nevada was produced and distributed to the public. Further investigation and survey work pertaining to the status of the desert tortoise in Nevada will continue. Work will be conducted on the Sheep Mountain permanent study plot near Jean, Nevada. A proposal to the United States Government requesting Section 6 (Endangered Species) money to fund a distribution study is currently under review.

After considering input from the Organization for the Protection of Nevada's Resident Tortoises (TORT-Group) of southern Nevada, the Nevada Department of Wildlife presented a proposal to the Nevada Board of Wildlife Commissioners suggesting a change in Nevada Administrative Code 503.080 which applies to the protection of the desert tortoise. The code now reads:

503.080 -

1. The following reptiles are classified as protected and rare:
    a. Gila monster (*Heloderma suspectum*); and
    b. Desert Tortoise (*Gopherus agassizi*) outside the urban areas of Clark County.
2. All reptiles other than those listed in subsection 1 are classified as unprotected.

This change in the code has been in effect since 10 November 1983. Previously, the species had blanket protection within the state and people who kept tortoises as pets were in violation of the law. This change allows the TORT-Group to carry on their activities with us and with the public in compliance with the law. With this change, a public information campaign will occur in an attempt to advertise the availability of captive tortoises to people who wish to own them while at the same time emphasizing the necessity of leaving wild tortoises in their natural habitat. A television announcement has been filmed and edited and will be aired beginning in mid-March and continuing through the spring and summer. Newspaper articles are planned with the same format. In addition, distribution of informational pamphlets will continue.

The Board of Commissioners also reviewed Nevada Administrative Code 501.379 regarding the protection of wildlife from financial exploitation. This code reads as follows:

> 501.379 - Unlawful sale of wildlife or importation of game animals, or game amphibians. It is unlawful for any person to sell, expose for sale, to barter, trade or purchase, or attempt to sell, barter, trade or purchase, any species of wildlife, or parts thereof, except as provided in this Title or in a regulation of the Commission. The importation and sale of game animals, game birds or game amphibians or parts thereof is not prohibited if the deportation is from a licensed commercial breeder or processor outside of the state.

In the spring of 1983, Paul Schneider was contracted to conduct fieldwork on the Piute Valley permanent study plot in southern Nevada. This plot is located approximately 11.2 mi (18.4 km) south of the community of Searchlight. The design of the work was to collect data on the dynamics of this population. The plot was first worked in 1979 by Alice Karl (Karl 1979*a*). The initial work consisted of 30 mandays of study whereas the 1983 study required 60 mandays.

The following are some of the highlights of the study:

1. Significant changes in the population structure occurred over the four-year period. In 1979 the ratio of adult males to adult females was 79:100. In 1983 there were 131 adult males per 100 adult females.

2. Sixty percent of the population consisted of large tortoises of both sexes (subadult, adult I, and adult II) in 1979, whereas only 37% of the population consisted of this group in 1983. It should be noted that the contractor was required to maximize his search for small tortoises.

3. One hundred and nine mortalities were located on the study plot this year.

4. The ratio of adult male mortalities (> 180 mm) to females of the same size was 79:100. Most of the mortalities were potentially reproductive females or very large males.

5. Using the system of determining time since death developed by Woodman and Berry (*in* Berry 1984: App. 6), it was determined that 26% of the tortoises had been dead from 1-2 years and 57% had been dead from 2-4 years.

6. The estimated crude death rate was @26%.

Based on these and other data, it was determined that a significant die-off of this population occurred in 1981. This was a drought year and it is believed that this factor, combined with years of overgrazing, resulted in the die-off. Comparisons between data collected on the Crescent Peak grazing allotment (on which the study plot is located) and adjacent Christmas Tree Pass

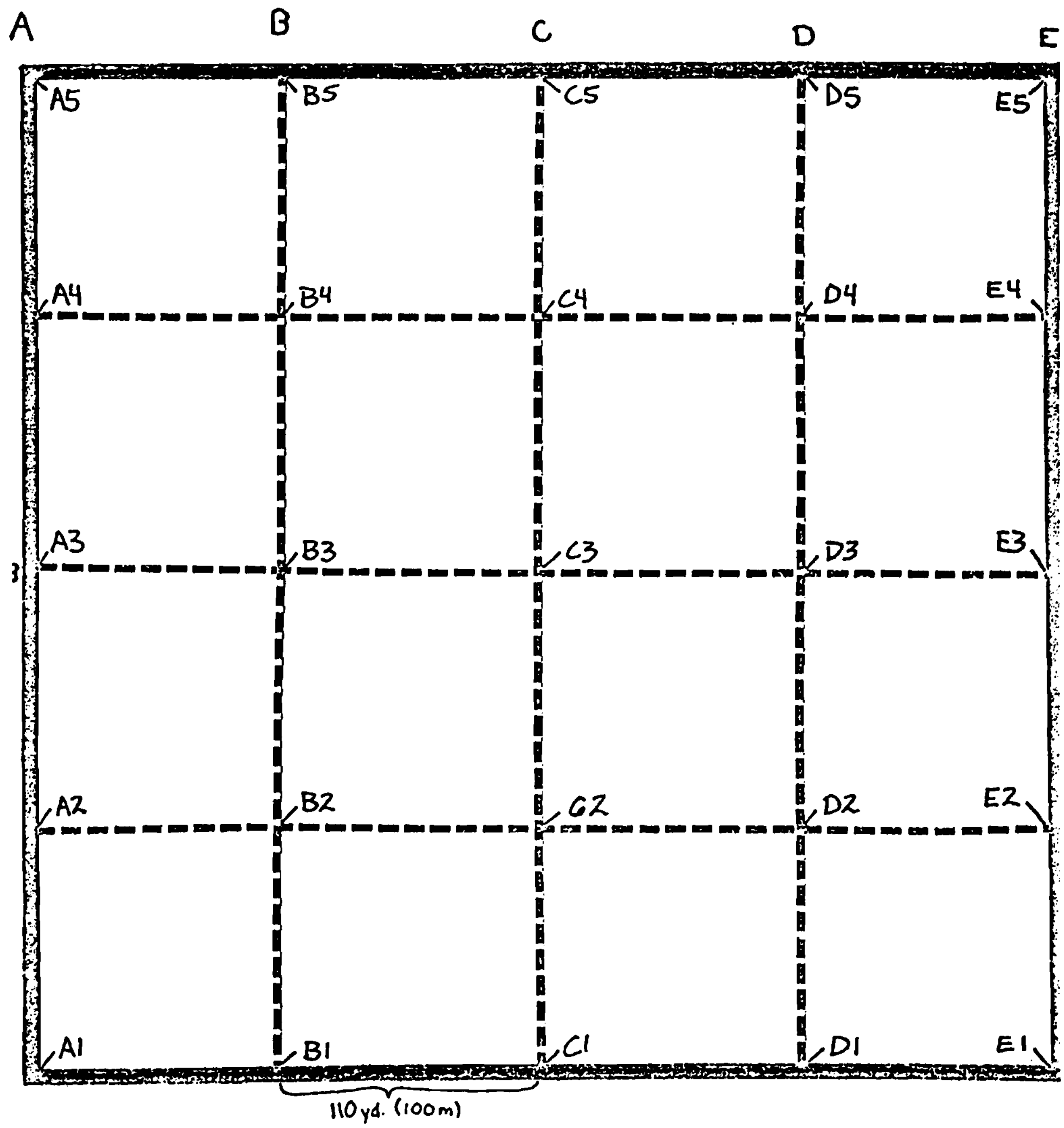
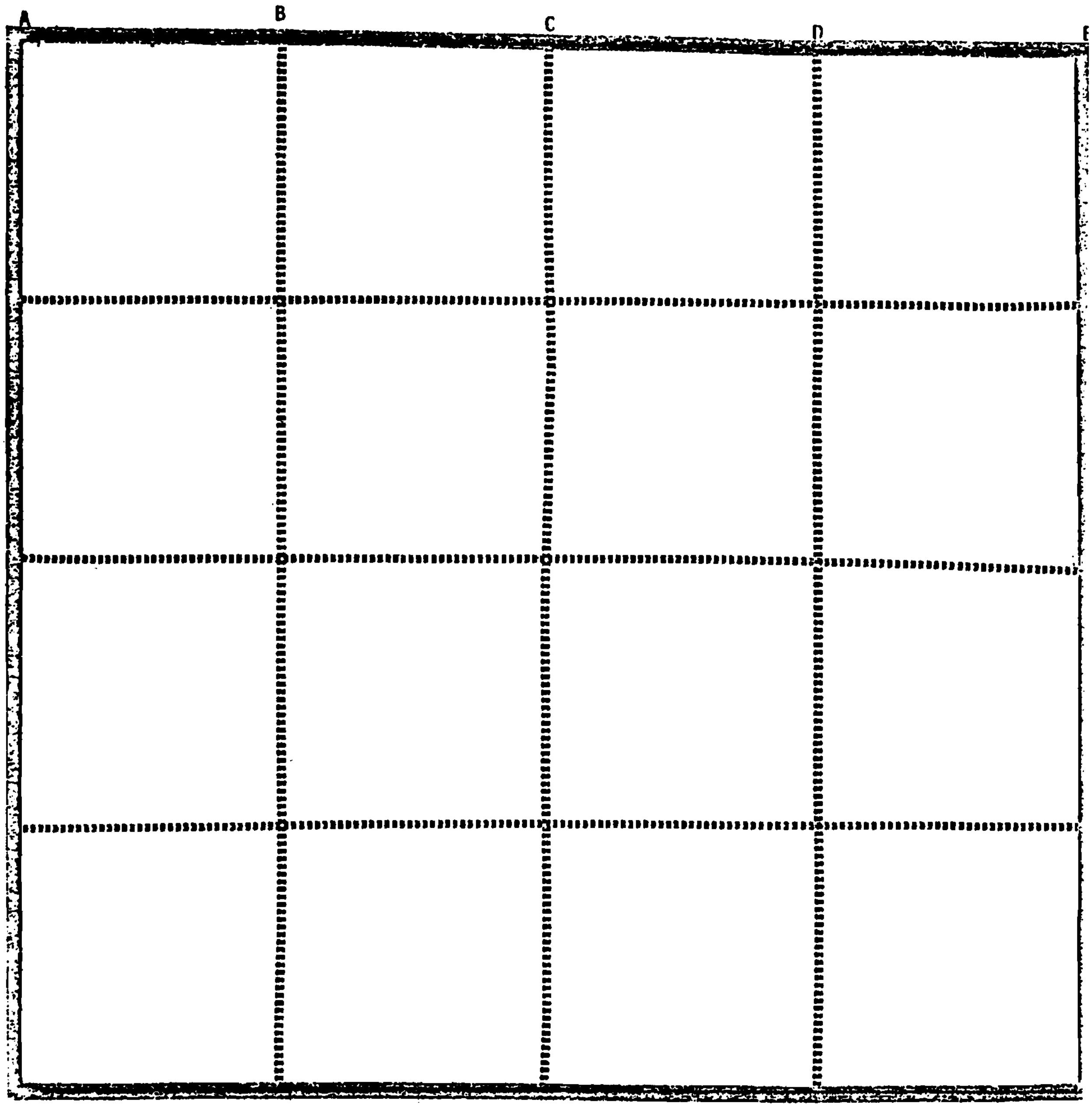


FIG. 1. — Diagram of a ¼-mi^2 comparison grid. Verticle columns are represented alphabetically. At each point where a column line and row line intersect, a lath is flagged, marked, and erected.



Grid #_____ Township__________ Surveyor____________________ Time____ Date_______

△ =recent burrow ◓ = old burrow T=live tortoise M=mortality S=scat P=pallet ⊕=scrape

Comments:____

FIG. 2.—A sample of the field forms used by surveyors of the comparison grids.

and Newberry allotments indicate that the die-off appears to be confined only to two ephemeral-designated grazing pastures on the Crescent Peak grazing allotment. This process will take place in the current coordinated resource management and planning process which is reviewing the Clark County Grazing Environmental Impact Statement.

When unusually high numbers of desert tortoise mortalities were discovered on the study plot by the contractor, it was decided by the supervising official to determine whether high mortalities occurred elsewhere throughout Piute Valley. A sampling technique was developed in anticipation that it might help illustrate the extent of the die-off. Data retrieved from the samples would also be invaluable in determining the actual cause of the mortalities.

The technique involved the establishment of a ¼-mi^2 (400 m^2) grid within which all sign of desert tortoises was actively sought. With the exception of two grids, 4½-ft-high surveyor's lath marked with high visibility flagging were posted at 110 yd (100 m) intervals in five rows of five markers each. The rows were also placed at 100-yd intervals, and the resulting grid was ¼ mi^2 (400 m^2) containing 16 units of 110 yd^2 (100 m^2). Refer to Figure 1 for a diagram of the grids. Vertical columns were represented alphabetically. Each lath was boldly marked with a magic marker as to which row and column position it occupied. This type of conspicuous marking allowed a surveyor to accurately estimate any location within the grid. Grids numbers 2 and 4 differed in that they were 220 yd (200 m) wide by 880 yd (800 m) in length.

Eight surveyors canvassed the grids. Under the circumstances, it was impossible to assemble eight individuals who had experience in tortoise-related fieldwork; however, inexperienced surveyors were given instructions on identifying sign by more experienced surveyors prior to surveying a grid. The participants included the supervising official (this author), the contractor, his assistant, and personnel employed by the Bureau of Land Management and the Nevada Department of Wildlife. The walkers were equidistantly spaced within the 110-yd distance between the marked columns and maintained this spacing while walking the 440-yd length of the four-unit section of the grid. After completing one section, the surveyors assembled at the beginning of another section and walked it in a similar fashion. Although the possibility existed that a surveyor could overlook tortoise sign (particularly scats), it was felt that the distance between walkers was not so great that tortoises or mortalities would be missed easily. In this manner the surveyors were able to "sweep" a grid of tortoise sign.

Surveys of the grids were restricted to the cooler morning hours when tortoise activity was expected to be at its peak. Each surveyor was supplied with a form that replicated the grid. This form is illustrated in Figure 2. Upon encountering tortoise sign, the surveyor marked the location of the sign using a character that represented that particular sign. This was important in llustrating the spatial relationships of the tortoises and tortoise burrows. Live tortoises were sexed and maximum carapace length measured. If possible, the same data were recorded on shell cards for each of the mortalities. These shells or shell fragments were collected and bagged for future examination. Most surveys took between 1.25 - 1.75 hours to complete. While walking a grid, the surveyors observed and estimated cattle activity (recent and present), forage utilization, diversity of annuals, and overall range condition. Upon completion of the survey, the participants assembled to discuss their observations. Notes from these discussions were recorded in the comments section of the grid forms.

For each comparison grid, a total adjusted sign (TAS) was calculated. Berry and Nicholson (1979) developed a strip transect method which used the TAS to estimate the density and distribution of tortoises. The method required a searcher to walk an equilateral triangular transect 1.5 mi (2.4 km) long. The number of tortoises and sign were recorded. Associated groups of sign such as a tortoise with a fresh scat nearby or a tortoise in a burrow, were considered to be one sign since multiple sign was associated with a single individual. Discretion on the searcher's part is required in order to determine whether multiple sign needs to be "adjusted" or not.

Since standardized equilateral triangular transects were not conducted on the comparison grids, it was necessary to calculate the TAS using the following equation:

$$\text{TAS} = s \div \frac{m}{1.5} = \frac{s(1.5)}{m}$$

TAS is determined by dividing the adjusted sign found on the grid(s) by the product of a division of 1.5 into the number of linear miles walked on the grid (m). By dividing the number of miles walked by 1.5, a figure representing the number of standard transects is produced. For example: if eight walkers surveyed a grid, then a total of eight linear miles were walked. If there were 1.5 linear miles in a standard transect then eight miles would represent the number of miles walked in 5.3 transects. To illustrate further, if the walkers found a total of 100 sign and it was adjusted to 90 sign, then 90 sign divided by 5.3 equals 16 and this is the TAS. The total adjusted sign calculated from data collected on a comparison grid should be very similar to the total adjusted sign found along a standard equilateral trangular transect walked within that grid and both should reflect the density of the tortoise population at that site.

In 1979, Alice Karl also conducted population studies on the Sheep Mountain permanent study plot near Jean, Nevada (Karl 1979*b*). This spring a follow-up study will be conducted to determine what changes, if any, have occurred between then and now. The contract for the work was awarded to Todd Esque of San Diego, California. Again, this will be a 60-manday study. This area is influenced by cattle grazing and off-road vehicle use.

A proposal from our department to the U.S. Fish and Wildlife Service has been completed and awaits approval. The study will require transect work to be conducted throughout parts of the desert tortoise's range in Nevada. Extensive surveys will occur in previously unsurveyed areas and intensive surveys will be undertaken in areas which have been previously designated as supporting moderate, medium, and high density tortoise populations. Many of these delineated areas are facing present and future resource conflicts and increasing the data base is essential in influencing land-use decisions. With the approval of this project, Section 6 (Endangered Species) funding will be used to hire a contractor to walk the transects in the fall of 1984.

A pamphlet was produced by the nongame section of the department which addresses the life history, distribution, and management of the desert tortoise in Nevada. This pamphlet was distributed to all Clark County schools, to all state parks and to various federal offices in an attempt to contact as many people as possible. One of the items emphasized in the pamphlet was that these animals are protected by law and that collection by humans has detrimental impacts on tortoise populations.

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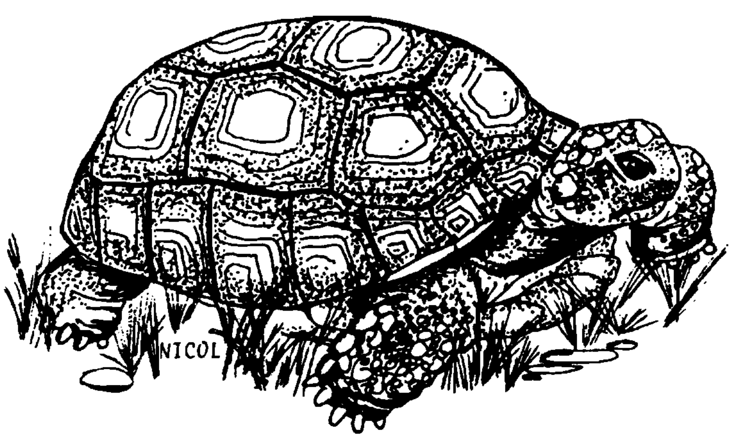

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STATE REPORT - NEVADA

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During 1983 and early 1984, the Bureau of Land Management (BLM) in Nevada was involved in several efforts on behalf of desert tortoise.

In the spring of 1983 a tortoise die-off was identified by Nevada Department of Wildlife (NDOW) contractor Paul Schneider while rereading Alice Karl's original 1-mi^2 permanent study plot in Piute Valley (Fig. 1). NDOW and BLM biologists developed and conducted an intensive survey to determine the extent of the die-off. Eleven ¼-mi^2 plots were thoroughly searched for dead tortoises and tortoise sign. Craig Mortimore of Nevada Department of Wildlife discusses the results of the die-off study in another presentation made at this meeting.

After 19 months and 16 public meetings, the Off-Road Vehicle Coordinated Resource Management and Planning (CRMP) process has been completed. CRMP is a public participation process used to bring various interest groups together to discuss and attempt to resolve conflicting resource uses on public lands in Nevada. A wide range of public interest groups including the Desert Tortoise Council spent enormous amounts of time and energy to develop a workable plan to assist the BLM with off-road vehicle (ORV) management in Clark County. Attachment 1 identifies the specific designations resulting from the CRMP recommendations, and the amount of crucial tortoise habitat affected. Implementation of these restrictions will be a significant improvement over present practices.

Intermountain Power Project is about to begin construction through Nevada. Stipulations presented in Attachment 2 were developed by the BLM in conjunction with the Nevada Department of Wildlife and Intermountain Power. Of particular significance, an experienced tortoise biologist is required to locate tortoise burrows or important sites for avoidance during construction. Similar stipulations are being incorporated into any right-of-way permit through tortoise habitat in Nevada.

The Clark Grazing CRMP process has been initiated. The planning process leading up to CRMP has identified the desert tortoise as a primary objective for resource conflict resolution. The objective states, "In critical tortoise habitat assure adequate amounts of spring ephemeral forage is made available to desert tortoise." Four grazing allotments have been discussed so far. The committee recommendation for tortoise is to reduce livestock pressure by turning off livestock waters in or near crucial habitat from the tortoise's important use period — March 1 through May 30 — unless 300 pounds/acre of air/dry ephemeral forage is produced.

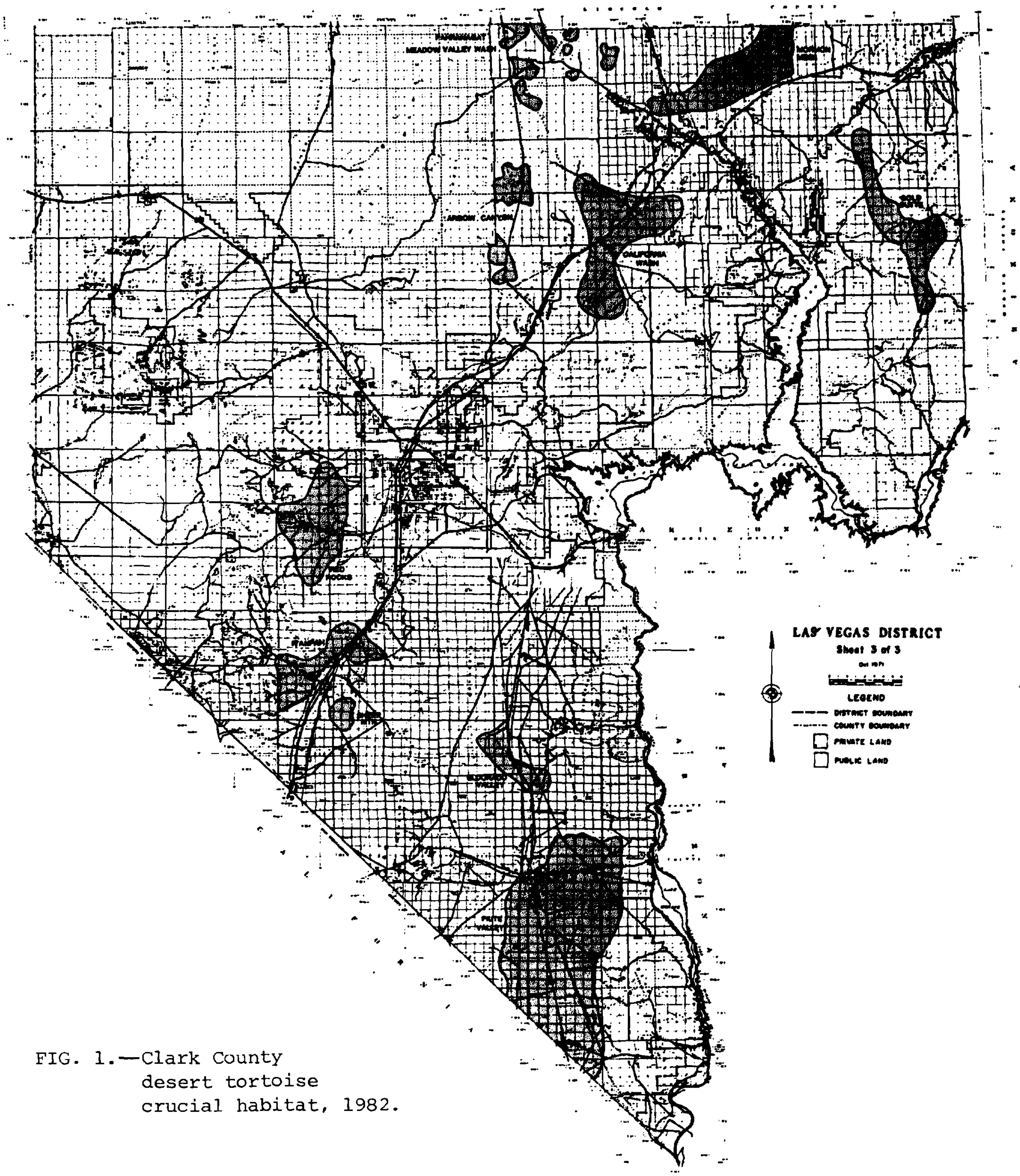

FIG. 1.—Clark County desert tortoise crucial habitat, 1982.

Attachment 1

ORV Designations

Gold Butte - 139,000 acres of crucial habitat.

Use is limited to existing roads, trails, and sand washes - no cross country travel, this applies to all vehicle users. No high speed events.

Arrow Canyon - 74,240 acres of crucial habitat.

Use is limited to non-speed competitive and non-competitive use. Highway 93 area is closed to racing except for a corridor along the future White Pine Powerline Road.

Pahranagat - Meadow Valley Wash - 59,904 acres of crucial habitat.

Use limited to November to April; only 2, non-pre-run motorcycle races per year; only 1, pre-run dune buggy race per year to take place on a designated route which will include old U.S. 93; no more than 3 laps; designated pitting areas; confined to existing roads, trails and sand washes.

Mormon Mesa - 147,456 acres of crucial habitat.

Limited to non-competitive use.

California Wash - 100,224 acres of crucial habitat.

Areas adjacent to the south and east sides of the Moapa Indian Reservation. Existing course only for competitive events; designated pitting areas; no more than 4 laps; avoid creation of new trails by non-ORV users such as seismic crews.

Red Rocks - 16,160 acres of crucial habitat.

No high speed competitive events permitted. In the Red Rock Canyon Recreation Lands, all vehicle users are limited to designated roads.

Bird Springs and Ivanpah Valley - 15,040 acres and 21,408 acres of crucial habitat, respectively.

Group or competitive use is limited to October-April; confined to existing roads, courses, trails, and sand washes; no more than 3 laps; designated pitting areas; maximum 3 events per year.

Sheep Mountain - 3,424 acres of crucial habitat.

Group or competitive use is limited to no more than 3 laps; designated pitting areas; use limited to October-April; confined to existing roads, courses, trails, and sand washes.

Eldorado Valley - 16,128 acres of crucial habitat.

Group or competitive use is limited to:

1. Non-Spectator Speed Events (Motorcycles).

   Limited to 200 entrants; no pre-running; avoid scheduling on opening weekend of game seasons; no more than 3 laps; designated pitting areas; use limited to October-April; confined to existing roads, trails, courses and sand washes.

2. Sport Car Rallies (Street legal only)

   Limited to 200 entrants; designated routes only; use limited to October-April.

3. Non-Speed Events

   Limited to 200 entrants; avoid scheduling on opening weekend of game seasons; no multiple lapped events; use limited to October-April.

4. Spectator Speed Events

   Limited to 200 entrants; pre-running is limited to the week before the event; no more than 3 laps; designated pitting areas; use limited to October-April; confined to existing roads, courses, trails, and sand washes.

Piute Valley - 36,742 acres of crucial habitat

The crucial habitat with 90+ tortoises/mi^2 has the following limitations on group or competitive use:

1. Non-Spectator Speed Events (Motorcycles)

   Limited to 200 entrants; no pre-running; avoid scheduling events on opening weekend of game season; no more than 3 laps; designated pitting areas; use limited to October-April; confined to existing roads, courses, trails, and sand washes; maximum of 3 events per year.

2. Sport Car Rallies (Street legal only)

   Limited to 200 entrants; designated routes only; use limited to October-April.

3. Non-Speed Events.

   Limited to 200 entrants; avoid scheduling events on opening weekend of game seasons; no multiple lapped events; use limited to October-April.

4. Spectator Speed Events

   No spectator speed events.

Tortoise crucial habitat in Piute Valley between 50-90 tortoises/mi^2, has three different designations.

The area around Searchlight (17,280 acres of crucial habitat) is limited to non-competitive use.

The area (69,281 acres of crucial habitat) south of Cottonwood Cove Road and east of Highway 95 limits group or competitive use to the following:

1. Non-Spectator Speed Events (Motorcycles)

   Limited to 200 entrants; no pre-running; avoid scheduling events on opening weekend of game season.

2. Sport Car Rallies (Street legal only)

   Limited to 200 entrants; designated routes only.

3. Non-speed Events

   Limited to 200 entrants; avoid scheduling events on opening weekend of game seasons; no multiple lapped events.

4. Spectator Speed Events

   Limited to 200 entrants; existing roads, trails, and dry washes only; only one event per year; use limited to period between the close of quail hunting season and March 15; start-finish, pitting and spectator areas will be designated within T. 32 S., R. 66 E., Sec. 9, 14, 15 and 16 if on public land; four laps only; and pre-running is limited to one week prior to the event.

The remaining 23,664 acres of crucial habitat in Piute Valley has the following designation for group or competitive use:

1. Non-Spectator Speed Events (Motorcycles)

   Limited to 200 entrants; no pre-running; avoid scheduling events on opening weekend of game season.

2. Sport Car Rallies (Street legal only)

   Limited to 200 entrants; designated routes only.

3. Non-speed Events (All types of vehicles)

   Limited to 200 entrants; avoid scheduling events on opening weekend of game seasons; no multiple lapped events.

4. Spectator Speed Events (4x4s, dune buggies, motorcycles)

   Limited to 200 entrants; pre-running is limited to the week before the event.

Attachment 2

INTERMOUNTAIN POWER PROJECT

Desert Tortoise Stipulations

1. The grantee will be required to provide an experienced desert tortoise biologist during new road construction and tower site clearing, and at pulling and tensioning sites within the following areas: Moapa Division, tower sites 2801 through 2818 and 2862 through 2905; Pole Division, tower sites 2612 through 2669; Ivanpah Division, tower sites 3466 through 3478, inclusive.

   a. During the above identified phases of construction and within the areas specified, the biologist will locate and flag tortoise burrows prior to the initiation of surface disturbing activities. The flagged areas will be avoided whenever possible during construction activities.

   b. Hibernating tortoises dug up as a result of contruction activities will be turned in to the Nevada Department of Wildlife, Region III Headquarters, 4747 W. Vegas Drive, Las Vegas, Nevada.

   c. Whenever active tortoises are encountered, they will be moved a safe distance (at least 150 yards) to avoid injury, to a shady place. Tortoises should be handled very gently and for as short a period as possible.

2. The grantee is required, in areas other than those specified under No. 1 above, to move active tortoises encountered during construction activities a safe distance (at least 150 yards) to avoid injury, to a shady place. Tortoises should be handled very gently and for as short a period as possible.

3. The grantee will inform the construction crews of techniques to properly move tortoises without inflicting injury. In addition, the grantee will be responsible for informing construction crews of the areas listed under No. 1 above and the restrictions required to protect tortoises.

4. Tortoises shall not be collected by construction personnel. The grantee will inform all individuals constructing the facilities of Nevada Administrative Code 503.080 which states that desert tortoise is a protected and rare species. Removal of tortoise from the wild is punishable by a minimum $100.00 fine. The grantee will inform construction personnel of the status and laws pertaining to desert tortoise.

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STATE REPORT - UTAH

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GENERAL DESCRIPTION

The desert tortoise (*Gopherus agassizii*) is found in Utah on the Beaver Dam Slope of Washington County. The population is sparsely scattered over 91 mi^2 (235 m^2) (Minden 1980) of Lower Sonoran vegetation comprised of a Joshua tree-creosote cummunity supporting a variety of annual forbes and grasses. Currently the Utah population of desert tortoises is federally listed as a threatened species (20 August 1980, Federal Register, CFR PT.17) with 35 mi^2 (91 km^2) of designated Critical Habitat.

PRESENT MANAGEMENT OF THE DESERT TORTOISE IN UTAH

The Utah Division of Wildlife Resources manages the desert tortoise the following ways:

1) Monitors the population dynamics of the desert tortoise;
2) Monitors grazing and vegetative conditions on the Beaver Dam Slope;
3) Has developed a computer file for all numbered tortoises released on the slope from 1973 to present;
4) Has released surrended and seized captive and recently wild desert tortoises onto the Beaver Dam Slope; and
5) Studies the success of the captive release program.

During all trips to the Beaver Dam Slope, notes are made of current range conditions and of grazing pressure in relation to the Bureau of Land Management (BLM) designated season of use. Relative numbers of livestock, as well as areas of concentrated use are recorded.

During 1982 and 1983, original tortoise field data sheets were obtained from the BLM and previous researchers. A computer file of these data was developed using commercial software programs and an "Apple IIe" computer. A total of 22 data entries, when available, were made for each tortoise. A summary of these data and data for captive releases are being presented at this symposium.

Approximately two weeks of field investigations were conducted in 1982 and in 1983 on the Beaver Dam Slope. Field data sheets have been completed for all observed tortoises. The Woodbury/Hardy plot studied by Minden in 1981 was re-staked and numbered caps placed at each quadrant corner to facilitate future work. A remote camera study is being conducted at a tortoise release site in a large winter den in Welcome Wash. This work will continue through 1984 and results will be available in 1985.

In spring and late fall of 1983, 29 captive and recently wild tortoises were released by the Utah Division of Wildlife Resources at a site in Welcome Wash on the Beaver Dam Slope.

BEAVER DAM SLOPE DESERT TORTOISE RECOVERY PLAN

The Utah Division of Wildlife Resources has contributed to the preparation of the Beaver Dam Slope Desert Tortoise Recovery Plan. Comments were made for the interagency draft, and the Division looks forward to its completion so that proposals for further research on the tortoise on the Beaver Dam Slope can be initiated.

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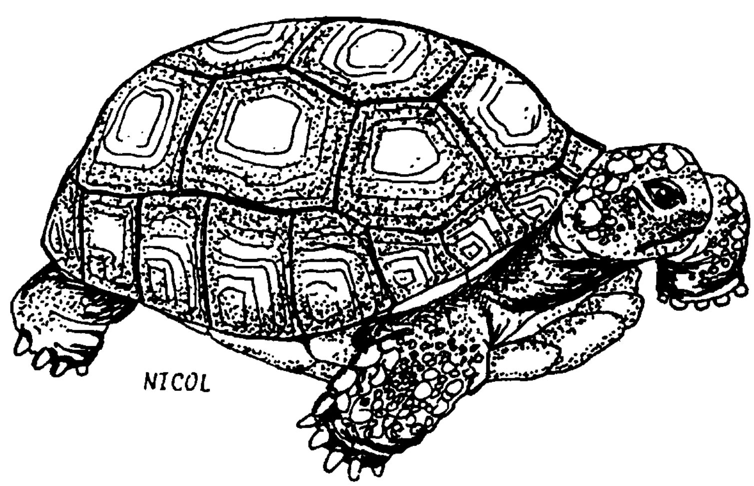
Minden, R. L. 1980. Investigations of the desert tortoise (*Gopherus agassizii*) on the Beaver Dam Slope, Washington County, Utah. Utah Division of Wildlife Resources. Publication 80-21.



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STATE REPORT - UTAH

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Present Protection and Management of the Desert Tortoise.—Multiple use management will continue in the designated desert tortoise Critical Habitat with some restrictions (Robison 1982).

The Allotment Management Plans (AMPs) on the Beaver Dam Slope have been implemented. The Castle Cliffs AMP includes the area east of Highway 91 and the Beaver Dam Slope AMP includes the area west of Highway 91. These AMPs provide for removal of cattle during the spring while desert tortoise are active and competition for forage may occur.

Both of these AMPs have a modified, deferred rotation plan. The Castle Cliffs AMP provides for yearlong rest in the Critical Habitat area two out of every four years. Spring rest would occur the remaining two years with cattle being removed after 28 February one year and 15 April the other. Critical Habitat area within the Beaver Dam Slope AMP will be rested in the spring after 28 February, two out of every three years, and after 15 April the third year. However, during years of abundant annual forage production, livestock grazing use may occur during the spring period. A 60% utilization rate has been established so a good cover of annuals remains.

A reduction of cattle numbers has been made in these two allotments. A reduction of grazing preference was made in Castle Cliffs AMP, while in the Beaver Dam Slope AMP the grazing permittees have taken a voluntary nonuse reduction the three years so the grazing capacity can be determined. The BLM is pleased with the cooperation received from the livestock permittees in the protection efforts of the desert tortoise and its habitat.

Land Uses Affecting the Tortoise.—During 1983 a number of mining claims were located in the Critical Habitat area (T. 43 S., R. 18 W., Sections 21, 22, 28). Recently, the BLM has received a plan of operation for mining exploration in this area. Because this is an area of high tortoise density, the BLM is very concerned. We are presently completing an environmental assessment on this action and will keep the Desert Tortoise Council informed during its development.

The 500 kv Intermountain-Adelanto Line is scheduled to be constructed through a portion of the Beaver Dam Slope tortoise habitat (T. 42 S., R. 19 W., and T. 42 S., R. 20 W.). This line will not cross through the Critical Habitat area but will pass to the north and west. A tortoise inventory of this corridor was completed. Tortoise densities are estimated to range between 0 and 50 tortoises/mi^2.

The anticipated impacts occurring during construction should be negligible in a regional sense. Long-term impacts due to access and spur road construction should be minor due to the presence of good existing access.

Impacts from construction of this line can be reduced through the recommended mitigation activities including construction during fall and winter only, and having a tortoise biologist present during periods of heavy construction.

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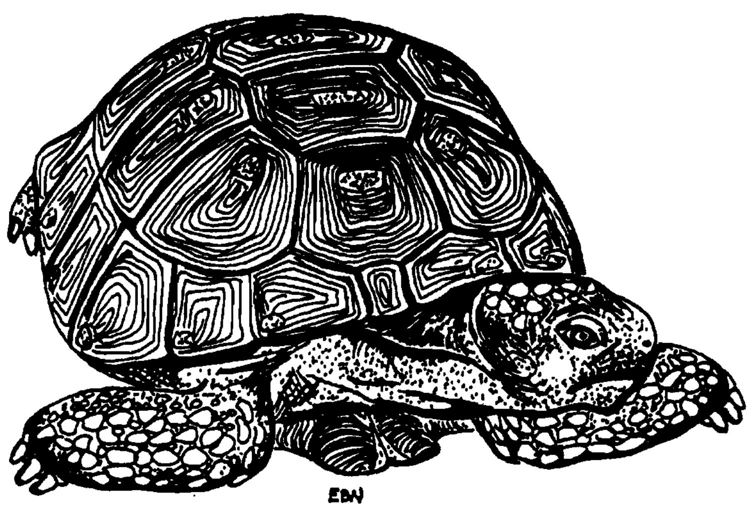
Robison, R. 1982. Management of the desert tortoise in Utah. Proc. Desert Tortoise Council 1982 Proc., pp. 78-80.



Proc. Desert Tortoise Council 1984 Symp., pp. 34-42

THORIUM, URANIUM, AND PLUTONIUM IN THE DESERT TORTOISE (*GOPHERUS AGASSIZI*): A PRELIMINARY REPORT

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Abstract.—The desert tortoise, *Gopherus agassizi*, found in the lower Sonoran life zone, has a lifespan exceeding 50 years. Its food consists of desert grasses and other desert plants. Its home range is 0.01 to 0.1 km^2 and individual ranges overlap considerably. These reptiles may be indicators of natural (U and Th) and manmade (Pu) radionuclides within a geographical area.

Ultrasensitive radiochemical and alpha-spectrometric analysis of a desert tortoise shell showed that concentrations of uranium and thorium in the carapace (13 pCi U/kg and 180 pCi Th/kg) and the scutes (17 pCi U/kg and 32 pCi Th/kg) were much higher than concentrations of these elements in human bones. The results in scutes may only reflect external contamination. By far the greatest activity was naturally occurring ^{228}Th, which may reflect uptake of the parent isotope ^{228}Ra. Similarly, the concentration of plutionium was higher in desert tortoise bone (2 pCi Pu/kg) than in human bone. However, these concentrations were not believed significant in terms of radiation doses to these reptiles.

The behavior of radionuclides in the environment began receiving attention only after the introduction of open air nuclear testing. Some of the first radioecological studies on plutonium and fission products were conducted along the fallout pathway of the test events beginning in 1945 by Larson et al. (1951) and Leitch (1951). Jinks and Eisenbud (1972), Hanson (1967), and Pendleton et al. (1964) have gathered large amounts of data demonstrating the availability of fission products in the human food chain. Information on the ecological behavior of radionuclides released from nuclear power plants is also abundant. However, not much information is available on the concentrations of naturally occurring alpha-emitting isotopes of uranium and thorium, and of manmade plutonium, in the desert tortoise, which may give an approximation of the radiation doses received by the desert tortoise. This information will be useful in assessing the biological effects of these radionuclides in these animals.

The desert tortoise, *Gopherus agassizi*, is a terrestrial reptile with a shell showing prominent growth rings on the carapace and scutes. Individuals rarely move more than 3 km from their hatch sites within their lifespan (Auf-

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fenberg and Iverson 1981) and have home ranges of 4-40 ha (Woodbury and Hardy 1948). Local movements usually consist of loop trips within a few hundred meters of favored burrows (Bury and Marlow 1973). The desert tortoise is estimated to live 50-100 years in the wild (Woodbury and Hardy 1948). Therefore, measurement of uranium, thorium, and plutonium in the scutes and bones of desert tortoises may give an indication of the concentrations of these radionuclides in the particular area where the tortoises were obtained. Other radionuclides could also be measured to obtain information about the desert tortoise and its environment.

METHODS

Collection of Scutes

Radiochemical analysis was performed on one tortoise shell which was collected from the Beaver Dam Wash, Washington County, Utah, on 5 May 1983 by Michael P. Coffeen of the Utah Division of Wildlife Resources. The tortoise was a large male approximately 70 years of age, recorded under catalog number 83-101.

Radiochemical Determinations of Uranium, Thorium, and Plutonium

Scutes.—The concentrations of uranium, thorium, and plutonium in scutes were determined by a method developed by Singh et al. (1984*a*). Briefly, the weighed amount of scutes spiked with ^{232}U, ^{229}Th, and ^{242}Pu tracers are wet-ashed with HNO_3, followed by a mixture of HNO_3 and H_2SO_4. Uranium, thorium, and plutonium are co-precipitated with iron as hydroxides. The precipitate is dissolved in 10 M HCl and the acidity adjusted to 10 M. Uranium and plutonium are extracted into an equal volume of 20% tri-lauryl amine (TLA) solution in xylene, leaving thorium in the aqueous phase. Plutonium is first back-extracted by shaking with a solution of 0.05 M NH_4I in 8 M HCl. Uranium is then back-extracted by shaking the organic phase with an equal volume of 0.1 M HCl. The aqueous phase containing thorium is evaporated to dryness. The residue is dissolved in 4 M HNO_3 and the acidity adjusted to 4 M. Thorium is then extracted into an equal volume of 20% TLA solution in xylene preequilibrated with 4 M HNO_3, and back-extracted by shaking with an equal volume of 10 M HCl. Uranium, thorium, and plutonium are electrodeposited separately onto platinum discs and counted alpha-spectrometrically using surface barrier silicon diodes and a multi-channel analyzer.

Bone.—A method developed by Singh et al. (1984*b*) was used for the determination of uranium, thorium, and plutonium in bone. The weighed amount of bone spiked with tracers are either dry-ashed in a muffle furnace at 550°C or wet-ashed with HNO_3 with the occasional addition of a few drops of HNO_3 and H_2O_2. Uranium is first reduced to the tetravalent state with $SnCl_2$ and HI; uranium, thorium, and plutonium are then co-precipitated with calcium as oxalates. The precipitate is dried and heated in a muffle furnace at 550°C, cooled, wet-ashed with HNO_3, and evaporated to dryness. The residue is dissolved into 10 M HCl,

TABLE 1. — Concentrations of uranium, thorium, and plutonium isotopes in bones and scutes of a desert tortoise (pCi/kg wet weight).

Sample	Plutonium	Uranium	Thorium
Carapace	$^{239,240}Pu = 1.7 \pm 0.3$	$^{238}U = 4.3 \pm 0.4$	$^{232}Th = 2.4 \pm 0.4$
64.3 g	$^{238}Pu = 0.4 \pm 0.2$	$^{235}U = 0.09 \pm 0.07$	$^{230}Th = 2.0 \pm 0.3$
		$^{234}U = 8.4 \pm 0.5$	$^{228}Th = 176 \pm 3$
Plastron	$^{239,240}Pu = 0.19 \pm 0.07$	$^{238}U = 3.8 \pm 0.3$	$^{232}Th = 1.4 \pm 0.2$
113.6 g	$^{238}Pu = 0.07 \pm 0.06$	$^{235}U = 0.07 \pm 0.04$	$^{230}Th = 1.1 \pm 0.2$
		$^{234}U = 5.4 \pm 0.3$	$^{228}Th = 153 \pm 2$
Scutes	$^{239,240}Pu = 1.3 \pm 0.3$	$^{238}U = 8.2 \pm 0.7$	$^{232}Th = 11 \pm 2$
43.3 g	$^{238}Pu = 0.1 \pm 0.1$	$^{235}U = 0.5 \pm 0.2$	$^{230}Th = 9 \pm 1$
		$^{234}U = 8.7 \pm 0.7$	$^{228}Th = 12 \pm 2$

and the acidity is adjusted to 10 M. Solvent extractions, back-extractions, electrodeposition, and counting are performed as for scutes.

Autoradiographs

Neutron-induced autoradiographs of bones containing fissile nuclides such as ^{235}U and ^{239}Pu have been used in our laboratory for several years (Jee et al. 1972, Smith 1980). Current techniques to obtain neutron-induced autoradiographs using plastic detectors are variations on work performed between 1964 and 1970, and reviewed by Becker in 1972. When a sample matrix containing one or more fissile nuclides in contact with a plastic detector is exposed to a thermal neutron flux for a length of time, fission tracks can be obtained by etching the plastic detector. The fission track density ρ (tracks/cm^2) in the plastic can be obtained in accordance with the following equation (Becker 1966, Pretre et al. 1968):

$$\rho = K\, n\, \sigma_f \qquad (1)$$

where K is a constant factor associated with the detection efficiency of fission tracks in plastic detectors; n (neutrons/cm^2) is the thermal neutron fluence and σ_f (barns) is the fission cross section of the nuclide considered.

High quality autoradiographs can be obtained by adjusting the neutron fluence in order to obtain a track density adequate for visual observation.

RESULTS AND DISCUSSION

The concentrations of ^{238}Pu and $^{239,240}Pu$, ^{238}U, ^{235}U and ^{234}U, and ^{228}Th, ^{230}Th and ^{232}Th are given in Table 1. The concentrations of $^{239,240}Pu$ ranged from 0.19 $\pm$ 0.07 pCi/kg in the plastron to 1.7 $\pm$ 0.3 pCi/kg in the carapace. The concentration of ^{238}Pu was almost non-detectable in scutes and bones. The concentrations of Pu isotopes in bones and scutes of the desert tortoise were significantly lower than the concentrations of uranium and thorium isotopes. This may be due to smaller amounts of plutonium in the environment compared to the naturally occurring uranium and thorium isotopes.

The concentrations of ^{238}U ranged from 3.8 $\pm$ 0.3 pCi/kg in the plastron to

TABLE 2. — Comparison of concentrations of uranium, thorium, and plutonium isotopes in bones of a desert tortoise and man (pCi/kg wet weight). N.D. = Not detected.

Nuclides	Man	Tortoise
^{238}U	0.11 - 2.49	3.8 - 4.2
^{234}U	0.89	5.4 - 8.4
^{228}Th	0.54 - 0.66	153 - 176
^{230}Th	0.32 - 0.92	1.1 - 2.0
^{232}Th	0.10 - 0.16	1.4 - 2.4
$^{239,240}Pu$	0.17 - 0.40	0.2 - 1.7
^{238}Pu	N.D.	N.D.

8.2 ± 0.7 pCi/kg in scutes, and the concentrations of ^{234}U were similar, ranging from 5.4 ± 0.3 pCi/kg in the plastron to 8.7 ± 0.7 pCi/kg in scutes. The concentrations of ^{235}U were non-detectable in the carapace and plastron; however, very low concentrations of ^{235}U were detected in the scutes.

The concentrations of ^{232}Th and ^{230}Th in bone were 3 to 5 times lower than the concentrations of ^{234}U and ^{238}U, ranging from 1.4 to 2.4 pCi/kg for ^{232}Th and 1.1 to 2.0 pCi/kg for ^{230}Th. However, in scutes the concentrations of ^{232}Th and ^{230}Th were almost equal to the concentrations of ^{234}U and ^{238}U (11 ± 2 pCi ^{232}Th/kg and 9 ± 1 pCi ^{230}Th/kg). The concentrations of ^{228}Th were the highest of all radionuclide concentrations measured, and ranged from 12 ± 2 pCi/kg in scutes to 176 ± 3 pCi/kg in the carapace. The high concentration of ^{228}Th in bone indicates that ^{228}Ra is available in the environment. This isotope of radium is absorbed into the body more readily than thorium, and after

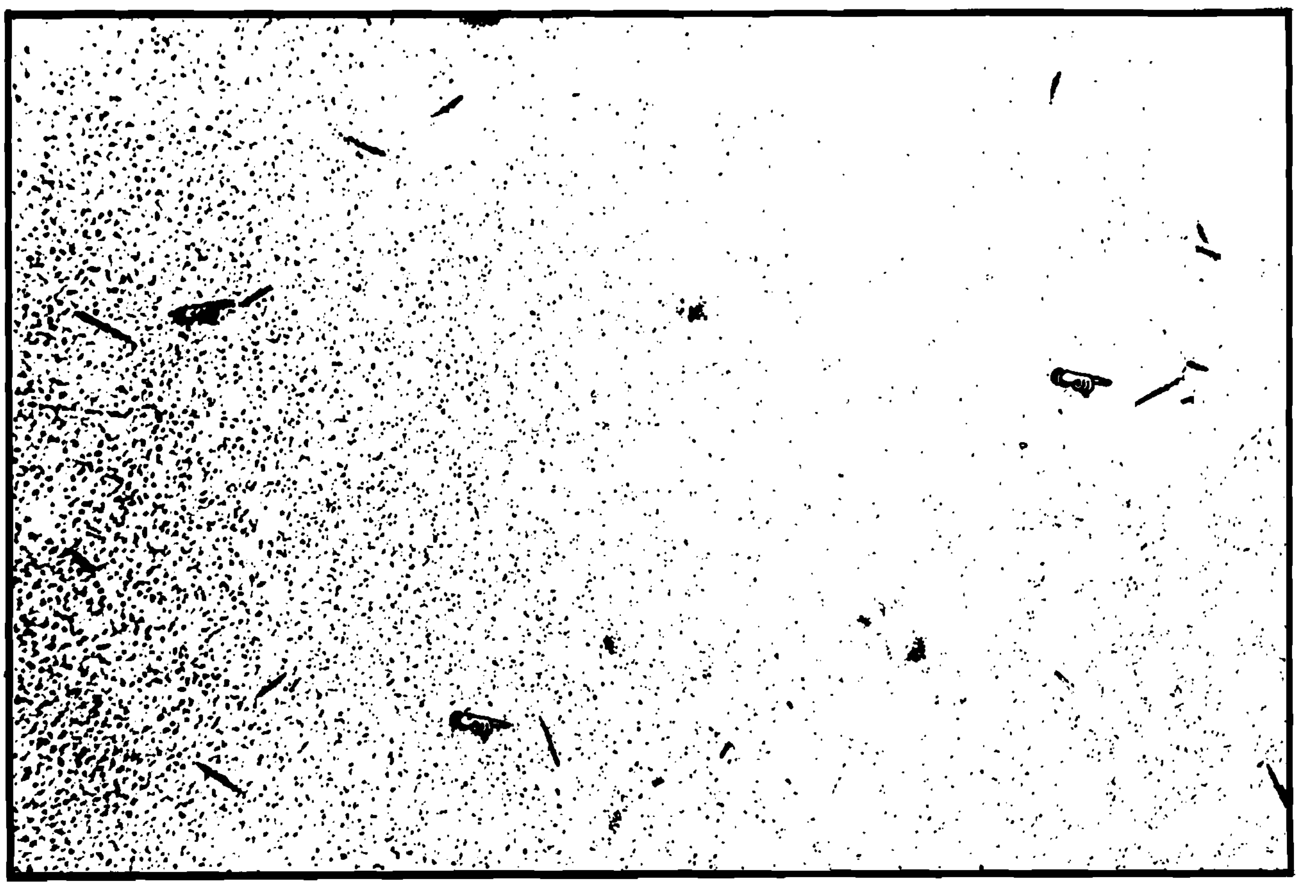

FIG. 1.—Autoradiograph of a portion of a vertebra from the center of the carapace of a desert tortoise (*Gopherus agassizi*). The pointers indicate selected neutron-induced fission tracks, which are more likely to be due to fissions of ^{235}U than of ^{239}Pu.

TABLE 3. — Alpha dose rates D_α (in µrad/hr) from long-lived alpha emitters in desert tortoises.*

PLUTONIUM

	$^{239,240}Pu$	^{238}Pu	Pu-subtotal
Top bone	$1.9x10^{-2}$	$4.7x10^{-3}$	$2.4x10^{-2}$
Bottom bone	$2.1x10^{-3}$	$8.2x10^{-4}$	$2.9x10^{-3}$
Scutes	$1.4x10^{-2}$	$1.1x10^{-3}$	$1.5x10^{-2}$
Subtotals	$3.5x10^{-2}$	$6.6x10^{-3}$	$4.2x10^{-2}$

URANIUM

	^{238}U	^{235}U	^{234}U	U-subtotal
Top bone	$3.8x10^{-2}$	$8.1x10^{-4}$	$8.5x10^{-2}$	$1.2x10^{-1}$
Bottom bone	$3.4x10^{-2}$	$6.3x10^{-4}$	$5.5x10^{-2}$	$9.0x10^{-2}$
Scutes	$7.3x10^{-2}$	$4.5x10^{-3}$	$8.9x10^{-2}$	$1.7x10^{-1}$
Subtotals	$1.5x10^{-1}$	$5.9x10^{13}$	$2.3x10^{-1}$	$3.8x10^{-1}$

THORIUM

	^{232}Th	^{230}Th	^{228}Th	Th-subtotal	Subtotals
Top bone	$2.0x10^{-2}$	$2.0x10^{-2}$	2.0	= 2.0	= 2.1
Bottom bone	$1.2x10^{-2}$	$1.1x10^{-2}$	1.8	= 1.8	= 1.9
Scutes	$9.4x10^{-2}$	$9.0x10^{-2}$	$1.4x10^{-1}$	$3.2x10^{-1}$	= $5.1x10^{-1}$
Subtotals	$1.3x10^{-1}$	$1.2x10^{-1}$	3.9	= 4.1	= 4.5 (Total)

*D_α (in µrad/hr) = $2.13x10^{-3}\ \Sigma_i\ \overline{E}_{\alpha i}\ C_i$ where $\overline{E}_{\alpha i}$ (in MeV/dis) is the mean alpha energy per disintegration of a radionuclide i, and C_i (in pCi/kg) is the concentration of a radionuclide i.

absorption it sequesters in bone and finally decays to ^{228}Th.

A comparison of the concentrations of these radionuclides in bones of man and this tortoise is given in Table 2. The concentrations of ^{238}U and ^{234}U in tortoise bone were much higher than the concentrations of these radionuclides in human bone. The concentrations of ^{232}Th were between 10 and 15 times higher in tortoise bone than in human bone. The most significant difference was in the concentration of ^{228}Th, which was almost 300 times higher in tortoise bone than in human bone. The concentrations of plutonium isotopes in the bones of the two species did not differ significantly.

An autoradiograph of a portion of a vertebra from the center of the carapace can be seen in Figure 1. The linear tracks are neutron-induced fission tracks, and are more likely to be due to fissions of ^{235}U than of ^{239}Pu.

The upper limits for the average internal alpha dose rates to the carapace, plastron, and scutes of the desert tortoise were calculated, based on a conventional mathematical formula for alpha dose factors, assuming uniform distribution of alpha emitters (Table 3). The concentrations of ^{239,240}Pu, ^{238}Pu, ^{238}U, ^{235}U, ^{234}U, ^{232}Th, ^{230}Th, and ^{228}Th presented in Table 1 were used in the calculations. The mean alpha energy per disintegration of each of these radionuclides were taken from a table published in the literature by Paschoa and Baptista (1978). The microdistribution of alpha emitters in the carapace, plastron, and scutes may give local alpha dose rates somewhat different than the values presented in Table 3.

Since 1 Gy equals 100 rads, one can make a rough comparison of the total alpha dose rate to the tortoise of 4.5 µrad/hr with the high dose rates of 0.16 µGy/hr (19) (i.e., 16 rad/hr) from ^{226}Ra occurring naturally in phytoplankton collected in the Agulhas Current off the coast of southwest Africa, and 0.14 µGy/hr (Paschoa and Baptista 1978) (i.e., 14 µrad/hr) from ^{239,240}Pu in zooplankton collected in Thule, Greenland, a few months after an accident involving a military aircraft carrying nuclear weapons. Although the alpha dose rate to the desert tortoise from ^{228}Th ($\approx$ 3.9 µrad/hr) is much higher than expected for an animal living in an area without known high natural radioactivity, it cannot be considered extreme, since it is lower than the natural dose rate from ^{226}Ra observed in the phytoplankton collected off the coast of southwest Africa. However, the lifetime alpha dose commitment to the desert tortoise will be considerably higher than that to either the phyto- or zooplankton, because of the tortoise's significantly longer lifespan. Further research is necessary before any definitive statement can be made regarding alpha dosimetry in the desert tortoise.

ACKNOWLEDGMENT

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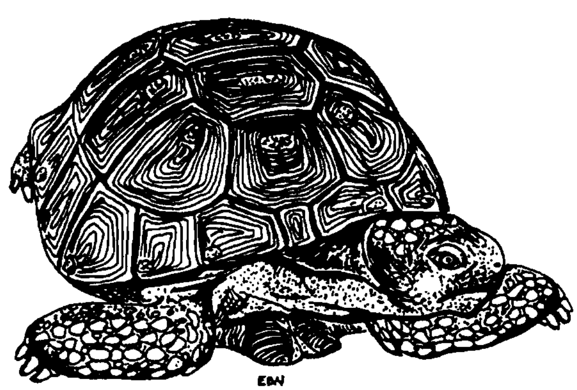

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THE CURRENT STATUS OF THE PARADISE CANYON, UTAH, DESERT TORTOISE POPULATION

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Abstract.—The tortoise population of Paradise Canyon has been monitored for over a decade; observations on population size structure and growth rates are summarized. The Paradise Canyon tortoise population appears to be in good condition with a large percentage of females of reproductive age and a healthy concentration of smaller size classes. Considerable growth was observed over periods of five to nine years.

Efforts are currently underway to protect Paradise Canyon from the expanding human population and development around St. George, including the incorporation of Paradise Canyon into adjacent Snow Canyon State Park. The idea that the desert tortoise may have existed as a native resident of the St. George area before human influence is discussed.

Paradise Canyon is a small sandy valley surrounded by Navajo sandstone cliffs and scattered extrusions of basaltic lava flows, 4.5 km northwest of St. George, Washington County, Utah. The canyon currently harbors the highest desert tortoise population density in Utah with approximately 120 tortoises/km^2 (Coombs, unpublished data). The Paradise Canyon tortoise population was first studied by Coombs (1977) during the early 1970s when he marked over 100 tortoises. During 1982 and 1983, additional tortoise data were recorded during a study on Gila monsters. The Paradise Canyon tortoise population has thus been monitored for over a decade. In this paper, we comment on the current status of the Paradise Canyon tortoise population, provide information on growth, and discuss actions currently underway to protect Paradise Canyon from encroaching human activities.

THE STUDY AREA

Paradise Canyon encompasses an area of approximately 2.5 km^2 (1.5 mi^2) at an average elevation of 975 m (3,200 ft.). Much of the valley floor consists of reddish-pink sand dunes deposited from the surrounding Navajo sandstone cliffs, and scattered lava rocks strewn about at the base of the cliffs and on the valley floor. The rocky areas provide winter den sites for desert tortoises. Tortoises leave the dens in the spring and are commonly encountered foraging on the dunes and along the many small washes. Several desert shrubs

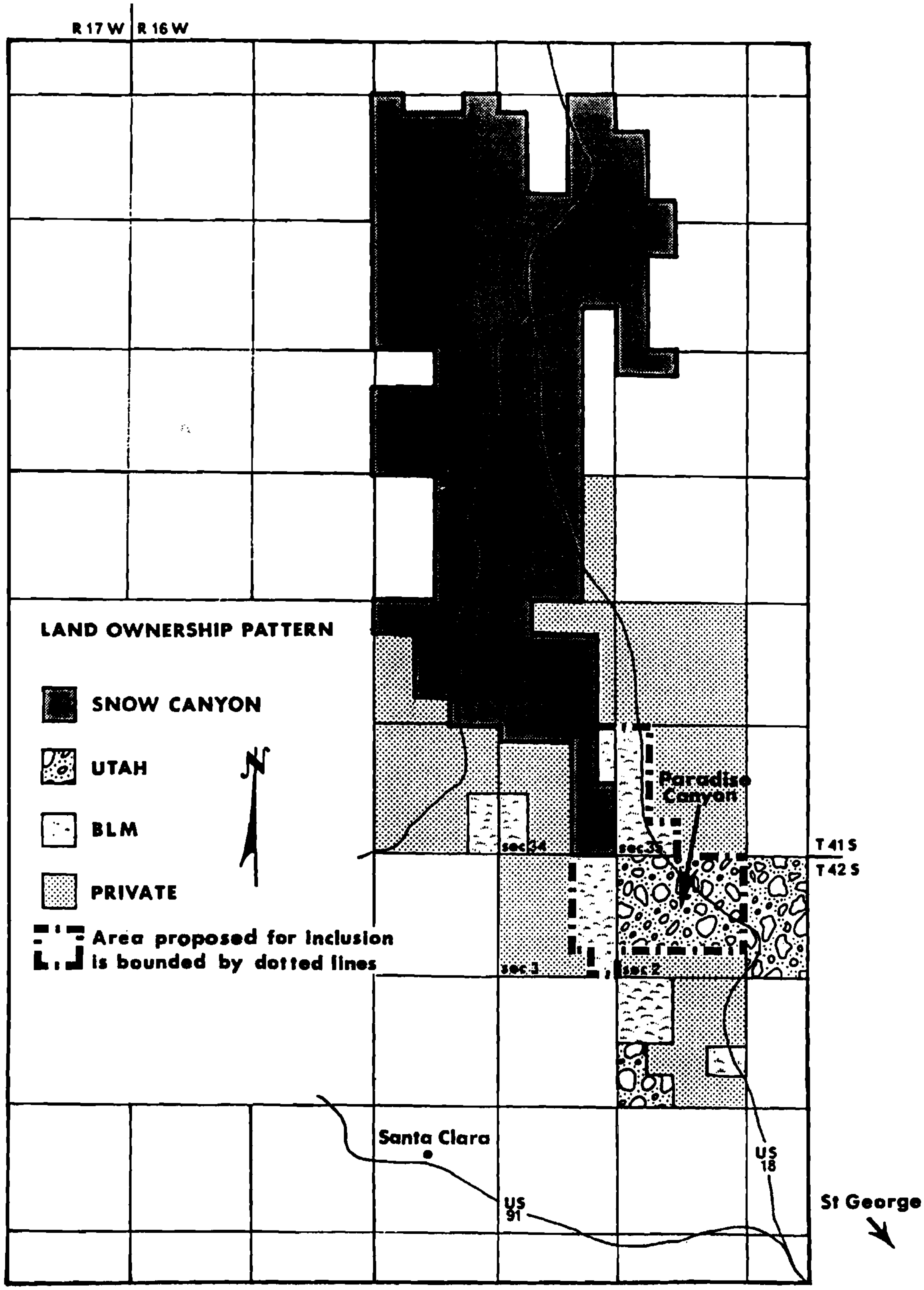

FIG. 1.—Land proposed for inclusion into Snow Canyon State Park.

growing on the dunes stabilize the sand and provide suitable substrate for tortoise summer pallets. The dominant perennial shrubs include sand sage (*Artemisia filifolia*), creosote bush (*Larrea tridentata*), blackbrush (*Coleogyne ramosissima*), and rabbitbrush (*Chrysothamnus viscidiflorus*). Annuals are abundant from late April through May after spring rains. Paradise Canyon has remained relatively free of livestock grazing.

PARADISE CANYON TORTOISES

Initial research in Paradise Canyon was summarized by Coombs (1974, 1977). During the 1970s, Coombs collected data on tortoise sizes, home ranges, sex ratios, and various other aspects of tortoise biology. Information gathered during 1982 and 1983 was taken during a Gila monster study and is the result of casual observations when time permitted collecting data on desert tortoises. Inferences drawn from these data should take this into consideration.

A total of 87 tortoises were measured for carapace length (MCL) during 1982 and 1983. The lengths, size class distribution, and sex ratios of these tortoises are presented (Appendix A). The current size distribution of the Paradise Canyon tortoise population compared with the previous size distribu-

TABLE 1.—Size class distribution (based on carapace length) of Paradise Canyon tortoise population in 1977 and 1983. Size class categories are from Coombs (1977).

	1977		1983	
Size class	N (estimate)	% of total	N (actual observations)	% of total
>250 mm (old adults)	26	15.5%	14	16%
200-249 mm (adults)	45	26.5%	29	33%
140-199 mm (young adults)	34	19.9%	19	22%
60-139 mm (juveniles)	47	27.7%	19	22%
<59 mm (hatchlings)	17	10.0%	6	7%
Totals	169 (estimated)		87 (observed)	

TABLE 2.—Weight (grams) of Paradise Canyon desert tortoises, 1983.

Weight	Length	Sex	Weight	Length	Sex
18	44 mm		2100	251 mm	f
28	48 mm		2165	221 mm	f
30	49 mm		2200	227 mm	f
44	59 mm		2215	217 mm	f
295	114 mm		2300	218 mm	f
314	120 mm		2350	221 mm	m
495	130 mm	m	2665	255 mm	f
515	136 mm	m	2675	246 mm	f
655	149 mm	f	2700	236 mm	f
780	157 mm	m	3220	250 mm	f
845	156 mm	f	3500	262 mm	f
865	155 mm	f	3565	265 mm	m
1005	169 mm	f	3800	269 mm	m
1200	184 mm	f	4250	267 mm	m
1215	171 mm	f	4300	276 mm	m
1330	186 mm	m	4900	295 mm	m
1850	214 mm	f	4985	220 mm	f
1985	218 mm	m	5300	307 mm	m
2015	227 mm				

tion obtained by Coombs in 1977 is presented (Table 1). During 1982 and 1983, numerous trackways of young tortoises were noted but not followed and often several tortoises would be passed in a single day. Perhaps a more intensive survey would have revealed more young tortoises and given the smaller size categories a larger percentage of the total. In any case, the Paradise Canyon tortoise population appears stable with a large percentage of mature females and a healthy concentration of small size classes. Weights of some Paradise Canyon tortoises are given in Table 2.

Growth data of tortoises have been gathered for over a decade in Paradise Canyon; growth information on 30 tortoises over periods of 5 to 9 years are presented (Table 3). The average growth per year for an individual tortoise in Paradise Canyon ranged from 25.2 mm per year to -0.45 mm per year (although this negative value may be an error in measurement). The overall average growth rate was 7.6 mm per year with a standard deviation of 6.2 mm.

TABLE 3.—Growth patterns of Paradise Canyon tortoises based on carapace length (mm). Size classes: 1=<60 mm; 2=60-99 mm; 3=100-139 mm; 4=140-179 mm; 5=180-207 mm; 6=208-239 mm; 7=>240 mm

Date	Length	Initial size class	Date	Length	Present size class	Change in length/years	Avg growth rate (mm per year)	Sex
9/74	42 mm	1	5/82	235 mm	6	193 mm/7.7 yrs	25.2	m
6/77	71 mm	2	4/82	135 mm	3	64 mm/4.8 yrs	13.3	
7/77	71 mm	2	6/83	120 mm	3	49 mm/5.9 yrs	8.3	
5/77	72 mm	2	6/83	130 mm	3	58 mm/6.1 yrs	9.5	m
8/77	91 mm	2	5/82	166 mm	4	75 mm/4.8 yrs	15.8	
7/76	91 mm	2	6/83	149 mm	4	58 mm/6.9 yrs	8.4	f
5/74	97 mm	2	5/83	218 mm	6	122 mm/9.0 yrs	13.6	f
6/77	104 mm	3	5/83	171 mm	4	67 mm/5.9 yrs	11.4	f
7/75	130 mm	3	5/82	247 mm	7	117 mm/6.8 yrs	17.1	
6/77	133 mm	3	5/83	220 mm	6	87 mm/5.9 yrs	14.7	f
6/77	144 mm	4	6/83	214 mm	6	70 mm/6.0 yrs	11.7	
7/75	145 mm	4	5/83	221 mm	6	76 mm/7.8 yrs	9.7	m
6/75	152 mm	4	6/82	237 mm	6	85 mm/7.0 yrs	12.1	m
8/75	157 mm	4	5/83	227 mm	6	70 mm/7.8 yrs	9.0	f
5/76	160 mm	4	6/83	222 mm	6	62 mm/6.9 yrs	9.0	f
8/75	161 mm	4	8/83	250 mm	7	89 mm/8.0 yrs	11.1	f
6/75	205 mm	5	5/82	210 mm	6	5 mm/6.9 yrs	0.7	f
6/77	211 mm	6	6/83	218 mm	6	7 mm/6.0 yrs	1.2	f
6/75	218 mm	6	5/82	227 mm	6	9 mm/6.9 yrs	1.3	f
6/75	222 mm	6	6/83	276 mm	7	54 mm/8.0 yrs	6.8	m
5/77	226 mm	6	5/82	240 mm	7	14 mm/5.0 yrs	2.8	
6/75	230 mm	6	5/82	240 mm	7	10 mm/6.9 yrs	1.4	f
9/74	234 mm	6	6/82	245 mm	7	11 mm/7.8 yrs	1.4	f
5/76	235 mm	6	6/83	251 mm	7	17 mm/7.1 yrs	2.4	f
6/75	245 mm	7	6/83	262 mm	7	17 mm/8.0 yrs	2.1	f
8/77	254 mm	7	5/82	263 mm	7	9 mm/4.8 yrs	1.9	m
8/76	255 mm	7	6/83	269 mm	7	14 mm/6.8 yrs	2.0	m
8/75	281 mm	7	6/83	307 mm	7	26 mm/7.8 yrs	3.3	m
5/76	283 mm	7	8/83	295 mm	7	12 mm/7.3 yrs	1.7	m
7/73	309 mm	7	5/82	305 mm	7	-4 mm/8.8 yrs	-0.45	m
							X = 7.6 mm/year	
							S = 6.2 mm/year	

Importance of the Paradise Canyon Tortoise Population

The importance of a second tortoise population is certainly enormous, especially in Utah where the desert tortoise is federally listed as a threatened species on the Beaver Dam Slope. Paradise Canyon tortoises could also serve as a wild transplant source for critical areas on the Beaver Dam Slope where tortoise populations have been dessimated by man. The free-living tortoises from Paradise Canyon would have a greater probability of survival on the Beaver Dam Slope than captive released tortoises. The issue of tortoise relocation and the potential of the Paradise Canyon population as a stock source will be further addressed in the panel discussion (as reported elsewhere in these Proceedings).

The Paradise Canyon tortoise population also has immediate research potential. Several years of data from Coombs' earlier studies and the recent observations provide a valuable foundation upon which further analyses of population structure and trends could proceed. The physical nature of Paradise Canyon (steep cliffs to the east, north, and west) has helped keep it relatively free from extensive human-related problems in the past and adds to an ideal field study environment. The lack of grazing in Paradise Canyon has helped to keep the vegetation relatively undisturbed. Tortoises can easily be found and monitored in Paradise Canyon. As trackways of hatchling and juvenile tortoises were commonly encountered, Paradise Canyon could provide a valuable site for observations of young tortoises.

Protection of Paradise Canyon Tortoises

Because of demands for human population growth and recreation, the Paradise Canyon tortoise population may be in jeopardy. Much of the south end of Paradise Canyon is planned as the site of extensive housing and recreational developments. However, efforts are underway to protect the remainder of Paradise Canyon and adjacent areas still under State and Federal ownership by including these regions within the boundaries of adjacent Snow Canyon State Park. A proposal describing the value of Paradise Canyon has been sent to various individuals and agencies in Utah and an intense campaign will follow in the coming months to persuade State officials that protection of Paradise Canyon is in the best interests of the people of Utah. Ownership of land surrounding Paradise Canyon and the region proposed for inclusion into Snow Canyon State Park is shown in Figure 1.

Are the Paradise Canyon Tortoises Native or Introduced?

The Paradise Canyon tortoise population has traditionally been considered as a "non-native" population, introduced to the area through the agency of man. There is little doubt that tortoise populations surrounding St. George have been augmented by released captives and escaped pets. Much of the parent stock of Paradise Canyon may have been released captive tortoises (Coombs 1977), but not necessarily all of it.

The Beaver Dam Mountains in extreme southwestern Utah and northwestern Arizona have usually been considered the northeastern boundary of the range of the desert tortoise (Hardy 1945, Woodbury and Hardy 1948, Coombs 1977). The

Beaver Dam Mountains supposedly have formed an abrupt immigration barrier that cuts off the Dixie Valley surrounding St. George from the deserts of Nevada and southern California, thus blocking the lowland route extending up the Virgin River toward St. George (Woodbury and Hardy 1948). However, several Mojave reptiles with distribution patterns similar to the desert tortoise have either crossed the Beaver Dam Mountains or, more likely, found alternative routes into the Dixie Valley. Among these reptiles are the Gila monster (*Heloderma suspectum*), the Mojave sidewinder (*Crotalus cerastes*), and the banded gecko (*Coleonyx variegatus*) (Stebbins 1966), all of which are native to the St. George area. It seems likely that the desert tortoise may have existed as a native resident of the St. George area before man's influence. Tortoises were found around St. George before 1922 (Van Denburgh 1922) and in 1926 (Tanner 1927). The idea that the desert tortoise may have been a native resident of the Dixie Valley before man's influence deserves further attention, and unless compelling evidence is presented to suggest otherwise, we believe the Paradise Canyon tortoise population should be considered as a native population augmented by tortoises released in the area.

ACKNOWLEDGMENTS

We are grateful to Ralph Foote, Roger Rumsey, Liz Krumpter, Mike Coffeen, and Jim Cline for field assistance. Jim Glenn, Mike Coffeen, and Dr. J. A. MacMahon provided valuable advice, support, and criticisms. Dave Emery and Gary Pascoe of Snow Canyon State Park generously provided field residence at Snow Canyon. The Utah Division of Wildlife Resources nongame section, Utah State University Department of Biology and Ecology Center, Utah Audubon Society, and Sigma Xi have provided financial assistance for current research in Paradise Canyon. Comments by reviewer Ken Dodd substantially improved the manuscript.

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APPENDIX A.

Size class distribution and sex ratios of Paradise Canyon, Utah, desert tortoises, 1982-1983. m = male; f = female. Overall sex ratio 23m:21 f. 27 undetermined. N = 87.

					m 237 mm	
					f 236 mm	
					m 235 mm	
					235 mm	
					m 235 mm	m 306 mm
					f 235 mm	m 305 mm
					m 230 mm	m 295 mm
					m 230 mm	m 289 mm
			175 mm		227 mm	m 287 mm
		138 mm	174 mm		227 mm	m 276 mm
		136 mm	171 mm		m 225 mm	m 269 mm
		135 mm	169 mm		m 222 mm	m 267 mm
		135 mm	166 mm		f 222 mm	m 265 mm
		135 mm	166 mm		m 221 mm	m 263 mm
		134 mm	160 mm		f 220 mm	f 262 mm
		130 mm	157 mm		f 218 mm	f 255 mm
		128 mm	156 mm		m 218 mm	f 251 mm
59 mm		128 mm	155 mm		f 215 mm	f 250 mm
50 mm	99 mm	120 mm	149 mm	f 205 mm	m 215 mm	f 247 mm
50 mm	91 mm	119 mm	141 mm	f 198 mm	f 214 mm	f 245 mm
48 mm	91 mm	114 mm	141 mm	m 191 mm	f 210 mm	m 240 mm
45 mm	80 mm	107 mm	140 mm	m 186 mm	f 210 mm	f 240 mm
44 mm	63 mm	102 mm	140 mm	f 184 mm	f 208 mm	f 240 mm
Juvenile I (MCL<60 mm)	Juvenile II (60-99 mm)	Immature I (100-139 mm)	Immature II (140-179 mm)	Subadult (180-207 mm)	Adult I (208-239 mm)	Adult II (>240 mm)
Sex ratios				2m:3f	10m:10f	11m:8f
Total=6	Total=5	Total=14	Total=15	Total=5	Total=23	Total=19

Proc. Desert Tortoise Council 1984 Symp., pp. 51-54

ARIZONA STATE REPORT ON THE DESERT TORTOISE (*GOPHERUS AGASSIZII*)

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Arizona is, to many, a paradox insofar as protection and management of the desert tortoise (*Gopherus agassizii*) are concerned. Desert tortoises may legally be taken from the wild by anyone holding one of several categories of hunting licenses or collecting permits. The legal take and possession limit, under the auspices of a hunting license, established in the 1984 Arizona Reptile Regulations (Arizona Game and Fish Commission Order 43, Part A) is one tortoise, which may be taken and possessed alive. None may be killed or exported from Arizona. Progeny of a lawfully held tortoise may, for twelve months from the date of hatching, be held in captivity in excess of the stated limits. Before or upon reaching twelve months of age, such progeny must be disposed of by gift to another person or as directed by the Department. Persons holding one of the special scientific or educational collecting permits can be authorized to take and possess as many tortoises as can be justified. These legal take limits are the most liberal of all states in which the desert tortoise occurs. Yet the tortoise is included in the 1982 Arizona Game and Fish Commission list of "Threatened Native Wildlife in Arizona." It is listed as a Group III species, or one whose ". . . continued presence in Arizona could be in jeopardy in the foreseeable future. Serious threats to the occupied habitats have been identified and populations (a) have declined or (b) are limited to few individuals in few localities."

Since the mid to late 1970s, several individuals and the Desert Tortoise Council have requested that Arizona "do something" to protect the desert tortoise. Such requests have included letters, meetings, telephone correspondence and intermittent dialogue of all kinds. Yet, in 1984, we see that the desert tortoise is no more (or less) protected in Arizona than it has been for several years. Obviously there has been no change in its legal status because of the considerable differences in opinion as to its biological status and the problems it faces in Arizona.

The explanation of the paradox of relatively liberal take limits and listing as a potentially threatened species is itself problematical. The intent of the "Threatened Native Wildlife in Arizona" list is to identify those species suffering from habitat related problems. Those species for which take and possession problems have been identified are addressed in various Commission Orders, such as Number 43, in which several reptiles are fully protected from any take or possession by listing in Part E. Examples of such species are the Gila monster (*Heloderma suspectum*) and various small, localized rattlesnakes (*Crotalus* spp.)

The logical conclusion to be drawn from this is that in Arizona the desert tortoise is presumed to suffer from habitat problems but not from the taking of individuals from the wild for private possession or for illegal sale in the pet trade. In fact, no substantial data drawn from Arizona studies have been presented to justify any such conclusion. The actions realized or proposed to date have largely been based on anecdotal information, in extrapolations of findings on tortoises inhabiting remarkably different ecosystems than the upland saguaro and paloverde dominated foothills in which the tortoise is most common in Arizona, on non-persuasive arguments made in highly emotional settings, and on conservative interpretation of the scant scientific information available.

There are several general and more specific areas in which more information must be obtained before progress can be made in developing management and protection programs for the desert tortoise in Arizona. First and foremost, we need an objective synthesis of past and current research on the tortoise in Arizona, with publication through a process that will ensure peer review. Such an effort must address similarities in conclusions in those studies but must also explain the real or perceived contradictions in their results. Publication of the several important agency and other reports must be a part of this process.

Secondly, in Arizona we need information in some specific areas of desert tortoise life history and population dynamics:

A. Reproductive rates: individual and population
B. Reproductive cycles: annual and long term
C. Age class distributions and sex ratios
D. Age class mortality rates
E. Mortality factors: e.g., predation, trampling, disease, etc.
F. Food habits
G. Dietary overlap and competition: what, who, where, when
H. Nutritional requirements and nutrient availability: native vs. exotic species available
I. Water balance and requirements
J. Winter denning characteristics and requirements
K. Impact of collecting
L. Impact of roads, canals and corridors on tortoise populations.

We also need information on the magnitude and effects of the captive desert tortoise problem in Arizona. Further, we must communicate information gathered to management agencies and to the public. We must provide our findings for peer review and scrutiny, so that agency action can be based on data and informed opinion, rather than on anecdotes and pressure. As we do so, perhaps we will finally achieve progress in managing and protecting the desert tortoise in Arizona.

ARIZONA
Reptile Regulations
1984

ARIZONA GAME & FISH DEPARTMENT
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COMMISSION ORDER 43: REPTILES OPEN SEASON DATES:	NOTES	EFFECTIVE DATE 1/1/84 - 12/31/84 OPEN AREAS	LEGAL REPTILES
A. January 1, 1984 through December 31, 1984	(1)	Statewide, except areas closed in R12-4-301 and R12-4-311.	Desert tortoise (Gopherus agassizii).
POSSESSION LIMIT: One (1) each — may be taken alive and possessed. None may be killed or exported from Arizona.			
B. January 1, 1984 through December 31, 1984		Statewide, except areas closed in R12-4-301 and R12-4-311.	Soft-shelled turtles (Trionyx spiniferus).
BAG AND POSSESSION LIMIT: Unlimited, except: On waters of the Colorado River the limit shall be five (5) per day or in possession dead or alive.			
C. January 1, 1984 through December 31, 1984	(1)	Statewide, except areas closed in R12-4-301 and R12-4-311.	Sceloporus undulatus and Lizards of the genera: Uta, Urosaurus, Cnemidophorus, Holbrookia, and Callisaurus.
BAG AND POSSESSION LIMIT: Twenty (20) per day or in possession in the aggregate dead or alive.			
D. January 1, 1984 through December 31, 1984	(1)	Statewide, except areas closed in R12-4-301 and R12-4-311.	All reptiles, except those named in Subsections A, B, and C above and in Subsection E below.
BAG AND POSSESSION LIMIT: Four (4) per day or in possession of each species dead or alive.			

E. There is no open season on Yellow mud turtle (Kinosternon flavescens), Flat-tailed horned lizard (Phrynosoma mcallii), Gila monster (Heloderma suspectum), Rock rattlesnake (Crotalus lepidus), Twin-spotted rattlesnake (Crotalus pricei), and Ridge-nosed rattlesnake (Crotalus willardi).

NOTE: (1) Progeny of lawfully held reptiles may, for twelve months from date of birth, be held in captivity in excess of the stated limits. Before or upon reaching twelve months of age, such progeny must be disposed of by gift to another person or as directed by the Department.

DO SOMETHING WILD
ON YOUR STATE TAX FORM

Class G or F hunting license is required for taking reptiles other than soft-shelled turtles.

A valid fishing license is required for taking soft-shelled turtles.

ARIZONA REPTILE REGULATIONS 1984 (continued)

R12-4-301 — SEASONS, OPEN AND CLOSED AREAS

A. Hunting or trapping seasons are closed on federal game ranges, federal refuges, federal parks and federal monuments unless specifically opened by Commission order.

B. The Fort Huachuca Military Reservation shall be open to the taking of wildlife in accordance with the Fort Huachuca Cooperative agreement. Any person hunting on the Fort Huachuca Military Reservation must have in possession a valid Fort Huachuca Military Reservation hunting permit.

C. Wildlife areas shall be open or closed in accordance with Commission order.

R12-4-313 — LAWFUL METHODS OF TAKING FISH, REPTILES, AMPHIBIANS, MOLLUSKS AND CRUSTACEANS

F. Reptiles, except soft-shelled turtles, may be taken only with legal firearm, by hand, spear, gig, snare, bow and arrow, sling shot, net, or trap. Reptiles may be taken at night with artificial light subject to the following restrictions:

1. Firearms shall not be used at night.
2. Moveable artifical lights shall not be attached to or operated from a motor vehicle.

A.R.S. Sec. 17-101 — Definitions

21. "Wildlife" means all wild mammals, wild birds and the nests or eggs thereof, reptiles, amphibians, mollusks, crustaceans, and fish, including their eggs or spawn.

A.R.S. Sec. 17-301 — Times when wildlife may be taken; methods of taking (See also R12-4-313)

A. A person may take wildlife, except aquatic wildlife, only during daylight hours unless otherwise prescribed by the commission. A person shall not take any species of wildlife by the aid or with the use of a jacklight, other artificial light, or illegal device, except as provided by the commission.

B. A person shall not take wildlife except aquatic wildlife, or discharge a firearm or shoot any other device from a motor vehicle, including an automobile, aircraft, train or powerboat, or from a sailboat, boat under sail, or a floating object towed by a powerboat or sailboat except as expressly permitted by the commission. No person may knowingly discharge any firearm or shoot any other device upon, from, across or into a road or railway

A.R.S. SEC. 17-306 — Importation, transportation, release or possession of live wildlife

No person shall import or transport into the state or sell, trade or release within the state or have in his possession any live wildlife except as authorized by the commission.

A.R.S. Sec. 17-331 — License Required

No person, except as provided by this title, or commission order, shall take any wildlife in this state unless at the time of taking he has a valid license therefor on his person and exhibits it upon request for inspection to any game ranger, wildlife manager or peace officer.

R12-4-319 — LIVE WILDLIFE REGULATIONS
(excerpts relative to reptiles)

A. Except as provided in Rule R12-4-111, live wildlife may be taken and held in captivity, imported, exported, possessed, transported, propagated, purchased, bartered, sold, leased or offered for sale only as authorized under the provisions of this rule.

B. The following live wildlife may be taken and possessed, transported, propagated or exported only as authorized by Commission Order:

1. Nongame mammals and nongame birds
2. Fish
3. Reptiles
4. Mollusks and crustaceans
5. Amphibians

C. No wildlife taken under the provisions of subsection B or their progeny may be purchased, bartered, sold, leased or offered for sale.

R. The following listed wildlife are "prohibited wildlife" and they may not be imported, exported, possessed, transported, propagated, purchased, bartered, sold, leased, or offered for sale except as expressly authorized by this rule.

3. Prohibited Reptiles:
   Alligators and Caimans, Family Alligatoridae
   Boomslang, Species Dispholidus typus
   Crocodiles, Family Crocodilidae
   Elapids, Family Elapidae (cobras, etc.)
   Gila monster, Mexican beaded lizard, Genus Heloderma
   Horned lizards, Genus Phrynosoma
   Rattlesnakes, Family Crotalidae
   Snapping turtles, Family Chelydridae
   Tortoises, Genus Gopherus
   Vine snake (Bird snake), Thelotornis kirtlandi
   Vipers, Family Viperidae

A.R.S. Sec. 17-371 — Transportation

A. A person possessing a valid license may transport lawfully taken wildlife other than big game given to him but in no event shall any person possess more than one bag or possession limit.

D. Heads, horns, antlers, hides, feet or skin of wildlife lawfully taken, or the treated or mounted specimens thereof, may be possessed, sold and transported at any time, except that migratory birds may be possessed and transported only in accordance with federal regulations.

REPORT VIOLATORS ON THE HOW-LINE
1-800-352-0700. IT'S TOLL-FREE

Proc. Desert Tortoise Council 1984 Symp., pp. 55-57

UPDATE OF DESERT TORTOISE (*GOPHERUS AGASSIZI*) DISTRIBUTION IN ARIZONA

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Distribution of desert tortoise (*Gopherus agassizi*) in Arizona has been generated from site specific studies (Hohman and Ohmart 1979, Sheppard 1982, Vaughan 1984, Schneider 1981, Whitham et al. 1982), Bureau of Land Management survey work (Burge 1979, 1980), museum records, and volunteer information from amateur herpetologists. To our knowledge there has never been a statewide survey that was designed to give an unbiased evaluation of the extent of desert tortoise distribution in Arizona.

Patterson (1982) synopsis of desert tortoise distributions indicates that the tortoise is limited to a few areas within Arizona and that there are no records of desert tortoise in large areas of potential habitat (upper Sonoran and Mojave Desert region).

Our work describes new desert tortoise distributional information that indicates the tortoise is distributed throughout Arizona within the upper Sonoran and Mojave Desert habitats.

MATERIALS AND METHODS

In addition to a thorough search of museum records and use of verifiable recent records from Burge (1979, 1980) we received sightings from a two-year Arizona Game and Fish Department survey of desert tortoises and used reliable sightings recorded in the Arizona Natural Heritage Data Management System.

During 1981 and 1982 Arizona Game and Fish Department employees were surveyed and asked to give recent sightings of desert tortoises. All sightings were evaluated to determine their reliability and only those sightings that were determined "reliable" were used in our survey.

In 1983 the files of the Arizona Natural Heritage Program Data Management System were evaluated and all reliable desert tortoise sightings were used in our survey.

RESULTS AND DISCUSSION

Our data, supplemented with museum records and Burge (1979, 1980) indicated that desert tortoise distribution in Arizona is extensive within the expected habitat types. There does not appear to be any major gaps in tortoise distribution with the exception of two sites in the Mojave Desert in northwestern Arizona (Fig. 1).

Because our data was gathered in a manner that was geared to a determina-

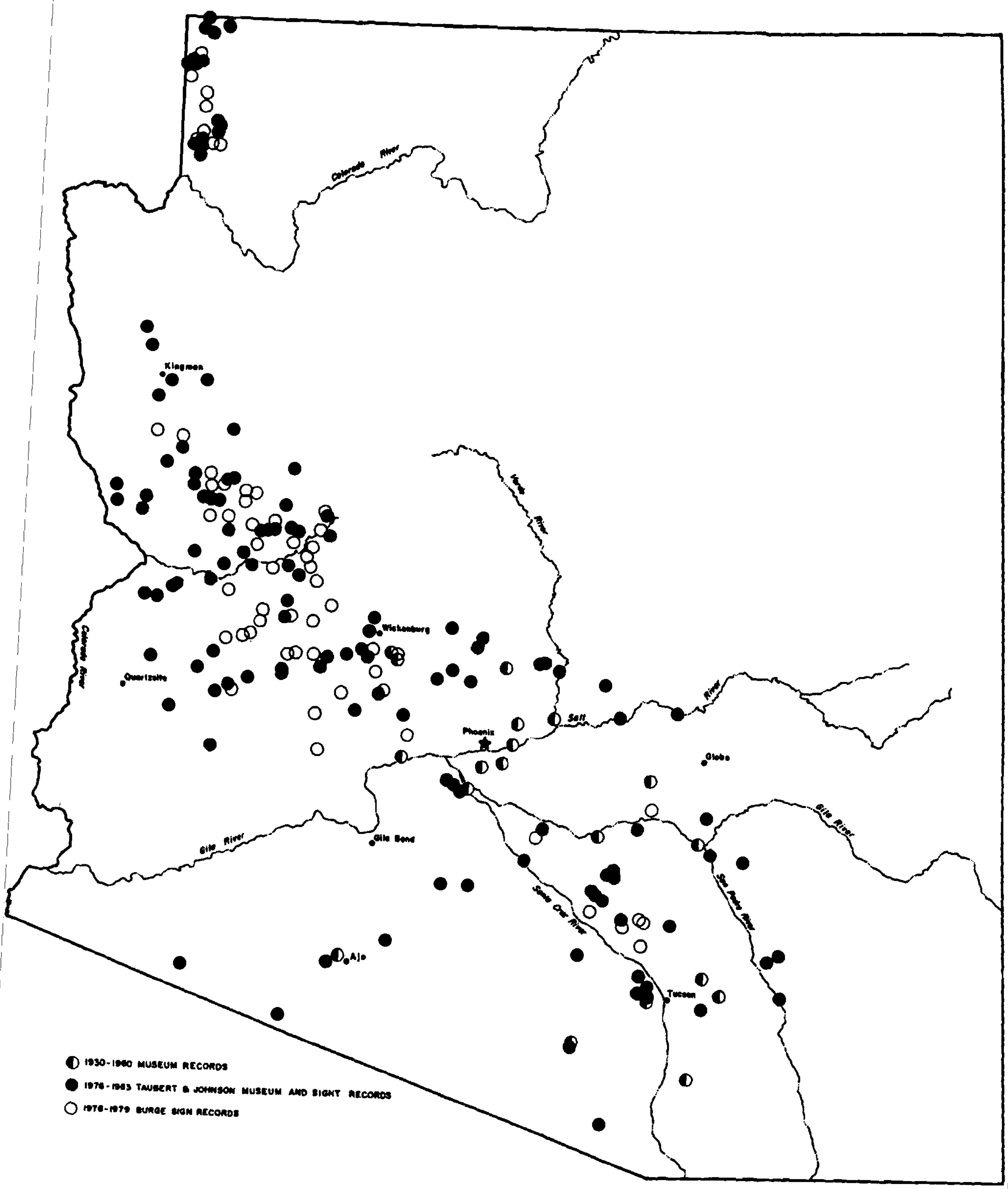

FIG. 1.—Update of desert tortoise distribution in Arizona.

tion of distribution alone, it does not speak to or add to our knowledge of the status of individual populations of desert tortoises. However, our data does suggest that distribution, in itself, is not limiting to desert tortoise numbers in Arizona.

Specific locality information is available from the Arizona Game and Fish Department.

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STATE REPORT - ARIZONA

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The following are highlights of management during the past year and continuing through the present, where the desert tortoise was involved.

Yuma District

The Yuma Resource Management Plan (RMP) is being written this year. Several special management areas are being proposed in the RMP. Part of the justification for some of these areas is occurrence of the desert tortoise and other state-listed species. The desert tortoise has become an issue for the Arizona Bureau of Land Management (BLM). Much of the credit is due to the Desert Tortoise Council and the Arizona Game and Fish Department (AGFD).

The Bill Williams-Crossman Peak Habitat Management Plan (HMP) was signed in the fall of 1983. It includes a planned action for AGFD to perform a reptile inventory, which would include the desert tortoise, to increase the database for future management. The Havasu Resource Area is documenting sightings of tortoises and the habitat in which they occur.

Phoenix District

The Hualapai HMP is presently being developed. This area includes Alamo Hill, the site of last year's Desert Tortoise Council field trip. Six monitoring sites will be set up for habitat monitoring. The sites will be picked in some areas of suspected higher tortoise densities and where the potential for deleterious range impacts are highest. Eventually, perhaps 30 sites in the Phoenix District will have habitat monitoring. We would like to work with the AGFD or volunteers on tortoise populations at a couple of sites.

One Allotment Management Plan has been written in the last year in tortoise habitat. The plan calls for spring rest of the best tortoise habitat, when tortoise forage is most crucially needed. The plan includes a rotational system that may improve perennial desert grasses used by the desert tortoise. Last year a computer database which stores habitat and locality information for sensitive species was developed. More than 350 desert tortoise records are in the database at the present time.

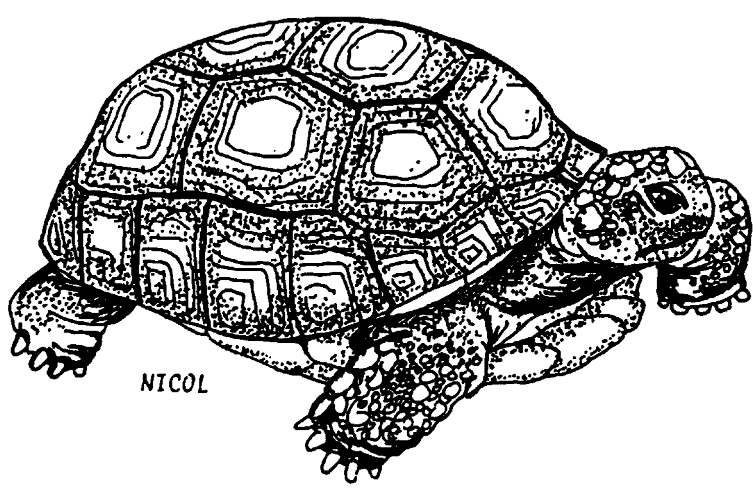
Arizona Strip District

The Virgin River-Pakoon HMP was completed in October 1983. The desert tortoise was the featured species, along with a nongame fish. The Littlefield land exchange is final. This action resulted in the exchange of 2,000 acres of private land comprising most of a desert bighorn lambing area in the Kingman Resource area for a small tract of public land near Littlefield, where crucial desert tortoise habitat occurs.

Two 20-acre exclosures in the Pakoon area were constructed in desert tortoise habitat. We will use these exclosures to evaluate fire and livestock effects.

Safford District

The Safford District has some tortoise habitat on its periphery. The District is obtaining more tortoise records for the scattered tracts on the west side of the district in preparation for a grazing environmental impact statement to be written in 1985.



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UPDATE OF THE DESERT TORTOISE (*GOPHERUS AGASSIZII*) STUDY IN THE PICACHO MOUNTAINS

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For the last two years, I have presented information to the Desert Tortoise Council on the study of the desert tortoise, *Gopherus agassizii*, in the Picacho Mountains in central Arizona. This study is funded by the Bureau of Reclamation to study impacts to the desert tortoise by the Central Arizona Project Canal, and is now in the final stages of data analysis.

From March 1982 to November 1983, seventy-one desert tortoises were marked, measured, and sexed for analysis of population structure. Fourteen tortoises were equipped with radio transmitters and monitored to determine home range and habitat use. Seasonal preference for den size, slope aspect, elevation, and percent slope, activity as a function of temperature, and food preference were measured. In addition, the study provided the opportunity to observe desert tortoise behavior in natural habitat and circumstances. Behavioral observations included combat between males, mating, and interspecific aggression with Gila monsters (*Heloderma suspectum*).

Combat between two male tortoises occurred 18 August 1982 at 0930 h, and consisted of 18 minutes of a dominant male (MCL = 226 mm) flipping, butting, and biting the head and legs of a subordinate male (MCL = 237 mm). The combat concluded when, in a righted position, the subordinate withdrew into his shell and offered no further resistance; the dominant retreated to a nearby den.

Two instances of mating were observed during the study. The first occurred 8 September 1982 at 0830 h (male, MCL = 236 mm; female, MCL = 235 mm). Courtship behavior consisted of cloacal sniffing, head bobbing and nipping by the male. The female responded by circling the male, keeping her head toward him. When the female tortoise finally allowed the male behind her, she elevated her pelvis and allowed him to mount her. After penetration and withdrawal of the penis, the male continued with thrusting motions until the female moved away causing the male to fall off. The male attempted to remount, but the female was not receptive and continued to move away. The second mating observation occurred 28 September 1983 at 1310 h (male, MCL = 274 mm; female, MCL = 221 mm). This pair was encountered after the male was already mounted on the female and mating ceased when the tortoises became aware of the observers.

Two accounts of agonistic interactions between female desert tortoises and Gila monsters were observed. The first occurred 14 July 1983 at 0538 h. For 1.5 h the Gila monster (est. 30 cm snout-vent length) attempted to enter the den (height 12 cm; width 62 cm; depth 70 cm) in which the female tortoise (MCL = 236 mm) was residing. Upon entry, the Gila monster began digging in the mouth of the den until it was aggressively pursued out by the tortoise. On one successful attempt, the Gila monster uncovered and consumed a tortoise egg (based on egg shell remains). During the encounter, the tortoise bit the Gila monster once on the tail and the Gila monster bit the tortoise once on the hind leg and once on the snout and jaws. The tortoise was located six weeks later and showed no adverse effects from the bites.

The second encounter between tortoise and Gila monster occurred 3.2 km from the first on 9 August 1983 at 0915 h. The female desert tortoise (MCL = 213 mm) was observed pursuing a Gila monster (est. 25 cm snout-vent length) out of a den (height 40 cm; width 49 cm; depth 25 cm). Upon leaving the den, the Gila monster became aware of the observers and attempted to reenter. The tortoise again pursued the Gila monster out of the den with mouth agape and neck extended. The Gila monster then retreated to a rock crevice and activity ceased.

Three desert tortoise eggs were found in the study area. The first egg was found in the middle of a wash on 13 July 1983, 19 m from the site of the first encounter between tortoise and Gila monster; the egg was not measured. A second tortoise egg was found on 25 August 1983 in the mouth of the den where the second encounter between tortoise and Gila monster took place; the egg measured 36.3 mm x 30.0 mm. The third egg was also found on 25 August 1983 in the mouth of another den (height 22 cm; width 37 cm; depth 150 cm) and measured 39.0 mm x 35.5 mm.

Details of these interactions between tortoise and Gila monster have been submitted for publication in *Southwestern Naturalist*. Details of the remainder of the study will be presented to the Desert Tortoise Council upon completion.

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THE ADOBE MOUNTAIN WILDLIFE CENTER

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The Adobe Mountain Wildlife Center, located north of Phoenix, Arizona, was designed as a facility to hold wildlife for various reasons, and is now administered by the Nongame Branch of the Arizona Game and Fish Department. The Center was built with aid from numerous conservation clubs, volunteer groups, the Game and Fish Department, and several veterinarians, e.g., Drs. Irv and Kathy Ingram, who have rehabilitated wildlife for many years.

The facility has many auxiliary functions in addition to holding wildlife. It is not open to the public daily, but does function as an information and educational facility due to the large number of telephone inquiries and the presentation of programs by the Coordinator and volunteers (slide shows, talks and demonstrations to educators, school groups, students and civic groups). The local media also focuses on some of the more popular programs and activities presented as a part of the Adobe Mountain Wildlife Program; television and press coverage has been excellent.

The Adobe Mountain Juvenile Institution is a residential correctional institution for juvenile male offenders, which is administered by the State Department of Corrections. Placement of the wildlife rehabilitation center on the grounds of the institution in 1983 was the result of innovative thinking and cooperative efforts among the two state agencies, the volunteer fundraisers and the veterinarians. Governor Babbitt spoke at the dedication ceremony held in May of 1983, and the Center has been extremely busy, housing thousands of animals since that date.

The Coordinator is the only paid employee budgeted for the Center. Volunteers aid in the transport and care of the animals, as well as in construction and maintenance. Certain young men residing at the school are allowed to help with the operation of the Wildlife Center by serving as Wildlife Care workers (feeding, checking, and providing water for the animals), or as Work Crew members (cleaning the cages and building, and maintaining the grounds). Many of the inmates seem to enjoy their duties at the facility and are learning about the various species which reside there.

Wildlife at the Center needs to be cared for because of a number of reasons. Most are injured and receive treatment from the volunteer veterinarians before being transferred to Adobe Mountain. Orphaned birds and mammals also account for a large percentage of the incoming wildlife, though attempts are made to discourage the public from bringing young animals, since many are NOT orphaned and will fare better in the wild than in captivity. Occasionally law enforcement cases require that an animal be confiscated and held as evidence until case settlement. Other instances include holding nuisance animals temporarily before release to the wild or placement (e.g., Gila monsters) and keeping desert tortoises until homes can be found for them. Wildlife recuperating, rehabilitating, or residing at the Center presently include red-tailed hawks, great horned owls, barn owns, a turkey vulture, a golden eagle, young javelinas, a coyote, gray foxes, desert tortoises, and several Gila monsters. The main goal is to release healthy animals to the wild when recommended, or to place those unsuitable for release in a facility (zoo, university, nature center, or breeding program) where they can be useful for educational or scientific purposes.

Whenever feasible, animals are released as close as possible to the location where they were obtained. This is most important for those low mobility species with small home ranges (desert tortoise, Gila monster). Springtime in Phoenix brings a rash of phone calls from the public regarding Gila monsters in backyards, or tortoises walking down the streets. Recently, questions about the advisability of releasing these reptiles in new locations have arisen. Do escaped captives carry disease organisms? Will a large, aggressive individual displace others from an established territorial and social system?

Rather than risk detrimental effects to the remaining native populations of these animals, no relocation of individuals will be carried out by our program. When wild-caught individuals are brought in, we record data (including location, date, and condition), provide veterinary care as needed, and then attempt to release the reptiles at the capture site. Desert tortoises and Gila monsters of unknown origin are provided to zoos, universities, and other licensed facilities. Gila monsters are protected by state law and cannot be kept as pets, while desert tortoises will be made available to individuals who wish to enjoy them as captives. This tortoise adoption program may help alleviate collection of wild individuals for pets.

Animals that do not survive also serve a purpose. The Game and Fish Department Information and Education Branch collects and distributes (to teachers) skulls which have been prepared at Adobe Mountain with the aid of a small colony of dermestid beetles. A volunteer functions as the Specimen Disposition Coordinator at the Center and is in charge of transferring the frozen, dead animals to properly licensed scientific or educational institutions. Some are preserved as study skins or skeletons for research purposes, while others are mounted for display. Museums and universities across the country have benefited from this program.

Food for the animals at the facility tends to be problematical because of budget problems and the ever-changing needs and requirements of the kinds of species held. Natural foods similar to what is available in the wild are important for proper health of the releasable animals. Donations of small animals — rabbits, pigeons, rats, mice, chickens, ducks, and larger farm animals to butcher for meat — are welcome, but rarely meet all the needs. Live animals are only used as food when the young birds of prey are learning to hunt. Other food items needed at the Center include produce, hay, seeds, grain, and dog and cat chow.

Future plans for the Center include expansion of the premises to include more space, and the construction of pens designed to hold small to mid-sized mammals. A compound designed for holding desert tortoises outdoors is projected. Streamlining the tortoise adoption program is also anticipated in the future.

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STATE REPORT - CALIFORNIA

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During 1983, Department activities regarding the desert tortoise included issuing captive tortoise permits, reviewing research proposals, and preparing a package for state listing. The Interagency Agreement with California State University, Fresno, was not renewed in 1983. Curt Uptain prepared a draft report on his work at the Desert Tortoise Natural Area as part of the agreement but has not finalized the report. The Department issued 6,318 captive tortoise permits during the past year, bringing the total to 26,500.

A research proposal to study genetic variations in California tortoise populations was submitted by Randy Jennings, University of New Mexico. The proposal was reviewed by the Department and the Desert Tortoise Council Research Advisory Committee. After some modification, the study was approved. A Memorandum of Understanding between the Department and the University of New Mexico will be issued to authorize the study.

A proposal to add the desert tortoise to California's list of Rare species was submitted to the Fish and Game Commission in July 1983. The proposal was withdrawn, however, because of concerns raised by the U.S. Bureau of Land Management (BLM). Basically, the Bureau was concerned with managing the many small and low density tortoise populations within California if the tortoise was state-listed. This concern was alleviated when both parties agreed to a modification of BLM's "Policies and Guidelines for the Conservation of Rare and Endangered Species Officially Listed by the State of California." Only tortoise populations shown on Map 8 of the California Desert Plan will be managed under the BLM's policy and guidelines.

We are planning to revise and resubmit the listing proposal to the Fish and Game Commission. If accepted by the Commission, public testimony will be heard at the August 3 meeting in Santa Barbara.

The California State Legislature passed an endangered species tax check-off bill which is eligible for the 1983 tax returns. We are anticipating about $500,000 the first year. First year funds will be used for promotion, enhancement, and acquisition projects.

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STATE REPORT - CALIFORNIA

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Declining budgets over the past few years have resulted in a wildlife program which can be described by three points. First, it precludes large expenditures for materials or contracts; in the past these have been the primary tools used in tortoise management and monitoring efforts. Second, current budgets support only one wildlife biologist in each of six offices (District and five Resource Areas); a few years ago we also had a tortoise specialist and a bighorn specialist. Third, low budgets necessitate the emphasis of projects for which funds and labor contributed by others can be obtained. It should be noted that due to a Congressional add-on of about 50% we have one of our highest wildlife budgets this year; however, the money was designated for specific federally listed species, and none could be spent on tortoise projects.

In recent years the Bureau of Land Management (BLM) has been very fortunate in obtaining assistance from various societies, corporations, individuals, and agencies, such as the California Department of Fish and Game and county wildlife commissions. The most significant of the wildlife accomplishments have involved fencing of burros and cattle from riparian and wetland areas, removal of tamarisk, and construction of upland game and bighorn guzzlers which are artificial water collection and storage devices.

To benefit the desert tortoise, Southern California Edison Company funded a study to examine tortoise natality, mortality, survivorship, and predation. A portion of this funding has gone to support the contributions of Dr. Kristin Berry of the Desert District Office. The study, being led by Dr. Fred Turner and Dr. Berry, is being conducted near Goffs over a period of several years using field personnel experienced in desert tortoise research. Dr. Turner will report elsewhere on this project. Southern California Edison also has supplied funding to the BLM to support Dr. Berry in analyzing behavior of small tortoises, developing a habitat model using 1,700 strip-transects, analyzing tortoise shell growth rings, analyzing causes of death in tortoises, and providing additional analysis of new data on carcass decomposition. Dr. Turner also is working on some of these projects. Dr. Berry will report separately on the findings on small tortoises.

Over the past ten years, the BLM has established 27 permanent trend plots, generally 1-2 square miles in size. Each plot assessment has consisted of a 30- or 60-day (or both) intensive search to gather data on population attributes and individual characteristics. Each of the 27 plots has been assessed from one to three times. These trend plot assessments have yielded a vast data base which has been used in analyses presented at previous symposia and which is being used in analyses currently in progress.

Fifteen of these permanent trend plots were selected for a monitoring program in which five plots per year would be assessed in a three-year cycle. It was intended that long-term population trends could be effectively determined and analyzed after several cycles. Unfortunately, funding over the last two years has been insufficient to implement this monitoring program; no trend plot assessments have been performed since 1982.

Last fall the BLM constructed a mile-square exclosure in a sheep allotment northeast of Kramer Junction in the western Mojave Desert. The hog-wire fence, raised 1-12 inches above the ground, excludes sheep but permits passage of tortoises and other small animals. The exclosure will allow future comparison of tortoise populations and vegetation between grazed and ungrazed areas. Unfortunately, this year we could not afford tortoise or plant composition studies which would have established baseline data in the exclosure for later comparison and which would have ensured that adjacent areas actually were comparable at the time the exclosure was erected. We have a slight reprieve, since annual plant production this winter and spring has been so poor that the BLM is not issuing any sheep grazing permits in the desert. The Desert Plan prescribed that 200 pounds of forage per acre be allocated to tortoises in crucial habitat and 350 pounds per acre in highly crucial habitat. Estimates this spring by wildlife and range staff of annual production were generally below 100 pounds per acre. Although poor forage production will presumably have a negative effect on tortoises, the lack of grazing outside the exclosure will give us another year to establish baseline studies.

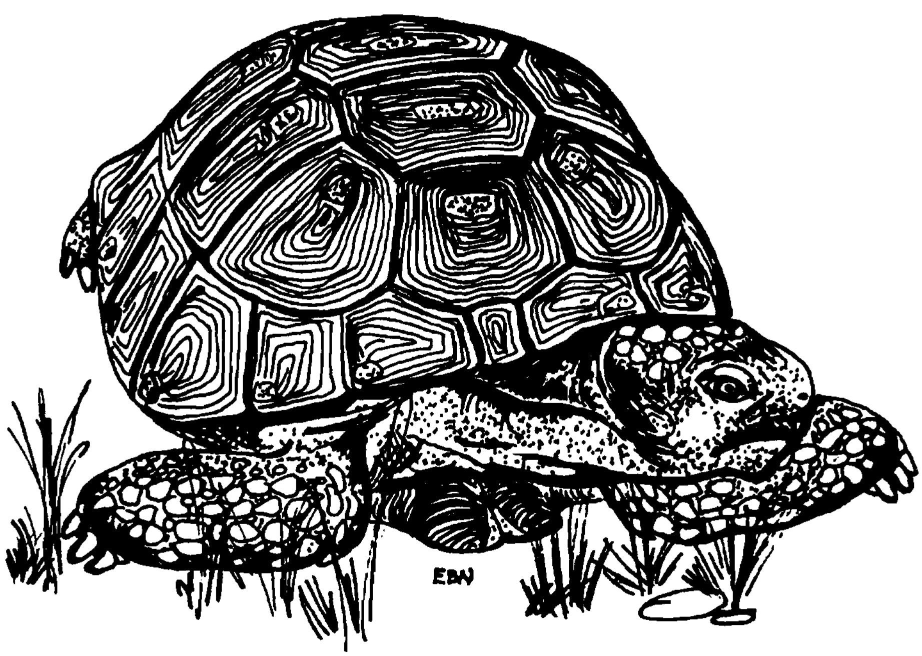
Two plans for Areas of Critical Environmental Concern (ACECs) involving crucial tortoise habitat have been drafted within the past year. The Chuckwalla Bench ACEC plan is being revised based on public comment; it will be reissued for public review this summer (1984). The West Rand ACEC plan underwent review in the fall of 1983 but has not yet been signed by the District Manager.

For the Desert Tortoise Natural Area (DTNA), the BLM has an agreement with a local firm to maintain the interpretive kiosk and other facilities. Hopefully, this will improve the maintenance record.

The DTNA currently has about 35 miles of fence. In the summer of 1983, three BLM employees repaired 10 breaks in the fence. This past winter, Steve Smith of the BLM in Ridgecrest walked the entire fenceline and recorded 41 breaks; only five of these appeared to be due to natural causes. In February, he and 11 members of the Desert Tortoise Preserve Committee repaired 27 of the 41 breaks; they plan to repair the remaining 14 breaks in late April. The BLM has attempted to emphasize patrol of the Natural Area, especially where violations have occurred in the past. On Washington's Birthday weekend, a helicopter was used, but no violations were observed.

BLM managers and rangers believe we are achieving improved compliance with measures instituted by the Desert Plan, especially those involving motorized vehicles. Our public contact program is aimed at further improving compliance with restrictions protecting desert resources. Our tortoise monitoring efforts should be increased, but since trend plots cannot be assessed by our staff biologists, the program must wait until funding is increased.

I expect that the results of current research will significantly improve our management potential. There are numerous and varied activities underway and proposed for the desert; our staff biologists do their best to furnish effective mitigation measures to reduce the impacts of these activities. We welcome your review of our plans and mitigations and your continued contributions of time and talent to projects, monitoring, and public awareness programs benefitting the desert tortoise.



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POPULATION ECOLOGY OF THE DESERT TORTOISE AT GOFFS, SAN BERNARDINO COUNTY, CALIFORNIA

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Abstract.—Work began in two 2.59 km^2 (1 m^2) areas near Goffs, California in 1983. Between April and October, 429 tortoises (⩾8 months old) were registered in Plot 1. Of tortoises ⩾180 m, 100 were females and 115 males. Egg production by 19 females was monitored in Plot 2 by radiography between mid-May and mid-July. Three females produced one clutch, 15 laid two, and one laid three. Mean clutch size was 4.2 ± 0.2 and mean clutch frequency was 1.9 ± 0.1. The smallest female laying eggs was 189 mm. Clutch size was positively correlated with body length. We estimated that 93 mature females in Plot 1 laid 796 eggs in 176 nests. At least 23% of nests in Plot 1 were destroyed by predators. We estimated that about 400 young were recruited in late summer 1983. Twelve hatchlings were marked at this time. Annual mortality of tortoises ⩾180 mm was estimated as about 2%.

Over the past 10 years the desert tortoise has emerged as a highly visible species — not only in California, but also throughout its range in the western U.S. (including parts of Arizona, Nevada and Utah). State and federal agencies have supported studies of local distribution, abundance and habitats. These studies have shown that some habitats of the desert tortoise have been and are continuing to be seriously disturbed by human activities. Strong circumstantial evidence suggests that the abundance of the tortoise has declined in many parts of its range. Concern for the tortoise in southwestern Utah led to its listing as Threatened under the Endangered Species Act in 1980.

Causes of habitat disruption are manifold. One source of impacts — both past and present — is development of energy facilities. Production and transmission of energy involves construction and maintenance of gas-, water-, and transmission-lines; roads, railroad spurs, wells, and power plants. The California Energy Commission recently identified the desert tortoise as the major biological issue associated with possible construction of a coal-burning power plant in Ivanpah Valley. The desert tortoise would also be a key issue if a 100 MW solar thermal power plant were constructed in Johnson Valley.

Southern California Edison Company is now considering wind and solar energy projects that will require considerable amounts of land — some of which will be habitat of the desert tortoise. These projects may require several hundred square miles of lowland desert habitat over the next 20 years. The requirements for such facilities will impinge on tortoise habitat already strained by other land-use commitments and demands.

The well-being of the tortoise will be an issue in connection with all future energy development projects within the species' geographic range. Utilities will be recurrently faced with questions as to likely consequences of new energy developments on the tortoise and how the effects of utility construction can be reduced or mitigated. Attacking these questions requires, first, a sound understanding of the natural history of the tortoise and the dynamics of its populations and, second, the conduct of appropriately designed field experiments. This report describes fieldwork during 1983 at a site in southeastern California, where we are measuring naturally occurring rates of recruitment and mortality of desert tortoises, and how such schedules may be affected by extrinsic factors. We expect this project to provide an appro-

TABLE 1. — Size distribution and sex ratio of desert tortoises registered in Plot 1 between 18 April and 14 October 1983.

Size class	Size range (carapace length, mm)	Sex: Not known[1]	Sex: Males	Sex: Females	Totals
Juvenile 1	<60	13			13
Juvenile 2	60-99	97			97
Immature 1	100-139	62			62
Immature 2	140-179	41			41
Subadult	180-207	1	15	32	48
Adult 1	208-239		29	66	95
Adult 2	⩾240		71	2	73
Totals		214	115	100	429

[1]The sex of tortoises <180 mm long cannot be reliably determined.

priate conceptual platform from which to design and carry out other tortoise-oriented studies related to siting and building energy facilities.

SITE DEVELOPMENT

The site selected for our study is in Fenner Valley southwest of Goffs, California, about 56 km west of Needles and north of I-40. We worked in two 2.59 km^2 areas. The first (Plot 1) is a BLM Permanent Tortoise Study Plot about 5.6 km southwest of Goffs. The second (Plot 2) is about 11 km southwest of Goffs. The elevation of this area is about 732 m. Both plots are on public land.

The Permanent Study Plot has been used in earlier BLM studies in 1977 and 1980 (Burge 1977, 1980). The plot lies on a bajada (2% slope) with southern aspect. The common perennial species are creosote bush, burro-bush, ratany, and various species of cholla cactus. Washes support smoke trees, catclaw, desert senna and joint fir. Cattle graze the plot in some years and have probably done so for 100 years, but usage in recent years apparently has been light. Plot 1 was used in investigations of death rates of various size groups of the population in 1983. Plot 2 was used to assess egg production by female tortoises. Further details of site development were given by Turner and Berry (1984).

RESULTS

Structure of the Plot 1 Population

Between 18 April and 14 October we registered 441 tortoises in Plot 1 (Table 1). Twelve of these were hatchlings entering the population in the late

TABLE 2. — Size distributions of desert tortoises at Goffs in 1980 (Burge 1980) and 1983.

Size classes (and ranges, mm)	1980	1983
Adults (208+)	161	168
Subadults (180-207)	26	48
Immatures (100-179)	84	103
Juvenile 2 (60-99)	20	97
Juvenile 1 (<60)	6	13
Totals	297	429

summer, and not included in the table. The other 429 tortoises were representative of the population occupying this plot during the 1983 field season. However, because of extensive movements of some males the April-October total is probably an overestimate of the population. The size distribution reflected in Table 1 differed importantly from similar data reported by Burge (1980: Table 2). Table 2 contrasts size distributions of the 1980 and 1983 sampling. These two distributions differ significantly (X^2 = 39.3, 4 d.f.), principally because relatively more small tortoises (<100 mm long) were taken in 1983. Chi-squared totals for the Juvenile 2 size-class contributed 70% of the total X^2 value. It is possible that the age composition of the Goffs population changed between 1980 and 1983, but we believe the difference simply reflects greater effort to find smaller tortoises in 1983. Burge worked alone in 1980 for about 60 days; in 1983 as many as four people searched for animals and the importance of small tortoises was emphasized from the outset.

Density of the Plot 1 Population

Burge (1980) estimated the density of tortoises at the Goffs plot in several ways. All of her estimates related to the entire population of tortoises (all size classes) occupying the study area. Paul Schneider reexamined Burge's 1980 capture-recapture data using the Stratified Lincoln Index (SLI). This analysis provided estimates of the total population (417) and of four constituent size classes (76 juveniles, 138 immatures, 40 subadults and 163 adults).

In 1983 we did not attempt to estimate numbers of tortoises less than 140 mm in length because of low recapture rates of smaller tortoises (*see* Schneider 1980, Shields 1980, Turner et al. 1982). We did carry out capture-recapture analysis of that portion of the Goffs population composed of larger tortoises. This analysis was based on four samples taken between 18 April-15 May, 16-18 May, 30 May-1 June, and 14-16 June. Other tortoises were registered between 19 and 29 May, 2 and 13 June, and after 16 June, but these did not enter our analysis unless they were recaptured in a subsequent census period. During the

TABLE 3. — Capture-recapture data for desert tortoises ⩾140 mm long in Plot 1 at Goffs in 1983.

Dates	X_t	n_t	x_t	$n_t X_t^2$	$x_t X_t$
May 16-18	157	88	63	2,169,112	9,891
May 30-June 1	182	76	63	2,517,424	11,466
June 14-16	195	91	81	3,460,275	15,795
				8,146,811	37,152

first census period 157 tortoises ⩾140 mm long were registered in Plot 1. The subsequently acquired data were treated as a chain of samples, as described by Schumacher and Eschmeyer (1943). These figures are given in Table 3. In this table X_t is the number of marked tortoises at risk just before the t_{th} sample, n_t is the number of tortoises in the t_{th} sample, and x_t is the number of marked tortoises in the t_{th} sample. The estimate of the number of tortoises ⩾140 mm in length is

$$N = \Sigma n_t X_t^2 / \Sigma x_t X_t \tag{1}$$

or 219. The 99% confidence interval — computed as described by De Lury (1958) — was 218-220.

We may now see (Table 1) that the total number of tortoises ⩾140 mm long marked in 1983 (257) exceeds the capture-recapture density estimate (219). This is because some tortoises marked during the periods between censuses were not subsequently recaptured, and others were captured after mid-June. There is also the problem of immigration. Certainly some tortoises moved into Plot 1 during the course of our work, and these transients may have been recorded. This problem is particularly acute with males. Fortunately, the exact size of the Goffs population is not an immediate concern. The size of the population of breeding females is more important, and this group is less influenced by immigration (or emigration). Hence, while there is uncertainty as to the number of tortoises ⩾140 mm in Plot 1, we are probably not too far wrong in taking the 100 females ⩾180 mm long (Table 1) as an estimate of the breeding population. We are even less certain as to numbers of tortoises <140 mm long (that part of the population we did not try to estimate), and can say only that we are dealing with a group exceeding 172 individuals.

Egg Production by Tortoises in Plot 2

We monitored egg production by tortoises in Plot 2 by X-irradiation (*see* Gibbons and Greene 1979). Most of this work was carried out with female tortoises fitted with radiotransmitters. Radiotelemetry was necessary because subject females had to be recaptured and examined periodically. We used SB-2 low power (0.11-0.20 ma) transmitters provided by AVM Instrument Company. The transmitters had frequencies distributed between 150 and 152 mHz. Transmitters and batteries were housed in a specially fabricated fiberglass holder attached to the anterior portion of a female's carapace. A 3.2 mm-wide copper foil loop antenna (1/4 wave length) was also affixed to the carapace. A Telonics TR-2 receiver, a hand-held directional antenna, and a Telonics TDP-2 digital data processor completed our telemetry equipment.

Our X-ray machine was a portable MinXray 300: a 30 mA-90 kV unit with built-in electronic timer and collimator. The machine was mounted on a specially fabricated stand and used with commercial current at the Goffs store. We used 24 cm square medium speed Cronex 4 X-ray film in metal cassettes. For the first month we used a setting of 20 mA and 80 kV peak for 0.4 seconds (8 mA-seconds). In mid-June we changed the time to 0.25 seconds (5 mA-seconds) and obtained better prints. Film was developed at the Mohave Veterinary Clinic in Bermuda City, Arizona.

TABLE 4. — Clutches of eggs produced by 19 desert tortoises at Goffs in 1983. Underline indicates different clutches.

Tortoise number	Carapace length (mm)	May 12-13	May 26-29	June 8-10	June 19-21	June 26-28	July 3-5	July 10-12	July 17-18	Clutch frequency
1004	205		3	0	2	2	0	0	0	2
1005	231		6	6	0	7	7	7	0	2
1007	195		6	6	0	0	0	0	0	1
1026	218		5			3	0	0	0	2
1027	200		4	4	0	4	4	4	4	2
1041	208	4	4	4	4	0	0	0	0	1
1059	215	0	4	0	6	6	6	0	0	2
1061	213	4	5	5	2	2	2	0	0	3
1063	193	0	3	3	4	4	4	0	0	2
1064	198	4	4	0	0	0	0	0	0	1
1065	216	3	0	6	6	0	0	0	0	2
1067	191	0	3	4	4	4	0	0	0	2
1071	202	0	4	0	5	5	5	0	0	2
1072	192	0	3	3	0	4	4	0	0	2
1073	247	6	5	6	0	0	0	0	0	2
1077	216		4	4	4	0	0	0	0	2
1078	189		2	1	1	1	0	0	0	2
1079	201		5	5	0	0	3	3	0	2
1084	227			5	4	4	4	0	0	2

On 12-13 May, 10 adult female tortoises were collected in Plot 2, taken to Bermuda City, X-rayed, and returned to be released at point of capture. Ten additional adult females were collected between 26-29 May. One of these tortoises had a carapace length of 189 mm, 5 were between 191 and 200 mm, 6 between 201 and 210 mm, 5 between 211 and 220 mm, and 3 were greater than 221 mm. Transmitters were attached to these individuals. They were X-rayed at the Goffs store and released. One of these animals disappeared and was never retaken. The other 19 made up our experimental group. The general procedure was to locate a group of 4-6 animals in the late afternoon. The following morning these animals were collected, taken by car to the Goffs store (7 miles), X-rayed, returned to the plot, and released at points of collection. This process usually took about 3-4 hours. These steps were repeated until all of the tortoises (or as many as could be found) had been processed. This procedure was repeated on 8-10 June, 19-21 June, 26-28 June, 3-5 July, 10-12 July, and 17-18 July.

Table 4 shows the history of 19 tortoises with transmitters between mid-May and mid-July. The interpretation of data in Table 4 is based on two points: first, the number of eggs counted in X-rays; and, second, egg shell thickness. When two clutches of the same size were produced by the same female, we were still able to recognize that one clutch had been laid and another started (e.g., *see* Number 1077, 26-29 May and 8-10 June). In this instance the June eggs had very thin shells.

By 3 July, 47% of females were still carrying oviductal eggs. On 18 July only one tortoise of 19 examined had eggs, and this was a clutch started in late June. The total interval of egg production (early May to July 18) was certainly sufficient for the development of three clutches, but in only one instance did our data suggest that this occurred (Number 1061).

We estimated mean clutch frequency (1.89) by dividing the total estimated number of clutches laid (36) by the number of females laying them (19). All females laid a first clutch, 16 of 19 apparently laid a second, and one a third. The mean size of the first clutch (4.1) did not differ significantly from the mean size of the second (4.3), and the overall mean clutch size was

TABLE 5.—Mean sizes and ranges in size of clutches produced in Plot 2 at Goffs in 1983.

Clutches	*n*	Percent of females laying	Mean size $\pm$ one standard error of mean	Range in size
First	19	100	4.10 ± 0.26	2-6
Second	16	84	4.25 ± 0.39	1-7
All	35	-	4.17 ± 0.22	1-7

4.2. The range in clutch size was from 1 to 7 (Table 5). Clutch sizes were positively correlated with female body size, and this was true whether one examined first clutches, second clutches, or all clutches combined. The equation for predicting clutch size (*C*) from carapace length (*MCL*, mm) based on the 35 clutches in Table 5 is:

$$C = 0.054MCL - 7.22 \tag{2}$$

This predicts a clutch size of around 3.1 for a 190-mm female and a clutch size of 5.7 for a female 238 mm long.

Copulation of desert tortoises has been reported in Arizona during the fall (Tomko 1972), and this behavior was conspicuously evident in our study areas between late summer and October 1983. Many courtship rings were observed

TABLE 6. — Estimated egg production by 93 sexually mature desert tortoises in Plot 1 at Goffs during 1983.

Mid-point of size interval (mm)	Number of females	Mean clutch size	Eggs laid (first clutch)
190[1]	1	3.10	3.10
193	5	3.26	16.30
198	6	3.53	21.18
203	6	3.81	22.86
208	11	4.08	44.88
213	12	4.35	52.20
218	13	4.62	60.06
223	18	4.89	88.02
228	13	5.16	67.08
233	4	5.43	21.72
238	3	5.71	17.13
247[1]	1	6.20	6.20
Totals	93		421

[1]Actual body size, no interval mid-point.

in Plot 1. Between mid-July and mid-September 82% of 17 females examined were mounted by one or more males. Temporary identification numbers were written with a permanent marking pen on the epoxy covering the antenna encircling each female's carapace. The numbers were on the fifth vertebral — at the rear of the carapace. Numbers were often obscured by vertical abrasion. Judging from this evidence, about 40% of females were mounted between 20 September and 13 October. Seven females apparently copulated during both intervals. We have no evidence that insemination occurred during these incidents, although Tomko reported discharge of fluids from the cloaca of the female tortoise he observed. Seventeen tortoises were X-rayed between 19-21 September and 11-13 October and no shelled eggs were evident in radiographs.

If viable sperm can be retained by females over winter, fall copulation may simply serve to increase the probability of insemination of every mature female. Or autumnal copulation may promote bonds between particular males and females. Whatever purpose is served, there is no evidence that eggs are produced in fall.

All of the 19 X-rayed females were sexually mature and produced at least one clutch of eggs. The smallest female in our sample was 189 mm long. We adopt this value as the size at sexual maturity, although we recognize that not all females become mature at the same size. The tortoises X-rayed were somewhat smaller than the Plot 1 breeding population. To compensate for this, we used Equation (2) relating clutch size to body size to estimate egg production by the Plot 1 females (Table 6). This shows that these 93 females could have been expected to lay about 421 eggs (first clutch) and then another 375 eggs in second clutches (421 x 0.89). These estimates do not make allowance for growth of females between the laying of the first and second clutches. It is also assumed that the likelihood of producing two clutches is not size-dependent. The 796 eggs laid would have been deposited in 176 nests.

Mortality of Tortoises in Plot 1

Pre-natal mortality.—Between mid-May and 1 July, 3-13 August, and late September and early October, we searched Plot 1 for signs of nest destruction by predators. Destruction of clutches was inferred from both excavated nests and remains of egg shells. During June, we located 18 nests excavated by kit foxes, coyotes, badgers and possibly other predators. Predation was attributed to foxes in five cases, badgers in four, and to coyotes in one instance. Destroyers of the other nests could not be determined. Between 1 July and 3 August when the next survey was begun, 41.4 mm of rain fell. This obscured much of the activity of predators. During the 11-day August survey, 21 nests and egg shell clusters were discovered. The August survey period was followed by extraordinarily heavy rains, but in spite of their effects two additional excavated nests were located in September and October. At least 41 nests, then, were destroyed by predators. We have assumed that no eggs survived these depredations, although one intact egg was found in one opened nest. If 176 nests were laid and 41 destroyed, we can estimate the minimal rate of nest destruction in 1983 as 23%.

Lampkin (1966) stated that it is not unusual for half the eggs laid by captive female desert tortoises to be infertile. Legler (1960) reared 60 eggs

TABLE 7. — Size distribution and sex ratio of remains of desert tortoises taken at Goffs in 1983.

Size Class	Size range (carapace length, mm)	Sex: Not known	Sex: Males	Sex: Females	Totals
Juvenile 1	<60	7[1]			7
Juvenile 2	60-99	38[1]			38
Immature 1	100-139	14[1]			14
Immature 2	140-179	0			0
Subadult	180-207		2		2
Adult 1	208-239	2	2	2	6
Adult 2	≥240			5	5
Totals		61	4	7	72

[1]The sex of tortoises <180 mm long cannot be reliably determined.

of box turtles in the laboratory and found 15 (25%) to be infertile. However, only 36 (80%) of the 45 fertile eggs hatched. We never located an intact nest with eggs, so we have no measure of natural infertility. For present purposes we will assume 66% of eggs laid (and not destroyed) hatch.

If nest destruction is independent of the number of eggs in the nest, we can estimate that of 796 eggs laid, 183 were destroyed by predators. Of the remaining 613, we estimate that about 405 hatched at some time during the autumn of 1983.

Death-rates of tortoises.—During the 1983 season we removed 72 carcasses or other remains of tortoises from Plot 1 (Table 7). Five of these remains were in scats, and of these four were of small tortoises (≤102 mm long). If Plot 1 was completely cleared of remains in 1980 and again in 1983, and if no carcasses were removed from or brought onto the plot during this interval, the figures in Table 7 provide estimates of numbers of death among size groups whose members were alive in 1980 (all but the Juvenile 1 category). The 1980 Stratified Lincoln Index analysis provided estimates of the numbers of tortoises alive in 1980, viz., 76 juveniles, 138 immatures, 40 subadults, and 163 adults.

A X^2-test of numbers of tortoises presumed to have survived and died among the immature, subadult and adult size classes is statistically insignificant (X^2 = 1.75, 2 d.f.). That is, if we take these values at face value, there is no support for estimating anything other than a common rate of survival for all

TABLE 8.—Remains of desert tortoises judged to have died at Goffs after 1 July 1983.

Size class	Size range (carapace length, mm)	1 July 1982 - 30 June 1983	1 July - 14 October 1983	Totals
Juvenile 1	<60	1	5	6
Juvenile 2	60-99	22	2	24
Immature 1	100-139	9	11	20
Immature 2	140-179	0	0	0
Adult 1	208-239	0	1	1
Totals		32	19	51

size groups, viz., 314/341, or 0.92. The deaths are presumed to have occurred over a 3-year period, and if we assume that survival was constant over this interval we can estimate annual survival ($\underline{\lambda}$) as:

$$e^{-3\underline{\lambda}} = 0.9208 \qquad (3)$$

Hence, the annual survival rate is about 97.3%.

The validity of this estimate rests on the conditions set forth on the previous page, as well as the reliability of the SLI estimates of various size components of the 1980 population. We consider the foregoing procedure reasonable for subadult and adult tortoises (i.e., those ≥180 mm long) because (1) carcasses of tortoises this size are fairly conspicuous and do not disintegrate readily (Woodman and Berry 1984, Berry and Woodman 1984), and (2) the SLI estimates of numbers are reliable. The picture is less clear for immature tortoises because smaller remains are harder to see, disintegrate somewhat more rapidly, and are probably more readily displaced. A conservative approach to the numbers in Table 7 would be to estimate a 3-year survival rate for only subadults and adults (190/213). The annual rate derived from this value is 97.8%, essentially the same as the previous rate. Berry and Woodman (1984) estimated an annual death rate of 1.2% for adult tortoises at Goffs between June 1972 and June 1980, based on remains collected in 1977, 1978, and 1980. This estimate spanned an 8-year interval because the time of death of some of the carcasses could be placed as much as 5 years in the past.

We can split out more recent deaths among the 72 remains collected in 1983 (Table 8). If one adult among an estimated group of 168 (*see* Table 1) died in 3½ months, we can convert this to an annualized death-rate of 2%, or a survival of 98%. This is about what the analysis of all carcasses showed. However, the figures pertaining to smaller tortoises suggest a problem. Table 7 shows that remains of 59 juvenile and immature tortoises were collected in 1983, and Table 8 shows that 50 of these were judged to have died since July 1982. This could be taken as evidence that roughly 5.5 times as many deaths occurred between July 1982 and mid-October 1983 than between the summer of 1980 and July 1982. We consider it more likely, however, that these data simply reinforce the idea that remains of small tortoises are not as persistent as those of older individuals (Woodman and Berry 1984). Hence, the data in Table 8 are a better estimate of death rates among smaller tortoises. The problem is that we do not know how many small tortoises were alive in the spring of 1982, i.e., there is nothing to which the 50 deaths can be related. If we want to assume that the 1982 population was like the 1980 population, and accept the SLI density estimates of 76 juveniles and 138 immatures, we can estimate a 16½-month survival

TABLE 9. — Life-table parameters for the desert tortoise at Goffs, California, based on work in 1983.

Parameters	Estimated values	Remarks
Sex ratio	1:1	Typical of most California populations
Female age at maturity	Not known	Usually assumed to be 15-20 years
Female body size at maturity	189 mm	
Reproductive lifetime	Not known	Captive females ⩾80 years old have laid eggs
Mean clutch size	4.2	
Clutch frequency	1.89	Probably approaching maximal capacity; certainly above modal performance
Pre-natal mortality due to predation	23%	Minimal estimate for 1983
Losses due to natural infertility of eggs or failure to develop	Not known	50% infertility of eggs of captive tortoises has been reported
Mortality from hatching to ensuing spring	Not known	
Annual mortality rate to size of 180 mm	Not known	
Annual mortality rate of larger females (assumed age-constant)	2%	Not an unusual estimate, but higher rates have been reported

rate of 164/214 (77%) among these tortoises (82.5% per year). There is, then, some suggestion in Table 8 that death-rates among smaller tortoises exceed those of older tortoises. This would not be at all surprising, and has been shown to be true among *Chrysemys picta* in Michigan (Wilbur 1975, Tinkle et al. 1981). However, there are so many uncertainties with respect to numbers of smaller tortoises and our ability to find their remains, that we must leave the issue of early mortality open for now.

SUMMARY

Table 9 summarizes the present status of our knowledge of the Goffs desert tortoise population. For present purposes we assume an age of 20 years for the attainment of sexual maturity by females at Goffs. The clutch frequency estimate (1.89) derived from 1983 sampling is probably higher than would normally occur. Turner et al. (1984) estimated clutch frequencies of 1.1 (1981) and 1.6 (1980) in Ivanpah Valley, California. For present purposes we will use a mean clutch frequency of 1.5. This means that each reproductively mature female will, on average, produce 6.3 eggs in a season, with the potential for 3.15 female hatchlings. The mortality parameters in Table 9 have already been discussed. We assume a maximum life-span of 100 years.

This information can be used to set up a provisional estimate of the lifetime egg production (and potential female offspring) of a cohort of 100 females which have attained the age of 20 years (12,691). This exercise, and problems in reconciling estimates of fecundity, apparent survival, and observed size-distributions of desert tortoise populations were detailed by Turner and Berry (1984: 36 et seq.). The difficulty is well illustrated by the actual registration of 12 hatchlings at Goffs in 1983, at a time when indirect calculations suggested recruitment of roughly 400 individuals. An understanding of this discrepancy is the most compelling problem of desert tortoise demography.

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VETERINARY MANAGEMENT OF THE DESERT TORTOISE, *GOPHERUS AGASSIZII*, AT THE ARIZONA-SONORA DESERT MUSEUM: A RATIONAL APPROACH TO DIET

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Abstract.—Using published surveys of plant species consumed by the desert tortoise, *Gopherus agassizii*, and published nutritional analyses of these plants, dietary guidelines for captive *G. agassizii* were calculated. A variety of foods commonly fed captive tortoises were evaluated using these guidelines, as were a number of artificial forages.

A number of pathologic processes may be associated with inadequate diet: fatty liver infiltration, enteritis, cloacal infections, and metabolic bone disease.

Based on levels of crude protein, fat, crude fiber, carbohydrates, calcium-phosphorus ratios, and dry matter content compatible with natural nutritional regimens, a combination of alfalfa hay, bermuda grass, and natural forages is recommended as the major component of the captive desert tortoise diet.

If the desert tortoise, *Gopherus agassizii*, is to be effectively managed in captivity, it is obvious that its nutritional requirements must be met. Captive *G. agassizii* are commonly fed a variety of fruits and vegetables. Other food items — including bran, hamburger, dog food, cat food, bread, and cheese — are also occasionally included in dietary regimens. Since no controlled studies of the specific nutrient requirements of *G. agassizii* have been conducted, most captive diets have been formulated either arbitrarily or on the basis of palatability, with only cursory attention to nutrient requirements of herbivorous reptiles. However, Fowler (1976) compared natural forages with common captive food items and noted disparaties in protein and available energy.

Unfortunately, diseases of dietary origin are commonly encountered in *G. agassizii*, as well as in other captive Testudinidae, by veterinarians practicing reptile medicine. Some diseases, such as metabolic bone disease, can be directly attributed to nutrient deficiencies or imbalances (in this case, deficient dietary calcium and/or deleteriously high levels of dietary phosphorus). Other disease processes, such as fatty liver infiltration, enteritis, and cloacal infections, may have more obscure relationships to dietary practices. To add further confusion, the results of nutritional deficiencies may not become apparent for some time. In my veterinary practice, it is not unusual to see *G. agassizii* which have existed on a diet of iceberg lettuce exclusively for two years before becoming severely debilitated.

TABLE 1.—Nutritional analyses of the major foods of the desert tortoise.*

Food	% Protein	% Fat	% Crude fiber	% CHO	% Ca	% P	Ca:P
Brome, foxtail (*Bromus rubens*)	8.5	N.R.	31.6	N.R.	0.28	0.23	1.2:1
Cryptantha (*Cryptantha* sp.)	7.5	N.R.	27.7	N.R.	2.06	0.30	6.9:1
Eriogonum (*Eriogonum* sp.)	6.6	N.R.	N.R.	N.R.	1.03	0.09	11.4:1
Euphorbia (*Euphorbia* sp.)	14.4	4.1	13.0	57.5	1.19	0.26	4.6:1
Fescue, six weeks (*Festuca octoflora*)	13.0	2.5	27.4	47.1	0.44	0.22	2.0:1
Filaree, redstem (*Erodium cicutarium*)	16.5	N.R.	18.2	N.R.	2.51	0.47	5.3:1
Fluffgrass (*Tridens pulchellus*)	7.6	1.4	29.1	39.2	0.99	0.06	16.5:1
Globemallow (*Sphaeralcea angustifolis*)	20.4	2.4	23.2	42.3	3.34	0.31	10.8:1
Grama, red (*Bouteloua trifida*)	7.6	2.3	33.0	48.4	0.61	0.10	6.1:1
Muhly, bush (*Muhlenbergia porteri*)	7.3	1.8	36.9	48.1	0.27	0.09	3.0:1
Plantain (*Plantago* sp.)	13.3	1.9	15.9	59.1	4.16	0.19	21.9:1

TABLE 1.—Nutritional analyses of the major foods of the desert tortoise (cont.)

Food	% Protein	% Fat	% Crude fiber	% CHO	% Ca	% P	Ca:P
Prickly pear (*Opuntia* sp.)	7.0	3.1	9.3	60.4	6.29	0.08	78.7:1
Sedge (*Carex* sp.)	11.5	3.1	29.5	47.5	0.46	0.29	1.6:1
Threeawn (*Aristida* sp.)	6.3	1.5	34.8	48.7	0.59	0.09	6.6:1
Tridens, slim (*Tridens muticus*)	9.1	1.8	34.1	44.1	0.61	0.17	3.6:1
Vetch (*Astragalus* sp.)	23.2	2.7	19.1	46.3	1.65	0.39	4.2:1
Winterfat, common (*Eurotia lanata*)	11.3	2.3	31.5	41.0	1.90	0.12	15.8:1

*Compiled from studies by Coombs (1977), Burge and Bradley (1976), and Hansen et al. (1976); nutritional data provided by Miller (1958).

N.R. = not reported.

TABLE 2.—Nutritional analyses of foods commonly consumed by captive desert tortoises.*

Food	% Protein	% Fat	% Crude fiber	% CHO	% Ca	% P	Ca:P	% Dry matter
Apples	1.1	3.6	6.4	85.5	0.04	0.06	0.7:1	15.6
Avocados	6.1	47.3	6.9	18.2	0.03	0.12	0.3:1	26.0
Bananas	3.0	0.6	2.5	62.1	0.02	0.07	0.3:1	24.3
Beans, green	19.3	1.8	14.1	71.6	0.57	0.44	1.3:1	9.9
Beet greens	24.2	3.4	14.3	50.6	1.31	0.44	3.0:1	9.1
Broccoli	32.9	2.8	11.9	54.1	0.94	0.72	1.3:1	10.9
Cabbage	16.9	1.9	10.5	71.4	0.64	0.38	1.7:1	7.6
Carrots	8.4	1.5	8.5	73.1	0.28	0.27	1.0:1	11.8
Chard, Swiss	27.0	3.5	9.0	51.7	0.99	0.44	2.3:1	8.9
Collards	32.7	5.4	6.1	51.0	1.70	0.56	3.0:1	14.7
Corn, sweet	7.0	2.0	2.9	44.5	0.006	0.22	0.03:1	27.3
Cress, garden	24.5	6.7	10.4	51.8	0.76	0.72	1.1:1	10.6
Dandelion greens	18.7	4.9	11.1	63.8	1.30	0.46	2.8:1	14.4
Endive	25.7	2.9	11.4	60.0	1.17	0.78	1.5:1	6.9
Grapes, American	4.0	4.1	2.7	55.4	0.05	0.04	1.3:1	18.4
Kale	34.6	4.6	7.5	52.0	1.44	0.54	2.7:1	17.3
Lettuce, iceberg	22.0	trace	11.1	66.7	0.44	0.44	1.0:1	4.5

TABLE 2.—Nutritional analyses of foods commonly consumed by captive desert tortoises (cont.).

Food	% Protein	% Fat	% Crude fiber	% CHO	% Ca	% P	Ca:P	% Dry matter
Lettuce, romaine	21.2	6.1	11.7	57.6	1.12	0.42	2.7:1	6.0
Muskmelon (cantaloupe)	7.8	1.4	6.8	85.1	0.16	0.18	0.9:1	8.8
Mustard greens	28.5	4.8	10.5	53.2	1.74	0.48	3.6:1	10.5
Oranges	5.2	1.2	4.3	63.5	0.21	0.10	2.1:1	14.0
Parsley	26.8	6.7	10.1	60.4	1.34	0.40	3.4:1	14.9
Peaches	4.7	1.0	5.5	77.5	0.07	0.15	0.5:1	10.9
Spinach	35.3	3.9	6.5	47.1	1.00	0.55	1.8:1	9.3
Squash, Italian	22.9	1.4	...	67.1	0.51	0.54	0.9:1	5.4
Strawberries	6.7	4.7	13.9	79.9	0.20	0.20	1.0:1	10.1
Tomatoes	15.4	3.1	9.2	66.2	0.18	0.38	0.5:1	6.5
Turnip greens	30.9	3.2	8.3	51.6	2.54	0.60	4.2:1	9.7
Watermelon	6.8	2.5	8.1	86.4	0.09	0.14	0.6:1	7.4

*Nutritional data provided by Adams (1975).

TABLE 3.—Nutritional analyses of artificial forages.*

Food	% Protein	% Fat	% Crude fiber	% CHO	% Ca	% P	Ca:P	% Dry matter
Alfalfa hay	17.3	2.1	31.4	40.3	1.64	0.26	6.3:1	89.7
Alfalfa meal, pelleted	20.9	3.2	23.2	41.2	1.35	0.30	4.5:1	91.9
Bermuda grass	11.6	2.1	25.9	50.0	0.53	0.22	2.4:1	36.7
Bermuda grass hay	8.9	2.0	29.6	52.8	0.46	0.20	2.3:1	91.1
Ryegrass, Italian	16.3	4.2	21.8	42.0	0.64	0.41	1.6:1	24.3
Timothy hay	7.7	2.6	33.8	50.3	0.37	0.19	2.0:1	87.7

*Nutritional data provided by Miller (1958).

TABLE 4.—Natural nutritional regimens of the desert tortoise.*

Study	% Protein	% Fat	% Crude fiber	% CHO	Ca:P
Burge and Bradley (1976)	15.4	2.9	18.7	52.3	3.6:1
Hansen et al. (1976) - lower Grand Canyon	10.9	2.0	31.0	45.5	5.8:1
Hansen et al. (1976) - New Water Mts.	9.0	1.8	34.0	45.6	4.6:1
Hansen et al. (1976) - Beaver Dam Wash	11.2	...	27.9	...	3.2:1

*Nutritional data provided by Miller (1958).

Several studies of natural foods of *G. agassizii* have been conducted at various localities. These include Coombs' study in Utah (1977), Hansen et al. (1976) in Arizona and Utah, and Burge and Bradley (1976) in Nevada. It would seem reasonable that nutritional analyses of the foods of wild tortoises should provide guidelines for formulating a desirable captive tortoise diet. This study augments Fowler (1976), and reveals further disparaties between natural and captive diets, and perhaps helps reveal possible dietary relationships to disease.

METHODS

A composite list of the major plant species consumed by *G. agassizii* was prepared (Table 1) utilizing the "major foods" described by Coombs (1977), and food items with a 4% or greater frequency of consumption listed by Hansen et al. (1976) and Burge and Bradley (1976). Nutritional data for these plant species were provided by Miller (1958). Values listed under the heading protein are actually crude protein, fat values are actually ether extract, and carbohydrate values (CHO) are actually nitrogen-free extract. All percentages are dry weight. Since seasonal variation of nutrients may be apparent in a given plant species, mean values of nutrients for all analyses are given for the majority of plants listed. Exceptions are red grama (*Bouteloua trifida*) where past bloom values are given; and *Euphorbia* sp., vetch (*Astralagus* sp.), and prickly pear (*Opuntia* sp.) where analyses of aerial portions of immature plants are given. Calcium (Ca) and phosphorus (P) values for fluffgrass (*Tridens pulchellus*) and bush muhly (*Muhlenbergia porteri*) are from mature and very mature plants, respectively. Nutritional analyses of *Chorizanthe rigida*, *Tridens pilosus*, and *Janusia gracilis* have not been reported, so these species were omitted from Table 1. Miller (1958) did not specify the species analyzed of the genera *Eriogonum*, *Cryptantha*, *Euphorbia*, *Opuntia*, and *Plantago*, and Hansen et al. (1976) did not specify the species consumed of the genera *Aristida*, *Sphaeralcea*, *Carex*, and *Astragalus*, so values listed for these genera may not reflect nutritional analyses of the actual plant species consumed. Since little information regarding moisture, vitamin, mineral, amino acid, and fatty acid content of these wild grasses and forbs is available, no attempt was made to include these important nutrients in Table 1.

A list of food items commonly fed to captive tortoises was compiled (Table 2). Nutritional analyses of these foods were provided by Adams (1975), and converted from "as eaten" to a dry weight basis by computation. Hence, the values in Tables 1 and 2 may be compared directly.

Table 3 consists of a list of artificial forages. Nutritional analyses were provided by Miller (1958). Again, protein is actually crude protein, fat is actually ether extract, and carbohydrate values are actually nitrogen-free extract. All percentages are on a dry weight basis. Values for alfalfa hay, bermuda grass, bermuda grass hay, timothy hay, and Italian rye grass are means of all analyses reported.

To formulate nutritional regimens of wild tortoise populations (Table 4), the nutrient proportions listed in Table 1 were applied to the frequencies of consumption reported by Burge and Bradley (1976) and Hansen et al. (1976).

The major foods reported by Burge and Bradley (frequency determined from feeding observations) were *Plantago insularis* (34.3%), *Sphaeralcea ambigua* (26.8%), *Festuca octoflora* (6.5%), *Euphorbia albomarginata* (6.5%), and *Opuntia ramosissima* (4.6%). Nutrient values for *Sphaeralcea angustifolis* were substituted for *S. ambigua* since values for the latter have not been reported. As described earlier, Miller's (1958) data for *Plantago* sp., *Euphorbia* sp., and *Opuntia* sp. were used, although some species variation is certain to exist.

The major foods reported by Hansen et al. (frequency determined from fecal pellet analyses) were: in the lower Grand Canyon — *Aristida* spp. (22%), *Sphaeralcea* spp. (21%), *Tridens muticus* (20%), *Bromus rubens* (19%), *Bouteloua trifida* (6%), and *Carex* spp. (3%); of the New Water Mountains — *Tridens muticus* (50%), *Muhlenbergia porteri* (17%), *Aristida* spp. (16%), *Janusia gracilis* (11%), and *Sphaeralcea* spp. (6%); and — of Beaver Dam Wash — *Bromus rubens* (64%), *Erodium cicutarium* (23%), *Eurotia lanata* (6%), and *Astragalus* spp. (4%). Nutritional data have not been reported for *Janusia gracilis*, so it was not included in computations. Likewise, nitrogen-free extract and ether extract percentages could not be located for *Bromus rubens*. Since its frequency of consumption is so great in the Beaver Dam Wash study, values for % fat and % carbohydrate could not be computed for this site.

Overall percentages of protein, fat, crude fiber and carbohydrate components, and overall calcium-phosphorus ratios (Ca:P) were calculated for each study site based on frequency of use of individual plant species. Table 4 provides a crude but usable nutritional description of the natural diet of *G. agassizii* from these study areas, and should, in turn, provide guidelines for formulating captive tortoise diets. In order to accurately describe natural dietary regimens, it is imperative that samples be submitted for nutritional analysis from the individual plant species, the plant parts, and from the season consumed.

It would be enlightening to compare natural dietary regimens of *G. agassizii* from different parts of its range. Since three of the four study sites represented in Table 4 are near the northernmost extent of desert tortoise range, nutritional component values may be biased toward high energy and low crude fiber content.

DISCUSSION

A number of the foods presented in Table 2 are considerably higher in fat content than the highest reported fat level in Table 1 (*Euphorbia* sp., 4.1%). These include avocados (47.3%), collards (5.4%), garden cress (6.7%), romaine lettuce (6.1%), and parsley (6.7%).

Under certain conditions high fat diets have been implicated in the pathogenesis of fatty liver infiltration (lipid hepatosis) of mammals (Smith and Jones 1966). Frye (1981) reports obesity as the most common cause of this degenerative liver change in captive reptiles. It may be significant that in a necropsy survey of 86 captive *Gopherus* spp. conducted by Rosskopf et al. (1981), lipid hepatosis was the second most common liver disease found.

High fat diets have also been implicated in metabolic bone disease. Excessive long-chain fatty acids in the small intestine result in the formation of insoluble calcium soaps, reducing absorption of ingested calcium (Harrison and Harrison 1974).

The majority of foods listed in Table 2 are lower in crude fiber than the lowest reported crude fiber level in Table 1 (*Opuntia* sp., 9.3%), and all foods listed in Table 2 have lower crude fiber levels than those presented in natural dietary regimens (Table 4). The importance of crude fiber in maintaining intestinal motility and a healthy intestinal mucosa is well known. Bacon (1980) provides a summary of the role of crude fiber in the normal digestive physiology of the Galapagos tortoise, *Geochelone elephantopus*, and implicates low dietary crude fiber levels in the pathogenesis of bacterial enteritis and cloacal infections. Rosskopf et al. (1981) found intestinal pathology evident in 50.7% of the captive *Gopherus* spp. surveyed. Obviously, insufficient dietary crude fiber levels do not account for all intestinal pathology of captive *G. agassizii*, but its importance as a contributing factor in the pathogenesis of enteritis should not be overlooked.

The lowest calcium-phosphorus ratio listed in Table 1 (*Bromus rubens*, 1.2:1) is higher than those of the majority of foods listed in Table 2. Only three captive food items (mustard greens, 3.6:1; parsley, 3.4:1; and turnip greens, 4.2:1) have higher calcium-phosphorus ratios than the lowest overall ratio presented in Table 4.

The high incidence of metabolic bone disease, resulting from feeding diets too low in calcium and/or too high in phosphorus, in herbivorous reptiles is well documented (Cooper and Jackson 1981, Fowler 1978, Frye 1981, Marcus 1981). The clinical appearance of metabolic bone disease in tortoises ranges from the soft shell, pathologic fractures and general debilitation found in rickets to the pyramidal carapace scute deformities and overgrown nails found in nutritional osteodystrophy (Cooper and Jackson 1981). A comprehensive summary of calcium and phosphorus metabolism may be found in Fowler (1978).

The high incidence of metabolic bone disease in captive tortoises, and the rather high calcium-phosphorus ratios found in natural nutritional regimens of *G. agassizii* (Table 4), may imply calcium-phosphorus ratios advocated by Cooper and Jackson (1981), 1.2:1 and Murphy (1973), 2:1, to be inadequate.

Although very little information is available on dry matter content of native grasses and forbs, it is expected that these values would be considerably higher than the dry matter content of most fruits and vegetables. Fowler (1976) effectively demonstrated the nutrient-dilution consequence of feeding a food item high in water content (lettuce).

The relatively high water content of fruits and vegetables may have a beneficial effect in facilitating phosphorus excretion by the kidneys through diuresis in captive tortoises receiving inadequate calcium-phosphorus ratios in their diets. This may account, in part, for the aforementioned ability of tortoises on calcium deficient diets to avoid obvious ill health for prolonged periods.

RECOMMENDATIONS

If the nutrient compositions of the diets of wild populations of *G. agassizii* (Table 4) are used as a guideline, it becomes apparent that no fruit or vegetable listed in Table 2 should be used as the staple of a captive tortoise's diet. The only artificial food item which closely approximates natural diet composition is alfalfa hay (Table 3). Therefore, I recommend that captive tortoises be fed either alfalfa hay or natural forages predominately. Other artificial forages may, and probably should, be included in a dietary regimen to provide diversity and to increase moisture content. A combination of alfalfa hay and bermuda grass should provide an excellent foundation for captive desert tortoise diets. Fruits and vegetables listed in Table 2 should be offered in small amounts and infrequently.

OTHER FEEDING PRACTICES IMPLEMENTED AT THE ARIZONA-SONORA DESERT MUSEUM

Meats, including dog and cat food, and cheese are discouraged because of their high fat and low crude fiber contents. Grains and grain products, including bran, bread, and wheat germ are discouraged because of their grossly inadequate calcium-phosphorus ratios.

At the Arizona-Sonora Desert Museum, and in private practice, I have found multiple vitamin supplements to be unnecessary. I have advocated carotene supplementation in the form of grated carrots once a week to avoid vitamin A deficiencies. Bermuda grass is also a good source of vitamin A, providing 127.5 mg carotene per pound of forage (Miller 1958).

Calcium supplementation, in the form of calcium gluconate, calcium lactate, or calcium carbonate are provided only to those tortoises with severe calcium deficiencies. Vitamin D is best provided by allowing tortoises exposure to direct sunlight.

To insure adequate levels of trace minerals are provided, tortoises at the Arizona-Sonora Desert Museum are offered shavings from a trace mineral salt block, sprinkled over their food, once weekly.

Tortoises become conditioned in their dietary preferences, and it may be difficult to convert a tortoise which has been eating fruits and vegetables to either natural or artificial forages. This conversion may be facilitated by at first sprinkling lightly moistened alfalfa leaves or pelleted alfalfa meal over its preferred food items, or by offering freshly cut alfalfa. Diligence is important in making these dietary transitions. Since these natural and artificial forages generally do not provide the moisture content that captive tortoises become accustomed to, it is advisable to provide frequent access to water during, and for at least two months following, dietary conversion.

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SHELL ANOMALIES IN THE DESERT TORTOISE (*GOPHERUS AGASSIZII*) POPULATIONS OF THE BEAVER DAM SLOPE, UTAH, AND DESERT TORTOISE NATURAL AREA, CALIFORNIA

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Abstract.—This study is a survey of shell anomalies found in two desert tortoise (*Gopherus agassizii*) populations. One is located on the Beaver Dam Slope, Washington County, Utah; the other is in the Desert Tortoise Natural Area, Kern County, California. Significant differences in the percent of total shell anomalies were found when these populations were compared: the Desert Tortoise Natural Area had 11.22% scute anomalies while the Beaver Dam Slope had 20.40%. Particular types of anomalies appear to be associated with each of the populations. Causes of shell anomalies may be environmentally and/or genetically based.

Anomaly frequency and type among desert tortoise populations in California and Utah are compared, and habitat variables are analyzed as to how these factors apply to the question of tortoise shell anomalies within the bounds of contemporary theory.

STUDY AREAS

Beaver Dam Slope, Washington County, Utah, and Mohave County, Arizona

The Beaver Dam Slope is located in extreme southwestern Utah and northwestern Arizona, surrounded by the Beaver Dam Mountains and the Virgin River. Baseline data from Utah (Minden 1980, Minden and Keller 1981) and Arizona (Hohman and Ohmart 1979) Beaver Dam Slope populations were combined to increase the total sample size from the Beaver Dam Area. Minden (1980) did a series of quadrat surveys within the Woodbury and Hardy areas, covering much of the Utah Beaver Dam Slope. Minden and Metzger (1981) examined a 2.59-km^2 plot in the southwestern portion of Township 43S, R18W, Utah, bisected by the Old Mormon Highway. This plot falls within sections 20, 21, 28, 29. Elevation ranges from 670.5 to 1066.8 m. The other study was done on two 2.59-km^2 plots (Hohman and Ohmart 1979): one is located in section 27 of T41N, R15W, and the other in a fenced enclosure in section 34 of T42N, R12W. Elevation ranges from 548.6 m at the Virgin River to 823 m at the Utah-Arizona border.

The soil type in these areas is a sandy loam. Vegetation is classified as a Lower Sonoran Community. An average precipitation of 24.2 cm occurs bimodality. Temperatures are extreme, and great daily and seasonal fluctuation is common. Cattle grazing is the major habitat disruption.

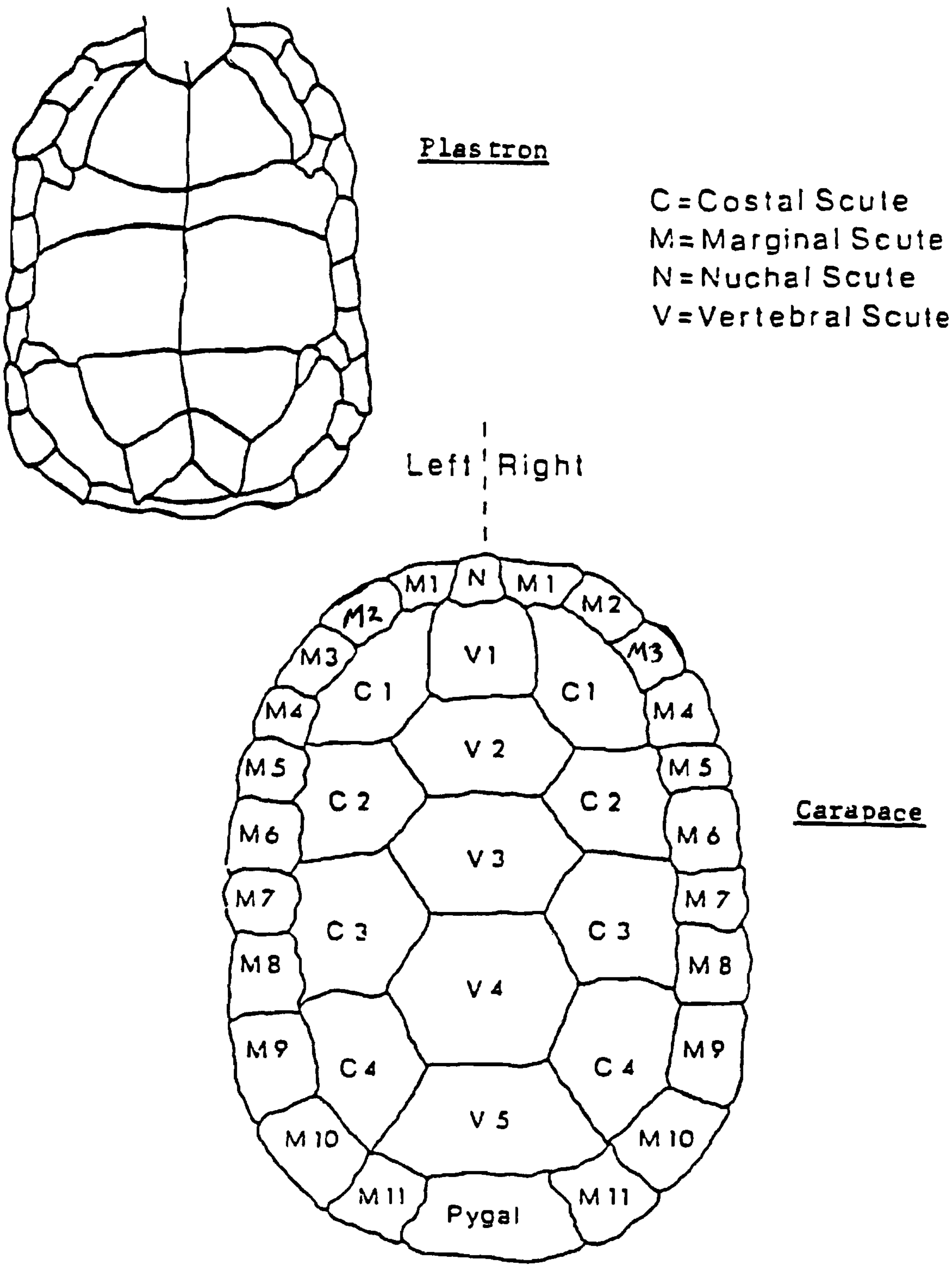

FIG. 1.—Standard scutellation on carapace and plastron of desert tortoise.

Desert Tortoise Natural Area,
Eastern Kern County, California

The site is approximately 9.5 km north-northeast of California City in the southwestern reaches of the *Gopherus agassizii* distribution range.

The data analyzed here was from a survey conducted by Shields et al. (1979) which covered these areas: T31S, R38E, SW 1/4 section 27, all of section 34, W1/2 section 35, and T32S, R38E; NW1/4 section 2 and N1/2 section 3. Seven of the twelve quarters chosen were inside the boundaries of the preserve and the remaining five were outside.

Elevation ranges from 739-799 m. The soil is mostly a sandy loam. Rainfall is unimodal, with an annual precipitation of 24.2 cm. Temperature fluctuations are gradual and taper fairly evenly from month to month. Prior to fencing the Natural Area in 1976-77, the entire site was subject to extensive off-road vehicle use (Shields et al. 1979).

MATERIALS AND METHODS

No known captive release tortoises were used in this study. Data from the Desert Tortoise Natural Area was obtained from the diagrams on standard data forms designed by Dr. Kristin Berry. Data from the Beaver Dam Slope was collected on site (Minden and Keller 1981) and taken from data forms for the other two sites.

Shell anomalies were noted by counting the number of scutes on both the carapace and plastron. The standard scute formation on the carapace of the desert tortoise is five central vertebrals, four costals on the left and right, and eleven marginals on either side of the nuchal and pygal scutes lining the outer rim of the shell (*see* Fig. 1).

TABLE 1.—Population structure and sex ratio for native desert tortoises in the Beaver Dam Slope (BDS) and Desert Tortoise Natural Area (DTNA) populations.

a.

Size classes	BDS	DTNA
adults	72	291
subadults	58	97
immatures	52	162
juveniles	14	47
totals	196	597

b.

Sex	BDS	DTNA
males	69	209
females	49	271
unknown	77	117

Tortoises were classified as having anomalies if there were more or less than the standard number of scutes on either the carapace or the plastron. Those tortoises with skewed or distorted carapace or plastron scute patterns, or those with hairline seams were not classified as abnormal. Included as anomalies were tortoises which had two toes fused together.

Both the Chi-square Contingency and Goodness-of-Fit tests (Minium 1978, Welkowitz et al. 1976), as well as the Test for Difference of Two Proportions (Bruning and Klintz 1977, Noel 1976) were used for statistical analysis of the data.

RESULTS

Population Structure

The three studies done in the Beaver Dam Slope were grouped to make a population totalling 196 individuals, while the Desert Tortoise Natural Area population totalled 597 individuals. Population structures are shown in Tables 1a and 1b. Chi-square Contingency tests do indicate differences in sex ratio (Chi-square = 8.5, DF = 1, $p < .05$) and age-class distribution (Chi-square = 18.2, DF = 3, $p < .05$) when comparing the two populations.

When analyzing each population alone, Chi-square Contingency tables show no significant age-class distribution difference in either population, but do indicate a significant predominance of females over males in the Desert Tor-

TABLE 2. — Size class and age of desert tortoises with anomalies. a = Beaver Dam Slope population; b = Desert Tortoise Natural Area population.

	Size classes	Males		Females		Unknown	
		Normal	Abnormal	Normal	Abnormal	Normal	Abnormal
a.	Adults	37	14	16	4	1	-
	Subadult	15	3	21	5	11	3
	Immature	-	1	3	-	41	7
	Juveniles	-	-	-	-	11	3
b.	Adults	114	9	139	26	2	1
	Subadult	45	7	40	4	1	-
	Immature	30	4	48	3	67	10
	Juveniles	-	-	10	1	34	2

TABLE 3.—Anomaly types and their location on the shell of desert tortoises in the Beaver Dam Slope (BDS) and Desert Tortoise Natural Area (DTNA) populations.

		Hohman and Ohmart 1979	Minden 1980	Minden et al. 1981	Total BDS population	Percent total anomaly	Total DTNA population	Percent total anomaly
Reduced number of scutes	Marginals	1	7	1	9	20.5	21	28.7
	Costals	0	0	0	0	0	2	2.7
	Vertebrals	0	1	0	1	2.3	0	0
Super-numerary scutes	Marginals	7	8	2	16	36.4	11	15.0
	Costals	1	6	1	8	18.2	9	12.3
	Vertebrals	1	0	0	1	2.3	16	21.9
	Other*	1	6	2	9	20.5	14	19.2
	Number of times anomaly occurs**	11	28	6	45	100.0	73	100.0
	Total number of tortoises w/anomalies	11	24	5	40	100.0	67	100.0

* 'Other' classification is detailed on pages 100 and 101.

** This classification accounts for tortoises with two anomalies.

toise Natural Area population (Chi-square = 8, DF = 1, $p < .05$).

Anomalies

Beaver Dam Slope Population.—Forty (20.40%) of the total 196 tortoises in the Beaver Dam Slope population had scute anomalies. All of these anomalies were located on the carapace, rather than on the plastron. No gross deformities or severe shape distortions were found among these individuals. Loss or addition of scutes to the carapace seemed to be compensated for in scute size, for symmetry in scutellation was retained in many tortoises.

There were no statistically significant differences in anomaly rate according to age-class or sex (Table 2a). All non-adults were merged for a test of differences in anomaly frequency as compared with adults. No significant differences were apparent from this comparison.

Type and location of anomalies on tortoises in the Beaver Dam Slope population are noted in Table 3. Supernumerary scute anomalies are significantly more common than any other anomaly found in this population (Chi-square = 11.0696, DF = 2, $p < .05$). Four out of the total eight times that supernumerary costals occurred were associated with anomalies in the marginal series. (In only one other incidence do two anomalies occur together.) An abnormal number of marginal scutes was associated with all five tortoises who displayed double anomalies. In four out of these five incidences, the scute series of both anomalies were either supernumerary or reduced. The remaining one had an extra costal and one missing marginal.

Nine individuals displayed various other conditions. Two tortoises had double nuchals; one tortoise had a triple nuchal; two tortoises had a small wedge for a scute; one tortoise had no nuchal scute; two tortoises had very pronounced and distorted sutures; and the last was a tortoise which showed a merging of the pygal and vertebral scutes.

The marginal scutes were the most commonly fluctuating series. Of the 40 anomalies, 56.9% were associated with the marginals. Supernumerary costals was the next most common condition. A reduction in the number of costals never occurred, while any fluctuations in the vertebral series, both supernumerary or the opposite, was very rare (*see* Table 3).

Desert Tortoise Natural Area Population.—Sixty-seven (11.22%) of the 597 tortoises had anomalies in the Desert Tortoise Natural Area population. All of the scute anomalies were located on the carapace, except one tortoise with a plastron abnormality.

No statistically significant correlation between age-class or sex and anomaly rate was found in the population (Table 2b). When adult classes were compared with merged non-adult classes, very similar totals resulted.

No specific type of anomaly, either supernumerary, reduced, or otherwise, occurred with significantly more frequency than any other.

In the six cases of tortoises with two anomalies, both anomalies were supernumerary. Supernumerary costals and vertebrals occurred together five times, the remaining one having an extra marginal and two fused toes. Two tortoises had three anomalies each. Supernumerary marginals, vertebrals, and costals were present in one; and supernumerary vertebrals with a reduction in the number of marginals and costals were present in the other.

Fourteen individuals displayed various other conditions. Seven tortoises had fusion of two toes; one tortoise had a tiny wedge-shaped scute; two tortoises had their seventh and eighth marginals fused together; one tortoise was missing a gular; another had two gulars; one tortoise had an extra scute at the junction of a vertebra, right costal and marginal; and one tortoise had a severely distorted plastron.

The marginal series had the highest frequency of anomalies. Supernumerary vertebrals were the second most common occurrence.

Comparison of the Beaver Dam Slope and Desert Tortoise Natural Area Populations

The Beaver Dam Slope population had a significantly higher percentage of anomalies (20.40%) than did the Desert Tortoise Natural Area population (11.22%) (Chi-square = 10.7, DF = 1, $p < 0.002$). The Beaver Dam Slope population also had significantly more male tortoises with anomalies (Chi-square = 11.5, DF = 1, $p < .05$), as well as more adult tortoises with anomalies (Chi-square = 5.1, DF = 1, $p < .05$) than did the Desert Tortoise Natural Area population (*see* Tables 2a and 2b).

Carapace anomalies were predominant in both populations. Both population had high percentages of supernumerary scute anomalies, with lower percentages of anomalies having reduced numbers of scutes. However, the Beaver Dam Slope population had significantly fewer scute reductions than did the Desert Tortoise Natural Area population (Test for Difference of Two Proportions: Z = 2.39, $p < .05$).

The marginal scute series had the highest frequency of anomalies in both populations. Neither population showed significant differences in the number of reduced marginals to supernumerary marginals when analyzed separately. The Beaver Dam Slope population, however, showed a significantly higher percentage of supernumerary marginals than did the Desert Tortoise Natural Area population (Test for Difference of Two Proportions : Z = 6.46, $p < .01$). The Desert Tortoise Natural Area population had significantly more incidences of reduced marginals than did the Beaver Dam Slope population (Test for Difference of Two Proportions: Z = 2.26, $p < .05$). Although occurrences of costal anomalies were quite similar, there was a large variation between populations in the number of vertebral scute anomalies. The Desert Tortoise Natural Area population had significantly more supernumerary vertebrals than the Beaver Dam Slope population (Test for Difference of Two Proportions Z = 6.35, $p < .01$). Supernumerary vertebrals in the Beaver Dam Slope population made up 2.3% of the total anomalies, while making up 21.9% of the total anomalies of the Desert Tortoise Natural Area population.

DISCUSSION

The most statistically significant finding in this study was the considerably higher frequency of anomalies found in the Beaver Dam Slope population when compared with the Desert Tortoise Natural Area population. The most interesting finding was that the two populations differ significantly in anomaly types and where the anomalies are located on the shell. Each population has a tendency toward certain anomalies. The Beaver Dam Slope population has significantly fewer reduced scute anomalies while also having significantly more incidences of supernumerary marginals than the Desert Tortoise Natural Area population. The Desert Tortoise Natural Area population, on the other hand, had significantly more occurrences of reduced marginals, fused toes, and supernumerary vertebrals (*see* Table 3). The question arises as to whether or not these differences are a result of genetically inherited factors or external conditions which influence specific anomalies during development.

Environmental factors which have caused shell anomalies to subjected embryos include soil moisture content (Coker 1910, Harless and Morlock 1979, Lynn and Ullrich 1960), temperature variations (Harless and Morlock 1979, Ynetema 1960), oxygen deprivation (Harless and Morlock 1979), and handling or rotation of the eggs (Harless and Morlock 1979).

It was beyond the scope of this study to analyze habitat differences in great depth. The Beaver Dam Slope and Desert Tortoise Natural Area habitats do differ: the Beaver Dam Slope has far greater temperature fluctuations and extremes than the Desert Tortoise Natural Area, where temperature increases and decreases are moderate and gradual as the year progresses; the Beaver Dam Slope has a bimodal rainfall pattern as well as cattle grazing where the Desert Tortoise Natural Area does not. How these factors affect soil moisture content, soil compaction, and nest injury, specifically, embryonic development, is not known, but each habitat certainly has peculiarities which in turn may contribute to the wide array of differences in shell anomalies found in both populations.

Genetic inheritance should also be considered as a possible explanation for the repeated occurrence of shell anomalies within a population (Coker 1910, Newman 1906, Carr 1952). Isolated gene pools tend to accentuate certain heritable traits by virtue of the fact that altered or mutant recessive genes are more likely to combine with similar alleles to produce patterns of abnormal phenotypes. I do not know the extent of isolation in either of the populations.

In the case of the Beaver Dam Slope population, radiation from the nearby Nevada Test Site (where aboveground nuclear weapons tests occurred between 1951-1963) is another potential causal factor. A recent study has shown high levels of naturally occurring radiation (uranium and thorium) as well as smaller amounts of man-made plutonium in a desert tortoise from that population (Singh et al. 1984).

However, this study shows no statistically significant relationship between size-class and anomalies within either population. As stated earlier in the results, all non-adults were merged for a test of differences in anomaly rate as compared with adults. Sharp differences could imply that changes occurred before or after fifteen years ago, bringing on higher or lower incidence rates of anomalies. Since no significant differences resulted from this comparison, developmental damage by direct irradiation to tortoise embryos during the years 1951 through 1963 appears unlikely. However, inherited abnormalities as a result of accumulated radiation dosages in present adult tortoises remain to be observed in the yet unstudied hatchling class.

ACKNOWLEDGMENTS

Many gracious thanks to Maggie Fusari, to my dear ones, to Kristin Berry, and to Bobsled the Ann.

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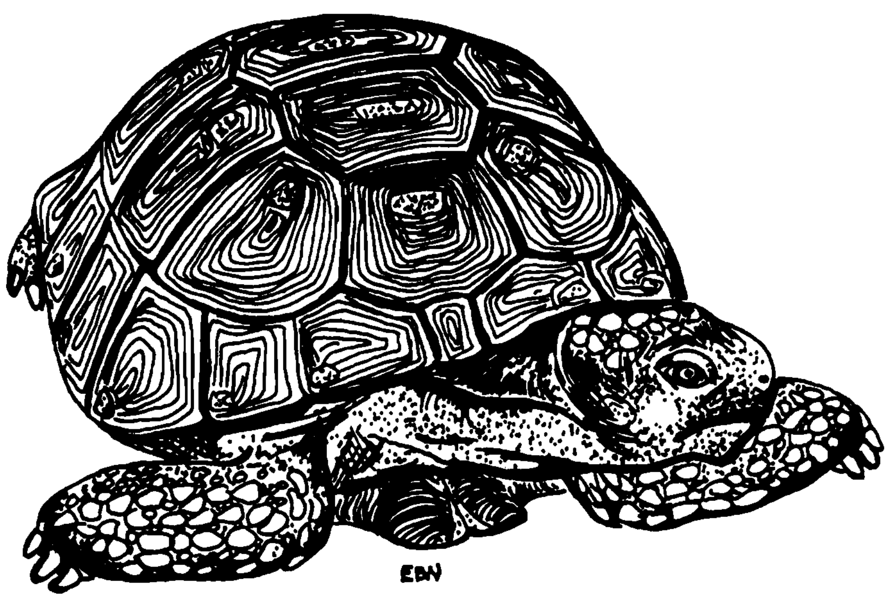

Proc. Desert Tortoise Council 1984 Symp., p. 105

BLOOD PANEL ANALYSES OF CAPTIVE DESERT TORTOISES (*GOPHERUS AGASSIZI*)

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Abstract.—A preliminary report on a statistical study of blood panel data collected for captive desert tortoises, both healthy and diseased, is presented. Twenty-one variables, involving 219 observations, were analyzed, including hematology (white and red blood cell counts, packed cell volume and differentials) and blood chemistry (blood urea nitrogen, glucose, total protein, serum glutamic oxaloacetic transaminase and uric acid). The data are analyzed using both univariate and multivariate statistics, and results are compared. Differences between healthy and diseased animals are compared by canonical variates analysis and those between males and females are highlighted. The implications of these findings may serve to refine monitoring techniques in desert tortoise management. Laboratory results are given in graphic and tabular form.

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TORT-GROUP REPORT - NEVADA

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The Organization for the Protection of Nevada's Resident Tortoises (TORT-Group) was organized in Las Vegas, Nevada, in 1981. It is now incorporated and has tax-exempt status. Membership in 1983 totalled 132.

TORT-Group's goals include (1) protection of free-living tortoises and their natural habitat, and (2) responsible care of captive tortoises that have become domesticated.

Although the TORT-Group has seven major objectives, it was the recent attainment of Objective No. 1 that removed a major obstacle to past efforts. Objective No. 1 was "To support establishment of regulations that allow legal possession of domesticated tortoises presently in captivity." Partly through the efforts of TORT-Group members, such a regulation now exists. Tortoises that have become domesticated — that are dependent upon human care — can be kept without permit, and the hundreds of captives that have been turned over to us by the Nevada Department of Wildlife (NDOW) and since held under crowded conditions can now be offered for adoption. The TORT-Group now uses mass media to announce to the public that there is an abundance of available captive tortoises, and that information about the care of tortoises is also available. As a result, we hope collecting from wild populations will be reduced and the quality of care of thousands of captives will be improved.

To aid our effort to educate the general public, we provide free printed information in the form of a detailed Tortoise Care Sheet, various supplemental Information Sheets, and a Newsletter. A flier announcing the new regulation has been inserted into each care sheet. Guest speakers at our monthly meetings include veterinarians and biologists. Each year, members of our Captive Management Committee answer several hundred inquiries about captive care and tortoise biology. We have recently distributed 1,000 copies of the TORT-Group brochure and more than 4,000 copies of our care sheet to local public libraries, veterinarians' offices, the Human Society, the City-County Animal Shelter, and the Department of Wildlife. We hope that, as a result of our efforts, the public will be better informed and less apt to collect a wild tortoise when chancing upon it in the desert.

Anyone wanting to adopt a tortoise is asked to pick up a care sheet from one of the convenient distribution points. If the person still wants a tortoise after reading about required care, we send an adoption application. The applicant's attitude about tortoises and their care, as well as the adequacy of the yard, are considered. This involves one or more visits to the applicant's home by a Captive Management Committee member. We offer suggestions on the possible arrangement of the yard in advance of yard preparation and, in some cases, we dig burrows for persons who are unable to do so.

Less than half of those who initially express interest complete an adoption transaction. We assume that, as a result, a large number of tortoises are spared stress, injury, and death. We have placed about 100 tortoises during the past year but almost as many remain available. We have started an aggressive publicity campaign which we hope will attract adoption applicants; meanwhile, crowding remains a problem. To help with the need for space, the Humane Society of Southern Nevada has offered two acres of land for use at the future Humane Society Complex. The TORT-Group must pay for building the tortoise enclosure, and this has encouraged us to undertake a vigorous fund-raising effort. Even after this enclosure is built, we expect that the general public will continue to take unwanted and escaped tortoises directly to the Department of Wildlife, and TORT-Group volunteers will continue to pick up those tortoises on-call. For more than a year, TORT-Group members have offered to help construct adequate shelter at the Department for tortoises awaiting our arrival. In mid-March 1984, we were granted permission to proceed. The shelter, which is almost complete, will protect tortoises from overheating during their short stay at the Department.

Efforts on behalf of the free-living tortoise have been indirect. At meetings we have discussed and viewed illustrations of the numerous impacts that are making the desert less productive as wildlife habitat. This is one reason that we discourage the release of long-time captives or their young. The suggestion that tortoises be released is a common response by people who hear about the many captives that await adoption.

Urban Las Vegas is rapidly increasing in size and in the number of single homes dotting the desert. The TORT-Group submitted a proposal to the Department of Wildlife that addressed the problem of wild tortoises living next to developed land or on land being developed or soon to be developed. The proposal included the gathering of pertinent information and the actual rescue of tortoises. Although TORT-Group volunteers would like to help the NDOW implement the plan, the Department responded that it could not budget the time to consider the proposal.

The TORT-Group also proposed to the NDOW that a special license fee be charged for vehicles and machinery that normally traverse undeveloped land or land under development, or are designed to do so, e.g., utility vehicles, trucks, campers, two- and three-wheeled motorcycles, mining trucks, water-tank trucks, earth-moving rigs, and vehicles used for gas and oil exploration. Funds could be used to help purchase or manage representative lowland desert habitat and support planning efforts for off-road vehicle parks and trail systems that are contained and maintained in fixed areas and on fixed routes. This proposal was rejected as not being cost-effective.

Last, but not least, are efforts to reach the young in order to inform them about tortoises and to foster attitudes that should enhance their enjoyment and appreciation of other reptiles in the desert. One of our members continuously meets with children in their classrooms and at youth-group meetings. The children are introduced firsthand to various reptiles, and in discussion consider reptile characteristics, behavior, captive care, and conservation. Since the new regulation was passed, the desert tortoise has become a regular part of the children's learning experience.

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DESERT TORTOISE PRESERVE COMMITTEE REPORT

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The Desert Tortoise Preserve Committee (DTPC) formed 10 years ago with the principal goal of establishing the Desert Tortoise Natural Area (DTNA) (Forgey 1982; Stockton 1980, 1981). During the last few years, the Committee has been faced with increasingly complex management issues and problems, primarily in the areas of stewardship of the Natural Area, coordination with government agencies, and communications with the public. To more effectively deal with these issues, the Committee established three new executive positions: Vice President for Stewardship, Vice President for Government Affairs, and Vice President for Communications and Publicity. Accomplishments and management problems are outlined below.

Land Acquisition.—Between 1977 and 1984, The Nature Conservancy, using funds provided by the DTPC, acquired 1,520 acres of private land on the Natural Area. In March of 1984, the DTPC purchased an additional 6 acres. About 11 square miles of private inholdings — about 400 parcels — remain to be acquired.

The Bureau of Land Management (BLM) has worked for several years to exchange a group of properties totaling 640 acres along the western edge of the Natural Area for a group of public lands of similar size outside the Natural Area. Due to problems with California mapping laws, the BLM decided to drop this effort (Stockton 1983). At present, the BLM is pursuing a policy of selling isolated parcels of public lands throughout California and is not going to work on acquisition of land in the Natural Area through the exchange procedure.

The Nature Conservancy has held discussions with the BLM regarding acquisition of private inholdings in the Natural Area. The Conservancy has offered to purchase as many private holdings in the Natural Area as possible, and then exchange these holdings with the BLM in a single major land exchange. These negotiations have reached a standstill because of the BLM's current policy of "no exchanges," and because the BLM insists that land values for exchanges must be based on the values of large parcels. The Conservancy would pay much higher prices to purchase many small parcels than to purchase a single large parcel. In a subsequent exchange with the BLM, the Conservancy would lose considerable money.

Management Issues inside the Natural Area.—Although the Natural Area was designated an Area of Critical Environmental Concern (ACEC) in 1980 with publication of the California Desert Plan (U.S. Dept. of Interior 1980), it has yet to be managed as such. The Committee is concerned that efforts to protect natural values have decreased since the designation. The BLM has discussed using the 1979 Desert Tortoise Natural Area Habitat Management Plan (HMP) as a ACEC plan. The Committee does not believe that the HMP was an adequate document when first prepared. The HMP would require extensive revisions and updating to meet current standards for acceptable ACEC plans. For example, no provisions exist in the HMP for regular patrol and maintenance of interpretive facilities, fence, or Natural Area lands. The BLM has, in our view, not patrolled or protected the area adequately in the last few years. Another issue is use of firearms. Under HMP guidelines, hunting is allowed with some limitations. The Committee recently checked the California Fish and Game Code and discovered that the proposed limitations on hunting were never incorporated into the Fish and Game Code. The Committee remains concerned that hunting is even allowed, because removal of animals is not compatible with maintaining "natural" wildlife populations.

The Committee's Vice President for Government Affairs has been working on development of a cooperative agreement with the BLM for maintenance of the Interpretive Center and fence. These efforts have resulted in the scheduling of long overdue fence repairs during 1984. The 41 or more breaks in the fence will be repaired by BLM personnel and volunteers from the Committee.

Committee members have continued to observe signs of sheep grazing inside the Natural Area during the last year, although such use is unauthorized. Trespass by sheep is particularly a problem at the fence gaps on the western boundary.

Management Issues Associated with the Natural Area Boundaries.—To the northeast of the Desert Tortoise Natural Area lies the Western Rand Mountains ACEC (U.S. Dept. of Interior 1980). This ACEC was established in prime or highly crucial tortoise habitat in order to protect tortoise populations and habitat and at the same time to allow recreational vehicle use. In 1982, the Ridgecrest Area Office of BLM released a "Draft Rand Mountains Recreation Area Plan" for public comment. This recreation plan included the Western Rand Mountains ACEC as well as a significant tortoise habitat in the Fremont Valley and Rand Mountains. When the Ridgecrest Area Office released the "final" plan in fall of 1983, they suddenly stated that this recreation plan was to function as the Western Rand Mountains ACEC Plan (U.S. Dept. of Interior 1984). The final plan included no measures to protect or monitor tortoise populations. Furthermore, and equally important, the public was not allowed to review the plan as an "ACEC plan." As of this time, the plan has not been signed by the BLM District Manager in Riverside. The Committee has expressed concern formally to the BLM over the inadequacy of the plan to protect the tortoise and over the lack of coordination with the public on an ACEC plan. The management of the Rand Mountains and Fremont Valley, areas of heavy off-road vehicle use, are critical to the integrity of the DTNA, especially the Western Rand Mountains ACEC. Management of this area is also of prime importance to the Fremont-Stoddard desert tortoise population.

I have discussed the Committee's lawsuit against the State Lands Commission and Great Western Cities previously (Stockton 1983). The Committee filed the suit in March of 1981 and had its first court hearing in January of 1983. In April 1983, the court rendered a decision in favor of the Committee. The Committee had made a motion to require the State Lands Commission to answer our questions and requests for information. The court decided in favor of the Committee, a ruling critical to the Committee's pursuit of the litigation. Numerous hurdles remain ahead for the Committee on this lawsuit.

We hope to report on additional land acquisition in 1985, on greater protection of the Natural Area, on increased public awareness of the Natural Area, and on a better working relationship with government agencies. We appreciate the efforts of the Desert Tortoise Council members to further Committee goals and to protect the Natural Area.

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NOTES ON THE BEHAVIOR AND HABITAT PREFERENCES OF JUVENILE DESERT TORTOISES (*GOPHERUS AGASSIZII*) IN CALIFORNIA

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Abstract.—The behavior and distribution of juvenile desert tortoises (*Gopherus agassizii*) ($\leqslant$140 mm in length) were analyzed using data from 1,403 captures at 18 sites in California. Air temperatures at which juvenile tortoises were encountered differed significantly as a function of body size and month. Juveniles were seen at increasingly higher air temperatures each month between March and June, but tortoises $<$60 mm in length were observed at significantly lower air temperatures than those 60-140 mm. The times of day when tortoises were captured were related significantly to month, with tortoises out at increasingly earlier times in mornings and at increasingly later times in afternoon as spring progressed from March to June.

When captured, 52% of the tortoises were in the open, 23% were in or adjacent to burrows and pallets, and 22% were under and adjacent to shrubs. Tortoises were engaged in five categories of behavior: 38.6% were walking or standing; 19.0% were basking; 23.1% were exiting, entering, within or adjacent to burrows; 14.0% were feeding; and 1.9% were interacting with other tortoises or other animals.

Burrows were identified for 35.6% of the individuals, and generally approximated the size and shape of the occupant. Creosote bush (*Larrea tridentata*) and burrobush (*Ambrosia dumosa*) were the most frequent species of shrubs used for cover (58.5%) and (21.1%) respectively. Significantly more burrows ($P<0.0001$) opened to the west, southwest, south, and southeast than in other directions.

Nine sites were examined for uniformity of distribution of juveniles by habitat types. Juveniles were found more often in such habitats as creosote-shadscale, creosote-burro bush on firm soils, and in narrow wash stringers near granitic boulders than near playas, in Mojave saltbush communities, on bare ground or cleared areas, or in wide river washes with desert trees and frequent scouring by water. Human influences such as paved roads, off-road vehicle use areas, and guzzlers contributed to lower tortoise numbers in some areas.

TABLE 1.—Captures of juvenile tortoises at 18 study plots in California.

Site No.	Site name	1971-1976	1977	1978	1979	1980	1981	1982	Totals
1	Argus	16							16
2	Fremont Valley	23		31	60		89		203
3	Desert Tortoise Natural Area (Sec. 11)	31		14	43			32	120
4	Desert Tortoise Natural Area (Inter. Center)			5	134			2	141
5/6	Fremont Peak		8	2		6			16
7	Kramer					55		81	136
8	Calico			2					2
9	Stoddard Valley			3	27		25		55
10	Lucerne Valley					29			29
11	Johnson Valley					24			24
13	Shadow Valley			4					4
14	Ivanpah Valley		26	6	43				75
15	Goffs		21	5		83			109
16	Ward Valley					67			67
20	Chemehuevi Wash			4	57			122	183
22	Cottonwood Springs			4					4
23	Chuckwalla Bench		17		91	6	1	69	184
26	Chuckwalla Valley					35			35
	Totals	70	72	80	455	305	115	306	1,403

INTRODUCTION

Hatchling and juvenile turtles and tortoises are difficult to find because of their small size and possibly secretive behaviors. As a result they are almost always underrepresented in samples and usually have exhibited low recapture rates in population studies (e.g., Stickel 1950, Legler 1960, Ream and Ream 1966, Ernst 1971, Grubb 1971, Brown 1974, MacFarland and Basilio Toro 1974, Froese and Burghardt 1974, Wilbur 1975, Bourn and Coe 1978, Gordon and MacCulloch 1980, Judd and Rose 1983).

Juvenile desert tortoises (*Gopherus agassizii*) are no exception. Woodbury and Hardy (1948) found only ~1% juveniles (<140-mm carapace length [CL]) among individuals captured and marked. However, their study focused primarily on adult tortoises in winter dens. Berry (1974, 1975*a*, 1975*b*) found higher frequencies of juveniles (14.9 and 27.2%) in two populations in the western Mojave Desert of California. Burge (1977) found 19.7% juveniles at a site in southern Nevada and noted that tortoises <100-mm CL were less detectable than those >100-mm CL. Juveniles had disproportionately low rates of recapture. Both Schneider (1980) and Shields (1980) also reported sampling biases associated with size in this species.

Since 1974, the U.S. Bureau of Land Management (BLM) has supported studies on distribution, relative abundance, and population attributes of desert tortoises in the Southwest (Berry 1984). Approximately 4,140 tortoises were marked in over 8,900 encounters, most of which occurred on 18 of 27 study sites in California. The sample included 1,403 captures of juvenile tortoises (≤140-mm CL). These data provided information on the activities, behavior, and distributions of juvenile tortoises on California study sites. This paper summarizes data relating to the natural history and spatial distribution of small tortoises, assesses factors influencing the visibility and susceptibility to capture of these animals, and recommends new and potentially efficacious methods for locating juvenile tortoises. The long-term goal is to enhance abilities of field-workers to capture juvenile tortoises and promote higher recapture rates among age classes critical to an understanding of the dynamics of desert tortoise populations.

METHODS

Between 1971 and 1982, data were collected on population attributes of desert tortoises at 27 study sites, each of which was 2.6 km^2 or larger (Berry 1984). Each plot was divided into grid with 100 quadrats in each 2.6 km^2 area. Data generally were collected by one or two field-workers during 30- and 60-day spring censuses conducted between March 1 and June 15. A single field-worker usually spent the full 30- or 60-calendar days on each site. From 1979 on, field-workers were instructed to make special efforts to find juveniles. Such tortoises (1,154 individuals) were captured 1,403 times at 18 of the 27 sites (Table 1). Techniques used by field-workers to find tortoises were compiled also.

The following data were recorded for most captures: date; time (PST); weather conditions, including air temperatures (°C) at 1 m, wind speed (kph), and cloud cover; carapace length (CL); tortoise activity (walking, basking,

TABLE 2. — Two examples of analyses of uniformity of distribution of small tortoises among different habitat types.

Site name and habitat type	% of habitat	Tortoise numbers for X^2 tests	
		Expected	Observed
Kramer			
A. Lomas with *Larrea tridentata, Ambrosia dumosa, Atriplex confertifolia*	38.9	18.7	30
B. Depressions and low areas with *L. tridentata, Ambrosia dumosa, Acamptopappus sphaerocephalus*	32.6	15.7	10
C. Lomas with *Yucca brevifolia, L. tridentata, Ambrosia dumosa*	16.6	7.9	8
D. Playa with *Atriplex spinifera, Amorosia dumosa*	8.5	4.1	0
E. Aeolian sands with *L. tridentata, Oryzopsis hymenoides*	3.0	1.4	0
F. Wash with *Hymenoclea salsola, Salazaria mexicana, Lycium cooperi, Tetradymia stenolepis*	0.4	0.2	0
Ward Valley			
G. Desert pavement and sandy soils with *L. tridentata, A. dumosa, Y. schidigera*	57.5	32.8	30
H. Same as G with *Eriogonum fasciculatum, Opuntia acanthocarpa*	28.4	16.2	18
I. Wash with *Fouquieria splendens, Acacia greggii, S. mexicana, Cassia armata*	10.7	6.1	9
J. Rock outcrops with *Encelia farinosa, Baccharis brachyphylla, Pleurocoronis pluriseta, Haplopappus gooddingii*	3.4	1.9	0

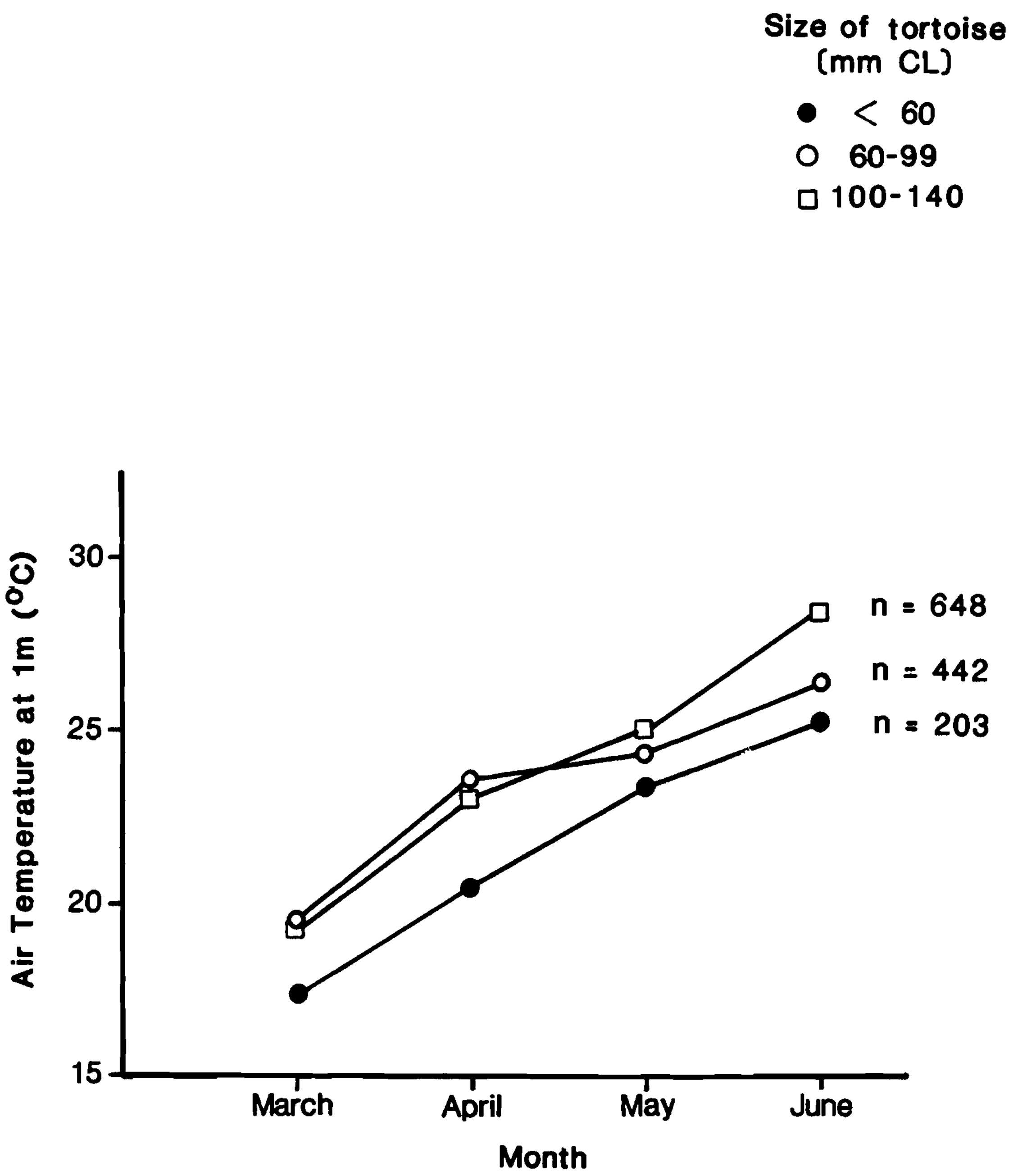

FIG. 1.—The relationship between mean air temperatures (°C) at 1 m, tortoise body size, and month. Air temperatures are the mean temperatures of all encounters for a given month.

feeding, digging a burrow, in a burrow or pallet, etc.); proximity to and type of shrub; proximity to burrow or other cover site ($\leqslant$5 m vs. >5 m); attributes of burrows and other cover sites (e.g., for burrows: length, width, and height at entry; amount of soil cover at entrance; aspect of opening; cover of shrubs); and the quadrat in which observed. We followed Burge (1977, 1978) in distinguishing between burrow and nonburrow cover sites of tortoises, i.e., nonburrow cover sites included pallets (below-surface cavities which partially cover the tortoise), exposed shaded ground, and low, overhanging branches of shrubs.

Tortoises were divided into three size classes by CL: class 1 = <60 mm; class 2 = 60-99 mm; and class 3 = 100-140 mm. These classes are essentially identical to the three smallest size classes used in analysis of desert tortoise data from California elsewhere in the Southwest (Turner and Berry (1984*a*).

Nine of the 18 study sites with juvenile tortoises had sufficient samples for X^2 analyses to determine whether tortoise distributions were (1) uniform throughout each study site and (2) uniform among the habitat types on each site. For the first analysis, each study site was subdivided into four equal quadrats, and the number of juvenile tortoise capture locations present in each quadrat was compared with the expected number. We assumed that tortoises were equally visible in the four quadrats. We tested the assumption that tortoises were equally abundant in the four quadrats.

For the second analysis, a habitat map was developed for each site using information on vegetation, soils, and topographic features. Data sources for the map included aerial photographs, maps prepared by field-workers, and annual and perennial vegetation transect data. The areal extent of each habitat type was calculated and percentage of coverage of each habitat in the site was determined (e.g., Table 2). We assumed that the number of capture locations of tortoises in each habitat was directly proportional to the amount of habitat present and that tortoises were equally visible in each habitat type. The capture location numbers constituted the expected numbers for the X^2 analysis. The number of capture locations actually in each habitat type was considered the observed number.

RESULTS

Juvenile Tortoises and Air Temperature

The numbers of captures were examined in terms of air temperatures (^{o}C) measured at 1 m. Data were grouped by month (March, April, May, and June) and size class. A factorial analysis of variance was undertaken with air temperature as a dependent variable and three size classes, four spring months, and tortoise location (inside or outside of burrows) as independent variables. The analysis of variance showed that air temperatures at which juvenile tortoises were encountered differed significantly as a function of body size and month, but not according to location. The relationship between air temperature, body size, and month is illustrated in Fig. 1. Figure 1 shows that, as one would expect, all size classes were observed at higher air temperatures as the season progressed, although tortoises < 60 mm long were observed at significantly lower air temperatures than larger ones.

Juvenile Tortoises and Observation Times

Tortoises were encountered from 0529 to 1830 h (PST), with substantially more observations occurring in morning (76.1%) than afternoon (23.9%). More

TABLE 3. — Mean times of observations for three classes of juvenile tortoises of burrows at 18 study sites in the California deserts.

Month and time period	Mean time[a] N[b]		
	< 60 mm CL	60-99 mm CL	100-140 mm CL
March			
0600-1200	10.45 (6)	10.53 (13)	10.19 (9)
1201-1830	13.71 (4)	13.78 (14)	13.45 (19)
April			
0600-1200	9.29 (58)	9.56 (110)	9.51 (131)
1201-1830	13.72 (17)	15.03 (30)	14.68 (63)
May			
0600-1200	9.20 (59)	9.02 (165)	8.90 (204)
1201-1830	16.38 (10)	15.64 (27)	15.91 (77)
June			
0600-1200	8.24 (13)	9.04 (28)	8.43 (55)
1201-1830	- (0)	18.22 (2)	15.44 (4)

[a] Time expressed using a 24-hour clock and tenths of hours.

[b] Sample size = number of captures. Number of individuals is slightly less.

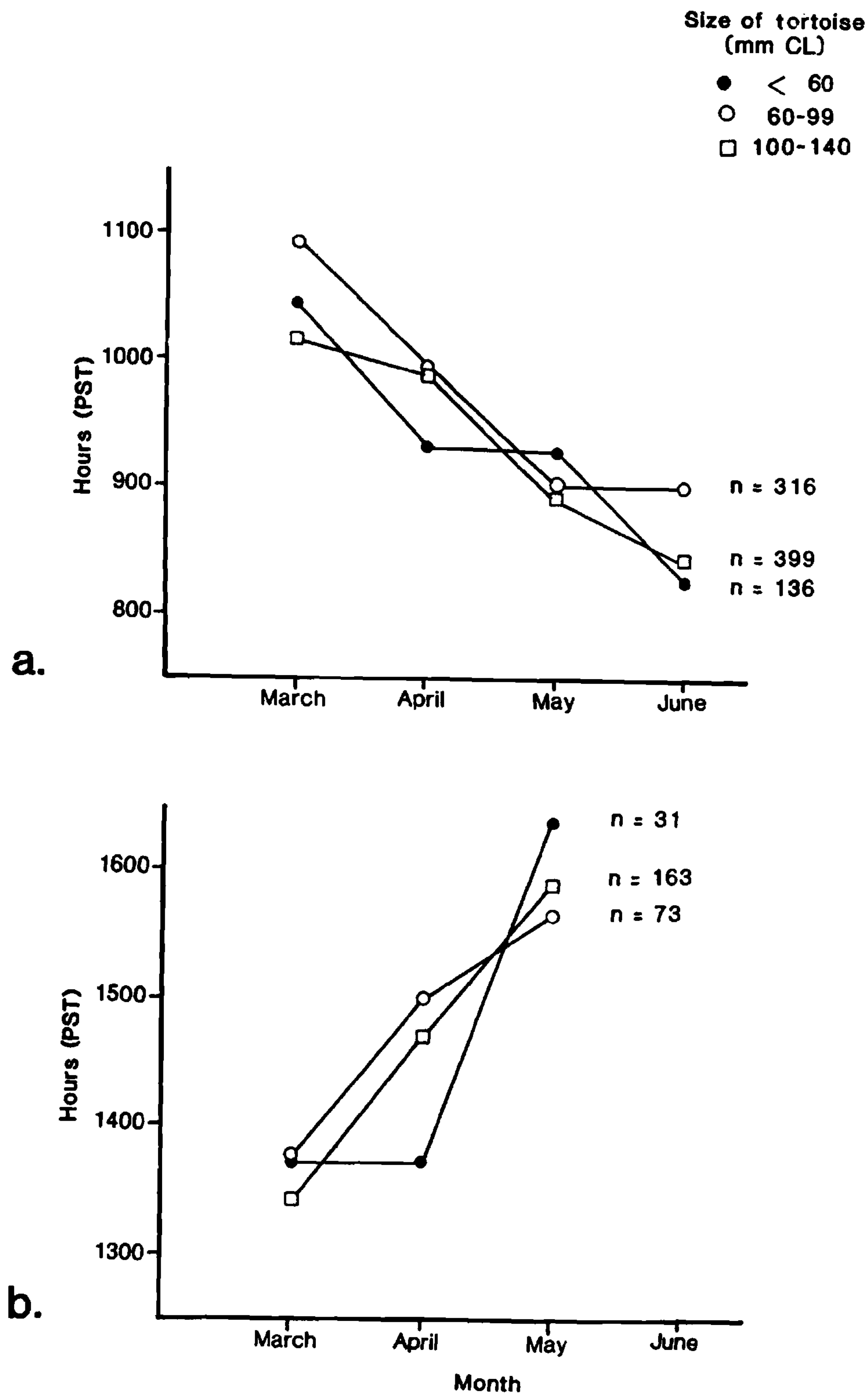

FIG. 2.—a. The relationship between mean morning hours at which juvenile tortoises were encountered, body size, and spring months.

b. The relationship between mean afternoon hours at which juvenile tortoises were encountered, body size, and spring months.

sightings were made on days with low winds, ranging from 1.6 to 19 kph and with clear skies ($<$10% cloud cover) that at other conditions, although tortoises also were found under situations ranging from 0 to 48 kph of wind and from clear to overcast skies and rain.

The relationships between time encountered, tortoise size class, and month were examined using a factorial analysis of variance. Observation times were divided into morning (0500-1200 h) and afternoon (1201-1830 h). Only observations of tortoises completely outside burrows were used. Mean times of observations for the three size classes of tortoises are shown in Table 3 for the spring months. The relationships between observation time, month, and size are illustrated in Fig. 2. For morning hours, the only significant relationship is between time and months ($F = 26.03$, $P = <0.0001$). In the afternoon, months were also a highly significant component ($F = 27.5$, $P = <0.0001$). In general, juvenile tortoises were out at increasingly earlier times in the morning as the spring progressed from March to June and at increasingly later times in the afternoon. The three size classes showed no apparent difference in activity periods.

TABLE 4. — Activities of 1,154 small tortoises when captured at 18 study sites in the California deserts.

Activity	Number of captures	Percent
Walking, standing	542	38.6
Basking	266	19.0
Feeding	209	14.9
Associating with a burrow or pallet		
Basking on burrow mound or apron	52	3.7
Inside a burrow or pallet	245	17.5
Entering or exiting a burrow	17	1.2
Digging a burrow	10	0.7
Engaging in inter- or intraspecific interactions	28	1.9
No data	34	2.4
Totals	1,403	99.9

Behavior of Small Tortoises

The activities of juvenile tortoises when captured were grouped into five categories: walking or standing; basking or resting; feeding; associating with a cover site; and engaging or suspected of engaging in inter- and intraspecific interactions (Table 4). Some of these behaviors are treated separately below. More tortoises were walking or standing (38.9%), basking (19.3%), or feeding (15.0%) than were associated with burrows and pallets (23.1%). On 13 occasions two or three juvenile tortoises were observed within 0.5-20 m of each other.

Locations of Juveniles.—Juvenile locations were: 51.5% in the open with no cover; 17.5% inside a burrow or pallet; 13.5% under a shrub in the shade, sun, or mottled shade; 8.6% near a live or dead shrub; 5.6% on the burrow apron, at the burrow mouth, entering or exiting a burrow, or digging a burrow; 0.7% under a rock or car; 0.1% in the shade of a forb; and 2.4% with no data.

Burrows and Other Cover Sites.—Burrows or pallets were identified for 499 (35.6%) of the juvenile tortoises captured. Most tortoises (94%) were associated with burrows, not pallets. Field-workers found burrows and pallets primarily (94.2%) when tortoises were within 5 m of or inside them. The positions of tortoises with respect to burrows and pallets can be grouped broadly into four categories: (1) inside the burrow or pallet (33.5%); (2) on the burrow apron, mound, or within the mouth (30.5%); (3) within 5 m of burrow but not as described in (1) and (2) (30.3%); and (4) 5 m from the burrow or pallet (5.8%). Many tortoises were probably near burrows or pallets when observed, but the field-workers did not look for or find these cover sites.

The pallets and burrows of juveniles were, for the most part, miniatures of those described elsewhere for subadults and adults (Berry 1974, Burge 1978). They were half-moon in shape, with a flattened base. The width at the base was usually slightly larger than CL, and the height slightly larger than the height of the tortoise carapace. Using a sample of 85 burrows from the Kramer site, the following equations were derived:

$$w = 0.91\ CL + 10.5 \qquad (1)$$

where w = burrow width and CL = carapace length, and

$$h = 1.02\ CL + 5.1 \qquad (2)$$

where h = burrow height and CL = carapace height. Correlation coefficients were 0.9 for both equations.

Most burrows (75.4%) received protection from the shrub canopy or basal branches of live or dead shrubs. A few burrows were found under rocks (3.3%) and a smaller number were located within another burrow (0.7%). The remaining burrows (20.6%) were in the open with no shrub cover. We suspect that some tortoises excavate their own burrows, while others modify rodent burrows.

The plants under which burrows were found were primarily woody shrubs (97.6%); 58.5% were creosote bushes (*Larrea tridentata*) and 21.1% were burrobushes (*Ambrosia dumosa*) or combinations of creosote bush(es) with other shrubs (0.9%). Other species used to some extent were two species of ratany (*Krameria* spp., 4.3%), Anderson thornbush (*Lycium andersoni*, 3.7%), and Mojave saltbush (*Atriplex spinifera* 3.1%).

TABLE 5. — Results of X^2 tests for uniformity of local geographic distributions of juvenile tortoises at nine study sites in California. All sites have 3 degrees of freedom.

Site No.	Site name	Census year	Sample size	X^2	*P*
2	Fremont Valley	1981	88	18.82	<0.005
7	Kramer	1982	48	10.49	<0.025
10	Lucerne Valley	1980	28	1.14	n.s.[a]
11	Johnson Valley	1980	25	0.44	n.s.
15	Goffs	1983	78	5.58	n.s.
16	Ward Valley	1980	57	4.12	n.s.
20	Chemehuevi Valley	1979	57	25.59	<0.005
20	Chemehuevi Valley	1982	118	81.39	<0.005
23	Chuckwalla Bench	1979	67	20.70	<0.005
23	Chuckwalla Bench	1982	69	24.16	<0.005
26	Chuckwalla Valley II	1980	34	4.12	n.s.

[a] n.s. = not significant

TABLE 6. — Results of X^2 tests for uniformity of distribution of juvenile tortoises within different habitat types at nine study sites in California.

Site No.	Site Name	No. of habitat types	df	X^2	*P*
2	Fremont Valley	2	1	6.42	<0.025
7	Kramer	6	5	14.62	<0.025
10	Lucerne Valley	3	2	83.45	<0.005
11	Johnson Valley	6	5	3.39	n.s.[a]
15	Goffs (1983)[b]	5	4	25.15	<0.005
16	Ward Valley	4	3	3.78	n.s.
20	Chemehuevi Valley (1982)	5	4	38.30	<0.005
23	Chuckwalla Bench (1979)	3	2	0.10	n.s.
26	Chuckwalla Valley II	3	2	0.67	n.s.

[a] n.s. = not significant

[b] From Turner and Berry (1984*b*)

Aspects (the compass direction of the opening) of 412 burrows were examined by X^2 analysis. The directions of openings were divided into eight 45° sectors. If equally favored, each sector would have contained 51.5 burrows. Values were significantly different from expected ($P < 0.0001$), with more burrows opening in a westerly to southeasterly arc covering 135° ($X^2 = 106$, 7 df).

Distribution of Juveniles on Nine Study Sites

Chi-square analyses of juvenile tortoise capture locations indicated that distributions were nonuniform on five of nine study sites (Table 5). We also examined distributions of juveniles by habitat type on each study site. Five plots exhibited nonuniform distributions of juvenile tortoises (Table 6). Habitats and tortoise distributions are summarized briefly for the five plots.

Fremont Valley.—Two habitat types, each with creosote bush and burro bush, were apparent. One type had sandy soils, and the other had firmer soils with scattered desert pavements. Tortoises were less common on sandy soils than on firmer soils.

Kramer.—Several creosote bush and salt bush (*Atriplex* spp.) associations were identified. Very few tortoises were found in the northwest quarter of the plot, where a one-hectare playa was surrounded by Mojave saltbush. More juveniles were found in a creosote-burro bush habitat with shadscale (*A. confertifolia*), Mohave aster (*Xylorhiza tortifolia*), and desert alyssum (*Lepidium fremontii*) than were expected.

Lucerne Valley.—Three habitat types were apparent: granitic boulder outcrops; small, narrow, sandy washes associated with the boulder outcrops; and open desert with creosote-burro bush scrub. Higher concentrations of juveniles were found in the narrow, sandy washes adjacent to granitic boulders than elsewhere.

Goffs.—Goffs supported a creosote-burro bush association. Most of the site had soils with gravelly loamy sand in the upper 2-3 cm and light sandy loam to a depth of 30 cm. However, on the southeast quarter where fewer tortoises were found, two different habitat types occurred: (1) a series of parallel river washes with smoke trees (*Dalea spinosa*) and catclaw (*Acacia greggii*), and (2) an area with darker soils with gravelly loamy fine sand on the surface and more very gravelly loamy sand at depths of 6 to 30 cm.

Chemehuevi Wash.—This site had six habitats: (1) creosote-burro bush with Indian wheat (*Plantago insularis*) in sandy loam; (2) creosote-burro bush with split grass (*Shismus barbatus*); (3) a wide river wash with smoke trees, catclaw, and palo verde (*Cercidium floridum*); (4) type (1) with desert pavement; (5) creosote-burro bush with lava and aeolian sand; and (6) bare ground or cleared areas. No juveniles occurred in either the river wash or on the bare ground, and fewer were found in the creosote bush with split grass habitat than were expected. Conversely, more juveniles were found in the creosote-burro bush with Indian wheat habitat.

Human uses also affected distributions of juvenile tortoises. Nicholson (1978) showed tortoise signs to be lower within 0.8 km of heavily-used paved roads and inferred lower densities in these areas. Lower densities were attributed to road kills and collections. Three plots analyzed in our study — Fremont Valley, Chemehuevi Valley, and Goffs — had paved roads nearby. Portions of study sites lying near or adjacent to roads had significantly fewer juveniles than expected (Tables 5, 6).

The Chemehuevi Valley plot experiences off-road vehicle use as part of an annual motorcycle and 4-wheel drive racing event (Parker 400). The southwest quarter is used for camping, spectator viewing, and joy riding, in addition to being part of the official race corridor. This quarter had significantly fewer juveniles than other parts of the plot (Table 5).

The Chuckwalla Bench plot had a nonuniform distribution overall (fewer juveniles than expected in the northeast quarter) but a uniform distribution when examined by habitat type (Tables 5,6). The northeast quarter contains an upland game guzzler used frequently by canids and game birds. Predators may kill and eat more tortoises near the guzzler than elsewhere.

DISCUSSION

Factors Affecting Visibility and Susceptibility of Juveniles Tortoises to Capture

The small size and cryptic coloration of tortoises $\leqslant$140-mm CL are factors affecting visibility and susceptibility to capture. Several behavioral characteristics and preferences are also important, including season of activity, time of daily activity, weather conditions, general location, and habitat preferences. Prior knowledge of these factors can influence search tactics and the success of the field-worker.

<u>Season of Activity</u>.—This study was limited to analysis of data collected in spring. Previous studies have indicated that tortoises of all sizes are more active in spring and easier to find than in summer, fall, and winter in California (Berry 1974, 1975*a*, 1975*b*, 1984; Berry and Turner 1984; Marlow 1979).

<u>Time of Day and Air Temperature</u>.—The time of day at which juveniles are active appears closely related to air temperature. In general, spring air temperatures in the California deserts may fluctuate 22^{o}C or more/day. They are lower near dawn and reach a peak from noon to late afternoon. Between March and June, mean midday air temperatures gradually increase and in some locations exceed 40^{o}C by late May.

The mean air temperatures at which the three juvenile size classes were observed ranged from 17.2 to 19.0^{o}C for March and increased monthly. By June the range was 25.2 to 28.4^{o}C. Temperatures were significantly lower for the $<$60-mm size class. The gradual monthly increase in tempeatures tracked the natural increase in environmental temperatures.

Naegle (1976) undertook laboratory experiments on the thermal relationships of captive desert tortoise. He found that tortoises $<$125-mm CL had significantly higher preferred body and mean cloacal temperatures (31.9^{o} and

33.4°C, respectively) than larger tortoises (29.2°C and 31.3°C, respectively). Critical thermal maximum temperatures were significantly higher in individuals $<$90-mm CL (44.3 $\pm$ 0.5 C) than those 91-mm to 199-mm CL (43.2 $\pm$ 0.5 C) and $\geq$200-mm (42.2 $\pm$ 0.4 C). Heat exchange rates were dependent on body size too, with heating and cooling rates decreasing with increase in body size. Naegle (1976) suggested that the thermal characteristics of small tortoises might offer ecological advantages because they ". . . would allow younger tortoises to be active at a lower ambient temperature and sustain activity over a longer seasonal and daily period. This increased time period would allow greater foraging and thus facilitate rapid growth." Although comparable data on air temperature preferences for tortoises $>$140-mm CL have not been analyzed, our data lend support to Naegle's (1976) hypothesis. Juveniles actually may be active at lower air temperatures.

Significantly more juvenile desert tortoises were located in morning (76.1%) than in afternoon (23.9%). Similar data were reported by Lambert (1981) for juvenile *Testudo graeca* (73.7% were active in morning and significantly fewer were active in afternoon). Adult male and female *T. graeca* showed more activity in afternoons than juveniles.

Mean observation times dropped for the mornings as the season progressed, from 10.2 to 10.5 h in March to 8.2 to 9.0 h in June for the three size classes. In the afternoon, juveniles were found out increasingly later as spring progressed — from 13.5 to 13.8 h in March to 15.4 to 18.2 h in June. These findings are similar to those of Marlow's (1979) for all sizes of tortoises. He reported that times of daily emergence, morning activity, and midday retreat were negatively correlated with the number of days elapsed during the active season (March-April to July), occurring earlier as the season progressed. Times of initiation of afternoon activity were correlated positively with the number of days elapsed since the beginning of the active season.

The changes in mean observation times as the season progressed may be related to temperature, time of sunrise and sunset, day length, solar radiation levels, or to the efforts of field-workers. The relationship of mean observation time, e.g., morning activity period, to sunrise and to solar radiation levels, still remains to be tested. Lindquist and Appleton (1982) found that captive bolson tortoises (*Gopherus flavomarginatus*) ". . . seemed to adjust their periods of activity to incident solar radiation, and to a lesser degree, temperature . . . most of the instances of first morning emergence and last evening descent occurred at the same level of incident solar radiation." They found few tortoises active during midday, when solar radiation was highest.

General Location and Behavior.—Data on location and behavior can be combined to give the field-worker some idea of where to look for juveniles and the types of search images necessary for success. For example, 52% were found in the open, 23% were in or adjacent to burrows and pallets, and 23% were under or adjacent to live or dead shrubs. The high percentage of encounters in the open may be a reflection of the greater visibility of juveniles in the open. More juveniles probably occur under cover of some type.

Burrows of juvenile tortoises deserve special attention because they were identified for more than one-third of the encounters. For the most part, these burrows were the size of the tortoise. Douglass (1978) summarized records of the refugia of hatchling and juvenile gopher tortoises (*Gopherus polyphemus*). He reported use of several types of refugia: self-constructed burrows, enlargement of existing burrows dug by mice or insects, burial in sand and litter, burial in sand several cm beyond the end of the tunnel in a self-constructed burrow, and self-constructed burrows dug in collapsed entrances of large burrows. Desert tortoises are known or suspected to do all but burial in sand and litter.

Most burrows (79.5%) were sheltered in some way by live or dead shrubs. These figures closely correspond to those of Burge (1977, 1978), who reported that 72% of burrows of all sizes of tortoises were under shrubs.

Burrows were most often found under creosote (58.5%) and burro bushes (21.1%). Burge (1977, 1978) found 59% under creosote. She analyzed the types of shrubs under which burrows were placed and reported that no correlation existed between the burrow and pallet sites and the availability or density of shrub species. She concluded that a correlation did exist with the shade-giving properties of the plant species, however. For example, catclaw was present in an average density of 0.9/180 m^2 but was the most common shrub cover for tortoise burrows relative to its density (37.7%). Mojave yucca (*Yucca schidigera*) with an average density of 1.3 showed 30.3% relative use. The corresponding values for creosote bush were 16.0 and 16.6%, respectively. Burro bush with the highest average density of 56.7 showed the lowest relative use, 0.3%.

Creosote bushes were generally the larger shrubs on most California study sites, and provided more areal cover than most other shrubs. The shrubs preferred by tortoises varied according to site, however. On some sites, Mojave salt bush and ratany (*Krameria* spp.) commonly were used.

In this study, significantly more burrows of small tortoises opened in westerly and southerly directions, covering a 135° arc from west to southeast. Such directions might provide the small tortoise with some thermal benefits for basking and for activity in the immediate vicinity of the burrow, both in early morning and throughout the day. The findings were in sharp contrast to those of Burge (1977, 1978), who reported that most burrows under shrubs opened to the northeast or north, and that a significant number of depressions and pallets faced north. Burge's data were primarily from larger tortoises, however. The west to southeast facing burrows may have been on the southwest to east edges of or within shrubs, but no data were collected on this topic.

Habitat Preferences.—Five of nine study sites had nonuniform distributions of juvenile tortoises. More tortoises were found in creosote-burro bush habitats on firm soil; in creosote-shadscale habitats; and in small, narrow wash stringers near granitic boulders. Fewer tortoises were found near playas, in Mojave saltbush communities, on bare ground or cleared areas, and in wide river washes with desert trees and occasional, substantial flows of water.

Fewer tortoises were found in areas with human use or influence, e.g., off-road vehicle camps, in the vicinity of a well-used paved road, and guzzlers. The sparse distribution of juveniles in these habitats and areas was probably a reflection of the distribution of adult females and other, larger tortoises and of higher mortality rates. The numbers of tortoises >140-mm CL were low in these same habitats and areas (BLM field notes).

Recommendations for New Search Techniques

Some useful information which can be valuable in developing new search techniques emerged during our study.

(1) In March and April, field-workers should start walking early in the morning, shortly after dawn. The hours of sightings may be earlier and temperatures lower for the late winter and early spring months than presented here.

(2) Field-workers should consider a number of search images, such as (a) the appearance of different sizes of juvenile tortoises when walking, standing, fleeing, feeding, and basking; (b) the appearance of the tortoises when in partial and full shade, as well as sunlight, e.g., under a creosote bush, in fields of annual plants, and on bare ground; and (c) shapes and sizes of burrows.

(3) Small tortoise burrows with westerly, southwesterly, southerly, and southeasterly exposures should be sought, near or within the drip-line of creosote bushes or other, large, shade-producing shrubs. More burrows may be found within a 135° arc covering westerly to southeasterly exposures of shrubs than for other compass directions.

(4) Juvenile tortoises show preferences for using burrows under certain species of shrubs. These shrubs might be identified by comparing frequency of small tortoise burrows found under each species of shrub with actual densities or relative frequencies of occurrence of shrub species on each study site.

(5) Field-workers should avoid inspection of areas of low potential or areas which have proven relatively unproductive, e.g., bare or scraped expanses, areas near well-used roads, and large washes with frequent scouring by water.

(6) The edges of litter piles should be examined for signs of small pallets or burrows, e.g., as described in Douglass (1978) for the gopher tortoise.

(7) The field-worker should walk briskly, keeping a narrow range of viewing (about 10 m or less) with eyes continually on the ground. Thoughts should be concentrated on images of juveniles and their burrows. Dark glasses should not be worn because they may reduce visibility of camouflaged tortoises.

(8) The field-worker should not assume that because one small tortoise is found no others will be nearby. Small tortoises sometimes occur in clusters within 20 m of one another.

(9) Dogs could be used to locate juvenile tortoises. In 1973, a smooth-haired

rat terrier was very successful at finding this size group on the Desert Tortoise Natural Area. Coombs (1977) and Marlow (*pers. comm.*) used dogs, but neither commented on his success in finding small individuals. Schwartz and Schwartz (1974), in a study of the three-toed box turtle (*Terrapene carolina triunguis*), employed a Labrador retriever and a pointer. These dogs were able to find the larger juveniles and adult turtles, but seldom located newly hatched or small juveniles.

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TORTOISE RELOCATION IN FLORIDA: SOLUTION OR PROBLEM?

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The gopher tortoise (*Gopherus polyphemus*) occurs in the southeastern Coastal Plain from Louisiana to South Carolina. It is, unfortunately, declining throughout its range. The major reasons for this decline are human predation and habitat modification. Thousands of hectares of sandhill and scrub habitat have been altered by urbanization, agriculture, forestry practices, and mining activity (Auffenberg and Franz 1982).

The State of Florida has long served as the stronghold for this species. Yet no other southeastern state rivals Florida in the magnitude of urban development. This increasing urbanization has focused attention on displacement of indigenous fauna. As a State-listed Species of Special Concern whose conspicuous burrows provide a refuge for other state and federally listed species, the gopher tortoise is often considered to be a prime candidate for mitigation efforts. Tortoise relocation is being advocated by environmental consultants and regional planning councils with little thought to biological impacts.

Despite the recent attention, tortoise relocations are not a new occurrence in Florida. Large numbers of tortoises have been collected and released by tortoise hunters, tortoise race organizers, park rangers, wildlife officers and foresters. For example, employees of one northern Florida paper company have relocated 500-600 gopher tortoises over the years because the tortoises were "raiding" wildlife food plots (T. Ortegas, *pers. comm.*). On a smaller scale, private citizens often pick up tortoises along roads and release them elsewhere in the State.

Relatively few studies have been conducted on gopher tortoise relocation in comparison with the extensive desert tortoise (*Gopherus agassizii*) relocation work (Berry 1972, 1973, 1974, 1975*a*, 1975*b*). Gopher tortoises have been relocated by biologists in coastal Alabama (D. Speake, *pers. comm.*) and southeastern Georgia (W. Seyle, *pers. comm.*); however, success rates have not been established for these relocation efforts. Landers (1981) evaluated tortoise restocking success on four sites in southwestern Georgia and concluded that only about 41% (estimated from burrow count data) of the introduced tortoises remained in the vicinity of the release sites three years after relocation. Tortoise relocation experiments conducted in southern Mississippi by Lohoefener (*pers. comm.*) revealed an increased success rate (70-100%, based on recapture data) when tortoises were initially penned and placed in "started" holes.

In an attempt to gather information on tortoise relocation in Florida, I have participated in several relocation efforts. This paper discusses my involvement — either as consultant or investigator — in five gopher tortoise relocations and illustrates some of the problems encountered in these efforts.

In June 1981, I received word that a xeric hammock north of Ft. Lauderdale was slated for conversion to a golf course. A number of tortoises had already been removed by construction personnel and given to a wildlife officer. The release of these animals in a nearby State park illustrates a major tortoise relocation problem: state and local parks too often serve as "dumping grounds" for displaced tortoises with little thought given to habitat suitability or possible overpopulation.

A request for tortoises to stock a sparsely populated island prompted me to assist in this tortoise relocation effort. In July, I removed 15 of the remaining tortoises from the development site. The tortoises were manually captured or trapped in five-gallon buckets that had been set directly in front of the burrow openings. Bucket-trapping these tortoises provided another insight: tortoise relocation is definitely a labor-intensive activity.

The displaced tortoises were to be relocated to a federally owned island off the northwest Florida coast, where follow-up surveys would be conducted to document their dispersal and survival. Concerns regarding long-distance tortoise relocation and the potential mixing of gene pools arose from within the U.S. Fish and Wildlife Service. As a result, the decision was made to release the tortoises as close as possible to the development site. Identifying a suitable tortoise relocation site on the heavily urbanized southeast Florida coast is indeed a challenge; the tortoises were finally released on a sand ridge 80 km north of the point of capture. Unfortunately, the relocation site is now slated for development. This ill-fated tortoise relocation strongly emphasizes the need to procure a biologically suitable and secure site prior to any relocation effort.

Although tortoises have been indiscriminately relocated in the past, the pleas for genetic conservation cannot be ignored. Recent research has indicated that female gopher tortoises vary latitudinally in size at sexual maturity (Iverson 1980, Landers et al. 1982). Latitudinal differences in the winter dormancy period and clinal variation in morphology and color have also been observed (Douglass and Layne 1976, Landers et al. 1982).

In October 1981, I was requested to serve as consultant for a joint Disney World-Department of Transportation (DOT) tortoise relocation. An area of scrubby flatwoods was scheduled for construction of an interchange connecting Interstate Highway 4 to the EPCOT Center in central Florida. Tortoise burrows were excavated with a DOT backhoe, resulting in the capture of 13 tortoises. The tortoises were subsequently released in the Disney World Conservation area; no follow-up studies were planned.

This illustrates another problem surrounding tortoise relocation. Although the Disney World/DOT relocation personnel sincerely wanted to save the tortoises, the fact remains that each such development erodes the tortoise habitat base in Florida. Thirteen tortoises and one gopher frog (*Rana areolata*) were saved; however, the habitat and other burrow-dwelling species were destroyed. This point must be conveyed to the public, for they are often made to believe that the developer who relocates a few tortoises should automatically receive a "gold star" and the right to permanently alter the land.

In April 1983, I again served as consultant on a relocation attempt by a Jacksonville utility company. The tortoises were to be trapped and moved a short distance within property boundaries. Unfortunately, the sandhill was bulldozed the day after the tortoise bucket traps were installed. This unsuccessful endeavor emphasizes the need for proper coordination between company biologists and construction personnel prior to and during relocation efforts.

The need for information on tortoise relocation success prompted me to collaborate with R. Franz on a follow-up study. In 1978, Franz relocated 24 marked and 5 unmarked tortoises from a sandhill slated for mining to a reclaimed site on the Camp Blanding Military Reservation in north-central Florida. Intensive search efforts during the late fall and winter of 1982 revealed 51 burrows on the site. In March 1983, 5 tortoises were removed from their burrows by use of a tortoise hook (Taylor 1982). Seven additional tortoises were captured in bucket traps during May and June 1983. Of the 24 tortoises originally marked in 1978, 7 (29%) were recaptured in 1983. This recapture rate is probably a reflection of many factors, among them trapping success, tortoise mortality, potential removal by tortoise hunters, and emigration of released tortoises. The latter factor is noteworthy in light of findings on another study site where harvest impacts were investigated. A "harvested" tortoise that was removed from a fenced plot and released on a sandhill 1.3 km away traversed the inter-sandhill flatwoods and returned to within 32 m of its original burrow. This apparent homing ability has been reported elsewhere (McRae et al. 1981) and may have implications in future decisions regarding tortoise relocations.

To gain further insight into tortoise relocation and the effects of races on tortoise populations, I marked, measured, and released 30 tortoises used in the 1983 west Florida tortoise races. The tortoises were divided into four groups and released on a State wildlife management area in September 1983. Efforts will be made to recapture these animals in 1984.

Like tortoise relocation, tortoise races have recently generated controversy. Although it would be difficult to pinpoint an exact date when Floridians first began pitting these testudinid speed demons against one another, organized races to benefit charities have been in existence for several decades. In the late 1970s, it was not uncommon for 100 or more gopher tortoises to be captured in Georgia and transported to Florida for the races (R. Stratton, *pers. comm.*).

In the past, treatment of race tortoises was often less than satisfactory. Many were painted and placed in overcrowded conditions (Dietlein and Smith 1979). Within the last decade, the Florida Game and Fresh Water Fish Commission began issuing permits to various communities wishing to race tortoises. These permits allowed the race organizer to possess tortoises in excess of existing limits; they also stipulated that only colored tape be applied to the shell, that the tortoises be kept in safe and sanitary conditions, and that they be released within 48 hours after the race.

The collection of race tortoises and their subsequent relocation back into the wild poses yet unanswered questions regarding population disruption, gene pool mixing, and parasite and disease transmission. Large numbers of tortoises kept in close quarters could make this latter concern a major problem. Other concerns include the humane treatment of the temporarily captive tortoises and the ethics of using these reptiles for such purposes in the first place. The Gopher Tortoise Council, a group comprised of both scientists and lay persons, has suggested that one of the more common aquatic turtles (genus *Pseudemys*) be used in lieu of the tortoise. Others opposed to the racing of tortoises have suggested using armadillos (*Dasypus novemcinctus*) instead. The tortoise race organizers, on the other hand, cite the educational and informational benefits for the tortoise as well as the humanitarian goals of these charity events. Because of the increasing controversy over the races, the issuance of permits in the future is under evaluation.

The preceding examples have outlined some of the problems associated with tortoise relocation in Florida. The identification of suitable secure relocation sites remains a major obstacle. In the future, reclaimed mining lands in central and northern Florida may serve as tortoise restocking areas. The legumes and broad-leaved grasses that are often introduced on these reclaimed sites are favored tortoise food items (Garner and Landers 1981). One large phosphate mining company already has relocated several tortoises to an experimental reclaimed scrub site; moreover, the company has expressed a willingness to continue such relocations (B. Goodrich, *pers. comm.*). Before additional relocations are undertaken on reclaimed mining lands, radio-telemetry studies should be conducted to gather data on tortoise dispersal and survival.

In conclusion, gopher tortoise relocation is not a black or white issue. Like most wildlife management controversies, it falls somewhere in that grey zone. Relocation is not the solution for tortoise conservation in the face of increasing urbanization. In the future, emphasis should be placed on the retention of natural habitat areas to serve as buffer zones for developments and the restocking of tortoises on available lands from which they have been severely reduced or extirpated.

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A PANEL DISCUSSION ON RELOCATION AND RELATED ISSUES AND IMPLICATIONS FOR MANAGEMENT OF THE DESERT TORTOISE

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INTRODUCTION — Margaret Fusari

This panel was convened to raise and present some question associated with relocation of desert tortoises — whether for returning captives to their natural environs or for moving wild populations threatened with imminent destruction by land development, road construction, or other events. The panel did not intend to make decisions, take general positions, or advocate any particular actions, although speakers and audience were free to advocate for themselves. I assumed, as we began to discuss relocation as an issue, that all of us were committed to habitat preservation and ecosystem management as primary objectives and that we did not advocate relocation as an overall solution for desert tortoises or other species of wildlife.

I did feel that we needed to look at relocation as a special method worthy of our notice and in need of guidelines, partially because it is already with us and will undoubtedly become a more pressing issue in the future. With that in mind, I asked each of the five panelists to give a five-minute statement of some points that they considered crucially important and then we opened to questions and comments from the audience.

STATEMENT — Joan Deimer

Joan Diemer's statement has been presented in her paper (*see* pp. 131-135.

STATEMENT — James A. St. Amant

Prior to 1969, large numbers of unwanted captive tortoises were released in various desert locations. There is no record of survivals, however, studies conducted by Stewart from 1969 through 1971 of released tortoises showed survival to be very low. The major reason for high mortality was believed to be that tortoises held in captivity rapidly became domesticated and could not readjust to the wild in time to survive.

To determine if captive tortoises could be rehabilitated for survival in the wild, an experimental program was conducted from 1975 through 1978. The results of this program provided methodology for effectively rehabilitating captive tortoises for release in the wild. The techniques developed consist basically of screening candidate tortoises for suitability, including:

1. Medical examination, visual, x-ray, and blood tests;
2. Testing for rehabilitation capability — observation in confined "simulated" wild situation; and
3. Isolation in confined wild situation with limited contact but sufficient observation to remove tortoises in trouble.

Tortoises that were found to be unsuitable or incapable of rehabilitation were turned over to the adoption program. In 1977 the first "graduates" of the experimental rehabilitation program were released into the Mojave Desert. At the end of seven months, the survival rate was 64-76%. A second group of rehabilitated tortoises were released in 1978 and no losses occurred after seven months in the wild. The improvement in survival shown in the 1978 graduating class is believed to be because these tortoises were in better physical condition and the environmental conditions were more favorable when these tortoises were released.

As with any initial experimental program, additional studies are needed to refine techniques before the program is put into widespread use. These include:

1. Determination of long-term survival (follow-up of tortoises released in 1977 and 1978); and
2. Determination of age group or groups and sex ratios most suitable for release and reestablishment.

We still have not resolved the question of when tortoises should be released.

There are a number of potential problems with the release of captive tortoises, including the following:

1. Introduction of diseases, particularly those foreign to wild populations;
2. Disruption of species integrity (gene pool mixing);
3. Interference with social structure of existing populations; and

4. Increased stress on existing populations — competition-space and food.

Unlike many species that are in trouble (e.g., the condor) desert tortoises are available for reintroduction when and if needed. However, at the present time I see no urgent need for tortoise introductions. I do see a place for introductions in the future when and if the following conditions exist:

1. A population has been extirpated or has reached such a low level that natural recruitment will not maintain a viable population;
2. The problems causing the loss of the population have been corrected (e.g., habitat has been restored sufficiently to maintain a viable population); and
3. Threats have been removed (e.g., livestock grazing).

Do such places exist? Due to the urgency of attempting to maintain existing wild populations, mainly through saving what little is left of tortoise habitat, there has been little effort in determining if any areas meet the criteria for reintroduction. More areas are being developed where the only so-called mitigation — this is particularly true on private lands — is the removal of tortoises ahead of the bulldozers. These tortoises would appear to be ideal for introduction purposes; however, the only feasible recourse we have at this time is to turn wild tortoises into captive tortoises. As of 27 March 1984, there were 22,270 permitted tortoises in captivity in California.

STATEMENT — Kristin H. Berry

In October of 1981 I had the fortune to go to Oxford, England, and be part of the Tortoise Specialist Group, an international group that is part of the International Union for the Conservation of Nature (IUCN), Species Survival Commission. This group met to discuss the status of tortoises worldwide; to identify those which were rare, threatened, or endangered; and to take action on the most rare, threatened, and endangered species. The Commission also discussed problems such as relocation and management of captives. I am going to read to you its resolution on dealing with captives.

"The IUCN tortoise specialist group urges all institutions or individuals having tortoises in their care to endeavour to breed them, successful captive reproduction being the best criterion of sound captive management and much behavioural and husbandry information resulting from well designed captive culture programs.

"The group nonetheless cautions against acquisitions of tortoises by institutions or individuals with the justification of the intention of captive breeding, especially when captive breeding is more of a fond hope than a confident expectation.

"The group urges that in all cases preservation of tortoise populations and species by habitat maintenance and controls on collections be the preferred technique, and that captive reproduction is essentially an *in extremis* approach to be used when habitat has collapsed or when the species is so rare that natural reproduction is unlikely.

"If captive breeding and subsequent release of tortoises is undertaken, the following precautions should be followed:

i) Genetic pollution should be vigorously avoided by utilizing stock of known origin and releasing subsequent generations in the same general area as that from which the stock was obtained; stock of unknown origin should only be used for extremely rare AND localized forms.

ii) Care should be taken to avoid introduction of parasites or bacteria to wild populations in the course of release of captive-bred individuals.

iii) Care should be taken to avoid shell distortions caused by over-rapid growth or nutritional deficiencies in tortoises propagated for release.

iv) Releases of captive tortoises anywhere and by anyone should be coordinated with accepted scientific and conservation authorities, ideally the members of the IUCN Tortoise Specialist Group.

v) The releases should be timed to coincide with the onset of optimal conditions of temperature, light, and rainfall.

vi) Tortoises for release should be uniquely and permanently marked and full records maintained.

vii) Wherever possible, captive breeding should take place within the geographic range of the species."

Some problems mentioned in the IUCN statement are also associated with relocation.

During the last few years, I've reviewed the literature on desert tortoises throughout their geographic range in the United States. I discovered that releases of captives have occurred since before 1950. Edmund Jaeger reported in a 1950 issue of *Desert Magazine* that he had taken tortoises to the desert by the truckload. In a 1955 issue of *Desert Magazine*, he said that John Laughlin of the California Department of Fish and Game also released numerous captives. Jim St. Amant and Glenn Stewart gave me records of over 800 captive releases at about 24 sites in California for the desert tortoise status report ("The status of the desert tortoise (*Gopherus agassizii*) in the United States," edited by K. H. Berry).

I also discovered that tortoises collected illegally in California in the 1960s and early 1970s were shipped to Salt Lake City, Utah, for sale, and ultimately, for possible release in Utah in the wild! California Department of Fish and Game wardens Carl McCammon and Frank Tharp told me about a tortoise collector whom they arrested in 1970 north of California City in the vicinity of what is now the Desert Tortoise Natural Area. The collector said that he had shipped 1,000 to 2,000 tortoises per year from that area for several years to Salt Lake City.

Finally, I want to discuss problems associated with relocating wild tortoises. Between 1971 and 1974, I worked for the California Department of Transportation on their Desert Tortoise Relocation Project. I was directly involved in release of 43 wild tortoises at two sites and peripherally involved in release of an additional 14 tortoises at a third site. Some tortoises traveled distances of at least 6.6 km from the release site. Most tortoises were tracked for only limited periods of three days to 12.5 months before they escaped us, so many may have dispersed greater distances. Because we released 31 tortoises on the Desert Tortoise Natural Area, we were able to recapture some of the relocatees years later during other studies. Six years after release, three were recaptured distances of 0.1 to 6.5 km from the release site. One was recaptured 10 years later 6.6 km away.

What do these dispersal distances tell us about criteria for release sites? If a tortoise travels 6-7 km before settling, the release site should be at least 7 km in radius (4.4 mi) or about 153.9 km^2 (60.8 mi^2). This is a large area. Where are we going to find a site this size without conflicting land-use commitments?

STATEMENT — Michael Coffeen

From the Utah viewpoint release of captive tortoises on the Beaver Dam Slope started with Woodbury and Hardy between 1936 and 1946. Seventeen once-captive tortoises were marked out of the 281 that they studied. Eleven of these were released by the authors themselves.

Records of captive releases started in 1973 with Eric Coombs and have continued until the present. Over 195 captive releases have occurred in this recent time period.

Excluding Woodbury and Hardy's work, there have been 221 native tortoises marked on the slope for a total of 416 marked tortoises. (When I say "the slope," I mean just the Utah part of the Beaver Dam Slope.) An analysis of these data on captive releases shows that up to 70% of some year's releases have survived their first winter, and some have been recaptured up to seven years later in Minden's 1981 plot. However, that does not represent very many tortoises. In fact, Minden's two studies on the slope recaptured 32 of these tortoises and showed that many are surviving. However, just surviving may not be enough. No data exists on the reproductive success of these captives. Only three breeding attempts have been observed in the captive releases. Two were between a captive and a native and one, that I observed this last fall, was between two captives. No data exists on egg or hatchling production from captive tortoises on the slope.

The size classes and sex ratios of these 195 captives showed that they are mostly adults with a sex ratio of almost 1:1. Recent captive releases occurred at four main areas:

1. The Tin Can Dam, which is east of Highway 91, where 72 tortoises were released over five different years;
2. The Woodbury-Hardy plot, which was Minden's 1981 plot, where 28 tortoises were released over five different years;

3. Castle Cliff Wash, where there were 19 different tortoises released during two different years; and

4. Welcome Wash, where 55 tortoises have been released in the last six years (and where most of my work has been done).

Little data exist on the origins of most of these captives. Some have been documented as having come from Nevada. I was involved in a seizure of some tortoises from a pet shop and the individual we arrested said they were from Nevada. I was still working at the zoo at that time and those tortoises were released on the Beaver Dam Slope by the Utah Department of Wildlife Resourced.

Consequences of the potential gene mixing from captive releases are unknown. Selection pressures are high on the slope and released tortoises not capable of surviving quickly die. Since Utah still prohibits possession of desert tortoises, except for scientific purposes, they are still being turned in at the rate of 15 to 20 per year. In recent years the majority of these came from southwestern Utah communities. They are usually escapees from current owners, some of which have been recent California residents who do not usually have permits. The tortoises are held in the Cedar City Office until spring or late fall and then taken to the slope and released.

So what we have is the legal problem of possession. It's not allowed and something has to be done with the captives that get turned in by people who move into the state, or with tortoises that just show up in other people's yards. Currently there are no federal funds available and will not be until the recovery plan is done. Tortoises will continue to come in as developments increase in western Washington County and something has to be done with them. Discussions have been held with the BLM on constructing a captive release exclosure but no one has the money for this. The BLM is quite interested in that idea. I wish that the Fish and Wildlife Service would give us some direction such as they've done with the gopher tortoise in Florida, but as yet they leave that entirely up to the state.

(*See also* Mike Coffeen's paper, pp. 43-50.)

STATEMENT — Daniel Beck

My involvement with the tortoise relocation issue centers around problems with Utah tortoise populations. Consider the following scenario: A development planned for an area (Paradise Canyon) with a high tortoise population density, and where the tortoises have little legal protection, may necessitate removal of some of these tortoises to save them from almost certain destruction as construction proceeds. The Beaver Dam Slope, less than 40 miles away, once an area estimated to support over 2,000 tortoises (Coombs 1977)[1] currently supports only a few hundred tortoises. Areas on the

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[1] Coombs, E. M. 1977. Wildlife observations of the Hot Desert region, Washington Co., Utah, with emphasis on reptilian species and their habitat in relation to livestock grazing. By Utah Division of Wildlife Resources to USDI, BLM Utah State Office. Contract No. YA-512-CT6-102. 102 pp.

slope that once carried tortoise populations have either no tortoises at all or small assemblages with unbalanced age structures and/or sex ratios.

The Paradise Canyon tortoise population could provide a valuable stock source for the areas on the Beaver Dam Slope in Utah where tortoise populations have been decimated by human activities. Data for over ten years exist on many of the Paradise Canyon tortoises. They are strong and healthy and well adapted to surviving in the wild.

Since it has such favorable tortoise habitat, Paradise Canyon could also serve as a buffer area where captives could be released and acclimated to habitat where they would have a better chance of survival than on the Beaver Dam Slope. The wild tortoises of Paradise Canyon could serve as the transplant stock to the Beaver Dam Slope because they would have a better probability of survival there than newly released captives. The State of Utah could monitor captive releases there to ascertain survival and adjustment to wild conditions.

Wild transplants could complement weak tortoise populations in Utah if considerable information exists on the sex ratios and age structure of the tortoises in regions where tortoises will be introduced. If transplants are free of diseases and selected to complement the existing tortoise population and not interfere with it.

If our goal is to bring threatened tortoise populations back to stable levels, I believe a transplant program could be beneficial under the proper conditions. Some of those conditions were just enumerated by Dr. Berry. Those conditions would have to be met for a viable relocation program and further discussion of the specifics of those conditions for the desert tortoise may be a good topic for further discussion.

My main concerns now are that we need to establish guidelines for such a program and to identify potential release sites or available habitats for tortoises in jeopardy of losing their habitats to development.

(*See also* Dan Beck's paper, pp. 43-50.)

SUMMARY OF DISCUSSION — All Participants

A 15-minute discussion period followed the presentation of statements. No attempt was made to transcribe the remarks word for word. The following is a summary of that discussion.

Question.—Is there any information available on people poaching the eggs from wild populations of desert tortoises?

St. Amant.— I'm not aware of any poaching because the eggs are so hard to find. We have had reports of people illegally collecting tortoises from the desert, especially from the Natural Area because they are easy to find there, and taking the tortoises to Los Angeles to eat them. Such poaching of tortoises is reported to be a common occurrence either for eating or for sale of live tortoises to the eastern United States or overseas.

Question.—We need to be careful to distinguish between introduced populations, reestablished populations, and native populations contaminated by addition of released captive tortoises. Each type of population warrants distinct attention and/or management priorities. How can we make such a distinction especially in areas such as Paradise Valley, Utah, where there is much ambiguity as to whether any particular tortoise is native or a release?

Beck.—We don't know for certain that we have completely natural populations. There is no question that some of the tortoises there were released or their ancestors were released in the St. Goerge area. Most of the tortoises now in Paradise Canyon, particularly in the younger age classes, were born there and are native in that sense, although their ancestral stock may not have been. Most probably some tortoises now in Paradise Canyon were introduced and some are native.

Question.—What evidence is there that some or all of the tortoises in Paradise Canyon were released animals? Were they marked?

Beck.—I've personally seen less than a half dozen known captives, that is, tortoises with drill holes or other evidence of captive existence. Eric Coombs reported that he had heard from a number of people from St. George, Utah, who reported releasing tortoises in the area. It's impossible to say now whether the ancestors of most of the tortoises of Paradise Canyon were native or introduced. The keeping of captive tortoises is now illegal in Utah and the pressures for release of captives has changed over the years. Many of the tortoises now in Paradise Canyon are wild in the sense of having been born in the wild and in the sense that they are surviving well in the wild.

Question.—Don't the characteristics of the population now in Paradise Canyon support the idea that the area is and has been good tortoise habitat for a long time? Isn't the area a natural one for tortoises in the sense that there have been tortoises thriving there for hundreds and hundreds of years?

Beck.—Absolutely. If it's such a good place for tortoises to survive, now that supports the assumption that they would have been there 300 years ago and that the habitat is a natural tortoise habitat.

Question.—Wouldn't you interfere with the continued survival of the native population of Paradise Canyon if you introduce more tortoises?

Beck.—Yes, it would have some effect, but the population is doing very well at present. With the development now happening in the southern part of Paradise Canyon, we're probably going to have to move some tortoises out if we are to save them. If we release a few at a time, over a period of several years, the impact should be low. We're going to try to work with developers to minimize the impact in areas of dense tortoise populations.

Question.—How is the release of captive tortoises being addressed in the recovery plan now being prepared in Utah?

Coffeen—The interagency draft of the plan is not yet available and I should not comment without having the precise wording here with me. The concept of of the release of captive tortoises will be addressed. The draft is now in Denver and we expect it to be ready within a year. We expect to have more opportunity to comment on it.

St. Amant.—That recovery plan included the release of captive tortoises as part of the recovery. I don't recall the precise wording. There are questions in my mind about the operation in a number of ways. I see a real problem in releasing captives into an area already stressed; that doesn't make sense to me. Would that enhance recovery or risk completely destroying the population?

Question.—Is there evidence that Native Americans carried tortoises from one place to another in prehistoric times? Wouldn't that have been a source of mixing of gene pools of different tortoise populations?

Berry.—Yes, definitely, to the first question. There are tortoise remains at Chemehuevi Indian camp sites along known trade routes. News articles and papers document that the Chemehuevi carried tortoises on long trips to use as food. To the second question — I doubt that such transport involved mixing of gene pools. The Chemehuevi very probably ate the tortoises that they carried for food.

Question.—Considering the risks of unknown effects of gene pool mixing and introduction of disease into native populations, wouldn't the release of tortoises on Beaver Dam Slope, Utah, be a violation of the Endangered Species Act?

St. Amant.—I don't know if it is or not; it should be. In dealing with recovery plans for fish, our policy is not to take fish outside their range. In working with the recovery plan for the Colorado River razorback sucker, we have had questions about raising fish in hatcheries and then releasing them at multiple locations along the river. Electrophoretic work indicates that, although there are intergrades involved, the populations are pretty much the same. With tortoises we are at step one. We really don't know enough about the genetic identity of populations or subpopulations to make such decisions.

Coffeen.—That is a good question and I would suggest a letter to the Fish and Wildlife Service in Salt Lake City would be in order. I've asked about that interdepartmentally and nothing has come up on that. I've just been told to continue with what I'm doing. That's where I have to be.

Question.—Is it being redundant to ask if the places where you would introduce tortoises are capable of carrying any more tortoises? Have you established the carrying capacity? Can you insure that livestock will not be threatened? Have you done at least a parasite scan to know that you are not introducing disease to the populations? Where are these places that can accept more tortoises and what are the criteria for their identification?

Berry.—One of my biggest concerns has been release of captives and relocation of wild tortoises. I don't think we can identify any places in California which are below carrying capacity for tortoises. While many sites have suffered depletions of populations, the habitat also has been degraded. We also cannot identify any tortoise habitat below carrying capacity which is also free of conflicting land uses, either existing, ongoing, or with future commitments.

Fusari.—Carrying capacity is a labile thing. Just because there once were 500 tortoises per square mile doesn't mean the same area today could hold that many. Habitat degradation, particularly by overgrazing, can have long-term effects on carrying capacity. Another concern of mine is that the public is not comfortable with the term "natural" applied to captive-released animals. I fear the potential of legal decisions going against the conservation of populations considered to be not natural or contaminated.

Berry.—If people are going to worry about whether Paradise Canyon tortoises are captive or native, why shouldn't they worry about the Beaver Dam Slope population which is composed of a combination of captives and natives? Forty-six percent of marked tortoises on the Beaver Dam Slope are released captives. Should the Beaver Dam Slope population be dropped from consideration because of its composition of captives?

Question.—Has the State of Utah considered introductions to other areas, and why or why not?

Coffeen.—The only historic habitat in Utah, other than little pockets in Matawqua, around Bloomington, Washington, and St. George, is the slope. We've surveyed an area around Sand Mountain where the Alan Warner Power Plant is due to go and the habitat does look good, similar to that is Paradise Canyon. Whether that could happen, I don't know. If the power plant project doesn't go and we get some money, that's a possibility. But usually projects don't die; they just go dormant for a while.

Question.—Perhaps we should consider whether our release of tortoises is in response to a tortoise problem or a human one. Are our actions for conservation purposes or just to solve a custody problem for an agency, individual, or organization? I feel it may be counterproductive to potentially confuse our field data by injecting captive tortoises of unknown origin or history into natural areas.

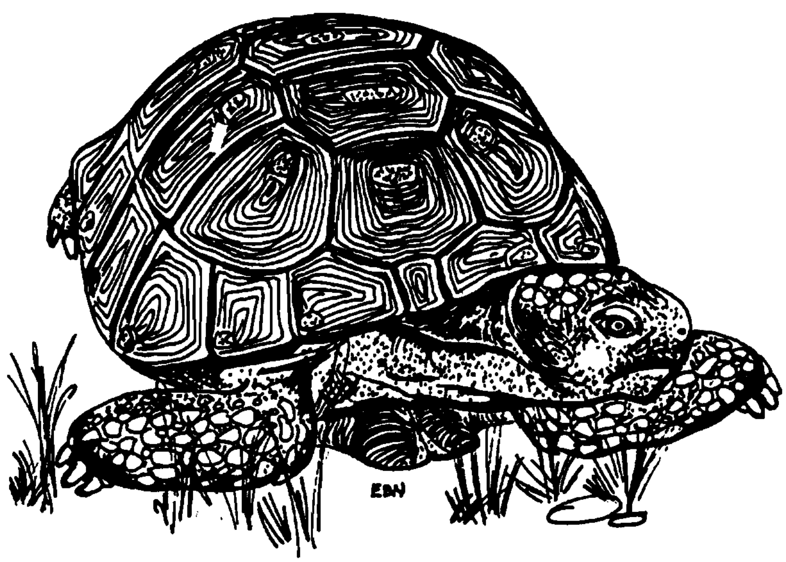
St. Amant.—I think that comment is well taken. I'd like to summarize three points:

1. The Desert Tortoise Council has informed the Department of Fish and and Wildlife in Utah, the Utah BLM, and the Utah State Division of Wildlife Resources, that we do not recommend the release of tortoises into the Beaver Dam Slope. According to what we know about the releases, the tortoises have not been checked for diseases, the habitat conditions on the slope have not improved, and no increase in the carrying capacity has occurred. Yet they are putting more tortoises in to stress the existing population. We commented on this on the recovery plan but have had no response as yet. The comment about the legal question of introducing tortoises into an area that has a listed population may offer a way to approach the problem.

2. What do we do with captive tortoises that people no longer want? California now uses an adoption program to at least temporarily solve the problem. This means that poeple who want a pet tortoise don't

have to go out to the desert to collect a wild tortoise (which is illegal); they can go to the adoption program for one.

3. What do we do with the tortoises that we are picking up just ahead of the bulldozer? These are wild tortoises and would be suitable for relocation. However, we still have not identified suitable sites, if they exist, and cannot yet expect successful survival or a lack of negative impacts on preexisting populations. I believe this panel, with participation of this audience, has presented a number of ideas and also raised a number of questions on relocations. The role of relocation in the recovery of the desert tortoise has yet to be determined.



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THE GENUS NAME FOR NORTH AMERICAN GOPHER TORTOISES

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Bramble (1982) coined *Scaptochelys* for two living species of gopher tortoises from the western United States: *Gopherus agassizii* (Cooper 1863) and *G. berlandieri* (Agassiz 1857). The former species was designated the type species for the genus *Scaptochelys*. He retained *Gopherus* Rafinesque, 1832 for *G. polyphemus* (Daudin 1802) and *G. flavomarginatus* Legler, 1959. Bramble's evidence conclusively showed that *G. polyphemus* and *G. flavomarginatus* are more closely related to one another than any other living gopher tortoises. His evidence linking *G. agassizii* and *G. berlandieri* together to form a natural (i.e. monophyletic) group is not as strong. The only characters shared by *G. agassizii* and *G. berlandieri* are also shared by *G. polyphemus* and *G. flavomarginatus* and are, thus, primitive for *Gopherus*. Based on the morphology of other tortoises of the world (*see* Crumly 1984, *in prep.*), it would be inconsistent to recognize *G. agassizii* and *G. berlandieri* as a separate genus. Wermuth and Mertens (1961) suggested that all gopher tortoises be considered subspecies of *Gopherus polyphemus*. Auffenberg (1966, 1976) recognized that *Gopherus* was divisible into two groups (the same groups recognized by Bramble 1982). Later, Wermuth and Mertens (1977) agreed that four species of *Gopherus* should be recognized.

My studies (Crumly 1984, 1985, *in prep.*) suggest that *Gopherus* include all four living North American tortoises because they share a unique combination of characters unknown in most other turtles. These characters include: (1) a median premaxillary ridge (also known in *Stylemys*, an extinct relative of gopher tortoises); (2) prefrontal pits, which develop in large adults of *G. agassizii* and *G. berlandieri*, but are present in most specimens of *G. polyphemus* and *G. flavomarginatus* regardless of size; (3) class I type mental glands (Winokur and Legler 1975); and (4) the absence of the dorsal crests of the postzygopophyses of the 8th, 7th, and 6th cervical vertebrae (the only other tortoise without dorsal vertebral crests is *Malacochersus*).

As an aside, Bour and Dubois (1984) have clearly shown that *Scaptochelys* Bramble, 1982 is a junior subjective synonym of *Xerobates* Agassiz, 1857 because Brown (1908) subsequently designated *Xerobates berlandieri* Agassiz, 1857 type species of *Xerobates*. Thus, for nomenclatural reasons *Scaptochelys* cannot be used, regardless of the closeness of the relationship between *G. agassizii* and *G. berlandieri*.

For these reasons, I strongly recommend that the gopher tortoises of North America continue to be recognized under the genus name *Gopherus*.

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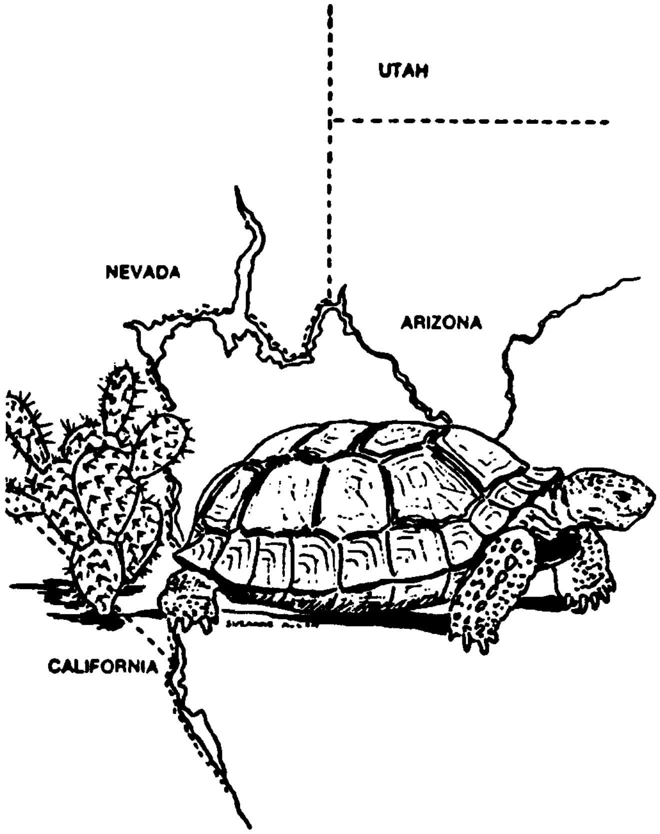

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