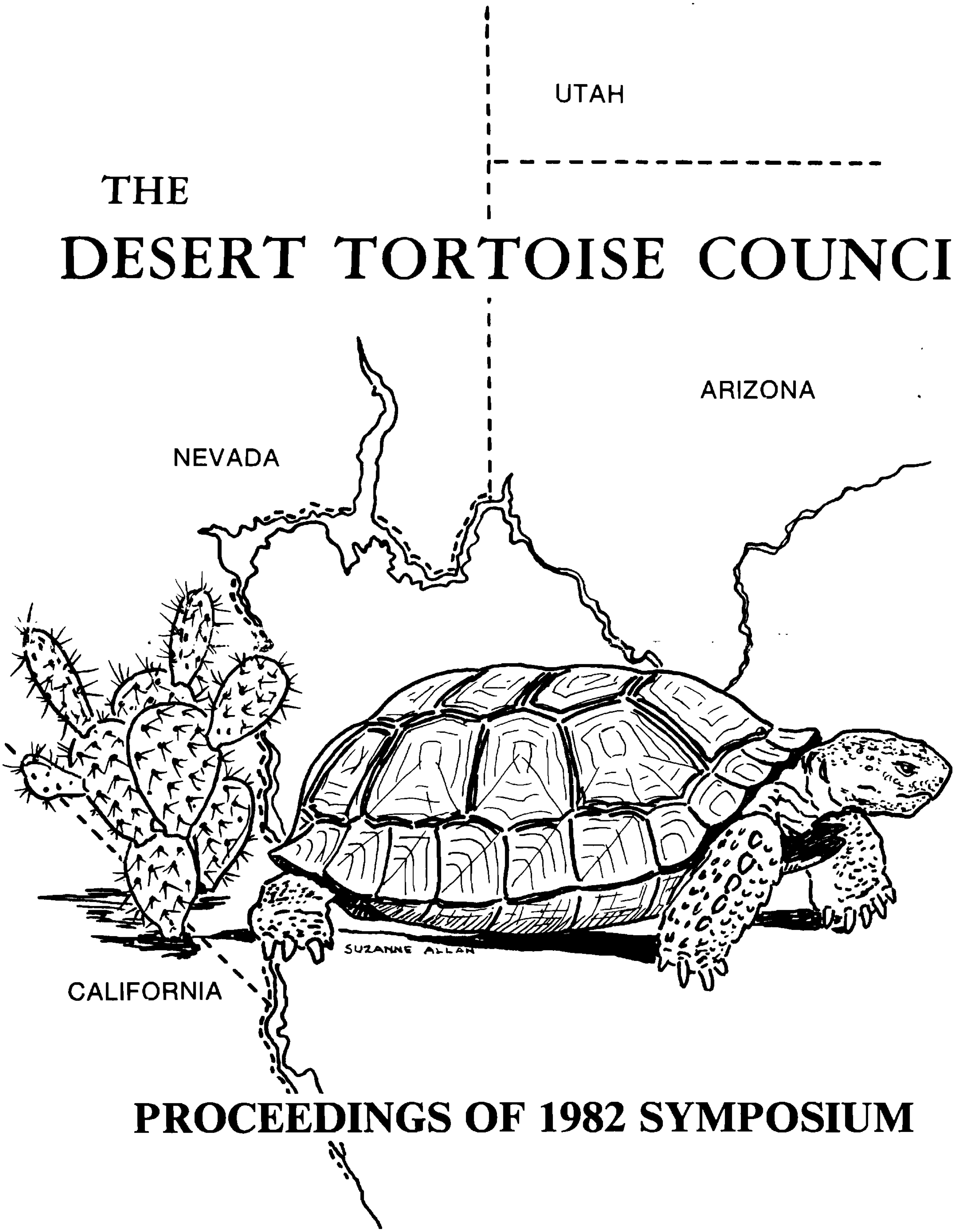
THE DESERT TORTOISE COUNCIL



PROCEEDINGS OF 1982 SYMPOSIUM

DESERT TORTOISE COUNCIL

PROCEEDINGS OF 1982 SYMPOSIUM

A compilation of reports and papers presented
at the seventh annual symposium of the
Desert Tortoise Council, 27-29 March 1982,
in Las Vegas, Nevada
and
St. George, Utah

Publications by the Desert Tortoise Council, Inc.

Proceedings of the 1976 Desert Tortoise Council Symposium	$5.00*
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DESERT TORTOISE COUNCIL

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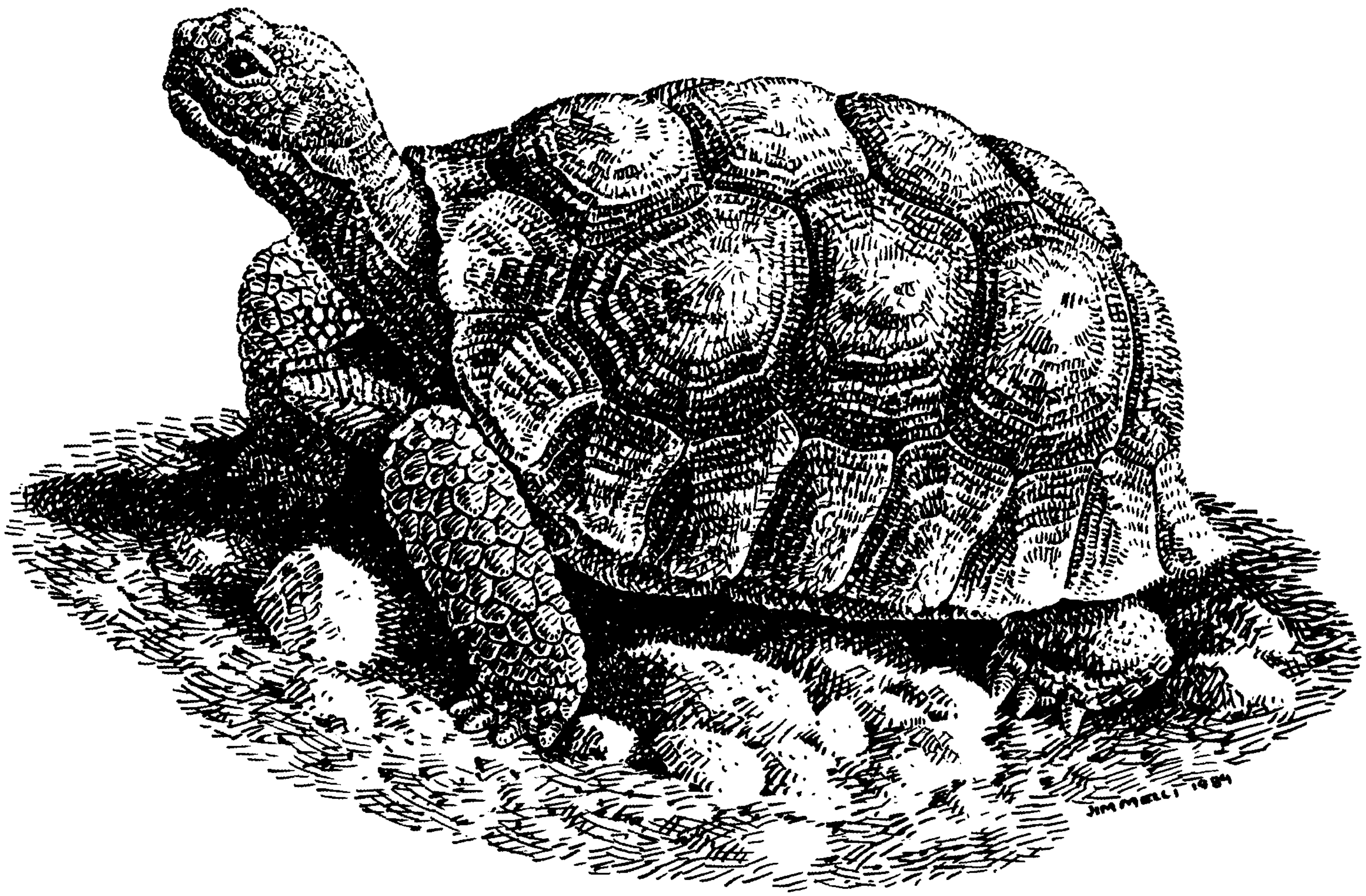
JIM MELLI 1984

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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 agassizi*. 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 agassizi*, 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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MAJOR ACCOMPLISHMENTS OF THE DESERT TORTOISE COUNCIL IN 1981

DAVID W. STEVENS
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Much of the Council's activities during 1981-1982 were focused on evaluations of actions and proposals that would potentially affect the continued survival of viable natural populations of the desert tortoise throughout its range, notably the following:

Desert Plan: Considerable time and effort was spent by the Council evaluating and commenting on the Bureau of Land Management's (BLM's) final California Desert Plan. Continued evaluation has resulted in the drafting of several plan amendment proposals. The continued evaluation of the Desert Plan will remain a high priority for the Council.

Resolutions: The following two major resolutions were passed by the Council this year: (1) a resolution which was sent to the Office of Endangered Species and key congressmen recommending protection for Ash Meadows, Nevada, a unique area which supports endangered species of fish, invertebrates, and vascular plants; and (2) a resolution which was sent to Secretary of Interior James Watt reminding him of the importance of the Endangered Species Act to the American people, and calling upon him to enforce the act for protection of threatened and endangered species.

Energy: Extensive comments were made to the Bureau of Land Management regarding protection of, and mitigation for, the desert tortoise populations within the sphere of influence of the proposed Allen Warner Valley Power Project. The BLM indicated in its reply to the Council that all Council recommendations were reasonable and would be implemented.

In addition to evaluating such actions as outlined above, the Council contracted with the U.S. Navy to conduct biological surveys to determine the presence of sensitive amphibian and reptile species, with emphasis on the desert tortoise, on the Chocolate Mountains Naval Aerial Gunnery Range. This study is to be completed in 1983.

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1982 ANNUAL AWARD: PROFILE OF RECIPIENT, JAMES ST. AMANT

James St. Amant is the recipient of the Annual Award for 1982. Jim, as he is known to colleagues and acquaintances, graduated from Michigan State University with a B.S. in fisheries. Shortly thereafter, in 1955, he started his career with the California Department of Fish and Game as a seasonal aide. He is now an Associate Fisheries Biologist.

James St. Amant

Jim's entire career has been devoted to conservation, protection, and enhancement of natural resources — particularly habitat for fishes, amphibians, reptiles, and other wildlife. During the 1960s and early 1970s, he worked to develop regulations to prevent overcollecting and commercial exploitation of amphibians and reptiles for the pet trade. Also in the early 1970s, Jim initiated and founded the unofficial Four States Desert Tortoise Recovery Team. This team was the forerunner of the Desert Tortoise Council. Jim thought that the desert tortoise and its habitat could be better served by a Council similar to the Desert Fishes Council. Jim co-founded the Desert Tortoise Council in 1975 and was its first Co-Chairman. Since that time, he has continued to be one of the more active and productive leaders through his work on the Executive and Advisory committees. Rehabilitation and eventual release of captive tortoises was one of Jim's early interests. He focused on efforts on experimental rehabilitation through the Halfway House at Ft. Soda. When this program revealed a number of problems, Jim worked to stop the California Department of Fish and Game's captive-release program. More recently he studied the effects of the U.S. Bureau of Land Management's draft and final Desert Plan and the Desert Plan Amendments on tortoise populations and habitat.

Jim also has been Chairman of the Desert Fishes Council and the Prohibited and Protected Species Committee of the Colorado River Wildlife Council, as well as Team Leader of the Colorado River Fishes Recovery Team. He has been or continues as a member of the Unarmored Threespine Stickleback Recovery Team, Desert Slender Salamander Advisory Committee, Mojave Chub Advisory Committee, Desert Pupfish Advisory Committee, and Western Pond Turtle Advisory Committee.

He also is advisor to the Coachella Valley Fringe-toed Lizard Advisory Committee. He played major parts in the establishment and development of these groups, as well as assisting in the acquisition of desert habitats near Boron and Camp Cady. Through his efforts and influence over the past 15 years, the Department of Fish and Game in southern California has shifted its focus from sport species to broader interests in nongame species, and in threatened and endangered wildlife.

Jim's efforts to protect the tortoise and its habitat, and habitat for fishes, amphibians, and reptiles in southern California have extended to his private life. He gives numerous presentations and lectures to organizations, elementary and high schools, and colleges. He has contributed to radio and television programs.

James St. Amant will continue his conservation efforts in the Southwest. He does not believe that he has accomplished enough, but we know that he has done more than most ardent conservationists. Symbolic of the Council's appreciation, Jim was presented with a bouquet of tiger lilies. The tiger lilies represent the ferocity with which Jim has and can pursue environmental and species' issues, the delicate nature of the ecosystems in critical need of conservation, the beauty of the environment he has tried so hard to protect, and the rarity of some of our most precious wildlife resources. Congratulations, Jim. Your enthusiasms and concerns for wildlife and habitat have influenced many biologists, students, and members of the public to take more active and protective interests in our native species.

—Kristin H. Berry

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1982 FIELD TRIP TO BEAVER DAM SLOPE, UTAH, AND HOHMAN STUDY SITE IN ARIZONA

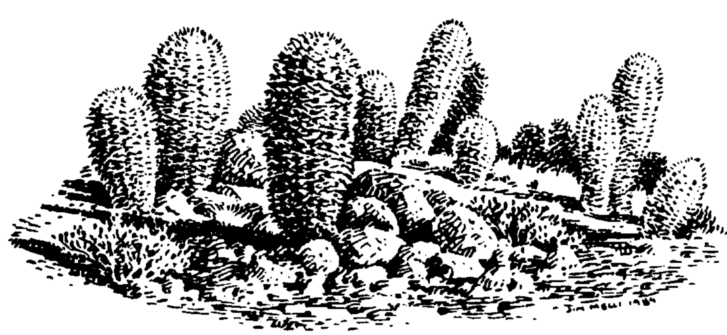
A cool, overcast, and windy day greeted a diverse group of desert rats, biologists, managers, and other interested individuals to the famed Woodbury-Hardy study area on Beaver Dam Slope in Utah. Frank Rowley was present to explain a bit about management of the area and answer questions as the resource area manager responsible for decisions affecting the critical habitat. The group then dispersed for a couple of hours to investigate habitat conditions and denning sites in washes. Although there was no apparent tortoise activity, all was not lost. The exchange of ideas Billy Templeton referred to earlier that morning became a sincere reality. Dr. Kristin Berry and Duane Blake enjoyed the opportunity to express ideas and common concerns for the desert resources as they walked among the shrubs and Joshua trees.

After the more than 20 participants completed their investigations in Utah, we all headed a couple of miles due south into sunny Arizona where the Bureau of Land Management established a 550-acre exclosure in 1976 as one of Judy Hohman's study sites. In 1979, I continued the study, which included tracking several radio-fitted adults. Enroute to tracking down one of those signals, Kristin Berry located one marked tortoise, aboveground and active. The radio-fitted animal was also found, resting under a shrub.

Judy Hohman offered to show Ken Dodd and Jerry Burton the den location of one tortoise. They accepted, but afterward wished they hadn't. After spending about 20 minutes scaling the rocky slopes, Judy showed them a site most people would consider inaccessible to tortoises.

Even with the chilling March winds blowing across the slope, a good time was shared by all. For many, the long-awaited visit to the historic study site of Ross Hardy and Angus Woodbury was well worth the trip.

—George Pat Sheppard



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Keynote Address

THE STATUS AND FUTURE OUTLOOK FOR THE DESERT TORTOISE IN NEVADA

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It is a distinct pleasure and opportunity for me to extend a hearty welcome to you and greetings from our past Director Joe Greenley. I can see from a quick review of your activities in the Desert Tortoise Council that Las Vegas has had the distinction of hosting three of your past six conferences. I want to compliment you on your choice of meeting locations.

I am also impressed that during your relatively short existence, being formally organized on April 25, 1975, that you have established and maintained worthy goals and have maintained high standards of professionalism, collectively as a Council and also as individual members. Your accomplishments are significant and meaningful in Nevada and throughout the Southwest. Your Council has met in symposium and disseminated significant knowledge on the desert tortoise. "Symposium" is an interesting word, derived from the Greek "Syn" meaning "together" and "Pinein" meaning "to drink." Webster's definition for symposium is a drinking party especially following a banquet; a social gathering at which there is free exchange of ideas; a collection of opinions on a subject; a discussion. For my part, I hope it is the later three definitions that apply.

The Nevada Department of Wildlife is a relatively infant organization, having been established as the Department of Fish and Game in 1947. Prior to 1947, game and fish management was the responsibility of each county of the State. The change in title from the Department of Fish and Game to the Department of Wildlife occurred in 1979. This change may have appeared to be a simple and logical one; however, it has had much greater significance in that the name includes all wildlife including fish whether they are hunted, trapped, fished for, or not. The nongame program in Nevada was formally initiated in 1973, when a single biologist was hired to work statewide. Today, we have three biologists responsible primarily for terrestrial wildlife. Limited work is also directed toward endemic fishes, amphibians, and reptiles. The Department's reptile work is presently restricted to desert tortoise with funding earmarked by the State legislature. By Commission Regulation there are presently only two species classified. The Gila monster and desert tortoise are the lone representatives of the entire Class Reptilia classified as protected and further classified as rare. "Rare" by Commission Regulation means "a species or subspecies: although not presently threatened with extinction, it exists in such small numbers throughout all or a significant portion of its range that it may become endangered if its environment deteriorates." All other reptile are unprotected and there is no closed season on those species.

Funding for the nongame program ($28,000 annually) is provided by the general fund from revenues appropriated by the State Legislature. A total of $5,000 is earmarked to fund endemic fish and a like amount for desert tortoise. The remainder of the funding is matched with Pittman-Robertson Federal Aid to Wildlife Restoration funds to carry out the Nongame Program of the State.

I share this very brief background with you to show clearly the state of infancy of the nongame work in Nevada and the relative position reptile management occupies in the State.

Despite the rather bleak picture presented, the Department has not been without success or effectiveness. Quite the contrary! We have made considerable gains in nongame work especially with the basic survey and inventory programs. With regard to desert tortoise, present programs identify the following activities:

1) Delineation of tortoise distribution and identifying key habitats.

2) Determination of tortoise densities in occupied habitat.

3) Maintaining tortoise input to land management agency plans.

4) Providing a solution to the problems associated with urban populations of tortoises and the possession of a protected species.

To date we have been successful, with the help of many outside of the Department of Wildlife, in delineating the limits of distribution of desert tortoise in Nevada, with the exception of those areas of central Nye and Lincoln counties within the boundaries of the U.S. Air Force Bombing and Gunnery Range. Some of these areas are so highly classified that access to do wildlife work is near impossible. Work in this area remains to be done in refining distribution boundaries.

Tortoise density work is progressing well and we are pleased with recent work accomplished in this area. Again, many agencies and individuals must be credited with major contributions toward meeting this goal. The Department plans to continue to establish new plots and monitor existing ones to determine any change in population density.

Wildlife input to Land Management Agency planning has been a very active area of work. The Bureau of Land Management has received Department recommendation relative to meeting the needs of desert tortoise. We consider this a necessary and ongoing activity that will continue to require considerable time. We are committed to this effort.

Contrary to what you may have heard and despite the dubious distinction of being labeled the Home-of-the-Sagebrush-Rebellion, not all Nevadans are rebels, not all are anti-environmentalist, or just plain "anti."

Admittedly, from some quarters strong sentiment and sensitivity against the environmentalist or special interest groups who vie for and compete with long-standing traditions and the "Nevada-way-of-life" is ever present.

Ranching, mining, and the railroad industries did indeed pioneer and develop Nevada. It is their blood, sweat, and tears that mark the land and contribute to what Nevada was and is in a large measure today. The progeny of these pioneers have a tradition to maintain even though they may no longer be directly associated with those base industries of the past. Nevada is changing faster than most natives would admit or accept. Attitudes and traditions are important and affect all of us in one way or another. Whether one is a teacher, miner, or banker, we are all affected by past history. So it is with biologists or wildlife managers or administrators. It is time we reckoned with it.

With greater frequency I have heard the statement, "Desert tortoise? Oh, those turtles; what good are they anyway?" To you and me the statement borders on sacrilege, and understandably so. However, to many native Nevadans it is a sincere question deserving an answer. Quite frankly, biologists in general have not successfully answered this simple question.

So often the retort is a surprised, "I can't believe anyone would ask such a stupid question," followed by a tirade of emotionalism. Desert tortoises do have a value but not one usually measured from an economic base. The tortoise is a unique and highly specialized animal which has evolved with its envisonment. To loose it would be forfeiting a vital part of the desert ecosystem and an irreplaceable part of our wildlife heritage. Humans would do well to learn from the desert tortoise. We could never justify the loss of a species simply because of man's disregard for his environment. I believe Aldo Leopold said it best:

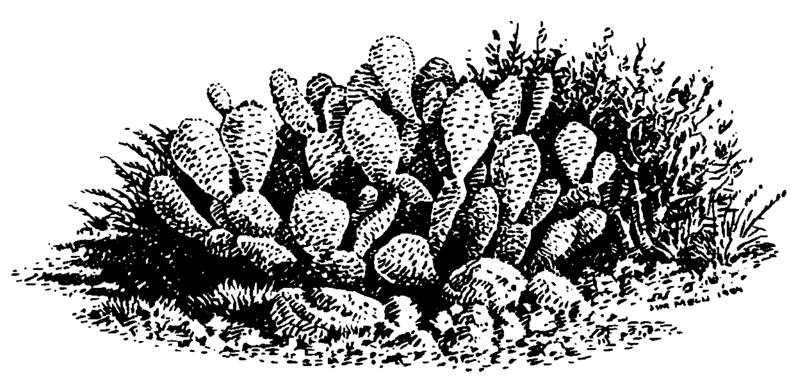
> "The outstanding scientific discovery of the twentieth century is not television or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little we know about it. The last word in ignorance is the man who says of an animal or plant: 'What good is it?' If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.
>
> "Have we learned this first principle of conservation: to preserve all the parts of the land mechanism? No, because even the scientist does not yet recognize all of them."

I believe it is imperative that professional wildlife biologists have a greater awareness of and come to an understanding of the socio-economic values of the people and area they serve. I am sure more would be gained for wildlife by abstaining from hostile debate and listening more.

A positive approach in resolving conflict in management direction and resource uses is the Coordinated Resource Management and Planning process (CRMP). The CRMP process brings together representatives from management agencies and resource user groups to establish dialogue so that decisions can be reached. It is not realistic to assume or demand that wildlife will always receive top priority in the decision process. A case in point is off-road racing in fragile desert habitats which has been recognized as a major cause of long-term habitat degradation. However, off-road racing has become an established activity that can be regulated but not completely curtailed. The Department of Wildlife has provided recommendations relative to new areas designated for off-road use. The proposed areas are assessed for the presence of wildlife and importance of the area for all wildlife including tortoises. Recommendations are made to protect the high value resources and requests have been made to remove established off-road trails from important wildlife areas. The CRMP process has the potential of reducing conflicts through compromise. Some compromise is inevitable, but let's make sure we win the major battles and not fret too much at the loss of lesser ones.

One of the most important decisions, that of listing, which may ultimately affect the desert tortoise more than any single action, looms on the horizon. This action should be carefully weighed and evaluated to determine, without a shadow of doubt, that listing will ultimately benefit the species. Quite ironically, while efforts are being made to list the tortoise, other efforts are directed toward determining what to do with all of those tortoises thriving in the urban environment. The question remains, is the tortoise threatened or endangered? Is the scientific evidence sufficient for listing? Will management authority improve with listing? Is the U.S. Fish and Wildlife Service prepared to manage the species and what about the question and legality of tortoise possession if it is listed as threatened or endangered?

I have hardly scratched the surface on a number of areas concerning desert tortoises. I offer opinions and few, if any, solutions. The future, as I see it, is in your hands as experts in resource managemeent, research, and administration. The decisions to be made are not easy ones nor are they clearly defined. This, then, is our first challenge. May we all be dedicated to this effort and exercise our stewardship responsibilities. This Council, as I see it, is up to the task.



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INTRODUCTION TO THE TORT-GROUP

BETTY L. BURGE
(for Jan Bowman, Chairperson)
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The Organization for the Protection of Nevada's Resident Tortoises (TORT-Group) was organized in November 1981, in Las Vegas, Nevada. The organization's goals are (1) protection of the free-living desert tortoise, *Gopherus agassizii*, and its natural habitat, and (2) responsible care of tortoises in captivity that have become domesticated. Its objectives are:

1) To support establishment of regulations that allow legal possession of domesticated tortoises presently in captivity;

2) To discourage removal of the protected free-living tortoise from public lands; to discourage release of domesticated tortoises or their young into undeveloped desert;

3) To provide a rescue and adoption service for unwanted or displaced domesticated tortoises, relocating them in homes where they will receive responsible care;

4) To support the establishment of measures that protect free-living tortoises on private, undeveloped land where tortoises are threatened directly or indirectly, or will be threatened by imminent development, and to assist the Nevada Department of Wildlife (NDOW) with rescue and relocation as requested;

5) To help NDOW and the Bureau of Land Management to meet their responsibilities regarding the protection of the desert tortoise and its habitat by supporting establishment of measures that assure that natural, free-living tortoise populations continue and do so at a self-sustaining level of vigor;

6) To promote responsible attitudes and action by providing information and educational programs for the general public; and

7) To cooperate with other groups interested in the conservation of Nevada's game and nongame animals and their habitat.

At present, it is illegal to possess a desert tortoise in Nevada without special permit, but no permit system has been operating on a scale that would serve the hundreds of households in southern Nevada where captive, domesticated tortoises reside. The TORT-Group Board of Directors has been working with NDOW staff and the Board of Wildlife Commissioners to continue protection of the wild tortoise while accommodating the needs of domesticated tortoises (to be given continuing custodial care in the homes of responsible persons) and do this with a permit system that is cost effective. California's permit system was scrutinized.

A possible solution lies in declassifying the domesticated, "urban" tortoise, thus avoiding the need for any permit system for the householders with tortoises. While legal implications are being explored more fully, one very large problem remains. NDOW staff are no longer releasing captives into the desert or confiscating captives, or promoting the relinquishing of captives to the Department by the general public. However, for various reasons, tortoises are being turned in to the Department, and the Department has no adequate facilities for caring for these tortoises. That is, until the regulations or policies are changed, hundreds of homeless but dependant captives are in need of immediate care.

TORT-Group has been authorized by NDW to find adequate facilities — extensions of the Department's holding area — where these tortoises will receive the care that they need. Various information and care sheets supplied by TORT-Group were given to persons helping members with the placement and care of domesticated tortoises.

The Nevada State Legislature convenes in January 1983. The necessary changes in regulations or policies should be operational by January 1984, after which TORT-Group will be allowed to advertise the availability of domesticated tortoises. This will not only provide homes for the many that are presently homeless but also provide an alternative to the poaching of free-living tortoises — adoption. Meanwhile, the TORT-Group continues to inform the public through its educational programs which include talks on reptiles to school classes and other groups, by answering telephone queries, through printed information on care and biology, through its newsletter, and its monthly meetings. It is already improving the standard of care given to captives and is bringing the plight of the free-living tortoise to the attention of persons who have been unaware and, in some instances, partially responsible for current impacts on the tortoise and its habitat.

TORT-Group representatives are participating in the Coordinated Resource Management Planning process that is developing recommendations to make to the Bureau of Land Management regarding off-road vehicle access and use limitations in Clark County for the next 10 years. This effort has helped our membership understand the very immediate threat of off-road vehicles and other land uses to tortoise habitat.

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THE DISTRIBUTION AND RELATIVE ABUNDANCE OF THE DESERT TORTOISE (*GOPHERUS AGASSIZII*) IN COYOTE SPRING VALLEY, NEVADA, WITH A DISCUSSION OF POSSIBLE IMPACTS OF THE MX PROJECT DEVELOPMENT [1]

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Abstract.—Data were gathered on the distribution and relative densities of desert tortoises in Coyote Spring Valley and vicinity, a proposed site for an MX project operating base. Tortoise distribution and abundance were estimated using 281 strip transects. In an area covering 431 mi^2, about 27% of the area surveyed had very low tortoise densities (est. at 0-10/mi^2); 41% had low densities (est. at 10-45/mi^2); 25% had moderate densities (est. at 45-90/mi^2); and 7% had moderately high and high densities (est. at $>$90/mi^2). Moderately high and high density populations were in relatively small, fragmented areas. Potential impacts to tortoise populations and habitat from development of the proposed operating base included loss of habitat from land clearing and construction of facilities for the base, collection and vandalism of tortoises, and increased vehicle use on and off roads. Several mitigation measures were discussed, including removal of tortoises from construction sites; relocation of tortoises; fencing of construction sites, base facilities, housing areas, and roads; posting of warning signs; implementation of a conservation education program; control of dogs and recreation use; a compensatory land acquisition program; increasing the carrying capacity of remaining tortoise habitat; and implementation of a monitoring program.

The Department of Defense (DOD) identified an area in southern Nevada and southwestern Utah as a proposed base for a mobile MX missile system (Huff 1981; U.S. Dept. of Defense et al. 1980). The Coyote Spring Valley in Clark and Lincoln counties, Nevada, was proposed for the central base of operations. This

[1] This paper does not represent the official views of the U.S. Air Force.

area was identified as important desert tortoise habitat by Karl (1981). Prompted by concerns for the desert tortoise populations, the Desert Tortoise Council proposed that the DOD fund studies to accurately assess the impact of the then proposed MX system. Such studies would facilitate elaboration of mitigation policies and procedures to reduce the impact and assure survival of the tortoise in this portion of Nevada. The study originally was planned as a two-part effort — the first phase was to focus on determining distribution and relative densities using a strip-transect technique, and the second phase was to consist of intensive censusing of two or more sites to determine population attributes. During the course of the study, the MX deployment and basing plans for Coyote Spring Valley were abandoned by DOD, and funding for the second phase of the tortoise study was rescinded. This paper summarizes the first and only phase of the study, offers a preliminary assessment of impacts, and proposes possible mitigation measures.

Background

Studies on the desert tortoise in Nevada are recent. The first study on a natural wild population in this state was completed at Arden by Burge (1977, 1978) and Burge and Bradley (1976). They studied growth, population attributes, movements, feeding habits, and patterns of utilization of cover sites. Another study on growth in confined wild tortoises in three 9-ha fenced areas at the Nevada Test Site was summarized by Medica, Bury, and Turner (1975).

The Nevada Department of Wildlife conducted some limited surveys to determine desert tortoise distribution and preferred habitat types at several sites in Nevada (Herron and Lucas 1978, 1979; Herron et al. 1980; Lucas and Oakleaf 1977). The Bureau of Land Management (BLM), Las Vegas District Office, funded 30-day censuses on three permanent study plots, each of which was one square mile or larger (Karl 1979*a*, 1979*b*, 1980*a*, 1981). The BLM also funded 300 strip transects to determine distribution and relative density on some BLM-administered lands in southern Nevada, including the Coyote Spring vicinity zone (Karl 1980*b*, 1981).

Data from strip transects provided crude estimates of tortoise distribution and relative densities for approximately 3,770 mi^2 of BLM-administered lands in southern Nevada, including the area proposed for the MX basing site in Coyote Spring Valley and vicinity (Karl 1980*b*, 1981). Although some crucial tortoise population areas were identified tentatively for the Coyote Spring Valley (Karl 1981), so few transects were walked (2 transects/36 mi^2) that an accurate determination of boundaries between low, medium, and high density tortoise populations was not possible. More detailed information was necessary to assess possible impacts and propose potential mitigation measures. BioSystems Analysis, Inc., was hired to conduct intensive surveys in Coyote Spring Valley and nearby areas, to determine tortoise distributions and relative densities, to outline possible impacts from an MX base, and to propose possible mitigation measures.

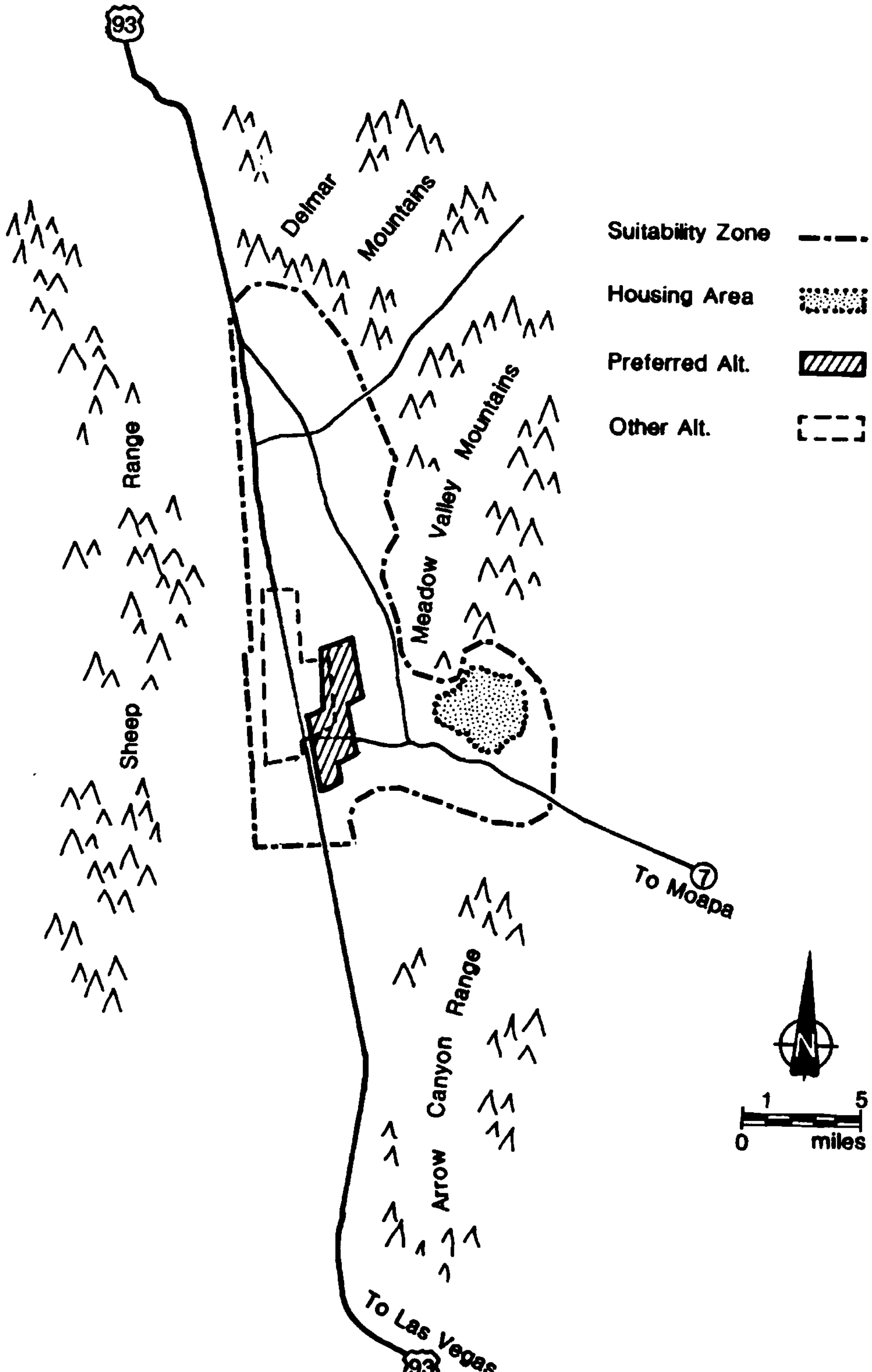

FIG. 1. — Locations of the suitability zone, housing area, and two alternative sites for military facilities for the MX base in Coyote Spring Valley, Nevada.

METHODS

The MX Operating Base and Facilities

The MX operating base and facilities are centered in Coyote Spring Valley (Fig. 1), and include a suitability zone and housing area, as well as the actual base facilities and structures. Two alternative locations for the operating base are also shown in Figure 1. The tortoise study area was considerably larger than the suitability zone and base, encompassing 430.7 mi^2. The tortoise study area extended from the lower slopes of the Delmar Mountains and Kane Springs Valley in the north, through Coyote Spring Valley and into Hidden Valley and Arrow Canyon in the south. The study area included major transportation routes to and from the base.

Tortoise Distribution and Relative Density

A strip-transect method, developed by Berry and Nicholson (1979, *pers. comm.*) was used to estimate relative density and distribution of tortoises within the study area. The method involves counting the number of tortoises and tortoise sign (burrows, scats, shells, tracks, etc.) along a strip transect 10 yd wide by 1.5 mi long. Transects were generally in the shape of an equilateral triangle but were occasionally modified to suit topography.

During the course of field work, 281 transects were walked within the MX study area. Transects were done between 14 July and 10 October 1981 by three field-workers experienced in the technique: A. Karl (156 transects), K. Bohuski (67), and P. Woodman (55). Bohuski and Woodman did three transects together, each recording sign for 0.75 mi. Chi-square tests were computed on sign composition frequency to see if differences existed in data collected in July-August vs. September-October. An additional 18 transects — called calibration transects — were walked on BLM permanent tortoise study plots in Piute Valley and near Sheep Mountain in Clark County, Nevada, where tortoise densities were better known. These transects were used to determine variations between field-workers, and to compare data from transects walked by Karl (1981) on the same study plots.

In recording data, the total number of tortoise sign was converted to total adjusted sign (TAS) by combining associated sign groups into a single adjusted sign. An example of an associated sign group is a burrow (1 sign) with four scats inside (4 sign) and a tortoise basking on the mound outside (1 sign). The total of 6 sign is adjusted to 1 sign. This adjustment is identical to the "corrected" sign developed by Berry and Nicholson (1979) and the adjusted total sign used by Karl (1981). The term TAS is used here because it was the term used by Karl (1980*b*, 1981) for previous transect work in Nevada.

Using regression analyses, Berry and Nicholson (1979, *pers. comm.*) found that corrected sign and burrow count data from strip transects were positively correlated with numbers of tortoises marked during 30-day censuses of six permanent study plots and with estimated densities of tortoises occurring on those plots. They then assumed a direct relationship between the numbers of corrected sign and the numbers of tortoise marked in an area, as well as between the numbers of sign and relative tortoise densities. They developed five relative density classes based on sign counts (0-20, 20-50, 50-100, 100-250, and >250 tortoises/mi^2). The relative density classes were verified later by analysis of mark-recapture data from 60-day censuses conducted on several study plots (Berry and Nicholson *pers. comm.*).

Karl (1981) used the same transect technique and similar method of data analysis to estimate relative tortoise densities and distribution in Lincoln and Nye counties. To establish the relationship of burrows and TAS to tortoise density, Karl used ordinary least squares regression with burrows or TAS as dependent variable and qualitative density estimates (rather than actual counts of marked animals) from five study plots as the independent variables. She then established five sign classes with associated relative density ranges for Lincoln and Nye counties. We have used these sign classes in our study. They are:

Relative density classes (tortoises/mi^2)	General description	TAS classes (TAS/transect)
0 - 10	very low density	0
10 - 45	low density	1 - 3
45 - 90	moderate density	4 - 7
90 - 140	moderately high density	8 - 11
>140	high density	⩾12

We added an additional density designation (0 tortoises/mi^2) for areas exceeding 4,000 ft in elevation. No tortoise sign was found above this point during the study, and Karl (1981) had described this as a general elevational limit for the species in Nevada. At about the 4,000 ft contour, blackbrush (*Coleogyne ramossissima*) begins to replace other shrub species, particularly creosote bush (*Larrea tridentata*), a key species in tortoise habitat.

For analysis of data from this study, only TAS or corrected sign were used. Both Berry and Nicholson (1979, *pers. comm.*) and Karl (1981) found higher coefficients of determination (r^2) between this index and relative density than between burrows and relative density.

After completion of field work, all transect locations were noted on a map of 1:62,500 scale. Using the TAS classes shown above, polygons were drawn around adjacent transects within each class. Boundaries of polygons then were adjusted to fall within physiographic types and elevational contours. Attempts were made to connect all adjacent transects within a given sign class to give generalized relative density estimates for large areas. However, polygons were drawn around single transects in some cases.

TABLE 1. — Frequency of tortoise sign found on strip transects walked in Coyote Spring Valley. Total adjusted sign = TAS.

Sign	July-Aug. (Karl)			Sept.-Oct. (Bohuski-Woodman)			Total July-Oct.		
	N (%)	Mean number per transect	Mean number per transect w/sign	*N* (%)	Mean number per transect	Mean number per transect w/sign	*N* (%)	Mean number per transect	Mean number per transect w/sign
Burrows	401 (64.9)	2.6	3.1	268 (50.6)	2.1	2.9	669 (58.3)	2.4	3.0
Scats	128 (20.7)	0.8	1.0	205 (38.7)	1.6	2.3	333 (29.0)	1.2	1.5
Shells	77 (12.5)	0.5	0.6	42 (7.9)	0.3	0.5	119 (10.3)	0.4	0.5
Live	11 (1.8)	0.071	0.084	13 (2.4)	0.104	0.143	24 (2.1)	0.085	0.107
Tracks	1 (0.2)	0.006	0.008	2 (0.4)	0.016	0.022	3 (0.3)	0.011	0.013
Total	618 (100.0)	4.0	4.7	530 (100.0)	4.24	5.8	1 148 (100.0)	4.1	5.1
TAS TAS/total	514 (83.2)	3.3	3.9	396 (74.7)	3.2	4.2	910 (79.3)	3.2	4.0

Sources of Error in Data Analysis and Interpretation

Several sources of error exist and can affect the numbers presented for relative density classes, as well as numbers shown on the map of tortoise distribution and relative abundance for Coyote Spring Valley. Error sources include use of (1) data gathered in different seasons and years, (2) data from more than one field-worker, and (3) density estimates from 30-day censuses and other types of censuses of permanent study plots. Several methods were used to check for the presence of and degree of importance of these errors. The error sources, methods of analysis, and our interpretations are presented below.

Use of Data from Different Seasons and Years.—During the data-gathering phase, three field-workers (Karl, Bohuski, and Woodman) walked transects. Karl collected data in July and August, whereas Bohuski and Woodman walked transects in September and October. Transects made by Karl were within the proposed primary impact areas for the MX siting, whereas most of those done by Bohuski and Woodman were outside. Sign data for the two periods were examined by X^2 analysis to determine if distribution of sign types was nonhomogeneous (Table 1). The X^2 analysis indicated that there was a significant difference between data collected from the two periods ($X^2 = 48.3$, $p < 0.005$, df = 5). Differences could have been due to differences in the field-workers, the season, and/or the location of the transects.

A second X^2 analysis was done using only transect data collected by all three investigators within the primary impact area (Table 2). The resulting X^2 value ($X^2 = 0.251$, df = 4) indicated that there was no significant difference between data collected in July-August and September-October. The difference noted in the first test was possibly a product of the different transect locations rather than a result of differences in seasons or field-workers.

TABLE 2.—Number of tortoise sign observed on transects made between July-August and September-October in the primary impact area.

	Signs observed			
Time period (number of transects)	Burrows	Scats	Shells, live tortoises, tracks	Total
July-August (156)	401	128	89	618
September-October (42)	98	31	19	148
Totals	499	159	108	766

TABLE 3. — A comparison of total adjusted sign (TAS) counts from 1980 transects (Karl 1981) with TAS counts obtained during the present study within the same or adjacent mi^2.

1980 transect no.	TAS/transect	1981 transect no.	TAS/transect
1	1	15	1
2	1	in polygon with 1-3 sign	
3	0 - 1	197	1
4	2	151	3
5	4 - 5	139	5
7	0	182	0
9	0	171	0
10	0	168	0

As part of a 1980 survey of Lincoln and Nye counties, Karl (1981) walked eight transects within the study area. These transects are close to or coincide with transects done for this study (Table 3). All the 1980 transects were in the same relative density class as those done for this study. A Spearman's rank correlation coefficient, r_s, was computed to test the correlation between these transects. The resulting r_s (0.9714) indicated a high correlation between the 1980 and 1981 transects.

Use of Data of Different Field-workers.—For this study, the three field-workers walked transects at two permanent study plots in Nevada—Piute Valley, and Sheep Mountain—so that possible variations in sign counts could be compared (Table 4) Their sign counts then were compared with the sign counts of Karl (1981), who collected data in Piute Valley in 1980. This comparison was of potential importance because 1981 had lower rainfall and lower winter annual production than the previous few years. Tortoises might have been less active in 1981 and have left less sign as a consequence.

Confidence intervals for the mean numbers of tortoise sign found by each field-worker at two plots were computed as ± 2 standard errors. Means with non-overlapping confidence intervals were considered significantly different. Using this criterion, the data collected by field-workers during this study showed no significant differences. However, Karl (1981) found significantly fewer sign in 1980 than during this study. Her mean for 1980 was lower than means for the Bohuski and Woodman data, while her mean for this study was higher. Reasons for the differences are unclear. Karl undertook a 30-day census of the Piute Valley plot in 1980 (Karl 1979*a*), and her experience on this and other plots may have contributed to higher sign counts. Uneven distribution of tortoises and sign at the plot may have been a factor, too. However, when burrows which Karl listed as questionable on her transects are omitted from the data analysis, the differences diminish.

TABLE 4. — A comparison of the sign counts from tortoise transects made by three field-workers at Piute Valley and Sheep Mountain study plots.

Location of study plots	Year	Mean, confidence interval and range of sign counts and number of sign. Karl	Bohuski	Woodman
Piute Valley	1981	17.3 ± 3.6 10 - 24 *n* = 6	12.3 ± 2.9 9 - 15 *n* = 3	13.7 ± 3.3 10 - 17 *n* = 3
	1980 (Karl 1981)	10.3 ± 2.9 7 - 14 *n* = 3		
Sheep Mountain	1981		5.0 ± 1.9 3 - 5 *n* = 3	5.3 ± 1.9 3 - 7 *n* = 3
	1980 (Karl 1981)	4.0 ± 1.4 3 - 5 *n* = 2		

Use of Relative Density Estimates from Permanent Study Plots.—The sign classes used to prepare the tortoise distribution and density map for Coyote Spring Valley are relative density estimates and may not reflect the actual number of tortoises present in a particular area. Actual densities could be higher or lower. The sign classes are based on linear regression analysis where the independent variable consisted of density estimates from five study plots (Karl 1981). Absolute densities were estimated for only one of the five plots, the Arden site, but were not used in the regression analysis. Burge (1977) and Burge and Bradley (1976) used several methods to estimate the density at Arden and considered 114 tortoises/mi^2 to be the best estimate. Their work was done in 1973-1974. Between 1973-1974 and 1980, when Karl (1981) did calibration transects at Arden and prepared a linear regression for the Nye and Lincoln County tortoise data, a number of changes occurred on the Arden plot. Recreational use and land development increased on and near the site and probably caused a decline in tortoise densities (Burge *pers. comm.*). Taking potential tortoise losses into consideration, Karl (1981) used a density estimate of 100 tortoises/mi^2 for Arden, a figure which may be too high considering elapsed time and degree of impacts. For the remaining four plots, Karl (1981) made qualitative estimates of density based on 30-day spring censuses. For example, Karl (1979*a*) captured 84 tortoises on the 1-mi^2 Piute Valley plot and estimated a density of 125 tortoises/mi^2. For the Sheep Mountain plot, 32 tortoises were captured in 1 mi^2, and a density estimate of 50 tortoises/mi^2 was offered (Karl 1979*b*).

Shields (1980) and Schneider (1980) have pointed out that 30-day and 60-day spring censuses on 1-mi^2 plots are inadequate for determination of absolute density because of low recapture rates and because smaller tortoises tend to be undersampled. Turner et al. (1982) recently evaluated the strip-transect method at a power plant site in Ivanpah Valley and pointed out problems in using the technique for determining densities.

Analysis of Possible Impacts and Mitigations

Materials used in determining existing and possible future impacts to tor-

TABLE 5.—Frequency distribution of total adjusted sign (TAS).

No. TAS	Frequency	% of total	Class frequency	Class %
0	56	19.9	56	19.9
1	45	16.0	115	40.9
2	37	13.2		
3	33	11.7		
4	30	10.7	83	29.6
5	27	9.6		
6	14	5.0		
7	12	4.4		
8	8	2.8	22	7.7
9	6	2.1		
10	4	1.4		
11	4	1.4		
12	3	1.1	5	1.9
14	1	0.4		
17	1	0.4		
Totals	281	100.0	281	100.0

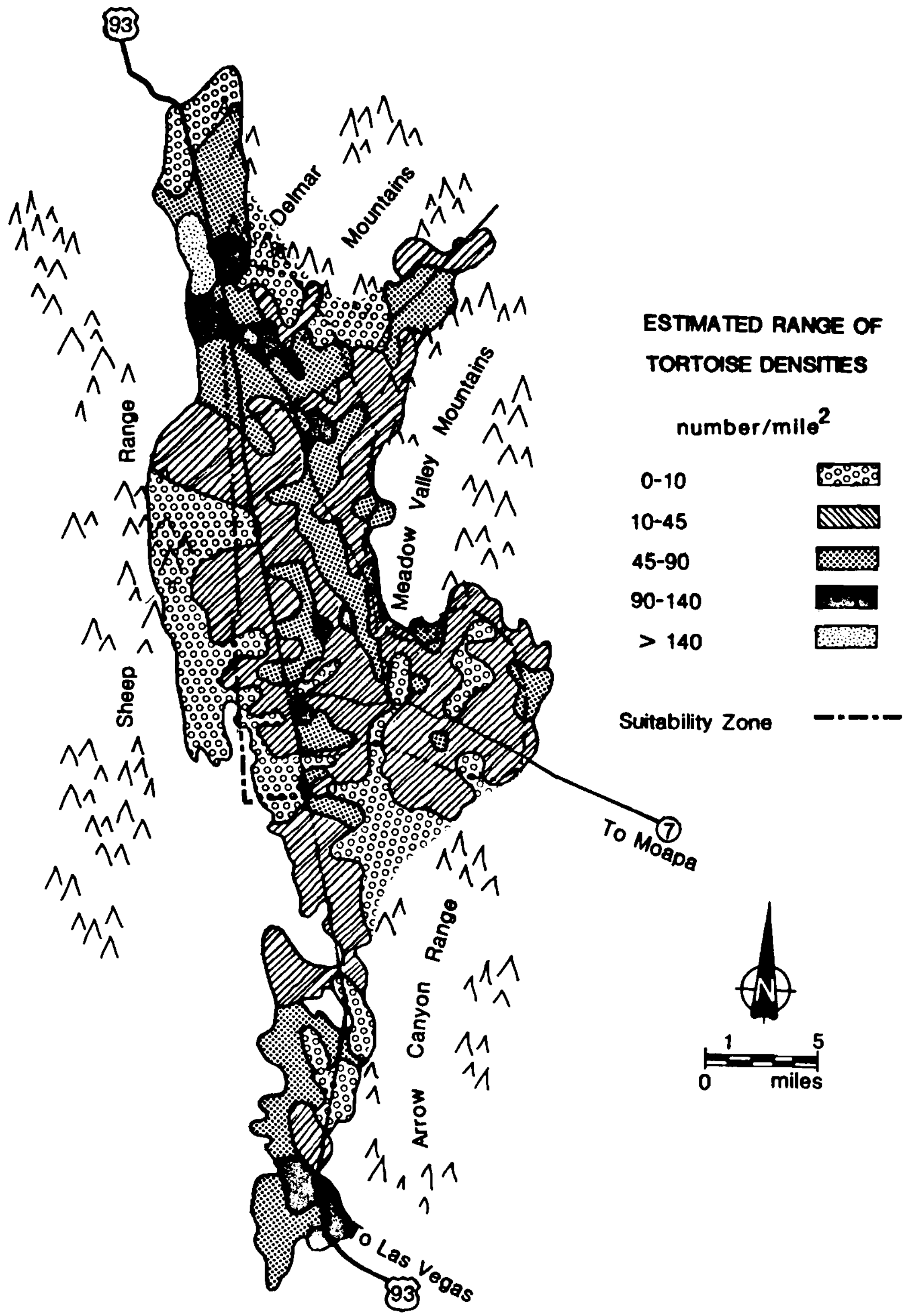

FIG. 2.—Estimated densities of desert tortoise populations in Coyote Spring Valley, Nevada.

TABLE 6. — Distribution of tortoise density classes in and adjacent to Coyote Spring Valley and the MX siting areas.

Density class (tortoises/mi^2)	Total area surveyed		Vicinity zone		Proposed facility sites: Preferred		Proposed facility sites: Alternative	
	mi^2	%	mi^2	%	mi^2	%	mi^2	%
Above elevational level (0/mi^2)	Not calculated		1.2	0.7	...	...	...	...
Very low (0-10/mi^2)	116.9	27.1	26.1	14.7	2.7	13.7	3.2	18.7
Low (10-45/mi^2)	178.1	41.4	92.2	51.9	11.4	58.5	12.4	71.3
Moderate (45-90/mi^2)	105.9	24.6	50.4	28.4	5.3	26.9	1.7	10.0
Moderately high (90-140/mi^2)	24.8	5.7	7.1	4.0	0.2	0.9	...	...
High (>140/mi^2)	5.0	1.2	0.5	0.3	...	...	...	...
Total	430.7	100.0	177.5	100.0	19.6	100.0	17.3	100.0

toise populations in Coyote Spring Valley were sought in the open literature, published and unpublished agency reports, presentations at the Desert Tortoise Council Symposia, and data gathered during this field endeavor. Potential mitigations from impacts to tortoise populations from construction and development of the MX site were developed using the same data sources, as well as discussions with herpetologists and biologists in federal and state agencies.

RESULTS

Tortoise Distribution and Relative Densities

The distribution and relative densities of the tortoise populations within the MX study area are shown in Figure 2. All six density classes are represented within the study area. Tortoise sign counts varied from 0-17 TAS/transect with an overall mean of 3.3 TAS/transect (Table 5). Transects with no sign (56) comprised the largest percentage of any single TAS value. Transects with 1-3 sign, the low density class, comprised the highest percentage of areas considered to support tortoises.

Amounts of land in each of the six density classes are shown in Table 6. Areas were calculated for the total study area, the vicinity zone, and for the preferred and alternative base boundaries. The low density category was the most prevalent class in all cases. However, a number of areas with moderate and moderately high tortoise densities are present, and pockets of high density populations were found.

Tortoise distribution is not uniform throughout the study area but follows patterns of soils, physiography, and vegetation. Low density areas (1-3 sign) comprise the largest percentage of land within the primary impact area. Most of these areas are flat with gravelly or rocky soils. These soils are poor for burrow construction and may contribute to lower densities. Even more rocky areas, such as the southwest corner of the primary impact area, often had no tortoise sign.

About one quarter of the acreage within the impact area supports moderate tortoise densities (4-7 sign). Habitat here has greater relief with hills and washes. Caliche caves in washes provide possible cover sites, and soils on the hills may be better suited for burrow construction. At both the north end of the primary impact area and south along Highway 93 are very small areas of moderately high to high tortoise densities ($\geq$8 TAS/transect). Possible habitat characteristics which might support higher densities are not readily obvious. Burrows composed most of the sign found on transects in these two areas, a possible reflection of suitable soils for burrowing and/or a product of higher tortoise densities.

Possible Effects of Existing Human Uses on Tortoise Populations

Desert tortoise populations in Coyote Spring Valley and adjacent areas have been subject to impacts from human activities for decades. The most obvious

TABLE 7.—Road mileage in the Coyote Spring vicinity zone.

	Type of road			
Road mileage	Improved paved roads	Improved dirt and unimproved paved roads	Jeep trails and unimproved dirt roads	Totals
Miles	35.5	26.0	33.5	95.0
Road density (linear miles/mi^2)	0.20	0.15	0.19	0.53

human-related impacts are from roads and cattle grazing. Impacts of roads on tortoises have been discussed by Hohman et al. (1980) and Nicholson (1978). The degree of disturbance due to roads is equivalent to the presence of 0.5 linear miles of road/mi^2 (Table 7). Highway 93 through Coyote Spring Valley probably poses the most significant impacts to tortoise populations. Of lesser importance are Highway 7, Kane Spring Road, and old Highway 7. Jeep trails and off-road vehicle (ORV) activity are potential conflicts, although ORV use appears to be fairly light.

Berry (1978*a*) has reviewed possible impacts of livestock grazing to tortoises. Unfortunately we do not know the history of cattle grazing in the study area. It may have begun in the 1800s, as it did elsewhere in the deserts of the Southwest. According to Bureau of Land Management range personnel, most of the current cattle grazing is restricted to Pahranagat Wash, north of Highway 7. Grazing here is seasonal, and water is brought to the cattle in trucks. In some years, no grazing occurs. Feral horses and burros occur in the study area, too. These species can present conflicts with the tortoise similar to those described by Berry (1978*a*) for cattle and sheep. However, in 1981 conflicts appeared to be slight because there was little overlap in distribution between tortoises and horses. Burros came in contact with tortoises only in the vicinity of Arrow Canyon.

Potential Impacts of the Proposed MX Operating Base and Facilities

Construction and operation of the MX base and associated facilities will lead to direct and indirect impacts on tortoise populations and habitat. The most significant direct impacts will result from clearing land and constructing the base, airfields, roads, transmission lines, pipelines, and housing and working facilities. Construction and facility development have high potential for causing direct mortalities and displacement of tortoises, as well as loss of habitat. After the initial clearing of land and construction of the base, further deterioration and loss of habitat and tortoise populations can be expected during operation of the base. Sources of impacts include uncontrolled or unauthorized activities of base personnel and visitors, and gradual expansion of base facilities and living areas. Of particular importance are impacts from recreation activities of base personnel and from ORVs. Other direct impacts to tortoises may occur from illegal collection of animals, vandalism, crushing of individuals on roads, and the killing and injuring of this reptile by domestic and feral dogs.

Indirect impacts also can affect tortoises. Examples of indirect impacts include: noise, obstruction of natural movements due to physical barriers, changes in social structure due to loss of local populations, impairment of vegetation used for cover and forage, reduction of home ranges or activity areas, and local increases in predator populations due to increased surface waters. Some direct and indirect impacts are discussed in more detail below.

Construction Activities.—Construction vehicles and other equipment will be the primary immediate cause of direct mortality to tortoises. During clearing, grading, paving, excavation, or filling activities, tortoises can be killed, severely injured, or buried alive, and their nests can be crushed (Berry 1973, Bury and Marlow 1973, Nicholson 1978). Tortoises may be indirectly and/or detrimentally affected by (1) road construction and maintenance, (2) any actions which alter or impair perennial and annual vegetation, (3) procedures affecting soil texture and permeability, (4) excavations or pits which could serve as traps, and (5) barriers to normal movements.

Interference with the aboveground activities of tortoises and with their cover sites (burrows, shrubs, etc.) may have detrimental effects. Tortoises may be forced to spend more time away from cover. Body temperatures could be elevated beyond critical levels or tortoises could be exposed to above-normal predation. Tortoises handled by construction workers, even for well-intentioned purposes, may void their bladder contents, losing water which may be critical to survival. Tortoises also may remain in their home sites in disturbed areas and may be subjected to increased risk from human activities.

Collections.—Tortoise populations are vulnerable to illegal collection from roads and the desert in the vicinity of the Coyote Spring operating base. Such collections of wild tortoises for pets have occurred for decades (*see* review in Hohman et al. 1980) and are very difficult to control or stop (Burge 1977; Coombs 1977*a*, 1977*b*; St. Amant and Hoover 1978). Conservation education methods can be used to reduce collections, but cannot be expected to halt such activities entirely.

Vandalism.—The deliberate crushing of tortoises with vehicles, shootings, and other molestation occur regularly within 75 mi of major urban centers (*see* review in Hohman et al. 1980). Tortoises frequently have been found shot at several permanent study plots in California, e.g., the Desert Tortoise Natural Area, Fremont Valley, Fremont Peak, Kramer Hills, Stoddard Valley, Lucerne Valley, Chuckwalla Bench, and Piute Valley (Berry *pers. comm.*). Some of these plots are within 30 mi of towns or valleys with approximately 20,000 residents, whereas others are in more remote regions. In spite of protective state regulations, vandalism does and will continue to occur. Some mitigation measures might reduce it, but cannot be expected to stop it entirely. The more people living in or near Coyote Spring Valley, the more likely vandalism will occur and the more severe the effects will be.

Roads.—The effects of paved and dirt roads on tortoises have been recognized for some time (Berry 1974, 1975*a*, 1975*b*; Berry and Nicholson 1979; Fusari 1981; Hohman et al. 1980; Nicholson 1978). Tortoises are both killed on roads and picked up by travellers and transported to towns and cities. Tortoise populations are likely to be depleted within 0.5 mi of either side of frequently used roads (Nicholson 1978). Tortoises will continue to be lost with each year the road is used, and impacts may extend beyond the 0.5-mi corridor. Using Nicholson's data, Humphreys (*pers. comm.*) has prepared a mathematical model of tortoise populations adjacent to roads and has estimated a 60% reduction in density along a 0.5-mi corridor on either side of a 40-year-old road.

The California Department of Transportation has funded studies to determine the effectiveness of such mitigation measures as tortoise-proof fences and culverts for safe passage of tortoises under roads (Fusari 1981). If these mitigation measures are adopted in Coyote Spring Valley, this source of loss to tortoise populations can be reduced markedly. Indeed, if existing highways are fenced with tortoise-proof fencing, tortoise populations next to those highways may recover gradually.

Off-road Vehicle Activity.—Off-road vehicle (ORV) activity can increase access to remote and relatively undisturbed parts of the desert, such as Coyote Spring Valley. Off-road vehicles have a negative impact on desert tortoise populations and habitat by killing tortoises both above and below ground, crushing burrows and other sites, crushing nests, and damaging and compacting soil, thus inhibiting growth and maintenance of plants used for forage and cover (Bury and Marlow 1973, Bury 1978, Berry and Nicholson 1979). People on ORVs may commit acts of vandalism (including shooting or deliberate crushing of animals) and collect tortoises for souvenirs, pets, or for sale (Berry and Nicholson 1979, Bury and Marlow 1973, St. Amant and Hoover 1978). Tortoises may be affected by the vehicle noise also. Brattstrom and Bondello (1978, 1980) have demonstrated that ORV noise can impair the hearing of desert reptiles and have suggested (*pers. comm.*) that tortoises are susceptible.

Berry (*pers. comm.*) reported that five tortoises were killed by motorcycles and other ORVs on dirt roads and trails on a 1-mi^2 tortoise study plot in the Mojave Desert during 1980. The plot was considered to have a relatively low density of roads and trails. Similar impacts have been documented by Bury et al. (1977) and Bury (1978).

Other Impacts.—The construction of housing and base operating facilities not only will destroy parts of or the entire home ranges of many tortoises, but also will act as a barrier to the movements of tortoises living immediately adjacent to the structures and facilities. If housing and base operating facilities are fenced, the barriers may be extensive and formidable. Tortoises may be prevented from using previous foraging and denning sites. In addition, tortoise social structure in the vicinity of a construction site is likely to be altered, especially if tortoises are removed or relocated. Tortoises experiencing loss of activity areas, changes in social structure, and relocation may be stressed. They may become more susceptible to natural sources of mortality. Where water supplies are increased locally, predators may congregate and may increase. Such predators may prey on nearby tortoise populations to a greater extent than normal. For example, the tortoise study plot on the Chuckwalla Bench in California has an upland game guzzler. Tortoise densities are lower in the immediate vicinity of the guzzler than elsewhere on the plot; conversely, tortoise remains are higher near the guzzler. Tortoises also have been found dead in guzzlers, apparently unable to escape.

Proposed Mitigation Measures[2]

Mitigation measures should be considered for three phases of the MX project: design and location of base facilities and housing areas, construction of facilities, and general operation of the base. Each phase is discussed below. We suggest that the U.S. Air Force hire an expert desert tortoise biologist to assist with tortoise management during the three phases of MX project development and for design and implementation of a monitoring program.

Design and Location of Base Facilities and Housing Areas.—Mitigation should begin with selection of sites, ideally in areas with low tortoise densities. Facilities should be located in a manner that would minimize fragmentation of tortoise populations and habitat.

Contruction of Facilities.—During the early phases of construction, land clearing and disturbance, the following mitigation measures can be used to reduce impacts to desert tortoise populations and habitat:

(1) *Removal of Tortoises from the Construction Sites.*—This should be done by individuals with field experience with tortoises during springtime to maximize captures. Plans should be developed for handling tortoises after capture.

(2) *Placement/Relocation of Tortoises.*—One possibility is to move the tortoises into areas immediately adjacent to construction sites, but this option needs further exploration. Sites suitable for relocation have not been identified and may not be available. If tortoises are relocated, monitoring studies are recommended to determine survival rates and impacts on resident populations.

(3) *Fencing of Construction Sites.*—All construction sites should be fenced to prevent tortoises from being killed inadvertently after work has begun. Tortoises often crawl under parked cars for shade and under woodpiles and other sources of cover (e.g., sheet metal).

(4) *Fencing of Roads.*—All frequently-used dirt and paved roads should be fenced. Culverts should be constructed under roads so that tortoises can pass under roads and so that fragmentation of populations can be minimized. Where vehicle traffic is very low, roads can be provided with locked gates to limit travel to authorized personnel.

(5) *Signs.*—Signs should'be placed on all roads stating that it is illegal to remove tortoises from their native habitat.

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[2]As the project has been abandoned, these recommendations are now moot. However, the recommendations can be used if the project is resurrected or if similar conflicts arise in tortoise habit.

(6) *Education Programs*.—A mandatory education program should be developed for all personnel who will be in the area. Posters and instruction sheets can be posted in obvious places at all construction sites and working areas. If mortalities occur, personnel should be required to attend brief periodic meetings where a tortoise expert presents a status report on the effectiveness of tortoise protection measures and problems with violations, as well as the results of the latest studies. Commanding officers of the military installation and construction crew bosses must use their authority to support and reinforce the mitigation measures and education program for the construction crews.

(7) *Control of Dogs*.—Regulations prohibiting dogs at any construction site or unfenced living area in Coyote Spring Valley should be developed and instituted.

General Operation of the Base.—Recommended mitigation measures for this phase Include:

(1) *Fencing and Culverts*.—Tortoise-proof fences should be placed around facilities (buildings, test areas, airfields, general housing, and recreation areas, etc.) to protect tortoises from people, vehicles, and dogs. The type of fence will depend upon the facility. For example, a low tortoise-proof fence of simple design may be perfectly adequate for an airfield, whereas a 6-ft high chain-link fence (with an additional foot underground) would be necessary around the housing and recreation areas.

Ideally, all frequently-used paved and dirt roads should be fenced as described for *Construction of Facilities* (3).

(2) *Signs*.—Permanent signs about regulations dealing with tortoises and the need to protect them should be placed on roads approaching Coyote Spring Valley from all directions. Signs in the work places, offices, housing, and recreation areas ought to be part of the conservation education program.

(3) *Conservation Education Program*.—This program should be designed to reach all ages and all types of people who will be working or living at Coyote Spring Valley or in the vicinity. Several approaches should be used, such as mandatory training of base personnel and residents, information programs aimed at local residents in general, and information programs developed for visitors to the Valley and surrounding regions. Some techniques include slide programs, brochures, radio announcements, guided field trips to tortoise habitat, and an established Tortoise Natural Area with self-guided trails and interpretive kiosks. A class on desert natural history, including discussion of the relationship of the tortoise to its environment, should be added to the curricula of grade and high schools to educate children of the base to the sensitivity of the species. A few pet tortoises could be kept with school classes, to reduce the desire of children for keeping illegal pets.

(4) *Compensatory Land Acquisition Program*.—Land can be acquired to replace tortoise habitat which has been destroyed or has lost its capacity to support tortoises. For example, several square miles of moderate to

high density tortoise habitat appears to occur in the area of the "conceptual location of the operating base" for Alternative I. This land will be lost to tortoises permanently. Private land which appears to contain good tortoise habitat could be acquired in the northwest corner of Coyote Spring Valley. Such a decision should await further studies on tortoise densities and population attributes.

Additional land could be acquired as compensation in other high density tortoise areas. For example, in California two areas have been identified by the U.S. Department of the Interior, Bureau of Land Management, to be managed and protected for high density tortoise populations. These areas are the Desert Tortoise Research Natural Area and Area of Critical Environmental Concern (ACEC) and the Chuckwalla Bench ACEC (U.S. Dept. of Interior 1980). Both areas have a severely fragmented land ownership pattern and would benefit from acquisition of private parcels.

(5) *Prevention of Development of Private Lands.*—One possible way to reduce fragmentation of tortoise habitat would be to prevent development of private land and release of more desert land entries to the public by BLM. Lands within 5 mi of the moderate to high density tortoise populations are of particular concern.

(6) *Control of dogs.*—Feral and domestic dogs have high potential for extirpating tortoise populations within 10 to 20 mi of any human residence, work area, or housing area. Regulations should be established to prevent movement of any dogs outside the housing area. Leash laws must be strictly enforced.

(7) *Control of Recreation Use.*—Plans should be developed to control access to moderate or high density tortoise populations by base personnel and residents for recreation or other purposes. Of particular concern is limiting ORV activity.

(8) *Increasing Carrying Capacity of Tortoise Habitat.*—Another means of compensating for loss of habitat is to attempt to increase the carrying capacity of nearby tortoise habitat. This might be done be removing competitors such as feral burros and domestic livestock.

(9) *Monitoring Program.*—A monitoring program should be developed to determine (1) the effectiveness of the mitigation program and (2) the status of tortoise populations in Coyote Spring Valley and surrounding areas. First, several permanent tortoise study plots should be established throughout the Valley. Data should be collected on a regular basis (e.g., at three- to five-year intervals). A study design similar to that used in California is suggested (Berry 1978, 1979). Sixty-day censuses of several 1-mi^2 plots were used. Plots in Coyote Spring Valley may need to be larger and of a different shape, depending on density of tortoise populations. Additional studies should address: the effects of fragmenting tortoise populations in the Valley and surrounding areas, the effectiveness of the conservation education program, the effectiveness of fencing, and the effects of noises typical of machinery and equipment at the base on tortoise populations.

DISCUSSION

Tortoise Distribution and Relative Abundance

The data presented above on tortoise distribution and relative abundance were to be used as the first phase in a two-phase effort to plan military activities with Coyote Spring Valley and surrounding areas. However, this effort has been abandoned. More information is needed on population densities from several sites in the Valley to confirm the estimated density levels shown in Figure 2. Data also are needed on other attributes, e.g., population structures, sex ratios, and mortality rates, to determine population condition. Such data are available only through intensive sampling at several sites. Hopefully several study sites can be established and intensive censusing undertaken in the near future. Such studies would be useful as a baseline.

Actual and Potential Impacts of MX Project Development on Tortoise Populations and Habitat

We have outlined several kinds of impacts from the MX missile project. The extent to which the above impacts are manifested will depend on several factors: (1) the specific location of the base, base facilities, and housing areas; (2) the size and distribution of the human population occupying the base and traffic levels to and from the base; (3) the actual densities and condition of the existing tortoise populations; (4) the degree to which the proposed mitigation measures are implemented effectively; and (5) the degree of fragmentation of tortoise habitat in Coyote Spring Valley and vicinity.

The impacts of some land uses (clearing of land, construction and occupation of housing areas) on tortoise populations and habitat are obvious. Other impacts are more subtle (attacks by dogs on tortoises, collecting, vandalism, and noise) and have not been measured quantitatively for the species. The MX missile project would have offered an opportunity to study tortoise populations and habitat before the disturbances take place and to monitor the situation closely after the operating base is established.

The Importance of the Coyote Spring Valley-Arrow Canyon Tortoise Population

Preliminary studies on the distribution and density of the desert tortoise in Nevada have indicated that six areas with tortoise densities of 50 to >150 tortoises/mi^2 exist in the state: northern Ivanpah Valley and the vicinity of Arden; Piute Valley; Arrow Canyon and Coyote Spring Valley; Moapa; California Wash; and near the Virgin Mountains (Berry and Burge *pers. comm.*; Karl 1980*b*, Schneider et al. 1982, U.S. Dept. of Interior 1981 and files). Of the six areas, two — northern Ivanpah Valley and Arden — have low potential for long-term viability and management (Berry and Burge *pers. comm.*). The northern Ivanpah Valley is a very small part of the crucial Ivanpah tortoise population in California (Berry and Nicholson 1979, *pers. comm.*), and the Arden population is rapidly deteriorating from urbanization. Four of the remaining five areas —

Piute Valley, California Wash, the Virgin Mountains, and Noapa — already have pressure from livestock grazing, ORV use, and oil and gas leasing (Berry and Burge *pers. comm.*, U.S. Dept. of Interior files). For example, approximately 80% of tortoise habitat in Piute Valley has been leased for oil and gas and another 5% has leases pending. This same region also has a high level of vehicle access with 0.9 linear miles of roads and trails/mi^2 of tortoise habitat.

In the Virgin Mountains and the Moapa populations, virtually all tortoise habitat has been leased for oil and gas or has leases pending (Berry and Burge *pers. comm.*, U.S. Dept. of Interior 1981 and files). Also in these two areas, road and trail density averages 1.2 and 1.3 linear miles/mi^2, respectively. The California Wash situation is even more acute, with similar impact levels; in addition, the area is fragmented into three parts.

Because of the existing impact levels and extent of commitment of tortoise habitat to other uses in Piute Valley, Moapa, the Virgin Mountains, and California Wash, and because of the lack of any significant protected tortoise population in Nevada, the Coyote Spring Valley-Arrow Canyon tortoise population must be considered as important to the overall well-being of the desert tortoise in Nevada.

The Coyote Spring Valley-Arrow Canyon populations are also important when considering the overall geographic range of the tortoise in the United States. Berry and Nicholson (1979, *pers. comm.*) identified four major population centers in California with estimated densities in excess of 150 to 200 tortoises/mi^2. No similar population densities have been found in Arizona (Hohman and Ohmart 1980, Schneider 1981) or Utah (Coombs 1977*a*, 1977*b*; Minden 1980), in spite of several years of study. The Utah population is federally listed as threatened. The four major tortoise populations in California have serious threats to their long-term survival (Berry and Nicholson 1979, *pers. comm.*). Therefore, each tortoise population with estimated densities of $>100/\text{mi}^2$ in Nevada should be managed carefully so that representative portions can survive.

ACKNOWLEDGMENTS

The U.S. Air Force provided the funding for the initial data collection and analysis to BioSystems Analysis, Inc. We thank them for their assistance and cooperation. We are grateful to S. Helfert for his comments on the manuscript. We thank K. Bohuski, A. Karl, and A. P. Woodman for their diligent assistance in the field.

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DISTRIBUTION AND RELATIVE DENSITY OF DESERT TORTOISES AT SIX SELECTED SITES IN SOUTHERN NEVADA

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Abstract.—Six areas in southern Nevada were examined to determine distribution and relative density of desert tortoise populations. These areas were: Desert National Wildlife Range, Blue Diamond, Valley of Fire State Park, Lake Mead Recreation Area, Piute Valley, and Goodsprings-Ivanpah valleys. Transects were walked in each area and sign counts were related to relative density. Most areas had low relative densities, but high density areas were found in Piute Valley and Cottonwood Valley in the Lake Mead Recreation Area. Based on the findings, management recommendations are offered.

The desert tortoise (*Gopherus agassizii*) is a protected species in Nevada, and a U.S. Fish and Wildlife Service status review is underway throughout its range. The tortoise is already listed as a threatened species in Utah (Dodd 1980). To assist in management of the species, the Nevada Department of Wildlife requested funding from the Fish and Wildlife Service, Office of Endangered Species, to determine distribution and relative density of the desert tortoise in selected areas in Nevada. Karl (1980*b* and 1981) conducted tortoise surveys on Bureau of Land Management (BLM) land in Lincoln, Nye, and Clark counties. These studies identified gross patterns of tortoise distribution. Intensive surveys were done in Coyote and Kane Springs valleys as part of the impact analysis of the proposed MX Missile System (Garcia et al., 1982).

METHODS

During this study, six areas in southern Nevada were examined to determine distribution and relative density of the desert tortoise populations. The areas were selected by the Nevada Department of Wildlife. Four of these areas, Desert National Wildlife Range, Blue Diamond, Valley of Fire, and the Lake Mead Recreation Area had not been previously surveyed. The other two areas, Piute

Valley and Goodsprings-Ivanpah valleys near Jean had been designated as high density by Karl (1980*b*). Additional data on the extent and boundaries of these areas were needed to assist prudent management.

Sixty transects were done in the Desert National Wildlife Range (DNWR). Thirty-six transects were walked adjacent to Alamo Road from Corn Creek to Pahranagat National Wildlife Refuge, six along Mormon Wells from Corn Creek to Yucca Forest Spring, and eight along the eastern side of the Wildlife Range west of Highway 93. Tortoise distribution data for the eastern side of the Wildlife Range are supplemented by transects done in Coyote Springs Valley for impact studies of the proposed MX Missile project. None of the 281 transects done for the MX impact assessment was within the boundary (Garcia et al. 1982) but patterns of tortoise distribution found in Coyote Springs Valley can be used to estimate probable distribution in the adjacent areas of the Wildlife Range.

Eight transects were walked in the Blue Diamond area, seven in Valley of Fire State Park, 46 in Piute Valley, and eight in Goodsprings-Ivanpah valleys (west of I15).

A total of 21 transects were done within the Lake Mead Recreation Area. Four transects were walked along the Overton Arm of Lake Mead, two in Eldorado Canyon, nine in Cottonwood Valley, and six west of Davis Dam.

A strip-transect method, developed by K. Berry and L. Nicholson (1979, *pers. comm.*), was used to estimate relative density and distribution of tortoises within the study areas. Equilateral triangular transects 2.4 km [= 1.5 mi] long were walked in each of the six areas and the numbers of tortoises and tortoise signs (burrows, scats, shells, and tracks) were recorded for each transect on standard data sheets. Associated groups of sign, such as tortoise in or just outside a burrow, or two or more scats apparently from the same tortoise, were combined into a single adjusted sign. The adjusted signs for each transect were tallied to yield the total adjusted sign (TAS) for the transect. Total adjusted sign is the variable used to relate transect results to relative tortoise densities. Total adjusted sign is similar to the method developed by K. Berry and L. Nicholson (1979, *pers. comm.*) called "corrected sign." Karl later used the method and referred to it as adjusted total sign.

This study has relied upon the results of past studies to relate TAS to relative tortoise density. Berry and Nicholson (1979, *pers. comm.*) were the first to establish the relationship between transect sign and tortoise numbers. Using calibration transects on six BLM permanent desert tortoise study plots (6-8 transects/site), Berry and Nicholson found that corrected sign and burrow counts were positively correlated with the number of tortoises marked in a quarter section [= 0.25 mi^2] encompassing each transect. Tortoises were censused for approximately 30 days at each of the sites. They then assumed a direct relationship between the number of tortoises marked and the relative density. Relative tortoise density represented qualitative estimates based on the permanent study plot data.

From these results, five classes of "corrected" total sign were established with corresponding estimates for relative density (Table 1). Tortoise relative density was predicted for all transected areas within the California Desert Con-

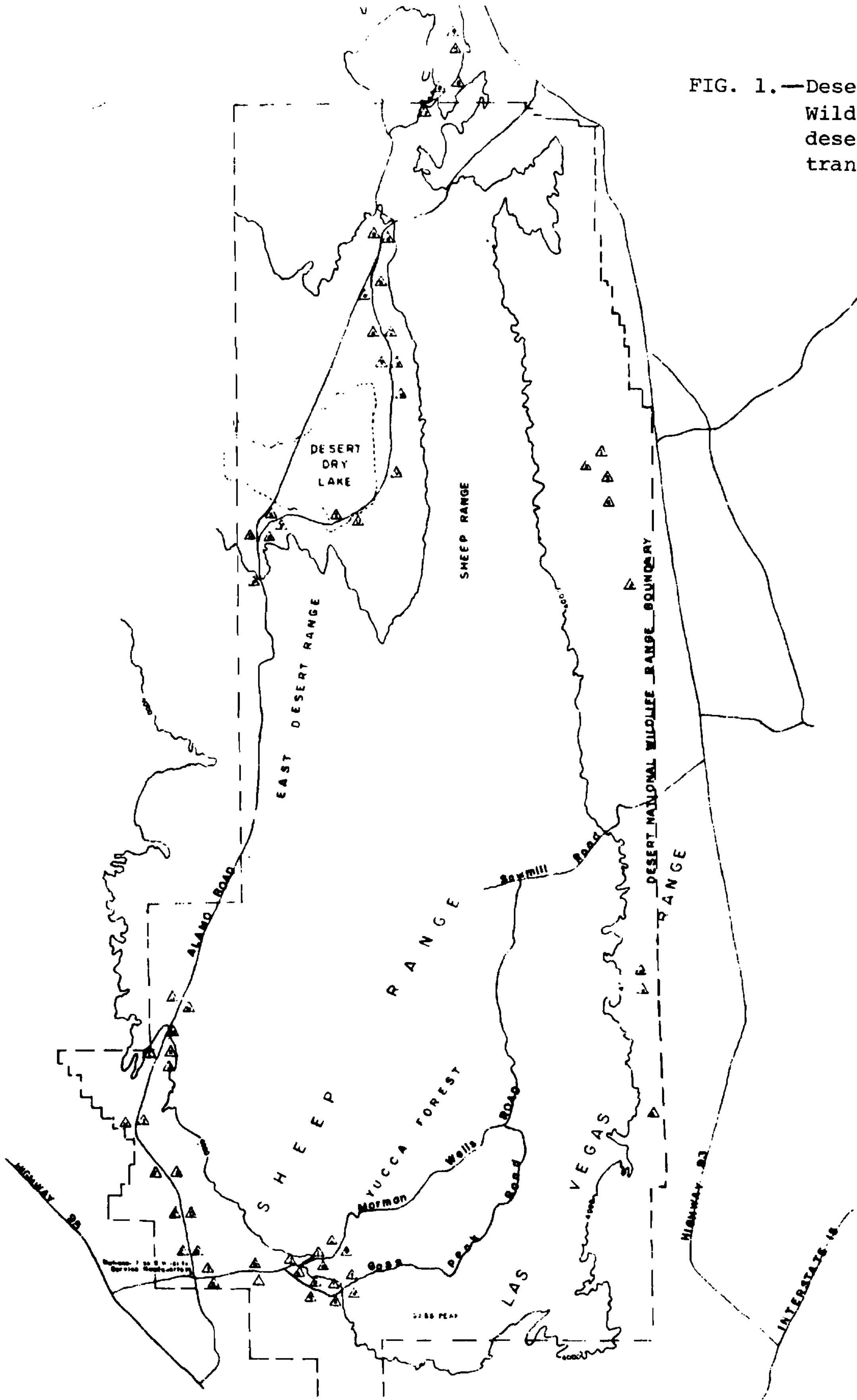

FIG. 1.—Desert National Wildlife Range desert tortoise transects.

Map reference	Transect number	Total adjusted sign (TAS)
1	1	3
2	2	2
3	3	1
4	4	0
5	5	4
6	6	6
7	7	0
8	8	0
9	9	1
A	10	2
B	21	2
C	22	0
D	23	0
E	24	1
F	25	0
G	26	0
H	27	0
I	28	2
J	29	3
K	30	0
L	31	1
M	32	1
N	33	1
O	34	0
P	35	0
Q	36	0
R	37	6
S	38	1
T	41	0
U	40	0
V	42	0
W	43	0
X	44	1
Y	45	2
Z	47	4
a	46	0
b	48	1
c	49	2
d	50	2
e	51	1
f	57	3
g	58	0
h	59	0
i	60	1
j	61	4
k	62	0
l	63	2
m	64	1
n	65	0
o	66	0
p	67	1
q	68	0
r	69	0
s	70	3
t	71	0
u	72	0
v	73	0
w	74	0
x	75	5
y	76	3

TABLE 1. — Sign classes and associated density classes for California* and Nevada**.

State	"Corrected" total sign	Density class	Qualitative description
California	0	0-20 tortoises/mi^2	Very low or none
	1-3	20-50 tortoises/mi^2	Low
	4-9	50-100 tortoises/mi^2	Moderate
	10-15	100-250 tortoises/mi^2	Moderately high
	15	>250 tortoises/mi^2	High
Nevada	0	0-10 tortoises/mi^2	Very low or none
	1-3	10-45 tortoises/mi^2	Low
	4-7	45-90 tortoises/mi^2	Moderate
	8-11	90-140 tortoises/mi^2	Moderately high
	12	>140 tortoises/mi^2	High

* From Berry and Nicholson 1979.
** From Karl 1980*b*.

servation Area by designating relative density polygons around areas where transects were in the same sign class.

Subsequent data from 60-day studies provided quantitative density estimates through mark-recapture analysis for the study plots used in the regression analysis and in areas not previously censused. The resulting estimates for the permanent study plots where calibration transects were done were similar to the qualitative estimates used and in areas not previously censused. The resulting density estimates were within the range estimated by the transect results.

Karl (1980*b*, 1981) used the same transect technique to estimate relative tortoise density and distribution in Lincoln, Nye, and Clark counties, Nevada. To establish the relationship of burrows and TAS to tortoise density, Karl used density estimates for the five study plots in Nevada and California — four in Nevada and one in California — where she had done calibration transects. For two of the plots — Shadow Valley, California, and Pahrump, Nevada — purely qualitative estimates were used (20 and 10 tortoises/mi^2, respectively). She also used data from Sheep Mountain and Piute Valley BLM permanent study plots in Nevada for the analysis (Karl 1979*a*, 1979*b*). These plots had 30-day censuses and densities were estimated at 50 and 125 tortoises/mi^2. However, Schneider (1980) has shown that 30-day censuses can yield inaccurate density estimates. The other study plot Karl used for calibration was near Arden, Nevada. Burge (1977) surveyed this plot and used several methods to estimate tortoise density

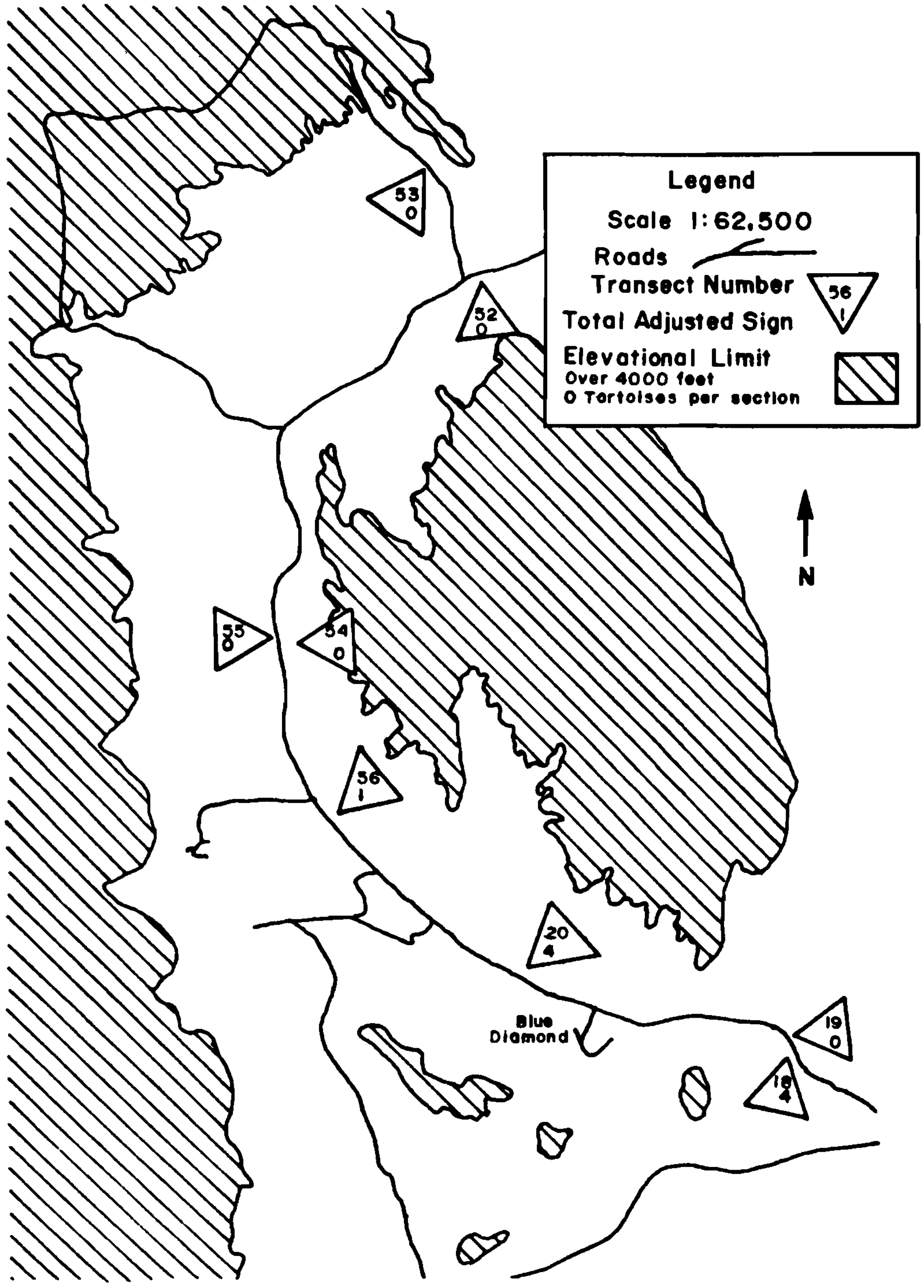

FIG. 2. — Blue Diamond area desert tortoise transects.

and considered 114 tortoises/section to be the best estimate. Karl used 100 tortoises/mi^2 for this plot in her analysis. In the time period between Burge's fieldwork (1973-74) and when Karl did calibration transects (1980), a considerable increase has occurred in the level of impact on the tortoise population from recreationists and on-site housing development (Burge *pers. comm.*). The impacts may have caused a greater decrease in tortoise densities than allowed by Karl.

The sign classes developed by Karl (Table 1) have been used in this study to maintain consistency in data for Nevada. However, Karl's associated density ranges are lower than those established for California, and no subsequent tests have been done to check tortoise density in Nevada as have been done in California. Thus, actual densities within the study areas may be higher than incicated by Karl's relative density estimates, and more in line with the relative density estimate ranges established for California. In light of the above discrepancies, numeric relative density estimates for the sign classes are given in Table 1 for both California and Nevada merely as reference points. Qualitative descriptions of the estimated relative density (low-high) are also shown, and these will be used throughout the text. In the event that further studies are done to obtain reliable estimates of densities at the study plots that Karl used for the analysis, the qualitative density descriptions could be re-defined without altering the basic findings of this study.

For analysis of the data for this study, only TAS was used, as both the California and Nevada studies indicated a higher co-efficient of determination (r^2) between the adjusted sign counts and relative density than for burrows and relative density (Berry and Nicholson 1979; Karl 1980*b*, 1981).

Between 13 September and 3 December 1981, one hundred fifty transects were walked by P. B. Schneider and K. E. Bohuski — 86 by Schneider and 64 by Bohuski. Both fieldworkers have had extensive experience censusing tortoises both through transect work and at permanent tortoise study plots in California and Arizona. Each researcher has done over 150 desert tortoise transects during 1981. To test the significant differences between the two workers, 58 pairs of transects done adjacent to each other were compared. First, a Spearman's rank correlation was done. The results ($r = 0.7735$, $n = 58$, $p < .01$) indicated that the hypothesis of no correlation between researchers should be rejected. The second test between the researchers was to compute the mean TAS with confidence intervals. Confidence intervals were computed as plus and minus two standard errors and the hypothesis of no difference between workers excepted if the confidence intervals overlapped. Schneider averaged 4.74 ± 1.4 TAS/transect while Bohuski averaged 4.93 ± 1.5 TAS/transect. Because the means are quite close and the confidence intervals overlap, it is assumed that the results from the two researchers are completely compatible.

Transects were usually done at the rate of two every 2-3 mi along dirt roads through suitable habitat. Suitable habitat was judged by elevation, vegetation, and physiography. The transect density was about four transects per township, though this does not imply that the entire township around a transect was suitable habitat.

Transects were mapped on U.S. Geological Service topographic maps. Rela-

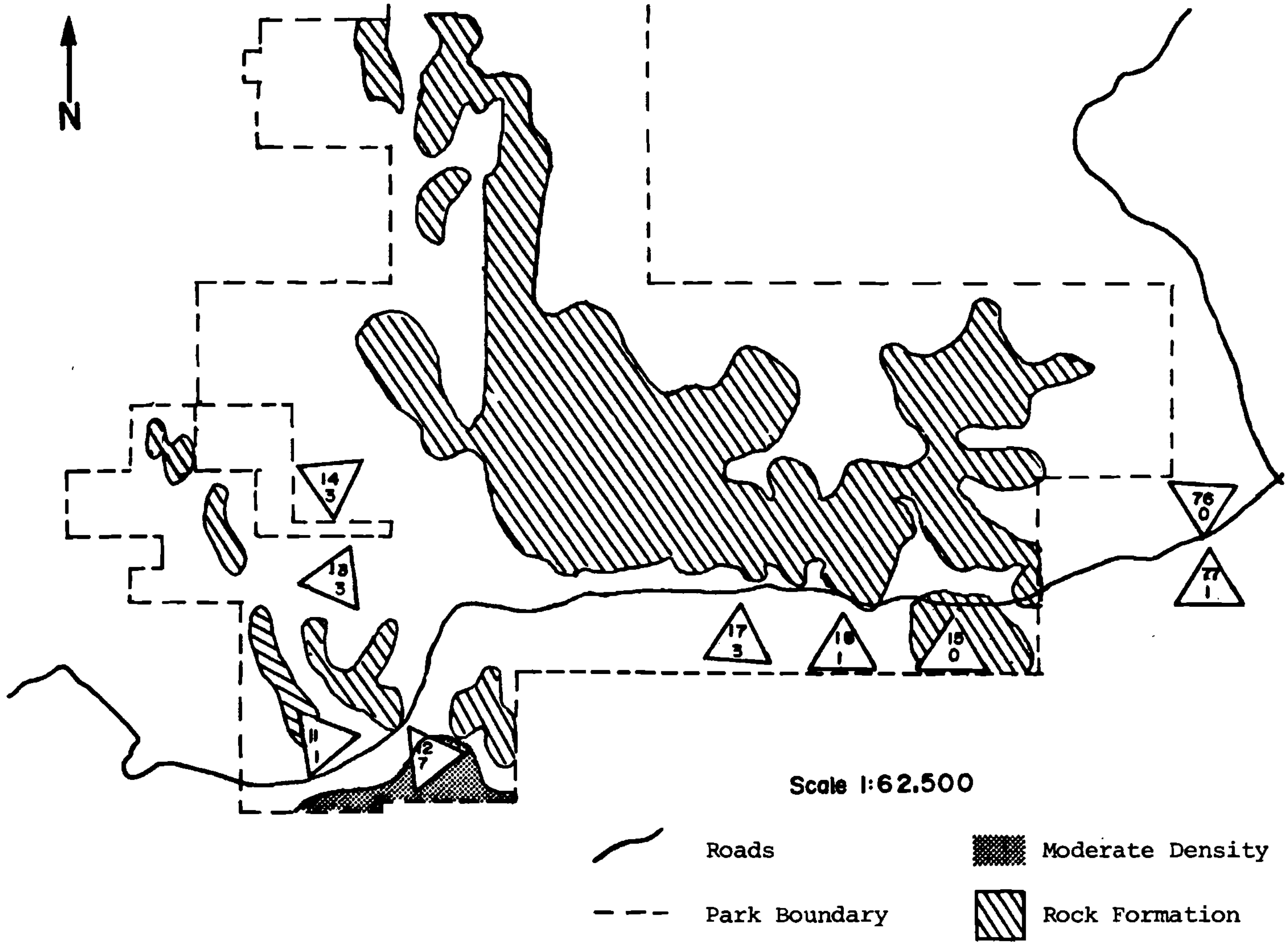

FIG. 3. — Valley of Fire State Park desert tortoise transects.

tive density polygons were drawn around transects within each of the sign classes established by Karl (1980*b*, 1981). Placement of the boundaries incorporated physiographic and elevational data. Areas of steep rock formation and areas over 4,000 ft elevation were assumed to have no tortoises.

RESULTS AND DISCUSSION

Desert National Wildlife Range.—Transect locations for the Wildlife Range are shown in Figure 1. Total adjusted sign varied from 0-6/transect with an overall mean of 1.75 $\pm$ 1.03 TAS/transect. No signs were found on 43.3% of the transects.

Potential tortoise habitat within the DNWR is confined to narrow strips less than 8 km [= 5 mi] wide along the eastern and western boundaries. Suitable habitat below 4,000 ft comprises less than 15% of the total land area of the game range. Along the western edge of the DNWR, adjacent to Alamo Road, signs were found in five separate areas. The first area starts about 3 mi north of DNWR headquarters and extends east to Yucca forest. Ten of the 20 transects in this area had signs. The next area where tortoise signs were found is approximately 13 km [= 8 mi] north of the headquarters and extends north another 13 km [= 8 mi]. Six transects in this area had tortoise signs. The next area found with sign is north of Sheep Pass and south of Desert Dry Lake. Three transects with sign were found in this area. Just north of Desert Dry Lake, eight transects were done and sign found on seven of them. The last area along Alamo Road where tortoise signs were found is adjacent to Pahranagat National Wildlife Refuge. Three transects with sign were walked in this area.

Whether the scattered locations represent patchy tortoise distribution or the uneven edge of a larger area of tortoise habitat outside the survey area is not known. This latter situation is the case with tortoise distribution along the eastern edge of the range. Sign within the DNWR suggests localized populations with low to moderate tortoise densities. With the additional data from Coyote Springs, the distribution is shown to be continuous, though not of uniform density, to the east.

No areas of moderately high or high tortoise density were found within the DNWR. However, high density areas were found within the proposed annex area along the eastern boundary (Garcia et al. 1982). The tortoise population in these areas, Hidden Valley, and between the Sheep and Delmar ranges would be afforded greater protection by annexation of these parcels into the Wildlife Range.

Habitat conditions vary markedly between the eastern and western sides of the DNWR. These areas are separated by the Sheep Range. On the west side, shrub diversity is low with shadscale (*Atriplex confertifolia*) co-dominant with creosote bush (*Larrea tridentata*). On the eastern slopes of the Sheep Range, shrub diversity appeared to be greater and burrobush (*Ambrosia dumosa*) is co-dominant with *Larrea*. The *Larrea/Ambrosia* association is the most common plant association in tortoise habitat throughout Nevada and California and may indicate conditions more favorable to tortoise populations.

The substratum in most of the areas surveyed is quite rocky and apparently

Map reference	Transect number	Total adjusted sign (TAS)
A	76	0
B	77	1
C	78	0
D	79	0
E	80	0
F	81	2
G	82	0
H	83	2
I	84	0
J	85	0
K	140	1
L	141	0
M	142	2
N	143	3
O	144	6
P	145	5
Q	146	6
R	147	11
S	148	8
T	149	0
U	150	5

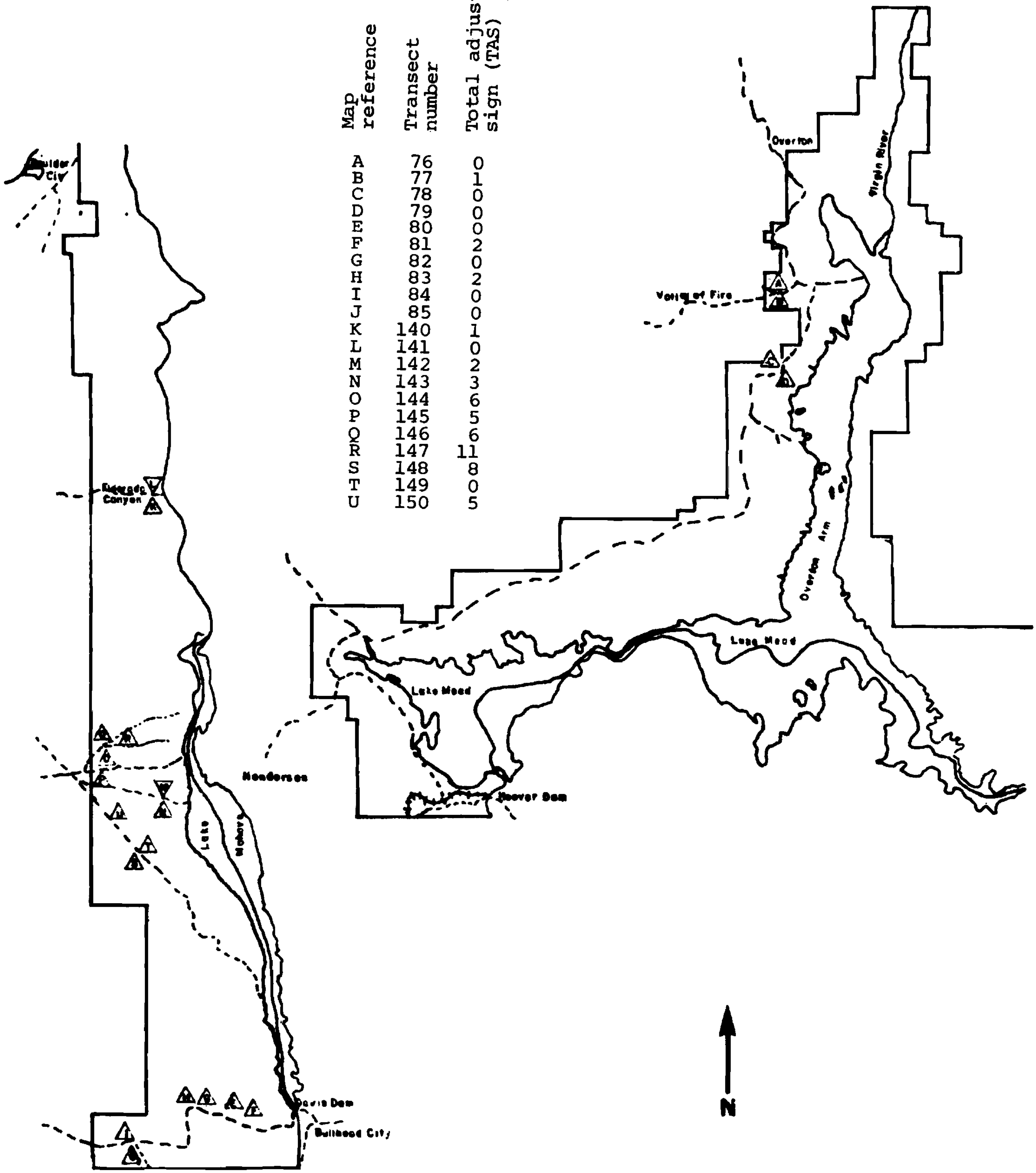

FIG. 4. — Lake Mead Recreation Area desert tortoise transects.

poor for burrow construction. The substratum may be a limiting factor for tortoise populations in the area. Caliche caves provide permanent tortoise cover sites along the eastern boundary of the DNWR and south of Corn Creek on the western side of the range. All areas of potential habitat (i.e., below elevational limits) with caliche caves had tortoise sign, although not all caves had sign and the sign in these areas was not necessarily associated with the caves found on the transects. Human impacts on the Wildlife Range are presently light. No off-road vehicle (ORV) tracks were noted and the only livestock sign was old cow droppings near Corn Creek headquarters and tracks and droppings from horses.

The kind of sign found in an area may reflect the nature of the population in the area. Along Alamo Road, the composition of sign found was quite different than what was observed in Coyote Springs (Garcia et al. 1982). A total of 35 signs was found of which 20 (57.1%) were burrows, 13 (37.1%) were shell remains, and only two (5.7%) were scat. A X^2 test indicates that these differences are highly significant ($p < .01$). The two transects along Alamo Road with the highest sign counts, No. 37 (6 TAS) and No. 47 (4 TAS), had five and three shell remains, respectively. According to shell disintegration criteria developed by P. Woodman and K. Berry (*pers. comm.*), these shells, and all others found south of Desert Dry Lake were from large tortoises dead more than four years. The preponderance of shell remains and the lack of scats may indicate that the present population in the area is lower than suggested by the total sign counts.

Similar results were found by Karl (1980*a*) near Pahrump, Nevada. Transects indicated a moderate density tortoise population. When the plot was censused in a 30-day study, shell remains from 53 individuals and parts from possibly seven other individuals were found but only 10 live tortoises were marked.

Three areas within the DNWR remain unsurveyed due to inaccessibility. They are (1) along the old Corn Creek Road in the northeast corner of the range, (2) northwest of Desert Dry Lake, and (3) west of Sheep Mountain Gunnery Range. All of these areas could have low to moderate density tortoise populations.

Blue Diamond.—Transect locations and results for the Blue Diamond area are shown in Figure 2. Most areas surveyed (approximately 70%) are marginal habitat as indicated by elevation and vegetation. Areas where black brush (*Coleogyne ramosissima*) was common or co-dominant with the creosote bush (*Larrea tridentata*) were unsuitable habitat and no signs were found. The three transects with sign were all at the south end of the area. Two of these each had four sign suggesting tortoise density similar to the Sheep Mountain permanent study plot (Karl, 1979*b*).

Valley of Fire State Park.—Transect locations and results for the Valley of Fire State Park are shown in Figure 3. Sign varied from 0-7/transect. The single transect with seven sign included the slopes of the Muddy Mountains. On this transect, signs were found strictly on the slopes and in caliche caves in the washes bisecting the slopes. This may suggest moderate density or higher in the slope habitat throughout the park. Even in areas of less relief, sign was often associated with caliche caves. The increased sign count in the slope habitat may correspond to increased numbers of caliche caves. The vegetation in

Map reference	Transect number	Total adjusted sign (TAS)
a	86	11
b	87	10
c	88	10
d	89	7
e	90	1
f	91	4
g	92	5
h	93	9
i	94	9
j	95	5
k	96	12
l	97	5
m	98	7
n	99	7
o	100	6
p	101	14
q	102	16
r	103	6
s	104	19
t	105	12
u	106	18
v	107	21
w	108	16
x	109	12
y	110	3
z	111	13
A	112	15
B	113	12
C	114	13
D	115	20
E	116	5
F	117	8
G	118	7
H	119	5
I	120	13
J	121	18
K	122	15
L	123	19
M	124	13
N	125	4
O	126	4
P	127	4
Q	128	9
R	129	14
S	130	10
T	131	13

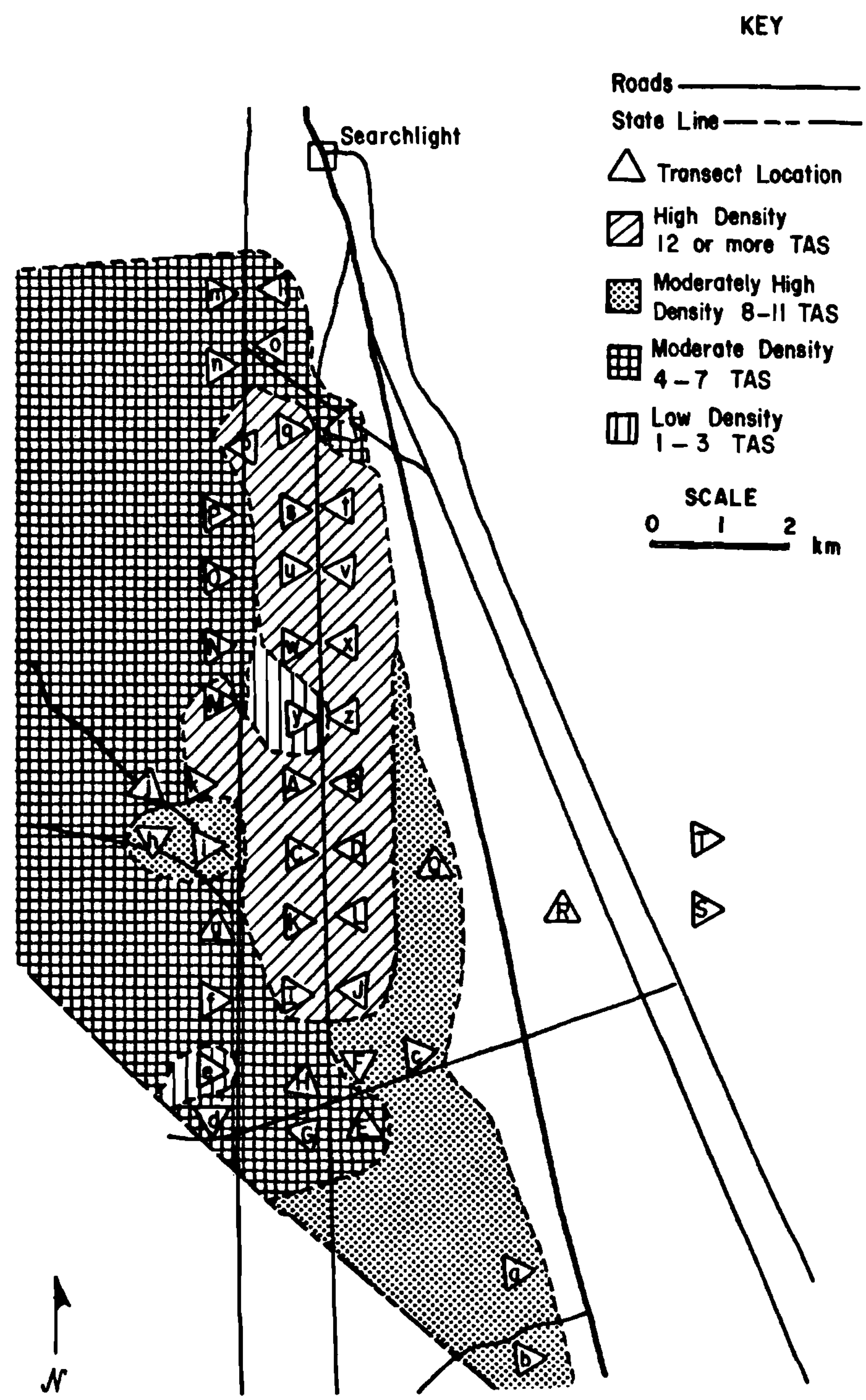

FIG. 5. — Tortoise destribution and relative density in Piute Valley.

the park is a creosote-bursage community with scattered *Yucca*. No relationship between the vegetation patterns and tortoise distribution was noted.

Lake Mead Recreation Area.—Transect locations within Lake Mead Recreation Area are shown in Figure 4. Sign within the recreation area varied from 0-11/transect. Vegetation was variable in the areas surveyed ranging from sparsely vegetated clay hills near Lake Mead to rather diverse creosote scrub with a major cactus component at the southern end of the recreation area near Davis Dam.

Data from Cottonwood Valley indicated moderate to moderately high tortoise densities. North of Cottonwood Cove Road, rolling hills with numerous caliche caves support a moderately high density tortoise population. One transect in this area had 11 sign. Most sign was along the washes, which are peppered with caliche caves. Sign was much less common on the hills around the washes. South of Cottonwood Cove Road along the powerline road, one transect along washes yielded eight sign, while no sign was found in an adjacent transect with fewer caliche caves. This illustrates the importance of caliche caves in this area. The transects done in the other areas indicated low to very low density tortoise populations.

Puite Valley.—Distribution and relative density of desert tortoise in Piute Valley are shown in Figure 5. Nineteen of the 46 transects done in this valley indicated a high density tortoise population extending over approximately 46.62 KM [= 18 mi^2]. This represents the largest area of high density tortoise population known in Nevada. This population is contiguous with a much larger high density tortoise area in California (Berry and Nicholson 1979).

Total adjusted sign varied from 1-21/transect, with all transects indicating high density (12 TAS) adjacent to each other, forming a 3.2 km [= 2 mi] wide strip down the valley. This strip is bordered on the west by a powerline and dirt road and approaches Highway 95 on the east. A dirt road runs down the middle of the high density area. Based on studies in California (Nicholson 1978), Highway 95 is assumed to have reduced the density up to 0.8 km [= 0.5 mi] on either side of the highway. If road traffic was to increase in the future, the effect on the tortoise population could be devastating. A 1/2-mi corridor on either side of the existing dirt roads would virtually encompass the entire high-density area. Present impacts on the site include ORV use, both on and off the dirt roads, and cattle sign. The area east of Highway 95 had much more cattle sign and fewer ORV tracks.

The vegetation in this valley is a fairly uniform creosote/bursage scrub with Joshua trees and Mojave yucca. No relationship was noted between tortoise distribution and vegetation. The low density area in the southwestern corner of the survey area may have been a result of the rocky substratum in the area.

Sign found during the transects consisted primarily of scats and burrows. Seven shell remains were found during transects, four of these on one transect east of Highway 95 and two in coyote scats. This may be indicative of a low mortality rate, similar to that found at the Puite Valley permanent study plot (Karl 1979a). The study plot is at the southern end of the high density area. Transect No. 120 was done on the study plot and 13 sign were found. Karl

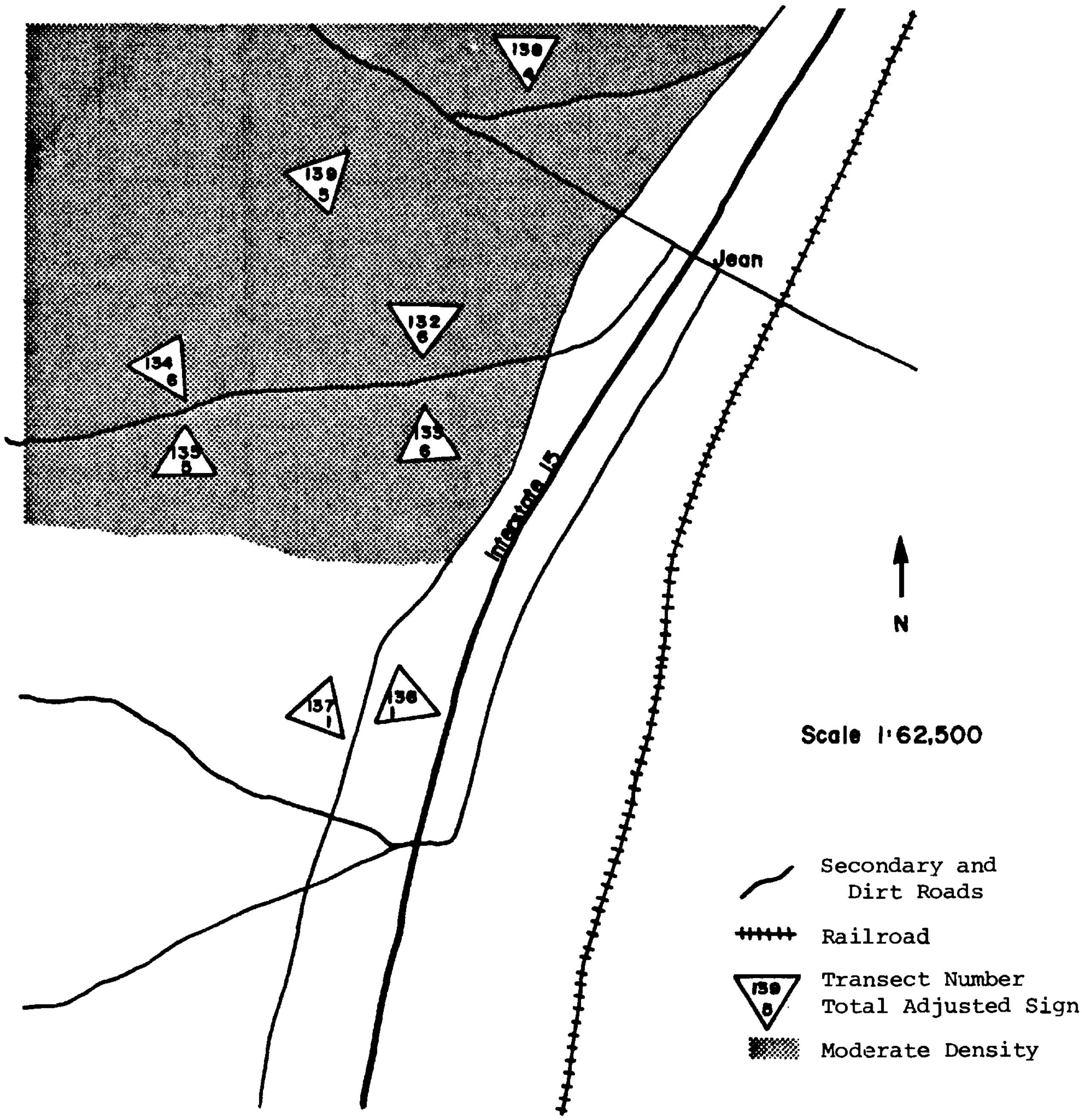

FIG. 6. — Goodsprings and Ivanpah valleys tortoise distribution and relative density.

(1980*b*) found between 7 and 14 sign on three transects she did here in 1980. This year's transects show that the study plot is bordered on the south and west by low density areas. What effect this would have on the observed population structure at the site is not known but this should be considered when analyzing the population data.

Goodsprings - Jean.—Eight transects were done in this area to determine relative density of tortoises (Fig. 6). The single transect done by Karl (1980*b*) indicated a high density tortoise population. However, transects done this year indicated a moderate density population similar to the Sheep Mountain plot. This moderate density extends a few miles south into Ivanpah Valley. A transect done north of the road to Goodsprings indicates that the moderate density population continues in this direction.

SUMMARY

A total of 150 transects were done in six areas of southern Nevada to determine relative density and distribution of the tortoise populations. These areas were (1) Desert National Wildlife Range, (2) Blue Diamond, (3) Valley of Fire State Park, (4) Lake Mead Recreation Area, (5) Piute Valley, and (6) Goodsprings - Jean area. Most of the area surveyed had low density tortoise populations. An important area of moderately high density was found in the Lake Mead Recreation Area in Cottonwood Valley. The extent of the high density population in Piute Valley (west of Highway 95) was determined. The area between Jean and Goodsprings that had been designated as a high density population area was found to have a moderate density. Assuming that the transects done in this area for this study accurately represent the tortoise density, any high density area that may occur here would be confined to a few sections.

RECOMMENDATIONS

Work should continue on desert tortoise in Nevada to further evaluate population status and conditions.

More transects should be run in all suspected high tortoise density areas, to a level of six to ten transects per township. More transects should also be conducted in areas near high tortoise densities to determine margins of higher tortoise density areas.

Additional permanent study plots should be established, especially in high density areas. Particular attention should be given Coyote Springs, Piute Valley, Valley of Fire, and Cottonwood Valley.

Land uses, such as ORV events and free play, mineral development, oil and gas drilling, and urban development have high potential for severe impacts to tortoise populations. These impacts should be studied. For example, the effects of urbanization on the study plot at Arden should be examined immediately.

The eastern boundary of the Desert National Wildlife Range should be extended up to State Highway 93 to afford greater protection for the desert tortoise population in Coyote Springs Valley and on the DNWR.

ACKNOWLEDGMENTS

The study was supported by the U.S. Fish and Wildlife Service and Nevada Department of Wildlife under Contract No. 14-16-0001-81138. We are grateful to Kristin H. Berry for assistance in preparing the proposal and reviewing the manuscript.

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AN INVENTORY OF DESERT TORTOISE POPULATIONS NEAR TUCSON, ARIZONA

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In February 1981, the Arizona Game and Fish Department (AGFD) contracted with the U.S. Bureau of Reclamation (USBR) to conduct a floral and faunal inventory west of Tucson, Arizona (Contract No. 32-V0151). Data collected will be used in preparing the Environmental Impact Statement for the Phase B Tucson Division of the Central Arizona Project Aqueduct (CAP).

One of the goals of this wildlife study involves habitat preference determination for the desert tortoise (*Gopherus agassizi*) in the study area, and subsequent delineation of high tortoise use localities. Stratified transect selection provided tortoise relative abundance data by vegetation type which was used to infer habitat preference. Casual observations, coupled with transect data, helped to pinpoint any high use areas within the study area.

DESCRIPTION OF STUDY AREA

Proposed routes for the CAP aqueduct are situated west of the Tucson metropolitan area. The study area extends roughly 12 mi north, 20 mi west, and 25 mi south of the center of Tucson (Fig. 1). Approximately 600 mi^2 are included. Part or all of Saguaro National Monument, Tucson Mountain Park, Arizona-Sonora Desert Museum, and San Xavier Indian Reservation are located within the study area. The topography of the area varies from the flood plains of Brawley Wash in Avra Valley (2000 ft) to the more precipitous Tucson Mountains (up to 4600 ft), and the desert grassland community in the far southern stretch (3200 ft).

Five vegetative communities (Brown and Lowe 1974) are present in the study area, as well as expanses of agricultural land, fallow fields, large- and small-scale mining operations, and suburban housing developments. Desert grassland (DG) exists in various locations within the site. Brawley Wash and the Santa Cruz River support remnant mesquite bosques (MB), and riparian deciduous woodland (RDW) is found in the north section of the study area along the Santa Cruz River. Sonoran desertscrub is well represented in the west Tucson area. Lower Colorado division (creosotebush-bursage, *Larrea tridentata-Ambrosia deltoidea* community [CB]) covers much of the flatland and bajadas south and west of the

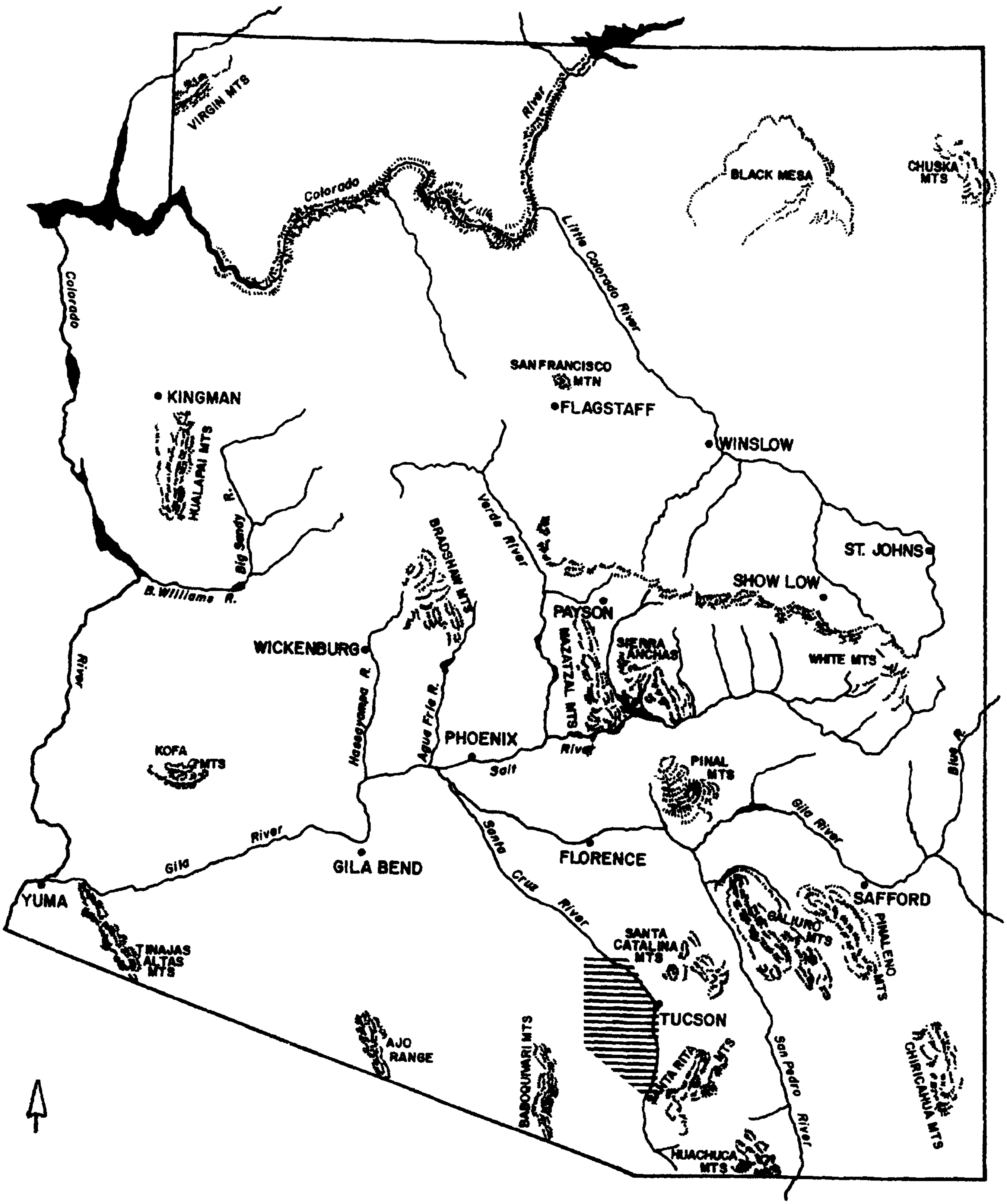

FIG. 1.—Map of Arizona showing CAP Phase B Tucson study area. ▤ = CAP study area.

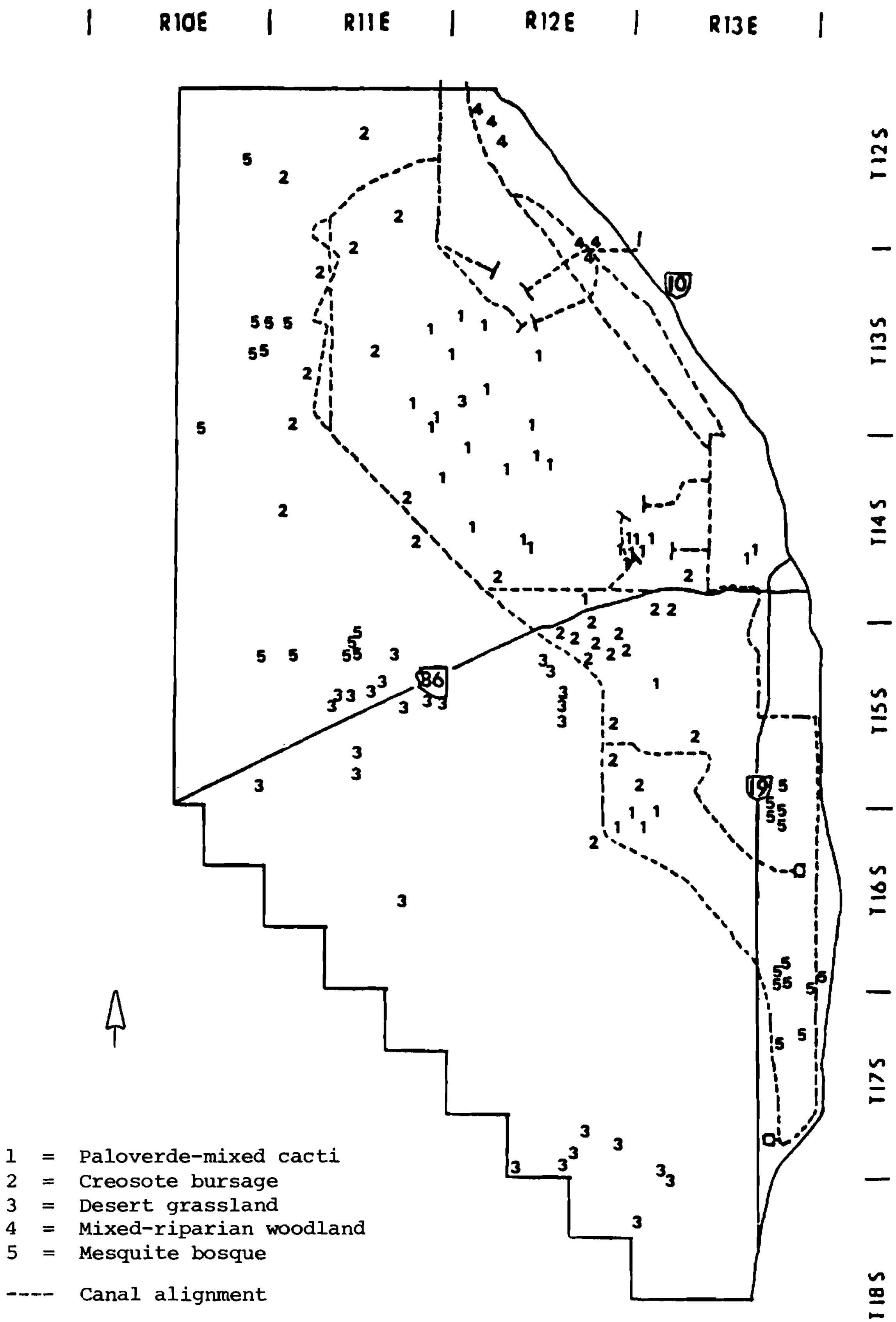

FIG. 2. — Map of CAP Phase B Tucson study area showing desert tortoise transect locations.

Tucson Mountains. Extremely dense paloverde-saguaro association (*Cercidium microphyllum-Cereus giganteus*) exists in the foothills of the Tucson Mountains in the Saguaro National Monument - West, and less spectacular examples of Arizona Upland vegetative communities (paloverde-mixed cacti; *Cercidium, Cereus*, and *Opuntia* spp. [MPC]) are prevalent throughout the study area.

METHODS

Information on desert tortoise distribution was gathered by walking transects and direct observations. Locations and pertinent information about all tortoises or sign found during field activities were recorded in field notes.

Stratified random selection was used to determine transect locations. Each transect was 1 mi long and 20 ft wide. Live tortoises, as well as sign of tortoise activity such as scats, dens, skeletal remains, and tracks, were noted along the transect. When encountered, tortoises were measured, sexed, photographed, and marked with permanent felt tip pens. Physical condition, anomalies, and behavior were recorded, as well as time of day, dominant vegetation in the area, weather, proximity to possible burrows, and topographic features such as elevation, slope aspect and angle. Skeletal remains were collected and cataloged.

A total of 132 walking transects were made; 22 transects per month were walked from May 1981 through October 1981. Five transects per month were conducted in each of the following vegetative communities: mixed paloverde-cacti, creosote-bursage, desert grassland, and mesquite bosque (Fig. 2). One transect per month was walked in riparian deciduous woodland, and in the Cat Mountain

TABLE 1. — Mean tortoise sign recorded on transects conducted May 1981 through October 1981 in the west Tucson study area. MPC = mixed paloverde-cacti; CB = creosote-bursage; DG = desert grassland (disclimax); MB = mesquite bosque; RDW = riparian deciduous woodland.

	Vegetation type					
	MPC	CB	DG	MB	RDW	All habitats
Transect miles	36	30	30	30	6	132
Live tortoises/mile	0.06	...	...	...	...	0.02
Scats/mile	0.42	0.07	...	...	...	0.13
Skeletal remains/mile	0.08	0.07	...	...	...	0.04
Dens/mile	0.92	0.23	...	...	...	0.30
Total sign/mile	1.47	0.37	...	...	...	0.48

basin (MPC) due to the importance of the latter as a potential terminal CAP reservoir site.

Tortoise sign density (per mile) was calculated from the tortoise transect data to provide relative abundance information. Frequency of transect sign relative to topographic features such as elevation, slope aspect and degree of slope was also determined. The Cat Mountain and Twin Hills basins transect results were analyzed separately because these basins are potential reservoir sites.

Casual observations were also summarized but could not be quantified in terms of actual time or distance sampled. These data were utilized, however, to aid in determining high use areas for tortoises.

RESULTS

The 132 walking transects conducted between May 1981 and October 1981 provided 58.2% of the total tortoise sign recorded in this study. Casual observations provided the balance. Mixed paloverde-cacti transects accounted for 82.8% of the total transect sign, and creosote-bursage contributed 17.2%. Transect data in terms of sign per mile and comparative frequencies of type of sign are presented in Table 1.

Of the total tortoise sign (N = 110) recorded on transects and as casual observations, 89.1% was located in mixed paloverde-cacti habitat, while creosote-bursage provided only 10.9%. The sign consisted of 12.7% live animals, 19.1% scats, 28.2% skeletal remains, and 40.0% burrows or dens. Casual observation data are summarized separately in Table 2, where it can be seen that a preponderance of tortoise evidence was collected in mixed paloverde-cacti habitat (97.8%).

TABLE 2.—Numbers of tortoise sign recorded as casual observations between March 1981 and March 1982 in the west Tucson study area. MPC = mixed paloverde-cacti; CB = creosote-bursage.

	Habitat types		
Types of sign	MPC	CB	All habitats
Live tortoises	11	1*	12
Tortoise scats	4	...	4
Skeletal remains	26	...	26
Tortoise dens	4	...	4
Total sign	44	1*	45

*Found in residential area.

TABLE 3. — Percent of tortoise sign by elevation. Recorded on transects May-October 1981 - west Tucson study area. MPC = mixed paloverde-cacti habitat type; CB = creosote-bursage habitat type.

Elevation (ft.)	% of sign on MPC transects	% of sign on CB transects	% of total transect sign
2100-2199	...	11.1	1.6
2200-2299	...	...	...
2300-2399	...	...	...
2400-2499	9.6	...	8.2
2500-2599	5.8	22.2	8.2
2600-2699	1.9	44.4	8.2
2700-2799	34.6	22.2	32.8
2800-2899	13.5	...	11.5
2900-2999	25.0	...	21.3
3000-3099	5.8	...	4.9
3100-3199	3.8	...	3.3
Range	2400-3100	2100-2700	2100-3100
Mean	2754	2555	2654

Data indicate that within this study area, tortoises are restricted to the creosote-bursage and mixed paloverde-cacti vegetative communities. No sign was observed in other habitat types represented west of Tucson.

Tortoise transect data were also analyzed in terms of several topographic features. Frequency of sign found at various elevations is shown in Table 3. In mixed paloverde-cacti habitats, sign was located in elevations ranging from 2400-3100 ft, with the majority recorded between 2700 and 3000 ft (73.1%). The characteristically lower elevation creosote-bursage habitat exhibited evidence of tortoise activity between 2100-2800 ft. Most of this sign occurred between 2600 and 2700 ft.

Table 4 shows the frequency of tortoise transect sign found in relation to slope aspect. North and northwest aspects provided 62.3% of the transect sign. Degree of slope was analyzed independently of aspect and is compared to transect sign frequency in Table 5. Creosote-bursage habitat is characterized by flats or gently rolling slope, so all tortoise sign found on these transects was located on 0-19° grades. In the more heterogeneous mixed paloverde-cacti communities, the majority of tortoise sign was recorded on foothills or steep slopes (20-40° grades).

TABLE 4.—Frequency of tortoise sign found at various aspects of slope. Recorded on transects May-October 1981 - west Tucson study area. MPC = mixed paloverde-cacti community; CB - creosote-bursage community.

Aspect	% of sign on MPC transects	% of sign on CB transects	% of total transect sign
North	28.8	88.8	37.7
South	9.6	...	8.2
East	3.8	...	3.3
West	7.7	...	6.6
Northwest	26.9	11.1	24.6
Southwest	23.1	...	19.7
North and Northwest Combined	55.7	100.0	62.3

TABLE 5.—Tortoise sign found at various degrees of slope. Recorded on transects May-October 1981 - west Tucson study site. MPC = mixed paloverde cacti habitat type; CB = creosote-bursage habitat type.

Topography	Approximate inclination	% of sign on MPC transects	% of sign on CB transects	% of total transect sign
Flats	0.9^{o}	15.4	55.5	21.3
Bajadas, rolling hills	$10\text{-}19^{o}$	15.4	44.4	19.7
Foothills, slopes	$20\text{-}29^{o}$	28.8	...	24.6
Steep slopes	$30\text{-}39^{o}$	38.5	...	32.8
Steep mountains	$40\text{-}49^{o}$	1.9	...	1.6

TABLE 6. — Mean tortoise sign (per mile) recorded on mixed paloverde-cacti (MPC) transects conducted May-October 1981 - west Tucson study area.

	Habitat			
	MPC Cat Mountain	MPC Twin Hills	Other MPC	Total MPC
Transect miles	6	5	25	36
Live tortoises/mile	0.17	...	0.04	0.06
Scats/mile	1.33	0.20	0.24	0.42
Skeletal remains/mile	...	0.60	...	0.08
Dens/mile	1.17	1.20	0.80	0.92
Total sign/mile	2.67	2.00	1.80	1.47

Data from transects conducted within desert basins in the Tucson Mountains seem to indicate that a higher number of tortoises exists in these areas (Table 6). The transects at the Cat Mountain and Twin Hills locations produced greater than twice the amount of tortoise evidence as transects from other mixed paloverde-cacti habitats. Non-transect tortoise records from these areas substantiate this observation, as 52.5% of total casual observations occurred in these two areas.

Several other locations which appear to support populations of tortoises include the San Joaquin Road dump area, a bajada on the west slopes of the Tucson Mountains; several other localities in the Tucson Mountains; Black Mountain on the San Xavier Indian Reservation; and Helmet Peak, the southernmost location. All of these areas are mixed paloverde-cacti habitat.

DISCUSSION AND CONCLUSIONS

From the preliminary data analysis, a general profile of preferred desert tortoise habitat in the Tucson study area can be suggested. The north and northwest aspects of bajadas or steeper slopes from 2700-3000 ft elevation in mixed paloverde-cacti vegetative communities appear to be the most suitable kinds of locations for tortoise habitation.

North and northwest slopes may ameliorate the effects of the intense desert heat, as vegetation and wildlife variety and composition were often richer on these aspects. Several locations with northern aspect had abundant growth of potential tortoise food items such as annual and perennial grasses, a factor lacking on other aspects.

Areas within this habitat profile provide more favorable tortoise habitat in this area than the lower, more level locations indicated in a previous Arizona study (Ortenburger and Ortenburger 1927). While the presence of dug-out burrows is negligible on rocky slopes, cover sites are provided in the form of natural crevices and caves (Bogert and Oliver 1945; Burge 1979, 1980; Lowe 1964). The importance of slopes as tortoise habitat may be increasing in this area due to habitat encroachment by urban sprawl and associated human activity in the more accessible flatlands, bajadas, and foothills. The magnitude of this encroachment is evidenced by a dramatic increase in human population figures. Census data indicate that the population of Tucson in 1980 was over nine times greater than the 1940 count (Arizona State Data Center 1981, Valley National Bank 1952.)

Several factors have contributed to the present profile of desert tortoise preferred habitat in this area. Many contiguous tortoise populations and habitat which existed historically in this location have been altered by land use patterns around the city of Tucson. Factors which have undoubtedly had negative effects on the tortoise populations include cattle grazing, road building, off-road vehicle use, development of suburban housing, collecting, and mining activities. Much of the mixed paloverde-cacti habitat surveyed in this study happened to be included in the Tucson Mountain Park and Saguaro National Monument areas, where urban development is prohibited. Favorable natural features, as well as lack of major development and building efforts, may together help to explain why most tortoise sightings and sign occurred in this habitat type.

The results of this inventory indicate that tortoise densities are low to moderate in the Tucson Mountains and surrounding areas. The habitat appears favorable and larger populations might be expected under ideal conditions. Undocumented information indicates that tortoise populations were higher prior to 1950. Tortoises were harvested at the rate of two to four during each family outing by an individual who utilized them for food (George Medina *pers. comm.*). Higher densities exist in similar habitat adjacent to the study area, such as Ragged Top Mountain to the northwest (Schneider 1980), the Picacho Mountains to the north (Burge 1979, Schwartzmann and Ohmart 1976), and in the McClellan Valley near the Picacho Mountains (Dave Brown, AGFD *pers. comm.*).

The locations that are delineated as high use areas within our study area are distant from intense human disturbances but are not immune to future development. Further habitat alteration in these areas should be considered carefully because of the impact on the remaining isolated desert tortoise populations.

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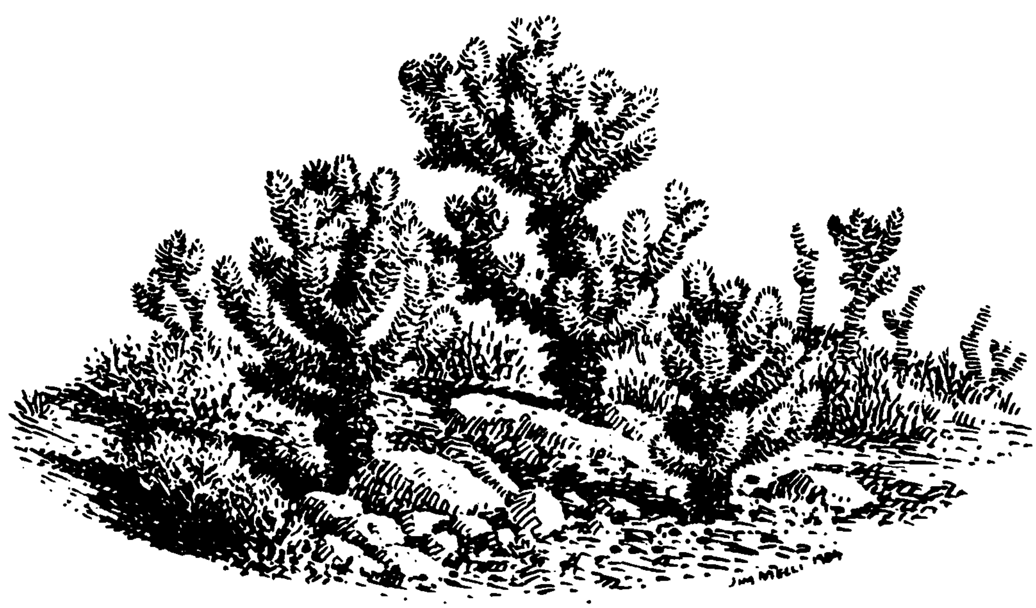

Proc. Desert Tortoise Council 1982 Symp., pp. 61-63

HOME RANGE AND HABITAT REQUIREMENT STUDY OF THE DESERT TORTOISE, *GOPHERUS AGASSIZI*, IN THE PICACHO MOUNTAINS

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The purpose of this study is to determine the home range and habitat requirements of the desert tortoise, *Gopherus agassizi*, on the southwest side of the Picacho Mountains. The study will more accurately determine the expected effects on the tortoise population from the construction and operation of the Central Arizona Project (CAP) canal through the study area. Based on the results of the study, recommendations will be made for the location and design of barrier walls and wildlife crossing structures as committed to in the Tucson Aqueduct Phase A Environmental Impact State (USDI 1981). Additional mitigation measures may also be recommended.

As described in the draft environmental impact statement (EIS), the preferred route of the CAP canal alignment will result in wildlife habitat degradation and loss, severance of contiguous habitat, and direct loss of wildlife in open canal sections. The desert tortoise merits an individual study due to its designation by the State of Arizona as a Group III species — a species or subspecies whose status in Arizona may be in jeopardy in the foreseeable future (Arizona Game and Fish Commission 1978).

The alignment of the canal will bisect an area of reportedly high tortoise density in the upper portions of the bajada and foothills (Burge 1979) on the southwest side of the Picacho Mountains. To fulfill the mitigation plan described in the EIS, information is needed to determine tortoise movement patterns, breeding and foraging areas, and hibernation and estivation sites. This information will be used to determine the necessary dimensions and location of a barrier wall to prevent tortoises from entering the canal and dying from drowning or exposure, and to determine the spacing of aqueduct crossovers to avoid disrupting tortoise movements.

The study area will be Secs. 4, 5, 8, 9, 16, 17, 20, 21, 28, 29, 32, 33, and 34 of T. 8 S., R. 9 E., and Secs. 1, 2, and 3 of T. 9 S., R. 9 E. Areas of concentrated study will be Secs. 20, 21, 28, and 29 of T. 8 S., R. 9 E. The program designed for this project involves radio tracking approximately 10 tortoises to determine home ranges. Within these home ranges, vegetation transects and ground cover measurements will be taken to correlate home range areas with foraging patterns. To accurately describe food habits, fecal analyses will be run on tortoise scats that are found. Tortoise transects will be walked throughout the proposed area to look for tortoise sign. Measurements of tortoise burrows and dens that are encountered will be taken and soil analyses will be made at each site. Size, age, and density of the tortoise population will be measured to determine the status and viability of the desert tortoise population in the study area.

METHODS

The radio tracking in the project will be carried out with Telonics equipment. The receiver is a TR-2 with a 200 KH_Z coverage, direct frequency reading, and a low power consumption. The transmitting subsystems are S2B5 with dimensions of 1.8 X 3.2 X 4.3 cm. The antenna is a hand-held, 2-element beam (4 dBd gain with deep side nulls), directional "H" antenna with 18 db front-to-back ratio.

Identification marking, vegetation transects, tortoise transects, and percent ground cover measurements will be carried out according to the standardized methods put forth by the Desert Tortoise Council to permit comparison of data to previous work. To achieve accurate results, the fecal analysis will be contracted out to a university laboratory.

Tortoise burrows and dens will be measured for depth, height, and width of hole and thickness of soil above the hole. To determine if there is a direct correlation between location of dens and burrows and soil type, chemical and physical soil analyses will be run to measure pH, conductivity, particle size, and compaction. The soil samples will be sent to the Bureau of Reclamation Regional Soil and Water Laboratory for analysis. Various methods of field studies will be investigated to determine their suitability to determine if a correlation exists between compaction and burrowing.

Tortoise size will be measured using the maximum carapace length of each tortoise. Age will be determined using seven categories of shell degradation. These categories are distinguished by the degree to which the growth annuli are visible, the amount of peeling and chipping of the annuli material, the amount of fissuring at the seams, and the presence and degree of scute depression (K. H. Berry and A. P. Woodman *pers. comm.*).

SCHEDULE

Preliminary investigations for tortoise sign were made in February of 1982 to define the approximate boundaries of the tortoise range. Radio equipping the tortoises began in March 1982 with intensive radio tracking continuing throughout the spring, summer, and early fall months. Field time will decline slightly during the months of hibernation as tortoise movements will be slight or none. Field time will again increase during the following spring, summer, and early fall months of 1983. Vegetation and tortoise transects will be run concurrently with the radio tracking.

COSTS

The major initial cost for this study is the telemetry equipment at $4,214.00. The contract for the fecal analysis will be approximately $400.00

for 50 samples. The following table contains a complete breakdown of estimated costs.

Cost Estimates

A.	Telemetry Equipment	
	1. Receiver	$1,214.00
	2. Antenna w/Coaxial Feedline and Carrying Case	71.00
	3. Headset	37.00
	4. Twelve Transmitters @ $241.00 each	2,892.00
B.	Fecal Analysis Contract	400.00
	TOTAL	$4,614.00

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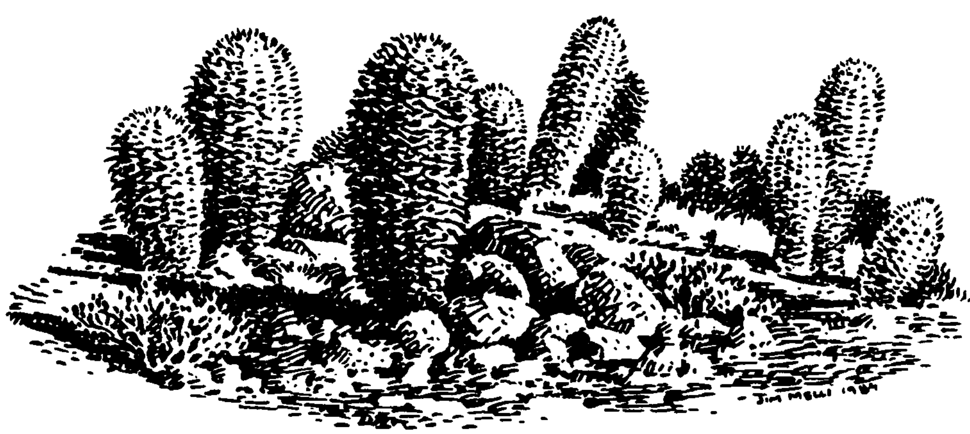

Proc. Desert Tortoise Council 1982 Symp., pp. 64-66

MULTIPLE USE MANAGEMENT ON DESERT TORTOISE HABITAT

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Abstract.—A discussion of Range Management Systems design, grazing season establishment, grazing pressure adjustments, and project location as facets of allotment management planning that offer alternatives to optimize range and habitat resources. Combinations of these alternatives are being made in the emerging range management program for tortoise habitat areas on the Arizona Strip District. The economics of system implementation will not cause poor range management practices to damage habitat.

This morning I intend to respond directly to the question asked in your letter inviting me to participate in this symposium. The question was: "Regarding management of desert tortoise habitat and the realities of political decisions facing us today, are economics going to force the use of particular grazing systems when clearly the desert range will continue to suffer if such systems are implemented?"

The simple answer is "no." Neither political decisions nor economics will force us to knowingly implement a grazing program that will result in deterioration of the range or the habitat. Now, I will try to amplify this answer so that you understand what has been done and what will be done to ensure continued improvement of the desert range.

When I spoke to you two years ago, the Arizona Strip District was just beginning a grazing Environmental Impact Statement (EIS) on the District's tortoise habitat. Since then, the statement has been filed and grazing decisions issued. As you may recall, I outlined a program that included adjustment of livestock numbers to grazing capacity based upon 50% utilization of key forage species and implementation of grazing systems. During the EIS process, the Sierra Club, among others, suggested that we develop an alternative other than intensive management under rest rotation grazing systems. A study analysis by Van Poolen and Lacey (Journal of Range Management 32(4), July 1979) indicated that on southwestern range sites, grazing intensity adjustments can be more effective in improving forage production than intensive grazing systems. Therefore, we developed an alternative that provides for managing certain allotments by adjusting grazing pressure to a light to moderate level and no pasture rotation. This system, in practice, results in about a 10% reduction in livestock numbers below grazing capacity.

Certain allotments will be managed under rotation systems at 50% utilization and others will operate as before, except at 45% utilization. Utilization is a measure of livestock and wildlife consumption of the current year's growth on key forage species. In tortoise habitat, key species would include such plants as 4-wing saltbush, white sage, sand dropseed, Indian rice grass, bush muhley, and galleta grass. Specific allotments that include desert tortoise habitat and the management decisions on those allotments are tabulated below:

Allotment Management Decisions

Map key	Allotment	Grazing systems	Level of utilization	Season of use
1	Beaver Dam Slope	Deferred Rotation	50%	W-S
2	Highway	Seasonal Deferred	50%	W
3	Littlefield Community	Deferred Rotation	50%	W-S
4	Mesquite Community	L-M Stocking	45%	W-S
5	Mosby-Nay	Rest Rotation	50%	YL
6	Pakoon Spring	L-M Stocking	45%	YL
7	Pakoon *	L-M Stocking	45%	S
8	Blackwillow Tasi Spring	L-M Stocking	45%	YL
9	Middle Spring	L-M Stocking	45%	W-S
10	Cottonwood *	Deferred Rotation	50%	YL
11	Mud & Cane Springs *	L-M Stocking	45%	YL

* Allotments include very little tortoise habitat.

In the design of the Allotment Management Plans, area personnel are considering wildlife habitat requirements. For example, George Sheppard has been identifying the high density tortoise areas for the Range Conservationists. Then water developments are located well outside these areas. The intent is to avoid concentrating livestock grazing in the better habitat area.

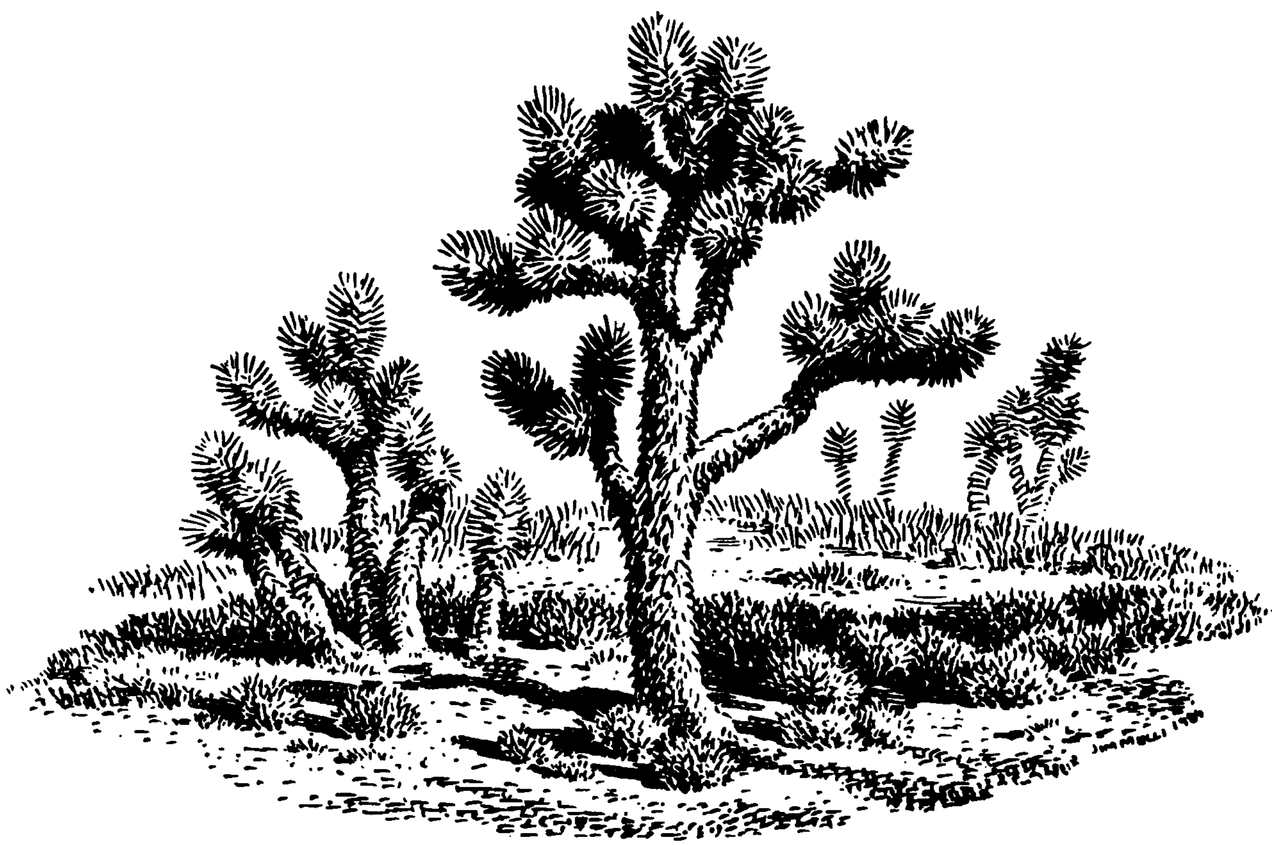
In summary, I believe that our grazing program will improve conditions for both wildlife and livestock for the following reasons:

1) The Beaver Dam Slope Allotment has been managed under a Deferred-Rotation system for the past 10 years. The overall range trend is improving and livestock forage production has increased by approximately 5 lb/acre over the allotment since the system was implemented. We can expect allotments under similar systems to respond as well.

2) On those allotments where a pasture rotation system is not involved, the reduction of grazing pressure and subsequent grazing patterns that develop will have the effect of leaving some habitat ungrazed or very lightly grazed.

3) Water placement will ensure that the better tortoise habitat is in lighter grazed range areas.

4) The provision for 45 or 50% utilization, measured at the end of the grazing season, is expected to result in approximately 10 to 15% utilization in the critical spring period for tortoise.



Proc. Desert Tortoise Council 1982 Symp., pp. 67-69

HABITAT MANAGEMENT PLANS, DESERT TORTOISES, AND THE ARIZONA STRIP DISTRICT

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The Arizona Strip District is located in the extreme northwest corner of the state. Desert tortoise habitat is found in over 150,000 acres of the district on the slopes of Beaver Dam and Virgin Mountains and in the Pakoon Basin west of the Grand Wash Cliffs and north of Lake Mead. The habitat area is further continuous with Nevada and Utah. Habitat Management Plans (HMPs) are designed to emphasize priority species and their habitats. The desert tortoise is one of five priority species identified within the Virgin River-Pakoon Basin HMP.

The other priority species are three native fishes in the Virgin River, and the Gila monster. This report will use the desert tortoise as a vehicle to gradually develop an understanding of the heart of the Bureau of Land Management's (BLM's) wildlife program, the HMPs.

A habitat management plan is precisely that — a gradual development involving preparation and development in consultation and coordination with state agencies, designed to improve wildlife habitat conditions. On the Arizona Strip District, we first generate a preliminary supporting document called the Habitat Analysis (HA). This report reviews any available research and data pertinent to the Habitat Management Area (HMA). For the Virgin River-Pakoon Basin HA, desert tortoise information is available for general habitat requirements. Previous BLM inventories (Burge 1978, Hohman and Ohmart 1980, Sheppard 1981) also provide distribution and density estimates. Historical accounts will also be of benefit when I review the present condition and trend of tortoise populations.

Of vital importance in our preparation of the HMP will be the assessment of habitat conditions. This requires extensive vegetation inventories throughout the HMA. The BLM's wildlife program philosophy is to "take care of the habitat and the wildlife will take care of itself." However, when threatened, endangered, or state-listed species are priority in the HMP, this requires more than just habitat inventory. It involves an assessment of the status for a given species — in this case, the desert tortoise. The following is a brief status summary for the desert tortoise in the HMA.

From studies conducted in the HMA since 1977, results have shown that densities of more than $50/mi^2$ occur in only 2-4 sections throughout the entire area (Hohman and Ohmart 1980, Sheppard 1981). If preliminary assessments from transects covering every section of tortoise habitat in the HMA are even distantly accurate, numbers may be too low for maintenance of a viable population of desert tortoises on Beaver Dam Slope, Virgin Mountain Slope, or the Pakoon Basin.

There have been a multitude of activities that historically led to the direct or indirect decline of desert tortoises in the HMA. It is suspected that the most damaging direct loss of animals occurred on Beaver Dam Slope where thousands of animals were collected and sold along Highway 91. Collection from this population on Beaver Dam Slope continued until the mid-1970s when Interstate 15 was completed and traffic along the old highway was limited. U'dell Johnson, an ex-truckdriver, referred to the 1950s when he used to drive from Salt Lake City to Las Vegas and "see dozens of turtles along 91, most of them small ones, smashed along the road." Since very few tortoises have been found on the highway since 1977, a zone of approximately 0.5 miles on each side of the roadway has been denuded of most resident animals, both from collecting and road kills (Hohman and Ohmart 1980, Sheppard field notes).

Indirectly, livestock grazing since the late 1800s has further impacted desert tortoise populations, primarily from habitat deterioration. Historical tax records from Mohave County show extensive sheep ranching had its early beginnings on the Arizona Strip around 1976 (Malach 1978). In 1936, there were 69,470 sheep, 10,523 cattle, and a variety of domestic animals reported on the tax rolls for north of the river. These animals had to winter in the low desert areas. Actual numbers could be much higher. This sustained grazing pressure over a period of decades on desert vegetation and soils would have extensive consequences, ultimately to desert wildlife populations, particularly herbivores like the desert tortoise.

In the Virgin River-Pakoon Basin HMA, tortoises occur in two distinct habitat types. The one area referred to collectively as the Pakoon Basin has more than 85,000 acres of tortoise habitat of which more than half was burned from wildfires in 1979 and 1980. An estimated 75% of the Pakoon allotment was scarred, removing dense Joshua tree stands, blackbrush-covered hills and perennial grasses (grazing should have been discontinued for at least one year to allow for recovery of plants and stabilization of soils but . . .). Tortoise densities in the Pakoon Basin area appear to be highest (25-50/mi^2) in the southern one-third along rolling hills and rock ledges. The washes and adjacent foothills of the Grand Wash Cliffs from Nutter Twist to the Colorado River outside the HMA also provide excellent habitat. The washes, many of which drain into Grand Wash, provide denning sites along their routes. Where unburned, they also provide excellent cover and forage conditions. Ledges and hills along Black Wash may also prove to be quality habitat but the area has very limited acreage. Vegetation for most of the Pakoon Basin area is a desert scrub mix. Estensive areas of basaltic lava flows, unsuitable habitat for tortoises, cut through the landscape, leaving narrow washes along which dens can be found.

The second half of tortoise habitat, at least 90,000 acres, are found on the Virgin-Beaver Dam slopes. The area is extensively drained by washes and rills, but, unlike the Pakoon Basin, tortoises appear more dependent on the bajadas for burrowing and foraging (Hohman and Ohmart, Sheppard 1981). Both the Virgin and Beaver Dam slopes provide excellent soil substrates for burrowing as well as denning sites in washes and rocky foothills. Most of the area is a homogeneous creosote-bursage vegetation type. This gradually mizes with Joshua tree on the northern Beaver Dam Slope and a more diverse desert scrub mix along the foothills.

Four core areas have been designated in this area of the HMA as requiring special management attention. This can best be focused through the HMP process.

The BLM, in coordination with the Arizona Game and Fish Department, will prepare and implement a comprehensive plan over the next five years under the following schedule:

- June 1983 - Habitat Analysis and Habitat Management Plan rough draft for review
- August 1983 - HA and HMP final
- August 1983 - HMP submitted to Arizona Game and Fish Commission for approval
- October 1983 - Begin implementation.

After objectives are established, planned actions are then generated which will lay out just how the objectives will be attained. The planned actions are generally habitat improvement projects which are intended to improve, protect, and enhance the habitat. The HMP, upon completion of projects, enters the evaluation/monitoring mode to see if the planned actions are getting the objectives accomplished.

The BLM has an enormous responsibility to manage for a multitude of resources in a multiple-use manner. To achieve proper wildlife management, the BLM has taken a holistic approach. This approach is best summarized by a recent BLM Manual release (Supplemental Guidance, Rel. 1-1232, 7/27/81), which states:

> "Ecosystem management encompasses featured species and species diversity to ensure compliance with existing laws; prevent species from becoming threatened or endangered; and provide values and uses for the public. The overall goal of ecosystem management for wildlife is retention of all natural habitats in sufficient quantities to support viable and self-sustaining populations of all native wildlife."

To be reminded of our responsibilities as land managers never hurts. The Desert Tortoise Council will be given an opportunity to review the Habitat Analysis and the Habitat Management Plan. Your comments and criticism would be valuable toward achieving our common goal. The status of species or wildlife management should not be a partisan issue but a joint endeavor.

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Proc. Desert Tortoise Council 1982 Symp., pp. 70-72

CONSERVATION, EDUCATION, AND PROPAGATION PROGRAMS FOR *GOPHERUS AGASSIZII* (COOPER) AT THE ARIZONA-SONORA DESERT MUSEUM

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Abstract.—*Gopherus agassizii* has been maintained at the Arizona-Sonora Desert Museum (ASDM) for nearly 30 years. An increased emphasis on the conservation of this species has guided the development of new goals and objectives. Captive-bred progeny are made available to qualified recipients in lieu of collection from the wild, and, through the Tortoise Adoption/Transferral Program, other interested parties obtain tortoises already in captivity. Efforts are in progress to establish a captive breeding colony of southern Arizona origin to allow the release of marked progeny into suitable habitat in Tucson National Park. A breeding plan has also been developed for the albinistic specimens. Improved management techniques have reduced tortoise mortality at ASDM. Public education efforts include planned improvements in the physical exhibit for the desert tortoise at the Desert Museum, conservation-oriented graphics, and expanded media coordination to enlighten the public about the plight of the tortoise.

Gopherus agassizii has been displayed at the Arizona-Sonora Desert Museum (ASDM) for nearly 30 years. During that time, countless visitors have become acquainted with this venerable denizen of the southwestern U.S. deserts. This educational experience has done much to enlighten the public about the nature of the desert tortoise. As times have changed, however, the Museum's mission and responsibilities toward the conservation of this species have expanded.

Conservation education remains central to these objectives. New interpretive graphics will address factors associated with the decline of the tortoise throught its range. Major emphases will include reasons for this decline and ways in which the general public can contribute to tortoise conservation.

The Museum is utilizing the printed and electronic media to convey practical information about the desert tortoise. The weekly television program "Desert Trails" recently featured an entire program on "The Natural History, Conservation, and Captive Care of the Desert Tortoise." Both newspaper and television news stories are planned for the coming year to convey the conservation message to the general public.

The Museum's Desert Tortoise Adoption/Transferral Program is designed to facilitate the transfer of specimens already in captivity to qualified persons seeking specimens. While the maintenance of tortoises as pets is not encouraged, a waiting list of prospective adopters is kept, and these persons are contacted when long-term captives or captive progeny are offered to the Museum. A detailed pamphlet outlining fundamentals of husbandry, diet, and natural history is distributed to interested parties and assimilating the information in the pamphlet is a prerequisite to the acquisition of a tortoise through the Museum.

Persons adopting tortoises through the Museum must sign a statement agreeing to provide proper care, diet, and, if necessary, veterinary care for the animal. They must also agree to comply with all state regulations regarding the possession of desert tortoises.

Reproduction of the desert tortoise at the Museum has occurred sporadically and has been incidental to the exhibition of the species. The existing exhibit has supported as many as nine specimens at a time, but inordinate population density, excessive agonistic behavior, a bland physical environment, and a lack of health controls have limited the long-term success.

Presently, the ASDM colony consists of individuals of unknown geographic origin. Offspring from this colony have been distributed to qualified recipients who might otherwise have collected specimens from the wild.

The primary management objective of the ASDM tortoise program is to establish a viable breeding colony of southern Arizona origin. Progeny from such parent stock might be genetically suitable for release into appropriate habitat in southern Arizona.

Plans have been approved for a major renovation of the existing tortoise exhibit to incorporate natural food plants and appropriate topography to allow the construction of efficient summer and winter burrows. Efforts are in progress to determine the optimal carrying capacity of this captive environment.

In addition to advancements in the physical environment for tortoises at ASDM, major improvements are already in progress regarding health and dietary management. Lower vertebrate veterinarian Dr. Jim Jarchow has enabled a greatly expanded veterinary program for reptiles, amphibians, and fishes at the Desert Museum. Early detection and effective treatment of respiratory problems have reduced tortoise mortality to virtually zero. The incorporation of natural vegetation into herbivorous diets at the Desert Museum has been a strong priority for 1982. This can be expected to facilitate further advancements in general health and reproduction.

Keasey (1979) reported on the development of a colony of albino *G. agassizii* at the Desert Museum. At present, this group consists of four completely albinistic specimens and 11 heterozygous specimens. Two of the complete albinos appear to be approaching sezual maturity and are a pair. The captive management of these specimens has presented unique problems because of their sensitivity to light and their rarity. To date, they have been maintained entirely indoors. In April 1981, these specimens were provided with artificial ultraviolet lighting in the form of one Vita-lite (Durotest) and one BL blacklight (General Electric) in tandem suspended 45 cm over the enclosure. A photoperiodicity replicating that of Tucson, Arizona, is provided, as is optional shelter from the light. The specimen which hatched on 11 October 1974 had reached 21.8 cm by 15 March 1982. This specimen, a male, shows moderate "pyramiding" of epidermal laminae on the carapace. It is likely that this growth phenomenon is a syndrome of captive-rearing, as suggested by Jackson et al. (1976). However, a second specimen, a female hatched in 1975, has not demonstrated this, and has grown much more slowly, having reached a carapace length of only 15.2 cm by 15 March 1982.

A new summer yard, which is protected from excessive sunlight, predators, and human interlopers, has been developed for these unique specimens. Since they are siblings from the same parent stock, they will be out-bred to normal specimens unless unrelated albinos can be located.

The basic program for the desert tortoise described here is designed to fulfill the multi-faceted potential inherent in the Arizona-Sonora Desert Museum. As new information and advice becomes available, some plans may change. But, in the final analysis, the survival of the desert tortoise will judge its success or failure.

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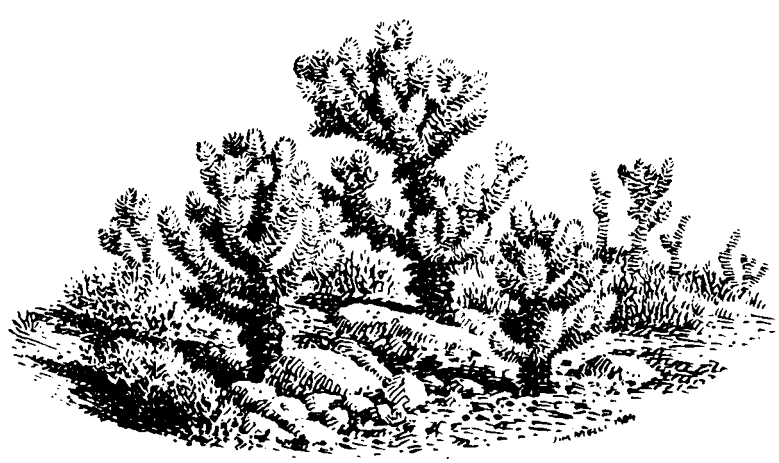

Proc. Desert Tortoise Council 1982 Symp., pp. 73-75

A RECOVERY PLAN FOR THE DESERT TORTOISE

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The reason for my presentation today is threefold. First, I would like to report on the status of the recovery plan for the Beaver Dam Slope population of the desert tortoise, *Gopherus agassizii*. Second, I would like to review the total process of developing a recovery plan and getting it approved. Lastly, I will try to answer any questions you may have concerning the first two topics.

Preparation of the recovery plan for the Beaver Dam Slope population of the desert tortoise began with a meeting in Salt Lake City on 26 January 1982. Present were several representatives of the U.S. Bureau of Land Management, Utah Department of Wildlife Resources, and the U.S. Fish and Wildlife Service who were familiar with the desert tortoise and its problems.

The first action the group took was to review the history of actions which have occurred, especially since the tortoise was listed as threatened in 1980. Critical habitat was also designated in 1980. Since then, listing petitions have been presented to list additional populations of the species, as well as to delist the Beaver Dam Slope population. No final action has been taken on the petition to list additional populations, and the petition to delist has been denied.

The second task the group pursued was development of the primary goals for the recovery plan. The goals were (1) to manage the habitat of the Beaver Dam Slope population of the desert tortoise to improve sex ratios, reproduction, and recruitment to the population through an enhanced vegetative community, such action to eventually lead to delisting; and (2) to have delisting considered when the population improves in density, age ratio, and sex ratio during any consecutive three years.

The group then developed a list of possible reasons for the present condition of the Beaver Dam Slope population. In doing so, they reviewed physical and biological impacts. Reasons identified include overgrazing, collecting, vehicular impacts, predation, fire, trampling, radioactive fallout, low reproductivity, low recruitment, precipitation, and age at sexual maturity.

Lastly, the group identified several studies and monitoring actions that are needed. These include such things as studying food overlaps and competition, determining population numbers, gaining a better understanding of population dynamics, gathering life history data, determining ways of producing habitat, and studying the possibility and feasibility of reintroduction.

Using the information assembled at this meeting, the Fish and Wildlife Service is drafting a recovery plan for the Beaver Dam Slope population of the desert tortoise. The plan will emphasize needed research projects and studies and eventual management actions which will help achieve recovery. If you have any information or would like to discuss some aspect of the recovery plan, you may call Robert Benton at (801) 524-4430, FTS 588-4430 or Jim Coyner at (801) 524-5637, FTS 588-5637. The draft should be ready for review by the end of April or early May.

This completes my status report on the recovery plan that we are preparing for the desert tortoise. I am sure many of you have questions concerning the procedure involved in developing and approving a recovery plan, questions such as who develops a plan, who reviews it, how a person can input his own expertise and knowledge into a plan, and so on.

Once the Director of the Fish and Wildlife Service determines that funds and manpower are to be programmed for the development of a recovery plan, a decision is made at the Regional Director level as to how it will be prepared. There are several ways this can be done, such as by a recovery team; by the Fish and Wildlife Service; by an individual, committee, or group on a volunteer or contract basis; by a State agency; or by another Federal agency.

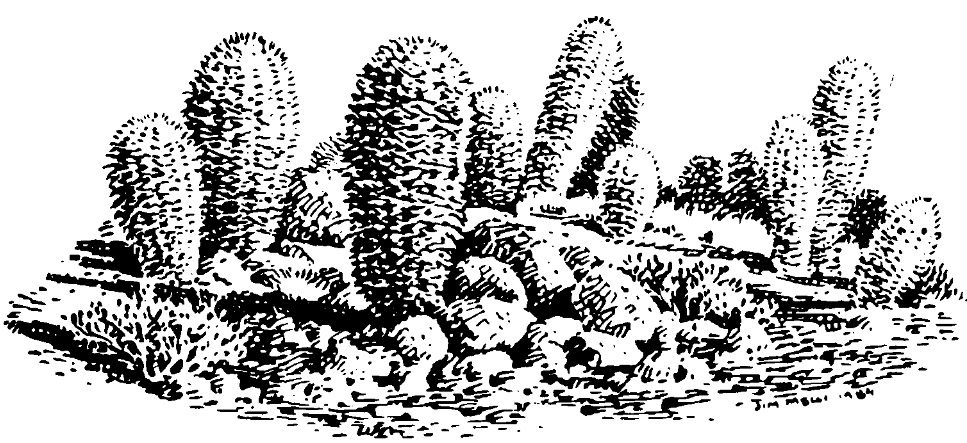
No matter who develops a recovery plan, it must go through a certain procedure before final adoption. The first draft that is developed is called a technical draft. This draft, when ready, is distributed to all interested, qualified parties for technical review. This review should concentrate on biological and ecological aspects of the recovery plan. Many of you here today will be asked to review this draft. Anyone with scientific expertise in the desert tortoise is welcome to comment. We need your help to make the recovery plan for the desert tortoise a sound, scientific, practical document which will eventually lead toward the delisting of the desert tortoise.

Generally 45 days are allowed for this review. All comments received will be incorporated as practical into a new draft called the agency draft. This draft should be prepared within 60 days and will be made available to all cooperating agencies for their review. It is imperative that agencies have an opportunity to comment on tasks or activities identified in the plan in which they are expected to participate. The plan must have their support.

Once again, 45 days are generally allowed for this review. A longer comment period can be provided, if necessary. The same is true of the technical review.

All comments received during the agency review will be incorporated into a final draft as appropriate. If some comments are not made a part of the final plan, an explanation will be made as to why they were not. The final will be prepared within 60 days of receipt of agency comments. This final draft is then sent to the Director of the Fish and Wildlife Service for his approval and signature. Forty-five days are again allowed for this final step in the approval process. Once the plan is signed, copies are distributed to all agencies involved and any other interested parties.

As you can tell, the total elapsed time from preparation of the technical draft until final approval can be eight to nine months, more if extra time is needed for the various reviews. After the plan is approved, the Fish and Wildlife Service will assist the other agencies in carrying out the various actions identified in the plan. The Fish and Wildlife Service will also fund those actions which have been identified as their responsibility in the plan. As progress is made on implementing the plan, the Fish and Wildlife Service, in coordination with the other agencies involved, will review the program. When the goals of the recovery plan are met, a recommendation to delist the species will be made to the Secretary of the Interior.



Proc. Desert Tortoise Council 1982 Symp., pp. 76-77

WASHINGTON COUNTY CATTLEMEN'S ASSOCIATION AND UTAH FARM BUREAU REPORT

ELDON HAFEN, President
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I would like to thank you for the invitation that has been extended to the Washington County Cattlemen's Association to participate here and to present this report prepared by the Utah Farm Bureau and the Washington County Cattlemen's Association.

I am not here in the spirit of confrontation but rather in the spirit of explanation. I will explain our position and concerns in relation to the listing of the desert tortoise on the Beaver Dam Slope as a threatened species with critical habitat. I hope to convey to you that we have no desire to harm the desert tortoise. This has never been our intention, even with the stand that we were forced to take in regards to the listing of the tortoise and the 35-mi^2 habitat.

We have what we consider to be a legitimate fear as to the consequences that could come from this action. This listing could impose unwarranted restrictions on the permittees operating within the habitat area. It could effectively turn the management of the habitat area over to the U.S. Fish and Wildlife Service. It could possibly change the use of this area from a multiple use area to a single use area.

I can almost hear you say that this has not happened and you are right. But that isn't to say that it can't and won't happen. We are in the early stages of implementing management plans for this area and the danger of these concerns becoming reality are of real concern to us.

You might say that these fears are not justified and are only exaggerated assumptions on my part. The Desert Tortoise Council and Dr. Glenn R. Stewart have taught me the value of assumptions and, yes, exaggerated assumptions. I read some of these exaggerated assumptions in Dr. Stewart's petition to list the tortoise and the habitat, and you were successful in your efforts.

I don't feel that the intent of Congress, in regards to the Endangered Species Act, was carried out in this listing. The Act states that the term, "Threatened Species," means any species which is likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. There is no argument as to the definition of the word "all," but there certainly is an argument as to the definition of the word "significant" in regards to listing of this very small portion of a species.

We would ask you to consider the positive trends that have been shown through study comparisons from 1948 to 1981 as to age structure, sex ratio, and density. While the information and studies may be somewhat limited, it is more than was available at the time the population and habitat was listed. These improvements in the population have come about with no change in management as to stocking rate or the time of use on this area since 1965. This shows to us that cattle and the tortoise are compatible on the same range and that some of the fears concerning competition between the two are not justified.

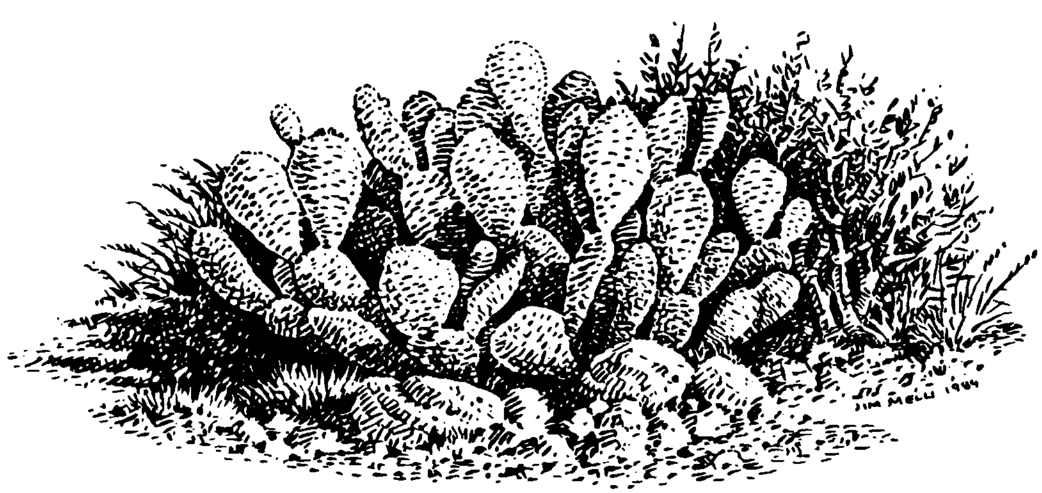
I would recommend to the Desert Tortoise Council that future studies relative to the desert tortoise be done by independent biologists not directly affiliated with the Council. I feel that studies done by Council members, regardless of how honest and sincere they are in doing the studies, will carry a cloud of suspicion and doubt as to the validity of the studies. I would parallel this to the Bureau of Land Management asking me to do a utilization study on my own allotment. No matter how sincere and honest I was in making the study, the question of its accuracy would be ever present.

Though I feel the listing of the tortoise and the habitat was not warranted, I feel something positive has developed from our differences. It has made us more aware of the tortoise and its needs.

I haven't wished to offend you in giving this report but hope that you can better understand our position as an Association in this matter.

I again say, we have no desire to harm the tortoise. We have never considered the tortoise as a problem. The only problem we are faced with is the implications that could come from this listing.

Thank you.



Proc. Desert Tortoise Council 1982 Symp., pp. 78-80

Bureau of Land Management Report - Utah

MANAGEMENT FOR THE DESERT TORTOISE IN UTAH

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General Description.—The desert tortoise, *Gopherus agassizii*, in Utah is located in the southwest corner of the state in the area known as the Beaver Dam Slope. This area is approximately 70 mi^2 in size. The vegetative aspect for the area is Joshua tree-creosote bush type with a variety of annual-perennial forbs and grasses.

Present Protection and Management of the Desert Tortoise.—The listing of the Beaver Dam Slope population of the desert tortoise as a threatened species was finalized in the 20 August 1980 *Federal Register* (CFR Part 17). This listing included the designation of 35 mi^2 of critical habitat. Multiple-use management will continue in the designated critical habitat area in accordance with the Endangered Species Act and the Federal Land Policy and Management Act.

Livestock Grazing.—In the *Federal Register* notice, the U.S. Fish and Wildlife Service reported that livestock grazing, as recommended by the Bureau of Land Management (BLM) in the Hot Desert Grazing Environmental Impact Statement, would not adversely affect the desert tortoise once the proposed grazing use adjustments were made. Presently, the BLM is working with the livestock operators to implement these grazing recommendations, and the Allotment Management Plan concerning this area is scheduled to be completed and implemented this fall in cooperation with the livestock operator, the Utah Division of Wildlife Resources, and the Fish and Wildlife Service.

Oil and Gas Exploration.—The critical habitat area will continue to be open for oil and gas exploration with the following special stipulations:

1) There would be no surface occupancy within the "Woodbury Desert Study Area" (3,040 acres).

2) Drilling would not be permitted in areas containing sensitive flora and fauna. Prior to issuing permits to drill, BLM will determine if sensitive flora and fauna are present.

3) No surface disturbing activity would be permitted during the months of April through September, while the tortoises are active.

4) No surface disturbing activities would be permitted within 500 ft of any desert tortoise winter dens.

5) All mud pits or ponds used in drilling activities would be fenced with chicken wire to prevent tortoise from falling in.

Off-road Vehicle Use.—The Off-road Vehicle (ORV) designations for Washington County were finalized in the 25 September 1980 *Federal Register*. Vehicular travel in the desert tortoise critical habitat area is designated as limited to existing roads and trails.

Desert Tortoise Monitoring Plan.—During 1980 and 1981, a study was completed on the Beaver Dam Slope desert tortoise. This study was completed by BLM through a contract with the Utah Division of Wildlife Resources. Larry Minden was the principal investigator on this study. Data were collected on a 1-mi^2 plot located east of Highway 91 in the "Woodbury Desert Study Area." A preliminary survey was conducted in the spring of 1980 which entailed locating and marking dens, locating transmitter-equipped tortoises, and conducting random searches. During 1981 field season, about one half of the time was spent sampling vegetation and permanently marking the study plot. The rest of the time was spent

TABLE 1.—Population size structure and sex ratio for 74 native desert tortoises captured in 1980 and 1981.

Size class (carapace length in millimetres)	Sex			Ratio of males to females	Percent of Population
	Male	Female	Unknown		
Juvenile I (*n*=3) (<60)	...	...	3	...	4.0
Juvenile II (*n*=7) (60-100)	...	...	7	...	9.5
Immature I (*n*=7) (101-140)	...	...	7	...	9.5
Immature II (*n*=7) (141.179)	1	1	5	...	9.5
Subadult (*n*=14) (180-207)	5	9	...	.56:1	18.9
Adult I (*n*=16) (208-240)	8	8	...	1:1	21.6
Adult II (*n*=20) (>240)	15	5	...	3:1	27.0
Adults (*n*=36)	(23)	(13)	...	1.77:1	(48.6)
Combined subadult & adults (*n*=50)	(28)	(22)	...	1.27:1	(67.5)
Totals (*n*=74)	29	23	22	...	100.0

TABLE 2.—Tortoise density.

Technique	Density		95% confidenceinterval	
	n/km^2	(*n*/mi^2)	*n*/km^2	(*n*/mi^2)
Lincoln Index	42	(109)	20-79	(51-205)
Stratified Lincoln Index	45	(117)	21-85	(55-220)
Schnabel Method	53	(136)	32-81	(82-210)

systematically censusing the plot. A total of 74 native desert tortoises was encountered in the study plot. Tables 1 and 2 summarize the population dynamics. The proportions of adult and nonadult tortoises were nearly equal. The combined sex ratio for adults and subadults was 1.27 males per female. Size composition of the sample by age, based on carapace length, was 13.5% juvenile, 19% immature, 18.9% subadult, and 48.6% adult. Three mark-recapture techniques estimate densities at 109, 117, and 136 individuals respectively, per square mile.

Copies of this study are available at the Dixie Resource Area Office in St. George, Utah, and the Utah Division of Wildlife Resources Office in Cedar City, Utah.

The Desert Tortoise Monitoring Plan as specified in the Habitat Management Plan will continue this spring. The Utah Division of Wildlife Resources will gather information on population dynamics with BLM continuing vegetation studies.

Conclusion.—Managers in Utah are pleased with the results of the latest study on the desert tortoise. The data indicate that tortoise reproduction is occurring, and that, in the younger individuals, a healthier sex ratio exists. With the present and proposed management which is being implemented, we are confident that the needs of the desert tortoise in Utah can be met.

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STATE REPORT - CALIFORNIA

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Since our last symposium, tortoise management efforts by the Department of Fish and Game have primarily been concentrated on evaluating various land use proposals and providing comments when appropriate. Most of these have centered around Bureau of Land Management Environmental Impact Statements and Environmental Assessments. Included in these were such important events as the Parker 400 Race, the Hare-Hound Motorcycle Race in the Lane Mountain area north of Barstow, and Amendments to the Desert Plan.

Tom Campbell, who contracted with the Department of Fish and Game to collect data on hunting, shooting, and trespass at the Desert Tortoise Natural Area near California City, completed his contract last June and submitted a report on his findings. Tom will present this information in detail later this afternoon so I will not go into that now except to say that I have seen the report and he has some very revealing data concerning the so-called hunting that is taking place there.

Curt Uptain took Tom's place on the Natural Area last July. He will continue to do the same type of work that Tom did. His contract will extend through June 1982. The decision has not yet been made to extend the study, but the impression I have is that such an extension is unlikely. Curt is here and will be able to answer questions on the current situation.

Since our last symposium, the Department of Fish and Game has issued 2,153 permits to possess live tortoises. During the past three years, this has fluctuated a bit but seems to be holding pretty close to 2,000 per year. A total of 16,261 permits has been issued by the Department since the program was started in 1973.

I commented last year that the flood of tortoises turned in to the Department of Fish and Game seemed to have abated. The same was true in 1981; 12 tortoises were turned in to our office in Chino. Several were given to Norman Edmonston for adopting out and the rest went into hibernation before I could get them to a turtle and tortoise club for adoption.

To end on a slightly positive note, Fort Irwin and the Twenty-nine Palms Marine Base in southern California each got a permanent civilian biologist position last year. I have met with both people and talked about the tortoise's precarious position in California. Both were agreeable to taking an active interest in preserving tortoises to the extent possible on these military facilities. Unfortunately, Fort Irwin was recently reactivated as a full-scale training base for approximately 16,000 troops. So even with permanent biologists stationed at these installations, I do not envision a dramatic comeback by tortoises there but at least now each base has someone on its staff looking out for the tortoise's well-being.

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STATE REPORT - CALIFORNIA

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The Bureau of Land Management (BLM) report for the California deserts is divided into three parts: (1) a summary of studies undertaken on two permanent study plots in 1981, (2) studies scheduled for spring of 1982, and (3) the study in Ivanpah Valley on the effects of cattle grazing on desert tortoise populations and habitat. Phil Medica, Craig Lyons, and Dr. Frederick Turner will present the Ivanpah Valley study in the paper entitled, "A Comparison of 1981 Populations of Desert Tortoises (*Gopherus agassizi*) in Grazed and Ungrazed Areas in Ivanpah Valley, California" (Medica et al. 1982).

STUDIES UNDERTAKEN IN 1981

Studies were conducted on two previously established permanent plots, each of which is 1 mi^2 (2.59 km^2). The methods used were the 60-day censuses described in the 1980 Symposium Proceedings of the Desert Tortoise Council (Berry 1980). The size class structure is slightly different than presented in previous years. The seven size classes are: juvenile 1 (<60-mm carapace length [CL]), juvenile 2 (60- to 99-mm CL), immature 1 (100- to 139-mm CL), immature 2 (140- to 179-mm CL), subadult (180- to 207-mm CL), adult 1 (208- to 239-mm CL), and adult 2 (>240-mm CL). Contractors were not required to prepare reports.

Fremont Valley, Kern County

The Fremont Valley plot was first established in 1976 and was sampled again in 1978 and 1979. The 1981 60-day census was the second such census conducted on the plot. Two hundred nine new and previously marked tortoises were encountered one or more times each. Of the total of first encounters, 3.8% were juvenile 1, 9.1% were juvenile 2, 17.2% were immature 1, 18.2% were immature 2, 8.1% were subadult, 27.3% were adult 1, and 16.3% were adult 2. Thirty carcasses or carcass parts were collected. The size class, sex, and estimated year of death are being determined for each one. Tim Shields was the principal contractor. Karen Bohuski and Peter Woodman also worked at the site.

Stoddard Valley, San Bernardino County

The Stoddard Valley plot was first established in 1977 and was sampled again in 1979 using a 60-day census. Ninety-seven new and previously marked tortoises were encountered one or more times. Of the total of first encounters, 1% were juvenile 1, 9.3% were juvenile 2, 8.2% were immature 1, 9.3% were immature 2, 10.3% were subadult, 35.1% were adult 1, and 26.8% were adult 2. Twenty-two carcasses or carcass parts were collected. The size class, sex, and estimated year of death are being determined for each one.

Woodman was the principal contractor. Karen Bohuski and Tim Shields also worked at the site.

STUDIES SCHEDULED FOR 1982

The BLM intends to award contracts for 60-day censuses of four permanent study plots during the first week of April. The plots, all previously established and at least 1 mi^2 (2.59 km^2), are: Desert Tortoise Natural Area (Sec. 11), Kramer, Chemehuevi Valley, and Chuckwalla Bench. The BLM unfortunately does not have funds to continue the study of cattle grazing and its effects on desert tortoise populations in Ivanpah Valley during 1982 and 1983. Therefore, radio transmitters will be removed from the tortoises sometime during spring or summer. Phil Medica and Craig Lyons will undertake this task.

Analysis of data collected at permanent study plots continues (Berry 1981). The coding of behavioral data collected on tortoises between 1977 and 1981 on permanent study plots for computer analysis is a major task and has not been finished. The coding of mortality data for the computer is almost complete. Assignment of an estimated year or years of death to each carcass or carcass part collected on permanent study plots is also nearing completion. We may be able to report on these projects in more detail in the next few years.

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Proc. Desert Tortoise Council 1982 Symp., pp. 84-85

CALIFORNIA TURTLE AND TORTOISE CLUB REPORT

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Thank you for this opportunity to speak for the California Turtle and Tortoise Club (CTTC).

As many of you are familiar with our organization, I will not go into much detail at this time. However, I would like to fully explain our adoption program as it concerns the desert tortoise, *Gopherus agassizii*. In 1981, our Adoption Committee placed a total of 631 animals, 480 of them desert tortoises.

Desert tortoises are turned in to us for many reasons. A family may be planning to move and be unable to take the animal with them. Illness or financial reasons may force a family to give up its tortoise, or the family may have outgrown the idea of a tortoise for a pet. Sometimes people give us their tortoise, along with its "friends" — rabbits, guinea pigs, and even lizards.

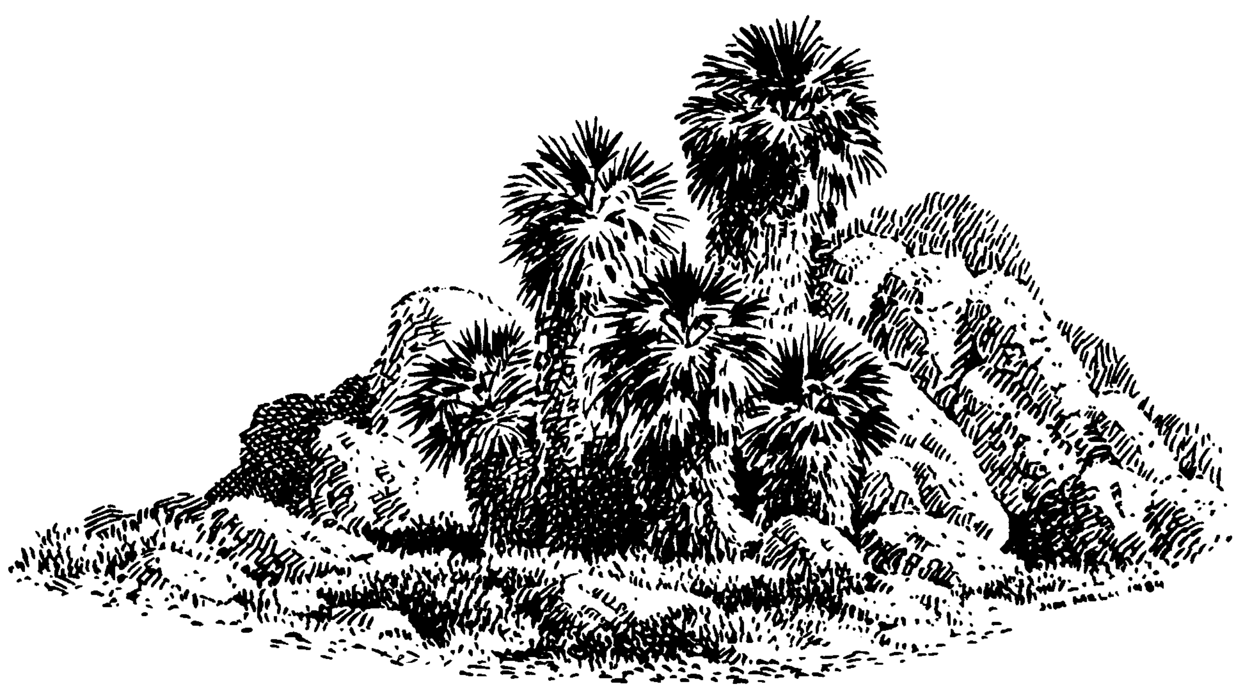
Occasionally the animal(s) to be adopted out is delivered to a member of our Adoption Committee, but usually one of us must pick it up. I'll never forget the day that Walter Allen and I picked up 132 tortoises from the Palm Springs area. They had belonged to a couple who had been raising tortoises for over 40 years, but the couple was no longer able to care for them. Anyway, I drove the car while Walter directed traffic — tortoise traffic, that is! Even with a station wagon, 132 tortoises is a carful. And one tortoise in particular was determined that HE was going to drive!

When a tortoise is turned in, we try to get as much history on it as possible — where the owner got it; whether or not he hatched it; how long he's had it; its diet; its hibernation habits; its illnesses or injuries; in the case of a female, its egg-laying habits; and, of course, its name. Then the tortoise is checked completely. The mouth is checked for mouthrot or other problems. Its shell is checked for breaks or injuries, and its legs and head are checked for signs of illness or injuries. Each tortoise is then isolated and observed.

Already on hand is a list of prospective "parents." The list of people desiring a female desert tortoise is especially long. We review the applications and try to select the parent(s) that is just right for the particular tortoise we have up for adoption. After first calling the family, we visit them to check out their facilities. We check to see that they have adequate fencing, as some tortoises are persistent diggers. Their tortoise enclosure must have a suitable grassy area and a shady retreat for protection from the sun. Other pets kept by the family, such as aggressive dogs, must be considered. The new "parents" are given a care sheet, and a list of veterinarians who treat turtles and tortoises. The tortoise is also registered with the Department of Fish and Game. The new "parents" are encouraged to call us should they have a problem, or if they just want to "talk turtle." If for some reason in the future they are no longer able to keep the tortoise, they are instructed to return it to the Club for re-adoption.

I feel that these tortoises should not have been taken from the desert years ago, but since they have somehow found themselves in the "Big City," I feel that our adoption program is the best way to arrange care for them.

Besides our adoption program, we have been busy with other projects this last year, including revising all of our care sheets and opening a new chapter in the San Fernando Valley area. At present, approximately 800 members receive our monthly newsletter, *The Tortuga Gazette*. If you would like a complimentary issue and/or copies of our care sheets, please see me at the break. Thank you for your time.



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DESERT TORTOISE PRESERVE COMMITTEE REPORT

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The Desert Tortoise Preserve Committee was organized in June of 1974 to consolidate and continue Dr. Kristin Berry's efforts to secure protection for the desert tortoise, and to promote its welfare in the deserts of the Southwest (Forgey 1976, 1977). Toward this goal, the 38-square-mile Desert Tortoise Natural Area (DTNA) was established north of California City and was formally dedicated on 26 April 1980 (Stockton 1981). The diverse ecosystem on the DTNA includes four habitat types — saltbush, creosote bush scrub on rolling hills and bajadas, Joshua tree woodland, and creosote bush scrub on valley floor — and supports 27 species of reptiles, 29 species of breeding birds, 23 species of mammals, 50 perennial plants, and over 100 animals. The Natural Area was listed in 1980 as an Area of Critical Environmental Concern (ACEC) in the Bureau of Land Management's BLM) California Desert Plan (U.S. Dept. of Interior 1980).

Objectives.—Currently, the Committee has two explicit objectives: (1) to raise funds to purchase private inholdings within the DTNA, and (2) to foster and publicize the uses of the Natural Area for education, conservation, and research. However, the Committee is instead forced to expend much of its energy exerting political pressure to protect the DTNA from the very government agencies — the BLM and the California Department of Fish and Game — that should be protecting it. In fact, the Committee has discovered that the members of the public who are most difficult to educate are sometimes those who work for government resource bodies and state agencies, such as the BLM and Fish and Game mentioned above. These problems can be illustrated by describing the hunting and the oil and gas leasing issues.

Hunting on the DTNA.—Efforts to effect the closure of the DTNA to hunting offer an excellent example. The Desert Tortoise Preserve Committee and the Desert Tortoise Council repeatedly have requested that the California Department of Fish and Game close all of the Natural Area to hunting and shooting. A 1980 response by Fish and Game was to place a naturalist on the DTNA to study hunting and its possible adverse effects on the tortoise populations. Subsequently, the naturalist, Tom Campbell, made a formal recommendation for the closure of the DTNA to all firearms use (Campbell 1982), but George Noakes, Manager of Fish and Game's Region 4, denied hunting closure on 10 April 1981. In a letter to the Fish and Game Commission on 10 December 1981, Noakes stated that hunting is not detrimental to the Natural Area. Ironically, Fish and Game continues to fund the naturalist position on the DTNA, and the new naturalist, Curt Uptain, continues to release monthly reports to Fish and Game of shootings and indiscriminate use of firearms on or near the Natural Area. Not only does hunting have a detrimental effect on the tortoise populations, but Uptain reports that eagles also are being shot, and the kit fox populations have diminished. The hunters also may have depleted the hare populations.

Oil and Gas Leasing on the DTNA.—A new concern of the Committee is oil and gas leasing. Although the DTNA was dedicated in 1980, it was not designated officially until July of 1981 when the Secretary of the Interior signed an order withdrawing public lands in the Natural Area from mineral entry The mineral withdrawal did not include leasing. Now, with the new insensitive Secretary of the Interior's insouciance toward all things uneconomic, the Committee must wrestle with the knowledge that individuals and companies have submitted applications to lease at least 10 sections of public land in the DTNA for oil and gas exploration and development. The Ridgecrest Area Office of the BLM, through the environmental review process, determined that oil and gas leases were incompatible with the management goals of the Natural Area. However, the BLM State Director has yet to make the final determination, and we must consider the possibility that his decision will be influenced by the Secretary of the Interior's new policies.

State Lands Commission.—On yet another front, the Committee is attempting to protect the Natural Area. The Second Community of California City borders the DTNA on four miles of the eastern boundary and contains sizable desert tortoise populations. In October of 1980, the State Lands Commission (SLC) voted to relinquish surface entry rights to 15,000 acres of the Second Community, but, ignoring its own environmental impact report, failed to provide sufficient measures to protect the wildlife by offering a buffer or retaining surface entry rights on property abutting the DTNA (Stockton 1981).

The Desert Tortoise Preserve Committee now has at its disposal three altruistic attorneys who are practicing environmental law. These attorneys requested that the SLC hear a Petition of Reconsideration on its ruling of October 1980. The SLC declined and litigation was necessary. The litigation may take several years because of the complexity of issues.

Land Acquisition.—In 1976, The Nature Conservancy (TNC) accepted the Desert Tortoise Preserve Committee as a "Project Committee" and since that time has lent its expertise in acquiring 3.5 square miles of property within the Natural Area (Hopper 1979). Since August of 1981, two more 20-acre parcels have been acquired using Desert Tortoise Preserve Committee funds. Approximately 11 square miles remain to be purchased. The TNC has prepared a proposal to BLM to acquire all private lands in the Natural Area and then to exchange these lands with the BLM for sections outside the Natural Area. The TNC could then sell the "surplus lands" to generate more funds for acquisitions on the DTNA. This proposal may be reported prematurely, but optimism is helpful. The BLM also has added to the optimism by indicating that it may be able to act in the Committee's interest and acquire acreage held by the State of California for back taxes.

The BLM is in the final stages of acquiring property in Section 31 in exchange for land in Section 8 which is outside the DTNA. Fifteen separate parcels are involved, with a preliminary value of $223,000. However, each parcel has encumbrances, and the BLM has asked Transamerica Title Insurance Company to secure agreement of the exchange from holders of deeds of trust. The Committee will provide the $12,000-plus needed by the BLM to equalize the land values in the exchange.

Even if this land acquisition is completed, it is negated by a BLM decision in August of 1981 to exclude Section 5 from the DTNA boundaries. The BLM decided that it was not feasible to acquire Section 5 because there were several hundred landowners, several of whom had made adverse comments about the Natural Area to the BLM. Land owners in Section 5 wanted the BLM either to acquire their land because of restricted access and lowered marketability, or to remove the fence. To exclude Section 5 from the fenced boundary, the BLM constructed three miles of ground-level fence which restricts tortoise movement. This new section of fence affects the home ranges and foraging areas of several hundred tortoises and threatens the integrity of the entire southern portion of the DTNA. These tortoises are vulnerable to collection, and vehicle use is becoming heavy in the fenced-out area. The BLM asked Fish and Game to reconsider relocating the Section 5 population, but Fish and Game has taken no action.

Activity on the DTNA.—Since the Desert Tortoise Natural Area was designated an Area of Critical Environmental Concern, some special management attention has been given this area. A Visitor Services Specialist is supposed to patrol the DTNA routinely and to contact visitors and distribute information. However, budget cutbacks and diversion of funds are occurring within the BLM, and Visitor Services may not continue.

During 1981, Desert Tortoise Preserve Committee tour guides, the Visitor Services Specialist, and the Fish and Game Naturalist conducted tours on the DTNA. Nearly 300 people joined formal tours, and 1,150 more signed the register. Other visitors elected not to sign the register, but estimating the number is impossible.

Other Committee Activities.—The Committee continued to publish a quarterly newsletter, and occasionally members appear on radio and television programs to discuss tortoise problems and conservation efforts. Slide programs and lectures are given as requested to interested groups, and the Natural Area does receive quite a bit of publicity. The *Long Beach Press Telegram* ran a three-quarter page article in August of 1981, delineating the scope of the Committee, the posture of the BLM, the indifference of the residents of California City toward the presence of the world's largest nongame preserve almost within the city limits, and the intent of landowners in Section 5 to bring suit against the BLM for denying access to their land. Other major newspapers which printed articles were the *Los Angeles Times*, the *Chicago Sun-Times*, and the *Pasadena Star News*. Sixty thousand brochures and 100 posters have been distributed to date. In April of 1981, the Committee co-sponsored a course entitled, "Field Study of the Desert Tortoise," with the University of California, Santa Barbara Extension.

The sale of T-shirts and other products grossed over $8,000 in 1981, and mail order business remains steady. The number of contributing members has grown, and generous contributions have been received from many individuals. The various chapters of the California Turtle and Tortoise Club continue to be noteworthy supporters of the Committee and the Natural Area.

Conclusion.—In closing, this writer wishes to emphasize the broad base from which this 18-active-member Committee operates for the preservation of the desert tortoise and its habitat. The Committee is involved and concerned by the adverse actions of state and federal agencies, and frustrated at being slowed by political and legal matters. But, by overcoming unfavorable circumstances, the Committee gains strength and incentive to remain on course to protect the existing acquisitions in the Natural Area, to continue to educate and inform the public, and to acquire private sections of land. And, as indicated above, the Desert Tortoise Preserve Committee believes there is promise for additional land acquisition in the ensuing months.

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Proc. Desert Tortoise Council 1982 Symp., pp. 90-98

HUNTING AND OTHER ACTIVITIES ON AND NEAR THE DESERT TORTOISE NATURAL AREA, EASTERN KERN COUNTY, CALIFORNIA

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Many individuals and groups (e.g., the Desert Tortoise Council and the Desert Tortoise Preserve Committee, Inc.) have expressed concern about the use of firearms on the Desert Tortoise Natural Area (DTNA) (Stockton 1980, 1981). They suggest that firearms are used primarily for plinking, illegal shooting of nongame animals, and vandalism, rather than for legitimate hunting of upland game birds and rabbits. They recommended to the California Department of Fish and Game (DFG) that the Natural Area be closed to firearms.

In response to these concerns, DFG funded a part-time "naturalist" position for the DTNA for the late fall of 1980 and the winter and spring of 1981 (Campbell 1981, Toffoli 1980). The naturalist was assigned numerous duties, including: (1) a survey to determine numbers of hunters, hunting sites, and harvest; (2) a survey to determine types, locations, and extent of recreation activities; (3) a study of the incidence and effects of indiscriminate shooting of desert tortoises (*Gopherus agassizii*) and other animals, and (4) an evaluation of the effects of off-road vehicle (ORV) use and grazing on habitat. Other tasks included patrolling to discourage vandalism, trespass, indiscriminate shooting, and other unauthorized activities, and educating the public about the DTNA.

This paper covers some observations of game animals, results of recreation and hunter surveys, a report of the incidence of indiscriminate shooting on desert tortoises and other animals, and a summary of ORV and grazing use in desert tortoise habitat.

MATERIALS AND METHODS

Observations were made from eight to 19 days monthly between November 1980 and June 1981, both inside of and near the DTNA. Data on the numbers and locations of game species were recorded. For hunting and shooting, data were gathered on numbers of hunters and shooters, the locations of their activities, and hunter success. Individuals engaged in hunting and shooting were sought, particularly during weekends and holidays. For the purpose of this study, hunters were defined as individuals actually known to be hunting. All other users of firearms were classified as shooters. Shooters were engaged in plinking and vandalism. For self-protection, the classification of an individual as a hunter or shooter generally was made at a distance. If the firearm user was violating state or federal laws, he/she was approached in an attempt to discourage further violations.

Tortoises killed by firearms were collected and catalogued, whether found

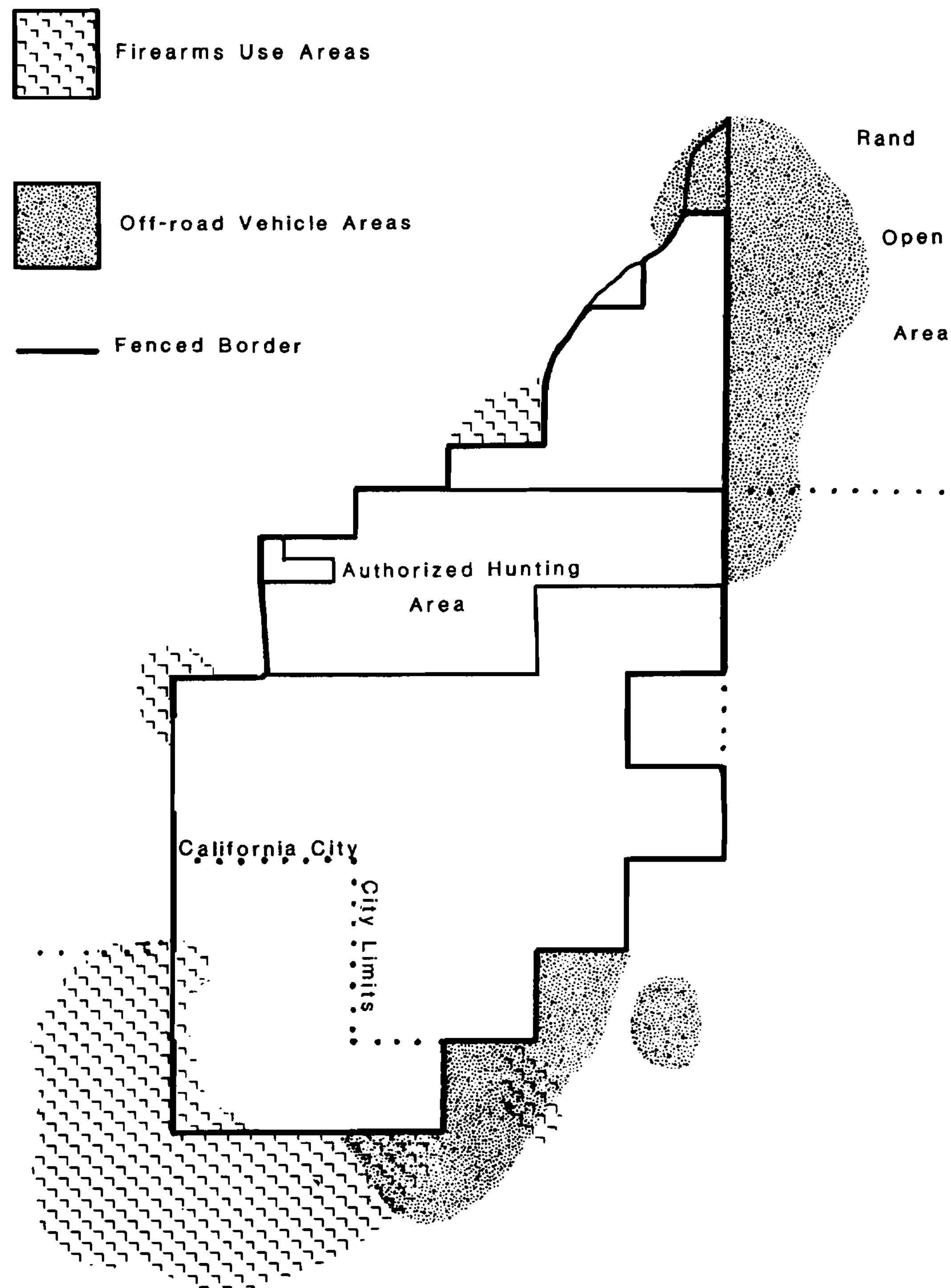

FIG. 1.—Locations of most intense firearms and off-road vehicle activities on and near the Desert Tortoise Natural Area.

on and off the Natural Area. Dead raptors and ravens also were collected. They were autopsied to determine cause of death.

For an evaluation of human uses on tortoise habitat, data were gathered on the numbers and types of ORVs and their locations. For this study, vehicles were placed in three classifications: (1) ORV — two-wheeled (motorcycles), (2) ORV — three- or four-wheeled, and (3) recreation vehicle — motorhome or camper. Locations of sheep herds were recorded and their numbers counted.

The fenced perimeter of the DTNA was checked several days each month, either on foot or with a small trail bike. Evidence of vandalism and trespass was described, locations were recorded on a map, and reports were sent monthly to the local office of the Bureau of Land Management (BLM) and the Department of Fish and Game.

RESULTS

Observations of Game.—During the eight-month-long study, one possible quail (*Lophortyx* sp.), one cottontail rabbit (*Syvilagus audubonii*), and a few Mourning Doves (*Zenaida macroura*) were observed. No Chuckar (*Alectoris chukar*) were seen.

Use of Firearms.—One hundred ten people were observed using firearms on or near the DTNA (Fig. 1, Table 1). Thirty-nine people were either observed hunting or stated that they were hunting. Of interest here is that many of these 39 "hunters" were observed shooting indiscriminately at anything that moved. Eight of the 39 were on the Natural Area. All hunters stated that they were pursuing jackrabbits (the black-tailed hare, *Lepus californicus*). On one occasion, three hunters were observed cleaning and packaging 45 hares. This is the only instance in which hunters were observed with kills.

Fish and Game wardens, local police, and others report that hares are collected, often in large numbers, and sold in the Los Angeles area for about $2.00 to $2.85 apiece for human consumption. Piles of hides and entrails of hares were a common sight in areas frequented by hunters.

With one exception, all hunters were observed inside the city limits of California City. Although discharge of firearms within city limits is illegal, the ordinance apparently is not enforced by local police. The only hunters who knew about the firearms restrictions for the city were the hunters collecting large numbers of hares.

Seventy-one people were classified as shooters. Almost all shooters were observed within the city limits of California City. The most popular area for shooting was the intersection of Phillips Road and the western border of the Natural Area. On one occasion, five separate groups were shooting simultaneously in a limited area. Only one shooter was observed on the Natural Area. The most popular targets were DTNA signs and fence posts, spent shotgun shells, and bottles. On three occasions, groups of shooters were seen firing from vehicles as they drove cross-country around the southern perimeter of the Natural Area. Their favorite targets were ground squirrels and small birds. One of these

TABLE 1.—Summary of hunting, shooting and off-road vehicle activities and number of fence breaks observed each month from November 1980 through June 1981 on and near the Desert Tortoise Natural Area (DTNA).

Year	1980								1981							
Month	November				December				January				February			
	Weekday	Weekend	Holiday	Total	Weekday	Weekend	Holiday	Total	Weekday	Weekend	Holiday	Total	Weekday	Weekend	Holiday	Total
No. of days surveyed	3	3	2	8	4	4	1	9	6	4	0	10	5	3	4	12
Hunters																
On DTNA	0	0	0	0	0	0	2	2	0	0	...	0	0	0	2	2
Near DTNA	0	1	6	7	0	6	0	6	2	3	...	5	0	0	2	2
Shooters																
On DTNA	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0
Near DTNA	7	0	0	7	0	7	3	10	3	0	...	3	0	6	13	19
Off-road vehicles																
All types	0	0	80	80	5	10	0	15	11	37	...	48	2	29	121	152
No. of dirt bikes	0	0	80	80	5	10	0	15	11	33	...	44	2	25	112	139
No. on DTNA	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0
Fence survey																
Total No. damaged sections				...				17				12				0
No. used by dirt bikes				...				7				5				0

Year	1981																
Month	March				April				May				June				Total (all months)
	Weekday	Weekend	Holiday	Total	Weekday	Weekend	Holiday	Total	Weekday	Weekend	Holiday	Total	Weekday	Weekend	Holiday	Total	
No. of days surveyed	8	5	0	13	12	6	1	19	8	5	3	16	10	6	0	16	103
Hunters																	
On DTNA	0	0	...	0	0	1	0	1	0	3	0	3	0	0	...	0	8
Near DTNA	0	3	...	3	0	0	0	0	0	4	4	8	0	0	...	0	31
Shooters																	
On DTNA	0	0	...	0	0	1	0	1	0	0	0	0	0	0	...	0	1
Near DTNA	0	1	...	1	1	9	0	10	2	10	2	14	0	6	...	6	70
Off-road vehicles																	
All types	1	39	...	40	24	67	96	187	5	10	153	168	3	17	...	20	710
No. of dirt bikes	0	35	...	35	23	67	90	180	5	10	146	161	3	15	...	18	676
No. on DTNA	0	1	...	1	0	0	0	0	0	0	0	0	0	0	...	0	0
Fence survey																	
Total No. damaged sections				2				2				5				2	40
No. used by dirt bikes				2				1				4				2	21

groups consisted of parents with children, and another group was composed of people who identified themselves as police officers.

Tortoises and Raptors Killed by Firearms.—Two tortoises were killed by firearms. Both carcasses had numerous bullet holes. A third carcass in similar condition was found along the Mojave-Randsburg Road near Randsburg.

Dead eagles, hawks, owls, and other large birds were found in several areas near California City and the Natural Area (Table 2). All were dried and decomposed when discovered. Three of the 14 birds obviously had been shot. Some of the others probably were shot also. Four of the birds had been electrocuted. The legs, feet, and wings of these birds were often missing and probably had been removed by a human.

Off-road Vehicle Use.—Off-road vehicle use was the most popular activity on or near the Natural Area (Fig. 1, Table 1). Of the 710 vehicles observed, 676 were motorcycles. The other vehicles were three-wheeled All Terrain Cycles and an occasional dune buggy or four-wheel drive vehicle. The most commonly used area was the Rand "pit," which is about 1.5 mi east of the eastern boundary of the Natural Area (Fig. 1). Only six vehicles were seen or heard on the Natural Area. Fresh vehicle tracks occasionally were observed on the Natural Area but were not included in these totals. More off-road vehicle use occurred on weekends and holidays than at other times.

Major ORV races were held in the vicinity of the Natural Area on two occasions. Part of one race course was on public land within a mile of the Natural Area. When on public land, race participants are supposed to remain on the designated race course, but this did not happen during my observations. For example, on 14 March 1981, flagrant violations took place all along the race course and in view of BLM personnel monitoring the race. During this same race, near-pristine wash on public land was disturbed and degraded.

A total of 455 recreation vehicles was observed near the Natural Area (Table 3). These vehicles were associated almost exclusively with ORV use. Most recreation vehicles used the Rand "pit" area, with smaller groups located near the Interpretive Center of the DTNA.

The frequency of use of firearms, ORVs, and recreation vehicles appeared to be affected by weather. Apparently relatively few people visit the desert during periods of inclement weather, especially in winter.

Tortoises Killed by Vehicles.—Three tortoises were killed by vehicles. The first was an adult, which was killed by a four-wheel vehicle on a road inside the Natural Area. The second was found in numerous pieces on the Mojave-Randsburg Road after the Memorial Day holiday in May. The third was found within an hour of death about 100 m west of the Natural Area. This female, which contained six or seven well-developed eggs, was killed by a truck which was watering a herd of sheep at the southwest corner of the Natural Area.

Sheep Grazing.—Sheep grazing was first observed near the Natural Area on 24

TABLE 2.—Raptor carcasses collected on and near the Desert Tortoise Natural Area between November 1980 and June 1981.

Date	Species	Location	Cause of Death	Comments
8 March 1981	Golden Eagle	T31S, R37E, S27, SW 1/4	Shot	Missing tail and feet
	Rough-legged Hawk	Do.	Unknown	Do.
	Red-shouldered Hawk (?)	Do.	Shot	Do.
	Prairie Falcon	Do.	Unknown	Do.
7 April 1981	Short-eared Owl	T31S,R37E, S1, SW 1/4	Road kill	Flattened
	Raven	Do.	Shot	...
17 May 1981	Barn Owl	1.5 mi N. of California City, near Neuralia Road	Electrocuted	Due to bare condensor box wires on a telephone pole
	Barn Owl	Do.	Do.	Do.
	Rough-legged Hawk	Do.	Do.	Do.
	Raven	Do.	Do.	Do.
24 May 1981	Red-tailed Hawk (Immature)	T31S, R37E, S11, SW 1/4	Unknown	...
	Swainsons Hawk	Do.	Do.	Foot and wings broken off
3 June 1981	Golden Eagle	Sewer ponds	Shot (?)	Appeared shot
16 June 1981	Turkey Vulture	T31S, R38E, S5, SW 1/4	Predation (?)	Wing torn off, near coyote tracks

TABLE 3. — Numbers of recreation vehicles, off-road vehicles (ORVs), and people observed near the Desert Tortoise Natural Area from November 1980 through June 1981.

Month	No. of recreation vehicles, etc.	No. of ORVs	Estimated No. of people
November	87	80	180
December	16	15	48
January	19	48	57
February	117	152	304
March	10	40	50
April	131	187	374
May	65	168	195
June	10	20	30

March 1981 and was seen regularly until 20 May 1981. Grazing occurred on the Natural Area on the western edge of Section 31 (T 31S, R 38E). Over 65% of the Natural Area perimeter was grazed. The greatest pressure occurred near the northwest corner of Section 18 (T 31S, R 38E) and along the western boundary of the Natural Area south of Phillips Road.

Although sheep grazing is not permitted within the city limits of California City, sheep herds are a common sight. When sheep were observed within city limits, the local animal control officer was notified. If he responded, he would give the sheep herder three days to move the herd — just enough time for the sheep to fully utilize the annual forage. Then sheep were often moved to another part of the city.

Vandalism of the Natural Area Fence.—The monthly fence survey revealed a total of 40 fence breaks or cuts over a seven-month period. Of the 40 damaged fence sections, 21 were utilized by dirt bikers to gain access to the Natural Area. One site was on the northeast part of the Natural Area. A popular short cut from the Rand pit to Koehn Dry Lake over the Natural Area was used repeatedly. The method most frequently used to gain access to the Natural Area was to pull up a few fence posts and then drive over or under the slackened fence.

DISCUSSION

The primary purpose of this study was to investigate the possibility of sport hunting adversely affecting the tortoise population on the DTNA. According to the Habitat Management Plan prepared by the BLM (1979), only dove, quail, chuckar, and cottontail rabbits are to be hunted on the Natural Area

(U.S. Dept. of Interior 1979). The results of this study indicate that the potential for successful, quality hunting of these species on the Natural Area is very limited. Upland game occur in very low numbers. No unique hunting opportunities appear to exist on the Natural Area. All hunters observed were hunting black-tailed hares, a common species throughout the western Mojave.

Most firearms use on and near the Natural Area was illegal. Indiscriminant use of firearms resulted in tortoise and other reptile mortalities, as well as the deaths of ground squirrels, and raptor and other bird species. Vandalism of Natural Area signs and fencing, and private property was also noted. Indiscriminant use of firearms may be limiting the use of the Natural Area for non-consumptive purposes such as sightseeing, photography, and nature study. The Department of Fish and Game and the BLM do not have the work force to control illegal activities on the Desert Tortoise Natural Area.

Off-road vehicle activity and sheep grazing were also noted to adversely affect the tortoises and their environment. The direct and indirect impacts of these activities, coupled with the indiscriminant use of firearms may be significant, with respect to maintenance of a viable tortoise population on the Natural Area.

The California Department of Fish and Game has recommended that nine sections of the Natural Area be open to hunting. However, this area has not been delineated in the Fish and Game hunting regulations. Because of a lack of landmarks around the perimeter of the nine-section area, it is unreasonable to expect even legitimate hunters to stay in such an ill-defined hunting zone. For this reason, and for those discussed above, I recommend that all of the DTNA be closed to firearms use of any sort. I also recommend that this closure be actively enforced by the appropriate state and federal agencies.

ACKNOWLEDGMENTS

This project was supported by the California Department of Fish and Game on an interagency agreement with California State University at Fresno. I would like to thank Dr. David Chesemore of California State University, Dan Christenson of the Department of Fish and Game, and Dr. Kristin Berry of the Bureau of Land Management for their advice and assistance. I am also grateful to members of the Desert Tortoise Preserve Committee, Inc.

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Proc. Desert Tortoise Council 1982 Symp., pp. 99-124

A COMPARISON OF 1981 POPULATIONS OF DESERT TORTOISES (*GOPHERUS AGASSIZI*) IN GRAZED AND UNGRAZED AREAS IN IVANPAH VALLEY, CALIFORNIA

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Abstract.—A field experiment designed to evaluate possible effects of cattle grazing on desert tortoises was conducted in 1980 and 1981 in Ivanpah Valley, about midway between Baker, California, and Las Vegas, Nevada. Cattle were removed from a fenced exclosure of 672 ha (Plot 1) on 10 April 1980. An unfenced area of the same size (Plot 2) was established just southwest of the exclosure. Winter rainfall during 1979-1980 was greater than in 1980-1981, and spring floras of 1980 and 1981 reflected this difference. Dry biomass of annual plants in Plots 1 and 2 ranged from 7.3 to 10.0 $g \cdot m^{-2}$ in 1980, but were only 0.04 to 0.11 $g \cdot m^{-2}$ in 1981. Tortoises in both plots were fitted with radiotransmitters, and in 1981 Plot 1 contained 15 males and 25 females while Plot 2 had 11 males and 28 females. Body sizes of males and females in the plots were similar in both years. Mobility of tortoises, as inferred from 1980 and 1981 home range polygons, did not differ significantly. Analyses of changes in body masses of females were used to estimate clutch frequency in 1981. Of 19 females analyzed in Plot 1, 4 laid no eggs, 11 laid one clutch, and 4 laid two clutches. Comparable figures for Plot 2 were 4, 9, and 8. These distributions did not differ significantly. Estimated mean numbers of clutches per female were 1.00 (Plot 1) and 1.19 (Plot 2). Tortoises relied heavily on cacti for sustenance in 1981, but even in 1980 these plants were used. Cows almost never consumed cacti. Annual plants were more heavily used by both cattle and tortoises in 1981. Cattle consumed perennial grasses almost to the exclusion of other kinds of plants in both years, and this is probably the principal focus of potential competition between cattle and tortoises. The study showed no important differences between tortoises occupying the two plots, but was inconclusive in terms of original objectives because of its brief duration.

The rationale for this experiment was rooted in growing concerns as to possible effects of cattle grazing on the well-being of populations of desert tortoises (Berry 1978). A description of this background and of work during the 1980 season was presented previously (Turner et al. 1980, 1981). The following article describes the conclusion of the experiment, presents data pertaining to desert tortoises occupying the two experimental areas in Ivanpah Valley in 1981, and contrasts observations during a generally favorable year (1980) with an extremely dry one (1981).

METHODS

The Ivanpah Valley (35°23'N. Lat., 115°18'W. Long.) is in extreme northeastern San Bernardino County, California, about midway between Baker, California, and Las Vegas, Nevada. The valley is a north-south basin lying at an elevation of around 3000 ft (915 m) between the Ivanpah Mountains to the west and the New York Mountains to the east.

Our study area included portions of the Bureau of Land Management's (BLM's) Ivanpah Valley Permanent Tortoise Study Plot, which lies in Section 27 (T15N, R15E). The area included that portion of Section 27 lying northwest of the power lines crossing the valley from southwest to northeast (Fig. 1). Before

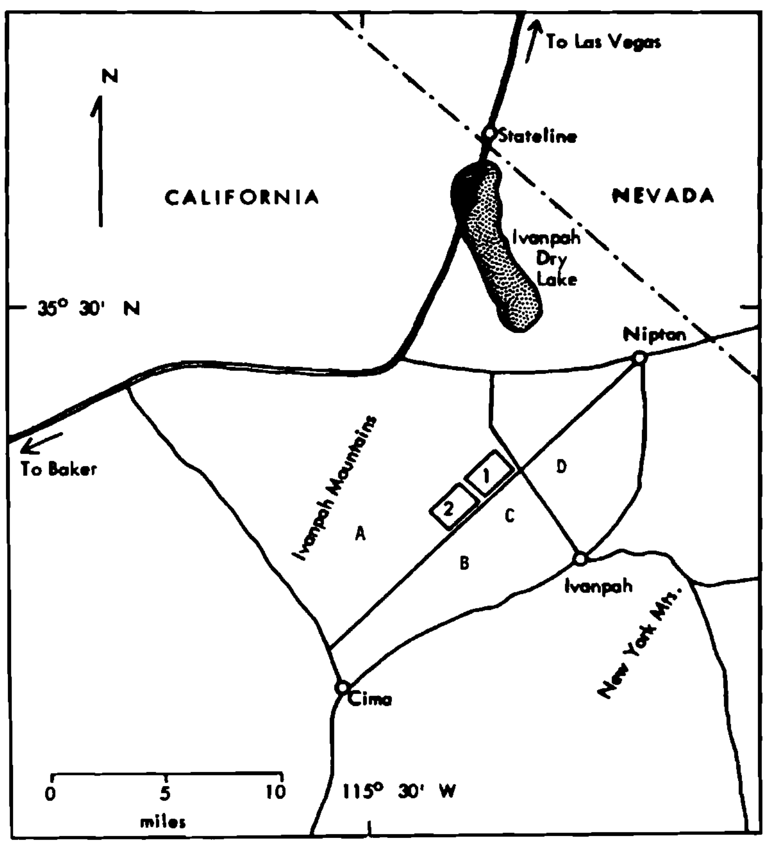

FIG. 1. — Ivanpah Valley, California, showing enclosure (Plot 1) and grazed area (Plot 2). Letters A, B, C, and D indicate locations of water tanks.

our study began, investigations of tortoises in the BLM plot had been carried out for 30 days in spring of 1977, for six days in April 1978, and for 60 days in the spring of 1979 (K. H. Berry *pers. comm.*).

The selection of the two areas for study during the spring of 1980, the fencing of the exclosure, and other general attributes of the two plots were described previously (Turner et al. 1981). Figure 1 shows the specific location of the exclosure (Plot 1) and the adjoining grazed area (Plot 2).

Cattle are normally grazed in the valley during the spring and fall. BLM-authorized usage on the Kessler Springs allotment varies from year to year, but usage has generally been in the range of 1.5 to 2.0 head per section per year (USDI 1980). This could also be 3 to 4 head per section on a semiannual basis. Cattle are authorized to graze at lower elevations during the early spring, and move, or are moved, to higher range around mid-May to early June. No precise estimates of cattle usage of the area adjoining the exclosure during 1980 and 1981 can be made, but 1981 was a distinctly drier year than 1980. Our observations suggest that there was less grazing in the area in 1981, and cattle in this part of Ivanpah Valley tended to concentrate around one or another of the four water tanks in the vicinity (Fig. 1).

The procedures used in 1980 and described previously (Turner et al. 1980, 1981) were continued in 1981. Annual plants in Plots 1 and 2 were sampled between 20 March and 10 April 1981. As in 1980, each plot was divided into six subplots and 30 sampling points distributed along six north-south lines. At each sampling point, four quadrats were laid out: two in the open, one beneath *Larrea tridentata* and one beneath *Ambrosia dumosa*. Quadrats beneath shrubs were 0.25 m^2, open area quadrats 0.50 m^2. Annual plants were thus counted in 760 quadrats in each of Plots 1 and 2. Densities were estimated as in 1980, making allowances for relative coverage of *Larrea* and *Ambrosia*. Diversities (Δ_1) of annual plants in Plots 1 and 2 were estimated as described by Hurlbert (1971).

Dry weight biomass of annual plants in Plots 1 and 2 was estimated from harvest samples. These samples were taken at a random point along each of the six north-south lines in each subplot. A total of 36 sampling points occurred in each of Plots 1 and 2. At each point two 0.5-m^2 quadrats were in the open, and two 0.25-m^2 quadrats were beneath shrubs (one beneath *Larrea* and one beneath *Ambrosia*).

Annuals were separated into six groups: *Cryptantha* spp., *Pectocarya* spp., *Caulanthus lasiophyllus*, other forbs, *Bromus rubens*, and other grasses. All samples were oven-dried and weighed. Standing crops were estimated for each group in the three situations. Overall standing crops were estimated as in 1980. Comparisons of data from Plots 1 and 2 were based on Wilcoxon two-sample tests (Sokal and Rohlf 1969).

Plots 1 and 2 were inspected for *Hilaria rigida* during March 1981. Plants were counted in 234 quadrats (each 4 x 100 m) in each plot. Thirteen quadrats were laid out end-to-end along eighteen 1300-m lines running north-south across each plot. Thus, in each 260-ha plot, 9.36 ha (3.6%) of the area was examined. Discrete clumps of grass tend to form aroung old crowns (because of die-back), and we counted clumps separately only if separated by >10 cm. Basal areas of all plants were measured.

The kinds of electronic equipment used (antenna, transmitters, etc.) were described by Turner et al. (1981), as were techniques for locating and working with tortoises. In 1980, we alternated our efforts in Plots 1 and 2 so that animals were recaptured and weighed every other week. In 1981, we attempted to recapture tortoises with transmitters at least every week so as to improve records of changes in individual body weights. Home ranges were estimated and analyzed as in 1980.

Between 31 March and 16 October 1980, a total of 220 tortoise scats were collected in Plots 1 and 2. Between 25 March and 25 June 1981, a total of 189 scats were collected in these plots. Only scats appearing fresh were collected. When a tortoise egested a scat while being handled, the scat was preserved. All scats were ground with a Wiley Mill. Five grams of material from each ground scat were used to make up composite "samples" forming various plot-time groups. For example, 94 scats taken in Plot 1 in 1981 were separated into six groups (ranging in size from 9 to 22). Each group was composed of material collected during roughly two-week intervals between 25 March and 25 June. These composite samples were examined by the Composition Analysis Laboratory at Colorado State University, Fort Collins. Slides were prepared from material in samples and examined with a microscope. Five subsamples of 20 fields were analyzed for each sample, and relative abundances of various food materials computed. Means and standard deviations were reported by the Laboratory at Fort Collins. Determinations of kinds of food materials were made by comparisons with standards on file in the laboratory or with reference material we supplied from Ivanpah Valley. Nine samples of fresh cow dung were gathered between 23 April and 27 June 1980, and 20 samples between 15 April and 12 June 1981. These were collected from within Plots 1 and 2 and also in the vicinity of a cattle tank about 2 km west and upslope of the plots (A in Fig. 1). All cow dung samples were processed and analyzed in the manner described above.

Blood samples were taken from three males and three females from each of Plots 1 and 2 in October 1980 and again in May 1981. Tortoises were collected in the morning and taken to Las Vegas so that samples could be drawn and processed. Blood was taken by inserting a heparinized capillary tube into the orbital sinus of the right eye (Nagy and Medica 1977). In 1981, some samples were taken by clipping toe nails on hind feet. Several tubes were taken from each tortoise sampled. One tube was centrifuged for about 30 seconds to separate serum and plasma. Two to four additional tubes were used to provide whole blood and smears of blood. Sealed capillary tubes and other materials were sent refrigerated by air express to Veterinary Reference Laboratory in Anaheim, California. Samples were analyzed the same day as collected.

RESULTS

Rainfall

Rainfall in Plots 1 and 2 during the seasons of 1980 and 1981 is shown in Table 1. Spring rainfall in 1981 was clearly less than that in 1980, but even more important was the paucity of the winter rain. We do not have records for

TABLE 1.—Rainfall (mm) in Plots 1 and 2 in Ivanpah Valley during 1980 and 1981.

Dates	Plot 1	Plot 2
1980		
April 1	4.3	...
April 28	10.2	...
May 2	5.3	...
May 16	7.9	...
June	0	0
July 1	4.6	3.8
July 14	1.8	1.8
1981		
February 2	9.4	8.9
February 11	8.4	8.9
March 9	9.1	11.4
March 23	1.3	2.0
March 30	0.3	0.8
April 20	trace	0.3
May 28-29	12.2	10.7
June	0	0
1981 totals (February-June)	40.7	43.0

the winter months of 1980 and early 1981, but amounts measured in other parts of the Mojave Desert were extremely low.

Annuals

Kinds of annual plants in Plots 1 and 2 were summarized by Turner et al. (1980: Appendix 1). In 1980, fifty-eight species of annual plants were recorded in Plot 1 (Turner et al. 1981). In 1981, only 26 species were observed in this plot, while 34 were recorded in Plot 2. Twenty-three species occurred in both plots so the 1981 index of similarity was (2 x 23)/(26 + 34) or 0.77. In Plot 1 we counted 950 plants in quadrats ($\Delta_1 = 0.75$); in Plot 2 we observed 1844 ($\Delta_1 = 0.80$). The estimated aggregate density of annuals in Plot 1 was $3.3 \cdot m^{-2}$, and in Plot 2 was $5.2 \cdot m^{-2}$. Table 2 lists overall estimated densities for common species in the two plots.

TABLE 2.—Estimated densities ($n \cdot m^{-2}$) of some annual plants in Plots 1 and 2 in Ivanpah Valley (1981).

Species	Plot 1	Plot 2
Bromus rubens	0.43	0.43
Caulanthus lasiophyllus	0.14	0.32
Cryptantha angustifolia	0.14	0.29
C. circumscissa	0.08	0.48
C. micrantha	0.09	0.14
Descurainia pinnata	0.02	0.15
Eriogonum trichopes	0.15	0.01
Pectocarya heterocarpa	1.49	2.16
P. platycarpa	0.13	0.44
Schismus barbatus	0.39	0.16

The density of *Hilaria rigida* was estimated as about $56 \cdot ha^{-1}$ in Plot 1 and $30 \cdot ha^{-1}$ in Plot 2. Coverage in Plot 1 was around 0.02%, in Plot 1 about 0.01%. Cover was somewhat overestimated in both areas because of die-back around old crowns. The grass was seen only along 8 of 18 lines in Plot 2, while it was observed in 14 of 18 lines in Plot 1. The distribution of the species was highly aggregated, and in Plot 2 about 73% of cover was distributed along the two westermost lines. In Plot 1, 75% of cover occurred in the western half of the plot. This grass is not an important element of the vegetation in either plot.

Medica et al. (1982) presented more detailed sampling data pertaining to various annual plants and grasses, and used Wilcoxon two-sample tests to compare densities in the two plots 1) in the open, 2) beneath *Ambrosia*, and 3) beneath *Larrea*. These tests showed that the only statistically significant difference among sampling data was that of counts beneath *Ambrosia* bushes. On the other hand, Plot 2 clearly sustained a greater dry weight biomass of annual plants in 1981 (Table 3). The threefold difference was expressed in almost all elements of the floras.

Tortoises

Capturing and Recapturing Tortoises.—Between 25 March and 13 June 1980, seventy-five tortoises were fitted with radiotransmitters. Thirty-five tortoises (12 males, 23 females) were in Plot 1; 40 (12 males, 28 females) in Plot 2. In 1981, eight additional tortoises (three males, five females) were fitted with transmitters in Plot 1; four (two males, two females) in Plot 2. Of the 87 transmittered tortoises, four died and four were not accounted for.

TABLE 3. — Estimated overall dry weight biomass ($mg \cdot m^{-2}$) of annual plants in Plots 1 and 2 in Ivanpah Valley (1981).

Category of plants	Plot 1	Plot 2
High density forbs		
Cryptantha spp.	1.0	8.5
Pectocarya spp.	20.5	58.7
Low density forbs		
Caulanthus lasiophyllus	8.9	5.1
Others	4.4	28.5
Annual grasses		
Bromus rubens	1.4	7.9
Others	0.3	0.8
All annuals	36.5	109.5

These animals either moved out of tracking distance or bore inoperative transmitters. The remaining 79 animals (15 males and 25 females in Plot 1, and 11 males and 28 females in Plot 2) were followed during 1981.

About 20% of all captures and recaptures of tortoises in 1981 were effected by tapping (cf. 23% in 1980). Tapping was successful 88% of the time during the spring of 1981. As in 1980, responses of males and females to tapping did not differ significantly.

From earlier work with tortoises near Arden, Nevada (Burge 1977 *a*, *b*), we judged that all animals 200 mm in plastron length (~214 mm in carapace length) should be sexually mature. Only one of 58 females fitted was less than 190 mm in plastron length (186 mm).

Sizes and Sex Ratios of Tortoises.—Sizes of tortoises marked in Plots 1 and 2 were similar (Table 4), as was true in 1980. However, mean weights in 1981 were generally lower than mean weights in 1980 (cf. Turner et al. 1981: Table 5).

Size distributions of 196 tortoises in Plots 1 and 2 in 1981 are given in Table 5. This table includes 79 tortoises fitted with transmitters as well as other tortoises observed in the two areas. Because our experiment focused on animals presumed to be sexually mature, we do not represent these data as reflections of the true size distributions of the two populations.

TABLE 4. — Mean carapace lengths (mm) and body weights (g), ± standard errors of means, of desert tortoises in Ivanpah Valley (1981).

	Plot 1		Plot 2	
Measurement	Males	Females	Males	Females
Carapace length				
Mean	256.9 ± 3.9	229.2 ± 2.0	265.0 ± 6.0	227.0 ± 2.2
n	14	24	10	27
Range	237 - 281	211 - 253	232 - 288	206 - 247
Weight				
Mean	3026 ± 139	2248 ± 60	3291 ± 199	2210 - 54
n	14	25	11	28
Range	2245 - 3735	1725 - 3005	2455 - 4575	1595 - 2800

Table 5 shows that 1981 size distributions of tortoises in the two plots were almost identical. Both areas had six tortoises in the two smallest size categories and 15 juveniles and subadults. Plot 1 had 79 adults, and Plot 2 had 75. However, the observed size distributions in 1980 and 1981 were not the same. In 1980, about 54% of the tortoises recorded were adults (119 of 221) and exceeded 207 mm in length. In 1981, 154 of 196 (79%) were adults. Some of this difference simply reflects growth of tortoises during 1980.

Whereas the sex ratios of tortoises observed in Plots 1 and 2 in 1980 did not differ significantly (Turner et al. 1981), the relative abundance of males and females in the two areas was not the same in 1981. Considering the 172 tortoises of known sex, we observed 51 males and 34 females in Plot 1, and 33 males and 54 females in Plot 2. When relative numbers of males, females, and tortoises of unknown sex in the two plots are compared, total X^2 (with 2 d.f.) is 9.84 ($p = < 0.01$). Hence, for unknown reasons the 1981 sampling indicated a distinct difference in apparent sex ratios in the two plots.

Seventy-seven tortoises (52 females, 25 males) were captured six or more times in Plots 1 and 2 during the 1981 season. Numbers of captures ranged as high as 19, with a mean of 14.5. Overall mean home range size (after bias correction) was 18.6 ha, with individual ranges as small as 1.6 ha and as large as 72.7 ha. Overall mean home range size estimated from 1980 data was 22 ha (Turner et al. 1981).

With few exceptions, tortoises were always recaptured within the plot where

TABLE 5.—Sex and size structure of desert tortoise populations in Ivanpah Valley (1981).

Age groups	Carapace length (mm)	Plot 1			Plot 2		
		Males	Females	Unknown	Males	Females	Unknown
Hatchlings	<56	...	...	1	...	...	2
Young juveniles	56-99	...	...	5	...	...	4
Juveniles	100-180	...	...	8	...	2	3
Subadults	181-207	4	2	1	3	7	...
Adults	208-299	47	32	...	30	45	...
Totals		51	34	15	33	54	9

TABLE 6. — Mean home ranges of desert tortoises in Ivanpah Valley (1981).

Sex	Range in carapace length (mm)	Plot	n	Mean home ranges (ha)
Female	211 - 225	1	10	15.7
	207 - 225	2	13	13.3
	226 - 253	1	14	18.0
	226 - 247	2	15	18.8
Male	237 - 250	1	6	32.9
	232 - 248	2	4	20.8
	253 - 281	1	8	17.7
	259 - 288	2	7	20.4

first marked. However, between 14 and 30 May 1980, a male 229 mm in carapace length moved about 3.1 km from Plot 2 to Plot 1. Between 26 June 1980 and 25 March 1981, a female 234 mm long moved 1.3 km from Plot 1 to Plot 2.

Our principal concern with mobility of tortoises lay in the relative behavior of animals in the two plots. We considered home ranges in terms of plots, sex, and two size groups of each sex. Smaller females ranged from 207 to 225 mm in carapace length, larger females from 232 to 250 mm in length. Smaller males ranged from 232 to 250 mm, and larger males from 253 to 288 mm in length. Table 6 gives means of estimated home ranges for eight groups of tortoises. Home range estimates (HR) were non-normally distributed so for analytical purposes we used square roots of ranges. Table 7 gives mean values of $(HR)^{1/2}$ for the same eight groups listed in Table 6. Group means are similar to those calculated from 1980 home range data (Turner et al. 1981).

Values of $(HR)^{1/2}$ were examined by factorial analysis of variance (two plots x two sexes x two size groups). Critical F-values (d.f. = 1, 69) were $F_{0.05} = 3.98$ and $F_{0.01} = 7.01$. Values of F resulting from the analysis ranged from 0.3 to 3.0, so no statistically significant main effects or interactions were evident in the 1981 data. The analysis of the 1980 home range data gave the same results.

Weight Changes Among Tortoises.—We have computed weight change profiles for male and female tortoises in the two areas by converting weight gains and losses by individuals to percent changes in body weights for selected time intervals. This was done for 52 tortoises weighed at the beginning (April) and end (June) of the 1981 season (Table 8). Individual measurements of these tortoises were reported by Medica et al. (1982). Females in both plots lost weight between April and June, while males gained. Differences between overall mean changes

TABLE 7. — Mean value of $(HR)^{1/2}$ of desert tortoises in Ivanpah Valley (1981).

Sex	Body size (see Table 6)	Plot	Mean $(HR)^{1/2}$
Female	small	1	3.81
		2	3.50
	large	1	4.10
		2	3.90
Male	small	1	5.56
		2	4.12
	large	1	4.01
		2	4.17

among males and females in the two plots were not statistically significant.

It is also instructive to examine weight changes over shorter time intervals during the season (Table 9). Here we include 22 measurements made during March 1981. Females gained weight until 1 April, then stabilized through most of April and dropped considerably in May. Males continued to gain weight until the end of April, then remained stable until the end of May. Both sexes increased in weight following rainfall at the end of May, then decreased steadily through the month of June.

Reproduction in 1981.—On 25 March 1981, a male and female tortoise (227 and 233 mm in carapace length, respectively) were observed together in a wash. A moist circle of soil nearby indicated probable copulation. One instance of mounting was observed on 1 April, but it was unsuccessful. Between 30 March and 4 May, eight different female tortoises were observed with mud on the posterior dorsal surface of the carapace indicating that copulation probably occurred. Twenty-six observations of pairs of tortoises were recorded: 5 in March, 15 in April, 1 in May, and 5 in June. These pairs were either observed in burrows or pallets together, or simply basking together within a metre of each other.

Deposition of eggs was never observed, but four nests excavated by predators were observed in Plot 2 on 18 May 1981. Shell fragments present indicated that from 1-4 eggs were deposited. In all instances, egg fragments were either at or near burrows or pallets.

Fifty-two female tortoises were recaptured and weighed often enough to draw some inferences pertaining to egg laying in 1981. In 1980, we analyzed weight changes by combining data pertaining to groups of females in each of the

TABLE 8.—Weight changes among desert tortoises in two plots in Ivanpah Valley between April and June 1981.

Plot	Sex	*n*	Range of initial body weights (g)	Mean initial body weight (g)	Range of final body weights (g)	Mean final body weight (g)	Range of % changes in body weights	Mean % change in body weight
1	f	18	1725 - 3005	2233	1500 - 3155	2115	-18.0 to 5.0	-5.6
	m	8	2275 - 3735	3175	2625 - 3700	3400	- 4.0 to 15.4	+5.9
2	f	20	1795 - 2800	2248	1595 - 2655	2115	-20.5 to 10.4	-5.9
	m	6	2455 - 4575	3437	2530 - 4625	3666	1.1 to 12.8	+7.1

TABLE 9. — Mean percent change (± one standard error) in live body weights of desert tortoises in Ivanpah Valley during 1981.

	Plot 1				Plot 2			
Dates	*n*	Males	*n*	Females	*n*	Males	*n*	Females
March 9-13	4	-7.0 ± 1.9	3	-6.5 ± 1.7	2	-5.2 ± 2.4	3	-4.7 ± 0.1
March 23-27	3	2.1 ± 1.2	2	1.4 ± 1.4	2	-1.7 ± 0.2	3	4.0 ± 1.4
April 6-10	7	4.2 ± 1.6	14	4.5 ± 0.6	4	2.8 ± 0.8	18	4.2 ± 0.6
April 13-17	10	0.7 ± 1.0	21	0.9 ± 0.6	7	2.4 ± 0.9	19	1.1 ± 0.9
April 20-24	11	1.0 ± 0.3	24	-0.9 ± 0.6	11	1.8 ± 1.0	26	-0.6 ± 0.5
April 27-May 1	11	1.0 ± 0.8	23	-0.2 ± 0.4	10	-0.2 ± 0.6	28	-0.2 ± 0.5
May 4-8	11	-0.4 ± 0.5	21	-0.2 ± 0.3	7	0.5 ± 0.6	27	0.5 ± 0.4
May 11-15	11	-0.2 ± 0.8	20	-1.9 ± 0.7	7	-0.4 ± 0.5	26	-0.7 ± 0.6
May 18-22	10	-0.2 ± 0.2	20	-1.8 ± 0.6	9	-0.8 ± 0.3	26	-2.9 ± 0.7
May 25-29	10	9.2 ± 2.0	23	6.3 ± 1.7	10	8.9 ± 1.8	27	6.1 ± 1.2
June 1-5	11	-1.2 ± 0.3	22	-2.6 ± 0.8	7	-0.3 ± 1.1	14	-2.4 ± 1.0
June 8-15	10	-1.3 ± 0.3	22	-1.5 ± 0.6	8	-0.1 ± 0.8	24	-2.4 ± 0.8
June 15-19	10	-1.4 ± 0.6	21	-2.2 ± 0.6	9	-1.0 ± 0.5	24	-1.7 ± 0.5
June 22-26	10	-1.1 ± 0.7	20	-0.8 ± 0.3	10	-1.7 ± 0.6	25	-2.1 ± 0.9

two plots. This procedure worked well because patterns of change were similar for almost all females — both in timing and magnitude of change. This was not true in 1981, and we had to examine weight change profiles for every female and attempt to deduce the most likely reproductive history for each individual. Some females apparently laid no eggs, others laid one clutch, and still others apparently produced two clutches. Figure 2 illustrates representative profiles for six female tortoises. Numbers of clutches laid by 40 females in 1981 were

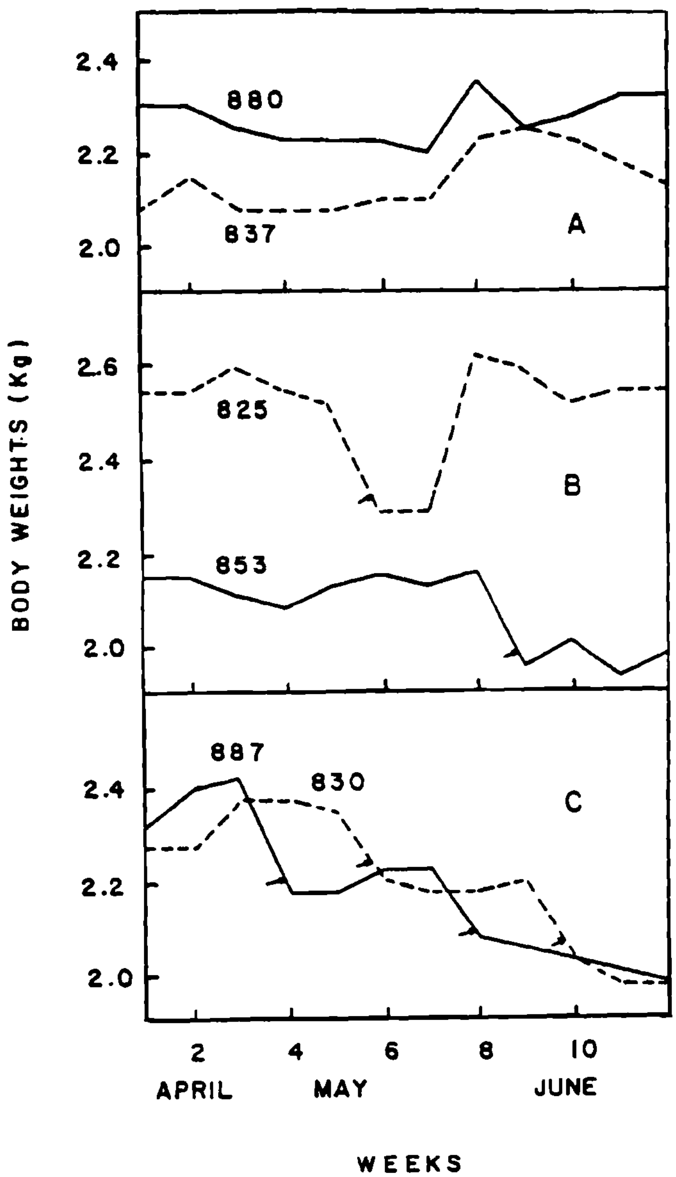

FIG. 2. — Observed weight changes among six female desert tortoises in Ivanpah Valley, California, in 1981. Solid lines: Plot 1; dashed lines: Plot 2. Weights of tortoises believed to have laid no clutches (A), one clutch (B), and two clutches (C) are illustrated. Arrows indicate times of egg laying.

TABLE 10. — Estimated reproduction by female desert tortoises in Ivanpah Valley.

Plot	Number of clutches (1981)			Mean number of clutches per female	
	None	One	Two	1980	1981
1	4	11	4	1.82	1.00
2	4	9	8	1.43	1.14

estimated from profiles similar to those in Figure 2, but we did not attempt to estimate sizes of clutches as in 1980 (Turner et al. 1981: Table 14). These earlier data can be used to estimate mean numbers of clutches laid per female in 1980. Table 10 gives estimated reproductive performances of tortoises in Plots 1 and 2 in 1981, and estimates of mean numbers of clutches laid per female in both plots in 1980 and 1981.

A chi-square analysis of the 1981 frequency distributions observed in Plots 1 and 2 (Table 10) gives a total X^2 of 1.4. The $X^2_{0.05}$ value (with 2 d.f.) is 6.0, so the estimated distributions do not differ significantly.

Feeding.—In 1977, Burge observed that species of *Cryptantha* and *Mentzelia albicaulis* were the species most often eaten by tortoises in Ivanpah Valley. A. P. Woodman's 1979 observations included these species, as well as *Camissonia boothii*, *C. dentata*, *Eriophyllum wallacei*, and *Chaenactis carphoclinia* among commonly eaten plants (K. H. Berry *pers. comm.*).

The spring of 1981 was very poor in terms of annual production, so we expected some variations from typical feeding patterns. Tortoises were observed feeding 59 times in 1981. Green annual plants were consumed until around mid-April: *Cryptantha angustifolia*, *Pectocarya* spp., and species of *Eriogonum*. As annual plants dried, tortoises switched to cacti. The first observations of a tortoise eating cactus was on 15 April. Between mid-April and the end of May, tortoises fed on beavertail (*Opuntia basilaris*), pencil cholla (*O. ramosissima*), cholla (*O. echinocarpa*), hedgehog cactus (*Echinocactus* sp.), cheesebush (*Hymenoclea salsola*), dry grasses (*Festuca octoflora* and *Hilaria rigida*), dry *Cryptantha* spp., and even cow dung. After the rain at the end of May, some tortoises fed on *Hilaria rigida* which had greened up at the bases, and on newly germinated *Bouteloua barbata*. Later in June, tortoises fed principally on various cacti and dried annuals. Tortoises ate fruits and pads of beavertail, new basal sprouts of pencil cholla and cholla, and even woody stem segments of cholla (16 June). Over 30% of the feeding observations involved cacti of one sort or another. In a dry year, the presence of cacti may be important for survival and/or reproduction, and may even have some influence on the local distribution of populations.

Food items reported from tortoise scats and cow dung were grouped in eight categories for convenience in reporting: 1) all types of cactus, including fruits of *Opuntia basilaris*; 2) annual grasses (*Bouteloua* sp., *Bromus rubens*, *Schismus barbatus* and others), 3) perennial grasses (*Aristida* sp., *Hilaria rigida*, *Sporobolus cryptandrus*, and *Stipa speciosa*), 4) miscellaneous boraginaceous annuals (*Cryptantha* spp., *Pectocarya* spp., etc.), 5) other annual plants (e.g., *Camissonia* spp., *Descurainia pinnata*, *Lupinus* sp., *Malacothrix glabrata*, *Mentzelia albicaulis*, *Nama demissum*, *Plantago* sp., *Erodium cicutarium*, *Cymopterus multinervatus*, *Delphinium* sp., *Lotus tomentellus*) and seeds of annual plants, 6) various perennial plants (e.g., *Ambrosia dumosa*, *Chrysothamnus nauseosus*, *Hymenoclea salsola*, *Grayia spinosa*, *Ephedra nevadensis*, *Larrea tridentata*, *Sphaeralcea ambigua*, *Lycium andersonii*, and *Yucca schidigera*), 7) unknown plants, and 8) arthropod parts. Tables 11 and 12 summarize mean percentage abundance of food items counted in these various categories in 1980 and 1981. Table 13 gives similar information for cattle dung.

Standard deviations of counts of various food items were often large relative to means, so the percentages in Tables 11-13 must be viewed carefully. However, some useful generalizations may be abstracted from the data. Shrubs (except cacti) and arthropod parts were never important elements of tortoise diets, and perennial plant parts made up less than 5% of cow dung samples examined in all but one sample. We expected substantial amnouts of cacti in tortoise scats taken in 1981, and scats collected after the end of April often seemed composed of little else. Table 11 shows, however, that even in a more favorable year (1980) cacti were still important in diets. It is possible that parts of cacti are less well digested than parts of other plants and, if this is true, counts of fecal samples could overestimate the relative importance of cacti. In any event, Table 13 shows that cattle almost never consumed cacti in Ivanpah Valley during 1980 and 1981. Annual and perennial grasses and various kinds of annual plants made up most of the remainder of tortoise diets. Scats collected in the fall of 1980 showed a conspicuous increase in consumption of both annual and perennial grasses relative to amounts utilized in mid-summer. In 1981, grasses were fairly abundant in scats during the early part of the season (up to mid-April) but never exceeded 10% in any subsequent samples. Annual plants were more common in scats in the early spring of 1980 than in 1981, which follows from annual plant sampling data in the two years. Table 13 shows that cattle in the vicinity of our plots consumed perennial grasses almost exclusively. The only samples in which other kinds of plants were well represented were those taken around the third week of April in both 1980 and 1981. In these samples, miscellaneous annual plants made up about 37% of material in 1980 and 79% in 1981. Based on the analyses reported above, one would conclude that tortoises may reduce competition with cattle by feeding on cacti, and that the principal plants for which the two species conpete are perennial grasses (or occasionally various annual plants).

Analyses of Blood of Desert Tortoises.—Table 14 gives normal ranges for attributes of blood of *Gopherus agassizi*, and contrasts these with ranges observed in Ivanpah Valley in the fall of 1980 and spring of 1981. Normal ranges are based on W. J. Rosskopf's findings (*pers. comm.*) and were computed from over 300 samples. Ivanpah Valley ranges are based on six males and six females each year. Slides prepared for counts of blood cells in 1981 were not always of adequate quality, and we view the 1980 data pertaining to blood cell types as

TABLE 11. — Percent relative abundance [illegible]f food items in scats of tortoises in Ivanpah Valley (1980).

Type of food	Plot	March [illegible] 1 to May 6	May 8 to May 30	June 9 to June 27	July 14 to July 18	Sept 4 to Oct 16
		Dates				
Cacti	1	16.[illegible]	19.6	16.8	32.8	1.5
	2	91.[illegible]	19.9	50.6	93.7	0.8
Annual grasses	1	5.[illegible]	14.8	39.4	14.2	37.3
	2	2.[illegible]	10.5	19.1	1.5	32.9
Perennial grasses	1	49.[illegible]	11.0	3.5	43.6	60.0
	2	4.[illegible]	1.6	11.0	0.3	49.1
Boraginaceous annuals	1	7.[illegible]	14.3	8.4	0.7	...
	2	...	18.7	7.1	0.6	1.4
Miscellaneous annuals	1	11.[illegible]	13.6	11.9	5.5	...
	2	0.7	22.7	4.9	0.3	7.6
Miscellaneous perennials	1	1.1	...	0.8	...	1.2
	2	1.5	0.9	3.3	0.3	4.5
Unknown plants	1	6.1	23.9	18.4	2.4	...
	2	...	24.0	4.1	2.0	1.3
Arthropod parts	1	2.7	2.2	0.9	0.8	...
	2	...	0.9	...	0.9	1.6

TABLE 12. — Percent relative abundance of food items in scats of tortoises in Ivanpah Valley (1981).

Type of food	Plot	Dates					
		Mar 20 to April 16	Apr 20 to Apr 30	May 4 to May 14	May 18 to May 29	June 1 to June 11	June 15 to June 25
Cacti	1	32.9	60.9	74.0	90.3	97.7	53.0
	2	24.9	73.0	80.9	92.5	94.7	92.8
Annual grasses	1	25.6	11.5	3.2	2.8	...	1.6
	2	12.7	5.7	3.3	0.9	0.9	...
Perennial grasses	1	35.1	16.7	16.4	2.3	0.6	1.1
	2	15.6	2.1	3.1	3.8	4.1	4.3
Boraginaceous annuals	1	...	3.1	2.8	0.4	0.7	8.9
	2	1.9	1.8	6.2	...	...	...
Miscellaneous annuals	1	1.4	4.5	1.1	1.2	0.8	21.8
	2	11.4	1.8	4.1	1.1	0.3	0.7
Miscellaneous perennials	1	...	3.3	1.8	0.8	0.9	1.7
	2	8.5	1.2	1.3	0.3	...	1.9
Unknown plants	1	2.1	...	0.7	1.8	1.5	11.3
	2	13.2	13.0	1.1	0.8	...	0.3
Arthropod parts	1	2.9	...	...	0.7	1.4	0.8
	2	11.8	1.3	...	0.6	...	...

TABLE 13. — Percent relative abundance of various food items in cow dung in Ivanpah Valley (1980 and 1981).

Type of food	1980					1981				
	Apr 23	Apr 26	May 7	May 13	June 27	Apr 15	Apr 22	May 6	May 26	June 12
Cacti	...	...	...	...	1.3	...	...	...	...	...
Annual grasses	1.3	1.3	...	...	...	...	...	...	...	0.3
Perennial grasses	34.9	81.4	94.3	52.2	97.8	98.8	17.0	98.8	98.3	97.6
Boraginaceous annuals	18.6	0.4	1.2	...	...	...	...	...	...	...
Miscellaneous annuals	37.1	6.3	2.9	47.8	...	...	78.6	0.3	0.3	...
Miscellaneous perennials	6.1	9.3	1.2	...	1.0	1.2	4.5	0.9	0.9	2.1
Unkown plants	1.8	0.5	0.6	...	,,,	...	...	...	0.6	...
Arthropod parts	...	0.7	...	...	...	...	...	...	...	...

TABLE 14. — Normally observed hemogram and blood chemistry values for *Gopherus agassizi* and ranges of values observed in Ivanpah Valley in 1980 and 1981.

Blood attribute	Normal range	Ivanpah Valley Oct 1980	Ivanpah Valley May 1981
White blood cells (10^3)	3 - 8	5 - 10	1 - 5
Red blood cells (10^6)	1.2 - 3.0	1.3 - 2.4	0.5 - 2.7
Hematocrit (%)	23 - 37	22 - 40	10 - 37
Neutrophils (%)	0 - 3	5 - 36	not reported
Heterophils (%)	35 - 60	22 - 66	8 - 68
Lymphocytes (%)	25 - 50	14 - 48	1 - 59
Serum glutamic oxyloacetic acid (I. U.)	10 - 100	17 - 446	50 - 1680
Lactic dehydrogenase I. U.)	25 - 250	236 - 800+	300 - 1950
Total protein (mg %)	2.2 - 5.0	0.4 - 4.7	2.7 - 4.4
Creatinine (mg %)	0.1 - 0.4	0.2 - 0.8	0.2 - 8.2 (?)
Calcium (mg %)	9.0 - 17.0	8.0 - 18.6	9.4 - 15.0
Glucose (mg %)	30 - 150	46 - 114	42 - 96
Uric acid (mg %)	2.2 - 9.2	2.3 - 7.7	4.6 - 8.2
Blood urea nitrogen	1 - 30	2 - 49	1 - 42

more representative. In both years, our samples gave unrealistically high values for serum glutamic oxyloacetic acid (SGOT) and lactic dehydrogenase (LDH). Rosskopf (*pers. comm.*) has suggested that these high values stemmed from either or both of the following problems: 1) the blood was not spun down fast enough, 2) removal of blood from the retroorbital sinus resulted in tissue trauma and tear secretion, thus contaminating samples. Comparisons of 1981 samples taken from toes and eyes of the same tortoise showed that the problem did not lie in the source of the sample (Medica et al. 1982: Table 22). Comparisons of other blood chemistry values in samples from eyes and toes also showed these to be essentially identical. Hence, we conclude that our sample

TABLE 15.—Measurements of seven attributes of blood of desert tortoises in Ivanpah Valley in 1980 and 1981. All means based on analyses of blood of three individuals. Bottom line gives overall means (± one standard error).

Area	Year	Sex	Hematocrit (%)	Total protein (mg %)	Creatinine (mg %)	Calcium (mg %)	Glucose (mg %)	Uric acid (mg %)	Blood urea nitrogen
1	1980	Male	37.3	3.5	0.3	13.0	91.0	4.7	14.7
		Female	29.0	2.3	0.5	14.7	65.3	5.3	29.0
	1981	Male	29.0	3.2	0.3	12.0	66.7	5.9	14.7
		Female	26.7	3.1	0.2	11.3	88.0	5.7	8.7
2	1980	Male	34.3	4.0	0.2	12.1	72.0	5.7	13.7
		Female	24.0	3.1	0.2	16.2	69.3	5.3	6.7
	1981	Male	33.3	3.2	2.9*	13.4	74.5	6.9	3.7
		Female	27.0	3.8	0.3	11.4	68.7	6.4	15.7
			29.4 (±1.4)	3.3 (±0.2)	0.6 (±0.3)	13.0 (±0.6)	74.4 (±3.5)	5.7 (±0.3)	13.3 (±2.9)

*includes one value of 8.2

processing techniques were not sufficiently refined to give reliable values for some blood elements.

Table 15 summarizes mean values for seven attributes of blood of desert tortoises in Ivanpah Valley in 1980 and 1981. These are blood characteristics where, with one exception, there was no evidence of serious technical artifacts among reported values. Of 24 values reported for blood creatinine, 23 ranged from around 0.2 to 0.5 mg %. One sample, however, was reported as 2.9 mg %. For each of seven attributes, the 24 values contributing to Table 15 were examined by factorial analysis of variance (two areas, two sexes, two years). Critical F-values were 4.5 (5%) and 8.5 (1%). Only one clear-cut effect was expressed in these analyses: a sex difference in hematocrits. Mean hematocrits for 12 males and 12 females were 33.5% and 26.7%, respectively, and the F-value (21.3) was highly significant. There were also two marginally significant interactions: between areas and years for hematocrits ($F = 4.57$) and between areas, sexes and years for total protein ($F = 4.72$). With such low F-values, it seems unwise to tender any biological interpretation of these interactions. For all other blood elements, F-values for main effects and interactions were insignificant, usually $\leqslant 1.0$. Neither were there any significant correlations between the values of blood attributes given in Table 15. The highest correlation coefficient (not significant) was 0.445. This was between total protein and uric acid.

Our work in Ivanpah Valley has disclosed some problems in taking blood samples in the field, processing them on the spot, and shipping them to a laboratory for analysis on the same day. We also encountered difficulties with SGOT and LDH, which were associated with our procedures. Nevertheless, seven blood characteristics exhibited plausible ranges and stability over the seven-month period between October 1980 and May 1981. These attributes may prove of use in future evaluations of the physiological status of tortoises occupying natural environments.

DISCUSSION

In terms of the original objectives of this project, i.e., to explore possible effects of cattle grazing on the well-being and reproductive performance of desert tortoises, our study is inconclusive. As pointed out by Turner et al. (1981), cattle occupied Plot 1 until 10 April 1980, and shortly thereafter all cattle left the area. Hence, grazing experience of Plots 1 and 2 hardly differed in 1980. Cattle were not present in the exclosure during 1981, but usage of Plot 2 was light and sporadic. Our observations of cattle in the vicinity of the plots in 1981 indicated that animals spent most of their time near water tanks, apparently because of general impoverishment of forage. The locations of four tanks (A, B, C, and D) are shown in Figure 1. Had the experiment continued, and had more effective arrangements involving grazing practices been consummated by the BLM, results relevant to the original questions posed might have emerged.

In spite of the foregoing problems, the study can be instructive in terms of improving the design and technical approach used in future field experiments. One of the most vexing questions in planning long-term field experiments is balancing the relative values of alternative designs against corresponding costs. Ideally, it is advantageous to examine the status of prospective control and experimental populations before any treatments begin in order to establish the initial similarity of all units. For field studies extending over areas measured in square miles, such pre-experimental analyses can be time consuming and expensive.

The present study began with little pre-experimental analysis, trusting that the vegetation and tortoise populations occupying contiguous areas were similar. The fact that the grazing experience of the two plots hardly differed in 1980 was an advantage in this respect: observations during 1980 could be used to test the foregoing assumptions. As it turned out, those structural and dynamic attributes of tortoise populations measured in 1980 were gratifyingly similar. In general, we believe that these similarities were sustained during 1981, although we have already referred to an unexplained change in observed sex ratios in the two plots. Sampling of annual plants in the two plots revealed distinct spatial heterogeneities, some differences in relative abundances of species, and some possible differences in species composition. Aggregate dry weight standing crops were similar, and the non-parametric tests we used for comparisons generally showed Plots 1 and 2 to be similar. At this point, we do not know if the observed differences in vegetation in the two areas (e.g., the abundance and dispersion of *Hilaria rigida*, the abundance of annuals—in 1981—beneath *Ambrosia*) are of any biological importance. More intense sampling of vegetation would have increased the probability of finding significant differences, but probably would not have helped in judging the importance of the differences. On the basis of what we observed in 1980 and 1981, it might have made more sense to compare the cactus floras of the two plots than to sample annual plants, but previous observations in other locales did not suggest this approach.

In spite of the additional costs, and the risk of analyzing some environmental attributes which turn out to have no experimental relevance, we feel that some sort of pre-experimental site comparisons are needed. Such comparisons should be quantitative, but based on the simplest and most easily interpretable techniques available (probably line transects of some form). It will also be necessary to examine a number of possible pairs of sites so that the best matched may be used. If one begins by comparing just two sites, it is often tempting to downgrade or ignore differences.

If any future studies are devoted to possible grazing effect, better arrangements concerning stock management will be needed. In this particular experiment, requirements of the grazer were paramount, and no control (other than enforcement of allotments) was exercised by BLM. The only way to make any sort of quantitative estimate of grazing usage (of Plot 2) would have been to employ someone to watch and count cattle. In the absence of this, we were only able to make rough qualitative estimates of grazing in Plot 2 in 1981.

The tortoise scats and cow dung collected in 1980 and 1981 afforded some ideas as to how tortoises and cows sustained themselves in these particular years. The large representation of cacti in tortoise scats (particularly in 1981) suggests an important compensatory behavior by tortoises faced with low production of herbaceous forage. Cacti were not consumed by cattle — at least in 1980 and 1981 — and the only evidence of significant competition between cattle and tortoises pertained to perennial grasses and annual plants. The dominance of *Hilaria rigida* in cattle diets suggests another problem in designing a grazing experiment. If, for any reason, the areas selected for comparison are already impoverished in terms of important cattle forage, the experiment is unlikely to have any significance because there will be little usage of the "grazed" area. Our sampling in 1981 indicated that the abundance of *Hilaria rigida* (in both plots) was low — on the order of a few hundredths of a percent coverage.

One of the most surprising results of the experiment was that tortoises reproduced so well in 1981. The spring of 1981 in Ivanpah Valley was highly unfavorable in terms of net production of herbaceous plants. Other portions of the California deserts experienced poor seasons as well. According to Wilbur Mayhew (*pers. comm.*), the spring of 1981 was one of the four or five worst in observed history in the vicinity of Riverside. While our comparisons indicated that, on average, female tortoises did somewhat better in 1980 than 1981, the 1981 effort was not inconsequential. Fifteen of 52 female tortoises observed in 1981 laid two clutches. According to Paul Schneider (*pers. comm.*), some tortoises collected in the vicinity of Barstow also produced two clutches. How was this accomplished? The only suggestion we can make is that energy (or water) derived from cactus parts contributed to this effort.

When we began this experiment, we proposed to draw inferences as to the reproductive performance of female tortoises by inspection of weight profiles based on regular measurements. This procedure worked very well in 1980, although weighings were usually separated by two-week intervals. Body weight changes of almost all females were well synchronized, and the magnitudes of weight losses and gains were comparable. The one big rain in 1980 came after reproduction had ceased. The 1981 data were not as readily interpretable. Female weight changes were not in synchrony, and there was more variation in amounts of weight lost and gained. Rain fell during late May, adding to the difficulty of inferring reproductive events. Our earlier suggestion (Turner et al. 1981) that X-rays of females could provide accurate measures of clutch size was confirmed by Kristin Berry, Paul Schneider, and others during the spring of 1981 (*see* Gibbons and Greene 1979). Female tortoises were captured in the field, taken to Barstow, and X-rayed professionally. Prints clearly showed the presence and number of eggs in some females (Schneider *pers. comm.*). We believe this technique could be extended to the field by the use of a generator-powered portable X-ray machine. Lightweight machines (ca. 9 kg) are available at a cost of $3,500 to $4,000. They are safe and require only moderate training and experience to use. The most inconvenient part of a field operation would be acquisition and management of the generator. Because of the problems we encountered in 1981, we recommend that any future studies in which egg reproduction by tortoises is a critical variable be based on X-radiography of females.

Naturally, X-rays would have to be taken periodically (though not necessarily weekly), and this would require that particular females be accessible as needed. Our experience with the electronic equipment supplied by the BLM was satisfactory in terms of performance and reliability of components. We did not face the problem of replacing batteries because the experiment ended so quickly, but in any continuing effort this need would arise as batteries expired. We used D-batteries instead of the smalled C-batteries in order to extend battery life in the field. However, the smaller batteries may be more desirable from the standpoint of the tortoise. We were not able to make any conclusive experiments testing the righting abilities of tortoises with D-batteries, but there is a possibility that these batteries may prevent an overturned tortoise from regaining its feet.

ACKNOWLEDGMENTS

We thank R. Capasso, D. Ferguson, H. Hill, N. Mays, and A. Vollmer for assistance with fieldwork. We are grateful to personnel of the U.S. Bureau of Land Management for assistance during the project: W. Radtkey, K. Berry, H. Johnson, L. Foreman, J. Bickett, R. Crowe, and E. Sorenson. J. Kinnear and L. Valainis assisted with data reduction. D. Garrison and J. Ransom gave secretarial assistance. We thank R. Hansen and T. Foppe at the Composition Analysis Laboratory at Colorado State University for analyses of fecal samples. The California Fish and Game Commission issued permits for this project. We acknowledge support by the Civil Effects Test Operations Office and A. Morrow. This work was supported by an inter-agency transfer of funds from the Bureau of Land Management (BLM Contract No. SS00012/UCLA) and by Contract DE-AM03-76-SF00012 between the University of California and the U.S. Department of Energy.

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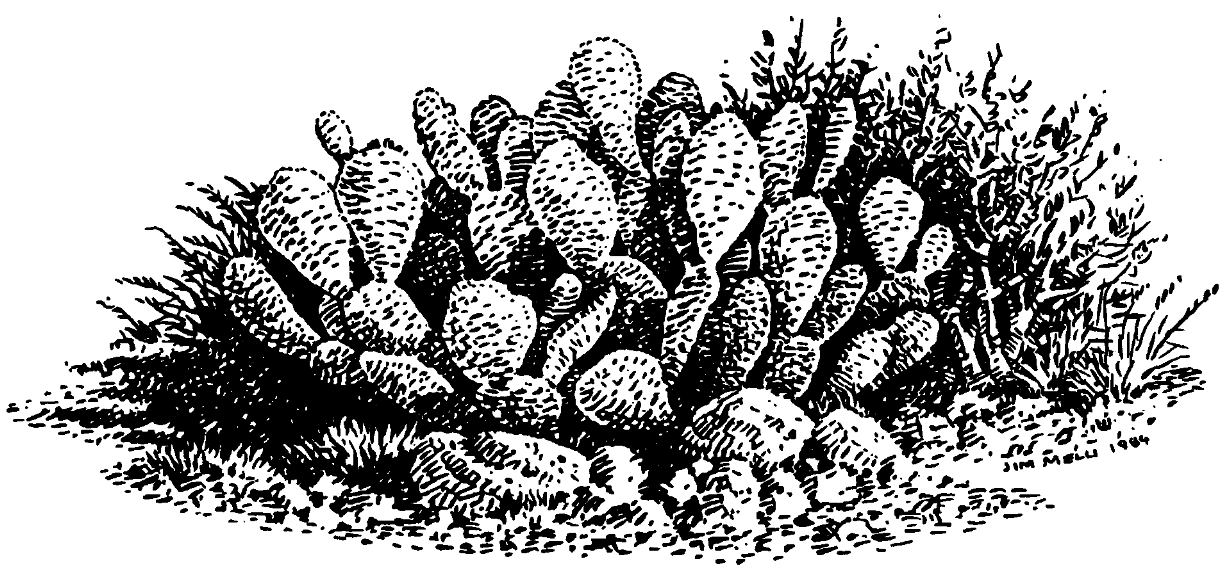

Proc. Desert Tortoise Council 1982 Symp., pp. 125-132

A STUDY OF THE REACTIONS OF DESERT TORTOISES TO DIFFERENT TYPES OF FENCING[1]

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Abstract.—During 1979 and 1980, a study was done for the California Department of Transportation on the feasibility of using a fence and culvert system to allow tortoises to pass safely under roads. As part of this study, we tested the reactions of tortoises to three types of fencing: 2-in.-mesh chicken wire, 1/4-in.-mesh hardware cloth, and solid metal painted a dull green. Tortoises exhibited different behaviors as they encountered the different fence types. Tortoises pushed more against open-mesh fencing and were more quiescent when confronted with the solid fence. Tortoises spent a greater percent of the time walking along the open-mesh fences than along the solid fence, and walked most freely — without pushing on the fencing — along the hardware-cloth fence. Two factors which may have affected the tortoises' reactions to the fences were (1) the presence or absence of a visual cue of open space beyond the fence, and (2) the mesh size of the chicken wire which allowed tortoises to push their heads through the fence. The implications of these findings for mitigation of the impact of roads on tortoise populations are discussed.

A final report has been presented to the California Department of Transportation (Caltrans) summarizing the findings of a two-year desert tortoise study (Fusari 1982). That study evaluated the feasibility of using barrier fences and culverts to pass tortoises safely under roads. The objective was to suggest ways to reduce mortalities caused by cars. Fusari et al. (1980, 1981) summarized the ongoing conclusions and recommendations of that report.

During the two-year study that led to the Caltrans report, experiments were conducted to determine the differential reactions of tortoises to three types of fencing differing primarily in their openness as visual barriers.

This paper reports the findings on desert tortoise behavior patterns as orientation responses to the different types of barrier imposed by the fencing.

In 1975, an extensive review of highway-wildlife relationships was published by Leedy.

[1] This paper is dedicated to the memory of Paul Schneider whose love of the desert and its lives served to stimulate my work. He was a valued colleague in several tortoise studies.

METHODS AND MATERIALS

The study was conducted during the spring and fall of 1979 and the spring of 1980. The study site was in San Bernardino County approximately 8 mi southwest of Barstow, California, and 2 mi west of I-15 via the Sidewinder Road exit (Barstow quadrangle, T9N, R2W, Section 7; elevation = 2,600 ft). The soil was firm-sandy desert alluvium. The vegetation was *Larrea ambrosia* scrub. We marked a total of 60 tortoises found within 1/2 mi of our fences. We estimated, subjectively, the tortoise population at over 150/mi^2.

Two experimental systems were used. The main fence system, constructed for Caltrans, was a double fence of 1- or 2-in.-mesh chicken wire, 1/2 m in height. The fencing was closed at both ends, separated by approximately 15 m and crossed by three mock culverts — two of corrugated steel and one of panelboard — all with dirt floors (Fusari 1982).

For the behavior experiments, a set of circular pens was constructed. Each single pen was 5 m in diameter with walls 1/2 m in height. The three pens were connected in a cloverleaf pattern by insulated culverts, each 3 m long and just under 2 m in diameter. Three types of fencing were used to build the walls of the pens. One pen was 2-in.-mesh chicken wire, the second was 1/4-in.-mesh hardware cloth, and the third was solid metal (roof flashing) painted a dull green.

Tortoises were captured, placed in the pens, and observed for their behaviors relative to the fencing. No tortoise was left in the pens for more than two consecutive days. Tortoises were released at their capture sites.

During initial observations, I described the inclusive set of behaviors exhibited by tortoises upon approach to the fences (Fusari 1982). Data on the occurrence of those behaviors was then taken for 15 different tortoises during their encounters with the fences. Due to the rapid succession of behaviors by the tortoises in these experiments, two 10-minute observation periods were needed for each tortoise encounter with each type of fencing. During the first 10-minute period, the frequencies of the different categories of behavior were recorded. A second 10-minute observation was done immediately after the first, and the durations of the behaviors were recorded. These data were reduced by calculating the average duration of a behavior and multiplying that by the frequency of occurrence to give a total time score for that behavior. Percents could then be estimated by calculating either (1) each time relative to the entire observation period, or (2) the time for one type of behavior relative to any other.

Statistical analyses were done by chi square tests on the frequencies and Wallis-Kruskal tests on the times (Sokal and Rohlf 1969).

RESULTS

Our results are derived from a total of 90 days of observation (30 during May-June 1979 and 60 during March-May 1980). Within those periods, we observed

34.5 hours of spontaneous encounter of tortoises with the 550-m main fence system. We recorded a total of 48 encounters, by 16 different tortoises. Of those, 11 encounters by five tortoises, resulted in the tortoise actually crossing the system through one of the culverts. Ten of the encounters, by six tortoises, resulted in deliberate avoidance of the fence system by the tortoise veering its approach and circling around the end of the long fence. Forty-four other tortoises, living within 1/4 mi of the fence, were never observed in an encounter with it.

A grand total of nine of the 16 different tortoises that encountered the fence system managed to cross it either through one of the three culverts or, alternatively, by passing around an end. Seven of those tortoises were resident in the near vicinity of the fence system, by virtue of having been present near it both years of the study. Those seven crossed the system up to four times apiece, and four of those tortoises were observed making direct "beeline" approaches to the crossing points during our observations in the second year of the study (1980). One is tempted to assume that those four tortoises had learned the spatial location of the fence and the passages through it for, in contrast to their observed behaviors in 1980, they had all been observed in characteristic and extended encounters with the fencing leading to those crossing points in 1979.

Our experiments in the cloverleaf pens yielded data on the types of behavior exhibited by tortoises upon approaching a fence. Three major categories of behavior were noted, as follows:

Category I. Progress parallel to the fence.—Locomotion by the tortoise, along the fence, either touching the fencing while walking or not.

Category II. Fence-perpendicular behavior.—Involved the tortoise heading into or toward the fencing and touching and/or pushing at it

TABLE 1.—Types of behavior observed at different types of fencing, expressed as percent of time of observation.

Behavior	Type of fencing			
	Chicken wire (% of time)	Hardware cloth (% of time)	Solid metal (% of time)	550-m main fence, chicken wire (% of time)
Category I: Progress parallel to fence	34	47	22	29
Category II: Fence-perpendicular	20	4	4	10
Category III: Activity away from fence	47	50	74	61

either with the snout, the entire head, the anterior surface of the shell, or, at the extreme, climbing onto the fence with the forelegs.

Category III. Activity away from the fence.—Involved that part of the observation time spent away from the fence either sitting, standing, or feeding.

The proportion of encounter time spent in each category of behavior was different according to the type of fencing encountered (Table 1). More walking (progress parallel to the fence) was noted during encounters with the hardware-cloth ($p \leqslant 0.01$). More fence-fighting (fence-perpendicular behavior) was observed during encounters with the chicken wire ($p \leqslant 0.001$). More time spent quietly away from direct contact with the fencing was notes during encounters next to the solid fencing ($p \leqslant 0.025$).

Progress parallel to the fence involved locomotion either with the near-fence foot touching the fence during the walk (foot pushing) or without the near-fence foot touching the fence during the walk (walking free). Walking free of the fence was more frequent at hardware-cloth fencing than at either chicken wire or solid fencing ($p \leqslant 0.01$). The foot-pushing walk was not observed at the solid fencing and was more common at the chicken-wire fencing than at the hardware-cloth fencing ($p \leqslant 0.01$).

Fence-perpendicular behavior involved four types of tortoise-fence interactions. The proportion of time ($p \leqslant 0.001$) was different according to the type of fencing involved in the encounter (Table 2). All four types of behavior occurred more frequently at the open, chicken-wire fencing. It is also interesting to note that the three types of interactions, termed "fence-fighting," occurred significantly more frequently ($p \leqslant 0.001$) at the open-mesh, chicken-wire fencing than at either the hardware-cloth or the solid

TABLE 2.—Types of fence-perpendicular behavior observed at different types of fencing, expressed as percent of time of observation.

	Type of fencing		
Fence-perpendicular behavior	Chicken wire (% of time)	Hardware cloth (% of time)	Solid metal (% of time)
Nosing	6.9	2.6	3.8
Head push	2.6	0.9	0.1
Body push	4.2	0.4	0
Climbing push	5.7	0	0
Totals	19.4	3.9	3.9

fencing (Fusari 1982). Data for encounters by tortoises with the main (550-m) chicken-wire fence system are shown for comparison in Table 1. Those tortoises were free-ranging as opposed to the captive state of the tortoises in the cloverleaf pens. Even so, the differences in proportionate behaviors was not significantly different from that observed at the chicken-wire fencing in the pens.

DISCUSSION

Can tortoises learn to get around fencing?

Although these results must be considered as preliminary, the data indicate that those tortoises resident in the vicinity of the fencing and culverts did develop a spatial sense of the position of those observations. Of the tortoises most closely resident at the site of the fence system, four were making straight-line (or "beeline") crossings in the second year of the presence of that fencing. Those same tortoises were observed in the expected fence-fighting behaviors (at a chicken-wire fence) during the first spring of the fence. I would hypothesize, at least, that those tortoises had learned the position of the fences and the culverts and were able to make use of that learning to cross the fence system without wasting energy on fence-fighting behaviors or on a need to follow along the fence until a crossing was encountered.

If this can be taken as an assumption, then it would follow that tortoises can be expected to learn to use culverts, on a regular basis, to cross highways. Proof of this must await further field tests of tortoise behavior, over several years, in the presence of actual freeway, fence-culvert systems. It is noteworthy that the Shire of Wanneroo, in Australia, has installed a road crossing, aquatic underpass system which is serving as a crossing for the aquatic *Chelodina oblonga* (Andrew A. Burbidge *pers. comm.*[2]).

Do tortoises see different fencing differently?

The behaviors exhibited by desert tortoises in their interactions with fences appear to involve locomotory progress (walking free and walking with a foot push), direct sensory perception (walking with a foot push and nosing), and fence-fighting (head push, body push and climbing push and perhaps walking with a foot push). It is more difficult to suggest which senses are being used as perceptual inputs and what specific purpose they serve. Tortoises are known to use the snout in nosing objects, and olfactory input is presumed to be important in their sensory input of immediate surroundings (Eglis 1962, Berry 1972). During this study, tortoises did the most mosing when they had just been placed in the pens and upon encountering unfamiliar objects in the pens. Of the four fence-perpendicular behaviors, the nosing was probably this type of sensing. Tortoises are known to use their forefeet as tactile inputs for spatial orientation (Patterson 1971). I would suggest that tactile sensing is the primary use

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of the foot push seen during much of the walking and may have been a factor in all three of the fence-fighting behaviors observed (head push, body push, and climbing push).

Tortoises are known to possess good visual capacity for both distance and depth perception (Patterson 1971, Coombs 1977). I suggest that the major cause of the differences in behaviors exhibited by tortoises in response to different types of fencing was the difference in the visual stimuli presented by each type of fencing. The solid metal fence presented a complete visual barrier. Tortoises could not see through it and so could not have recognized it as something to go through, nor could they see beyond it to something to go toward. The chicken-wire fence, at the other extreme, presented a clear view to open desert. That probably served as a stimulus for the tortoises to go directly toward the fence in an attempt to reach that desert habitat. Then the fence presented a physical barrier to passage, and the resultant conflict between visual and tactile stimuli resulted in the highest degree of fence-fighting behavior occurring at the chicken-wire fencing. The hardware-cloth fence presented both a more significant visual barrier by virtue of having smaller mesh and also presented the tortoise with a view of the desert which could act as a stimulus for attempted locomotion. This would explain both the low incidence of fence-fighting behavior and the high degree of locomotion associated with encounters with the hardware-cloth fence.

Implications of Tortoise-fence Interactions for Management

The results of this study must be viewed as preliminary and conclusions tentative. The next logical step for management purposes would be to implement a pilot project of barrier fencing associated with under-freeway culverts and to monitor tortoise movements at that site. Only then will the real feasibility of mitigation of road mortality be documented.

On the basis of these data, I would suggest that a fencing that allows animals to see through it, while also seeing it as a real barrier to locomotion, would be the preferred choice for barrier fencing. The hardware-cloth fencing in this study yielded the most locomotion along the fence with the least amount of fence-fighting behavior. This means that tortoises spend their energy in productive behavior that will eventually lead them to a crossing culvert instead of wasting energy fighting the fence. However, it is important to remember that tortoises resident by the fence systems did appear to learn to use the culverts effectively even though that system was built of the open-mesh chicken wire. I feel that, if cost is a critical factor, any reasonable barrier that lessens the unacceptable road mortalities discussed by Berry and Nicholson (1979), Humphreys[3], and Nicholson[4] will be of benefit to the tortoise populations.

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[3] Humphreys, G. Unpublished data. Differential equations and desert tortoises. Bureau of Land Management, Riverside, California 92506.

[4] Nicholson, L. Unpublished data. The effects of roads on desert tortoise populations. Report to the Bureau of Land Management, Riverside, California, in partial fulfillment of Contract No. CA-060-CT8-000024.

Finally, I would like to remark that, contrary to the 1980 article in the *Los Angeles Times*, we do not have to train tortoises. Rather, we have to let them teach us, through our research, how to use their desert without causing it and its residents unnecessary destruction.

ACKNOWLEDGMENTS

Acknowledgements are due to my colleagues in the Caltrans study: Stephen M. Juarez, Fresno, California; Dr. Glenn R. Stewart, California State Polytechnic University, Pomona; and John A. Edell, Caltrans District 09.

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Proc. Desert Tortoise Council 1982 Symp., p. 133

IS TIME A LIMITING RESOURCE FOR *GOPHERUS AGASSIZI*?[1]

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Utilization of time resources and allocation of time for different behaviors was investigated by analysis of daily and annual time budgets. Behavior was monitored by direct observation, remote sensing devices, and attached programmable microprocessors.

Daily emergence and basking can occur anytime during the year, but was most common from late March to late July. Time of daily emergence and the amount of time spent basking was negatively correlated with the number of days elapsed during the active season. The proportion of the population that emerged and the probability that an individual tortoise would emerge was greatest in late April to early May. Basking accounted for 19% of the daily time budget in late March and a lesser percent thereafter. Basking accounted for 1.5% of the annual time budget.

Morning activity occurred from early April to late July. The time of its initiation and the amount of time spent in morning activity were negatively correlated with the number of days elapsed during the active season. The proportion of the population engaged in morning activity was greatest in early May. Morning activity accounted for 0.8% of the annual time budget. Afternoon activity occurred from early April to late June. The time of initiation of afternoon activity was negatively correlated with the days elapsed during the active season. The proportion of the population engaged in afternoon activity and the probability that an individual tortoise would be active in the afternoon was greatest in late April. Afternoon activity at its greatest accounted for 7% of the daily time budget. It accounted for 0.7% of the annual time budget. Morning and afternoon activity together were 1.6% of the annual time budget.

Foraging was the most significant activity in terms of time spent, and was 1.5% of the annual time budget. Male-female interactions occupied 0.09% of the annual time budget. Male-female interactions in late April were 1% of the daily time budget and overall were 0.08% of the annual time budget. Other activities occupying significant fractions of the time budgets were burrow excavation and maintenance, and nesting.

The time of midday retreat was negatively correlated and the amount of time spent in midday dormancy was positively correlated with days elapsed during the active season. Midday dormancy was 33% of the daily time budget at its greatest in late June and overall was 2% of the annual time budget. The time of evening retreat was positively correlated with season. The amount of time spent in evening dormancy for tortoises that were active in the afternoon was negatively correlated with season and positively correlated for tortoises that were not active in the afternoon. Evening dormancy was 81% of the daily time budget in late March, highest for the active season. Dormancy accounted for 94.9% of the annual time budget.

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[1]Summary only; this author did not submit a paper in time for publication.

Proc. Desert Tortoise Council 1982 Symp., pp. 134-153

AN EVALUATION OF THE TRANSECT TECHNIQUE FOR ESTIMATING DESERT TORTOISE DENSITY AT A PROSPECTIVE POWER PLANT SITE IN IVANPAH VALLEY, CALIFORNIA

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Abstract.—In the spring of 1981, we attempted to evaluate the effectiveness of the Bureau of Land Management (BLM) transect technique for estimating the density of desert tortoises. This technique relies on counts of tortoises and signs, and a conversion of these counts to densities using regression equations derived in areas where both densities and signs were evaluated. Our work was carried out in two parts of Ivanpah Valley, California: the 4-mi^2 prospective site of a coal-burning power plant just west of Ivanpah Dry Lake, and the BLM's 1-mi^2 Ivanpah Valley Permanent Study Plot (PSP), about 21 km (13 mi) south of the power plant site. Twenty-three transects were examined at the plant site in April and May. Six transects were examined at the PSP in April and six in May. The density of desert tortoises in the PSP was estimated in April by capture-recapture analysis of data taken on three censuses one week apart. This procedure was repeated in May. The April data yielded an estimate of 227/mi^2, the May data an estimate of around 150/mi^2. We used the larger estimate and determined its relationship to mean counts of cover sites and total adjusted signs in both April and May. This procedure yielded four different equations with which to estimate density. We used each of these equations to estimate the abundance of the tortoise in various portions of the prospective power plant site. Estimates ranged from 5-10/mi^2 in the poorest habitat adjoining Ivanpah Dry Lake to 4-18/mi^2, 31-54/mi^2, and 55-187/mi^2 in progressively better habitats farther west (and at higher elevations). Both our 1981 study and an earlier 1980 study ranked tortoise habitat within the power plant site in the same way. Agreement between 1980 and 1981 density estimates in various parts of the site was generally good. The transect technique does not err in identifying poor habitat as good habitat, but is limited in how well it can discriminate between various

grades of the latter. No confidence ranges can be assigned to transect-count-derived density estimates. The transect technique served well in early stages of investigations of the local distribution and abundance of the tortoise in California, but cannot provide the accuracy and precision needed for today's land use decisions.

INTRODUCTION

Owing to efforts of Kristin Berry of the Desert District Office of the U.S. Bureau of Land Management (BLM) and her colleagues, the desert tortoise has assumed a position of social and biological significance in California and other western states (Berry and Nicholson 1979). The tortoise occupies lowland regions of southeastern California — in areas under consideration for various types of energy development. The well-being of the tortoise has emerged as — and will continue to constitute — a biological issue in connection with all future energy projects within the habitat of the species. Utilities will be faced with continuing reponsibilities for appropriate mitigating actions when such developments impinge on tortoise habitat.

In 1981, Southern California Edison Company (SCE) was seeking certification from the California Energy Commission (CEC) to construct a coal-burning power plant in Ivanpah Valley, California. The prospective plant site is just west of I-15, near the California-Nevada state line (Fig. 1).

The CEC has identified the desert tortoise as the principal biological issue relating to the construction of the proposed Ivanpah Generating Station. Concern for the tortoise has already led to revisions of the original plan to develop a fresh water well field in Ivanpah Valley to provide water for the power plant. Current plans are for water to be piped to the site from the Colorado River. The four sections (each 1 mi^2) where the plant may be built were examined in 1980, and the abundance of the tortoise estimated using the transect technique (Nicholson 1980). This work showed a gradient of abundance, ranging from low densities (0-16/mi^2) along the western edge of Ivanpah Dry Lake to higher densities farther west of the lake bed (20-65/mi^2). This gradient coincided with an increase in elevation from 830 m above sea level at the margin of the lake to around 930 m at the western edge of the power plant site. Vegetation also changed along this gradient — from a saltbush-dominated scrub (*Atriplex torreyi*) along the edge of the lake bed to more typical mixtures of creosotebush (*Larrea tridentata*) and bursage (*Ambrosia dumosa*) at higher elevations.

In 1981, SCE decided to reexamine the abundance of the tortoise at the Ivanpah power plant site, and evaluate the accuracy and reliability of the transect technique as a density estimator. The work was contracted to BioSystems Analysis, Inc. (BSAI) in San Francisco. The technique actually involves two steps. The first is the conventional procedure of counting tortoises and signs on transects. This was used in the inspection of 1,153 areas in California between 1975 and 1978 (Berry 1979, Berry and Nicholson 1979). The specific technique and data forms were described by Berry and Nicholson (1979), and is based on counts of tortoises and signs in three belt transects 9 m wide and 805 m (1/2-mi) long arranged in an equilateral triangle. The second step is the conversion of sign counts to density estimates. This can be done only if counts have been "calibrated" in areas where densities of tortoises are known. In deriving relationships between tortoise sign counted along transects and absolute numbers of tortoises, Berry and Nicholson (1979) considered both "burrow sign" (b) and "total corrected sign" (TCS). Burrow signs included burrows, pallets, and dens only. The TCS was based on all tortoises and signs observed, corrected as described by Berry and Nicholson (1979).

Our understanding of the relationship between numbers of tortoises and signs of various kinds has changed somewhat since the beginning of work in California. Initially, there were hopes that clear-cut associations between numbers of tortoises and their burrows could be discerned. Dimmitt (1977) referred to an early idea that a 1:1 correspondence existed between numbers of tortoises and "deep burrows" in the Mojave Desert. Luckenbach (1982) reported that Marlow observed a ratio of two active burrows per tortoises on the Desert Tortoise Natural Area near California City. On the other hand, Coombs (1977) asserted that there was no predictable relationship between numbers of tortoises and "summer

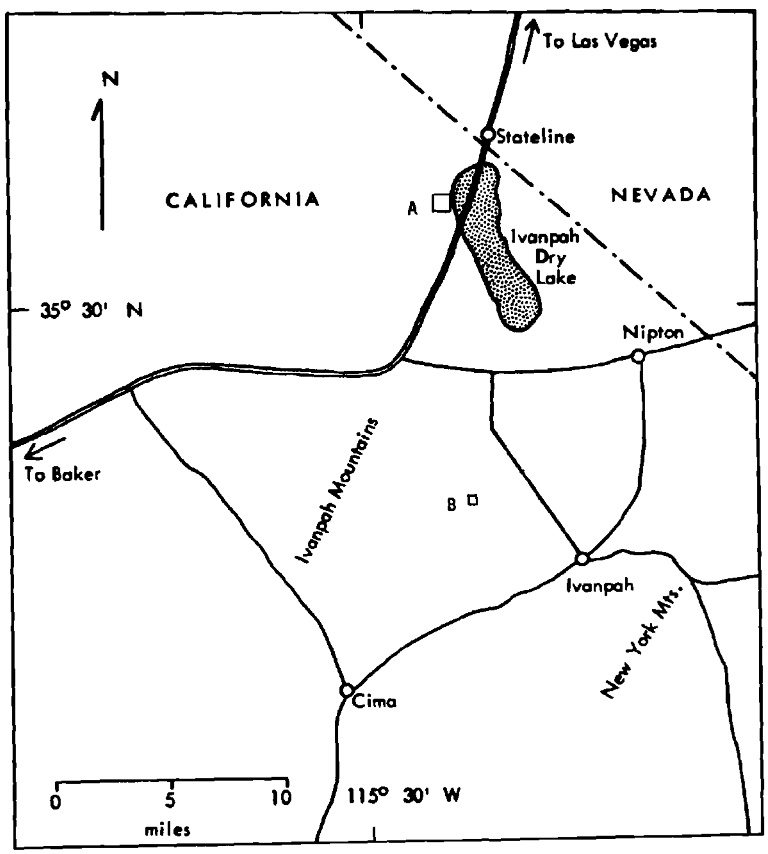

FIG. 1.—Ivanpah Valley, California, showing prospective power plant site (A) and Ivanpah Valley Permanent Study Plot (B).

holes" on the Beaver Dam Slopes in Utah. In Arizona, Burge (1979) found cover sites to be a "poor index" of tortoise presence and abundance, and judged both numbers of scats and total signs "inconclusive" indexes of tortoise density. These findings suggest that the procedures developed by Berry and Nicholson (1979) in California might not be applicable in other portions of the tortoise's range.

Other unavoidable sources of error and bias exist in such procedures. For example, different observers may record signs with differing efficiencies. The same individuals participated regularly in the transect work (over 950 of the counts were done by just two individuals), but the degree of observer bias has not been evaluated. The procedure is sensitive to differences in tortoise activity (and, hence, signs) in different years. We know that conditions for tortoise activity vary between years, and observations made in a favorable year (say, 1977) could not be easily compared with those made in a bad year (e.g., 1981). There may also be seasonal effects — within a given year — on the visibility of tortoises or their signs. Berry and Nicholson (1979) pointed out that transects examined during the spring in Ivanpah Valley yielded unusually high counts of burrows. This was attributed both to the time of year (burrows are more easily seen in the spring than in the summer and fall) and to general conditions peculiar to Ivanpah Valley. In areas with light-colored soils the dark scats of tortoises stand out, and in such areas sign counts may be unusually inflated because of high counts of scats.

The calibration of transect counts against estimated densities of tortoises is an indispensable step in the interpretation of counts of tortoise signs. The manner in which this has been done was described by Berry and Nicholson (1979). During 1977, permanent study plots, usually one mile square in area, were established, and numbers of tortoises directly enumerated in the course of 30 days of intensive sampling. Data from six of these permanent plots were used in calibration tests (Cottonwood Springs, Chuckwalla Bench, Fremont Valley, Ivanpah Valley, and two areas near Fremont Peak). Six to eight transects (total of 43) were examined in each of these plots in 1978. Seven of eight transects at Chuckwalla Bench, eight transects at Cottonwood Springs, five of the six transects in Fremont Valley, and seven of 15 transects near Fremont Peak were counted in October, 1978. One transect in Fremont Valley was examined in September, 1978, and the remaining transects (including six in Ivanpah Valley) were counted between 7 March and 1 June, 1978. Each transect was assigned to one of eight 1/4-mi^2 portions of the 1-mi^2 study plots, and numbers of tortoises marked during 30 days in these 1/4-mi^2 areas were computed from maps. Counts of burrows (b) and total corrected sign (TCS) along each transect were regressed on numbers of tortoises marked (m) in the areas. These analyses yielded two equations:

$$b = 0.14\, m + 0.7 \qquad (1)$$

$$\text{TCS} = 0.36\, m + 1.7 \qquad (2)$$

These regressions were based on 39 transects (with four variant points of the original 43 eliminated). Correlation coefficients were 0.71 and 0.79, respectively. Values of m were next regressed on values of b and TCS for each of 39 transects:

$$m = 3.5\ b + 7.70 \quad (3)$$

$$m = 1.7\ \text{TCS} + 3.98 \quad (4)$$

Correlation coefficients were 0.70 and 0.79, respectively. Equations (3) and (4) may be used, then, to estimate tortoise density ($n/0.25\ mi^2$).

This procedure is limited by the accuracy of total density estimates. Total densities were based on direct enumeration. Direct enumeration works well for larger tortoises, but is less effective for smaller tortoises. It is extremely difficult to find hatchling tortoises, and it is generally acknowledged that these individuals (and even tortoises up to 100 mm in length) are undercounted (Shields 1980). It is customary to adjust counts upward to allow for underrepresented younger tortoises. This problem has bearing on calibration procedures because if two populations have significantly differing age distributions, one may be more completely enumerated than the other. Subjective adjustments for missing tortoises may or may not remedy the discrepancy.

Some of the problems described in the foregoing can be avoided by adopting alternative modes of estimating densities. Schneider (1980) explored three ways of analyzing data from the Chemehuevi Valley by capture-recapture procedures, and emphasized the importance of considering different size groups separately. However, as pointed out by Schneider (1980), merely substituting capture-recapture techniques without tests of underlying assumptions will not alleviate existing concerns as to the reliability of estimators.

Heckel and Roughgarden (1979) have described a method of capture-recapture analysis which integrates field techniques with a method of statistical estimation. The field procedure requires marking and release of animals, and a chain of at least three samplings. The statistical method provides a number of different models with which to estimate total numbers from the census data, and enables the selection of the model giving an estimate with small error and good fit to actual data. The procedure permits the detection of and correction for differences in behavior (and catchability) of marked and unmarked individuals. If, however, there are suspected differences in sex or size groups, the groups must be treated separately.

In this paper, we attempt an evaluation of the "calibrated transect" procedure. The area of interest is the 4-mi^2 prospective Ivanpah Generating Station site in Ivanpah Valley, where conventional transects were examined in the spring of 1981. At the same time, we made transect counts in another part of Ivanpah Valley, and also estimated the abundance of the tortoise in this area by capture-recapture analysis. We then calibrated our transect counts against a measured density, using data acquired 1) in Ivanpah Valley and 2) in the 1981 season. The resulting equations were used to estimate the abundance of the tortoise at the power plant site, and our findings were compared with those reported by Nicholson (1980).

PROCEDURES

Our work during the spring of 1981 involved two related efforts. First, Burge made conventional transect counts of tortoises and tortoise signs in the environs of the power plant site. This work was distributed not only over the four sections proposed for the plant itself, but also 11 other sections in the vicinity where ancillary facilities would be located. Between 28 April and 16 May, 78 transects were examined. Each transect was composed of three legs 9 m wide and 805 m long, so that a "transect" embraced a total area of 2.17 ha. In this article, we will discuss only sampling data taken from 23 transects in the 4-mi^2 area proposed for the power plant (Sections 25, 26, 35, and 36 in Fig. 2).

The second element in our project was to make similar transect counts in the Ivanpah Valley Permanent Study Plot (PSP) and to estimate the absolute abundance of desert tortoises in the PSP. This plot is one of 26 areas used by the BLM for continuing studies of the status and dynamics of desert tortoise populations in California. The PSP is a 1-mi^2 area (T15N R15E, Section 27)

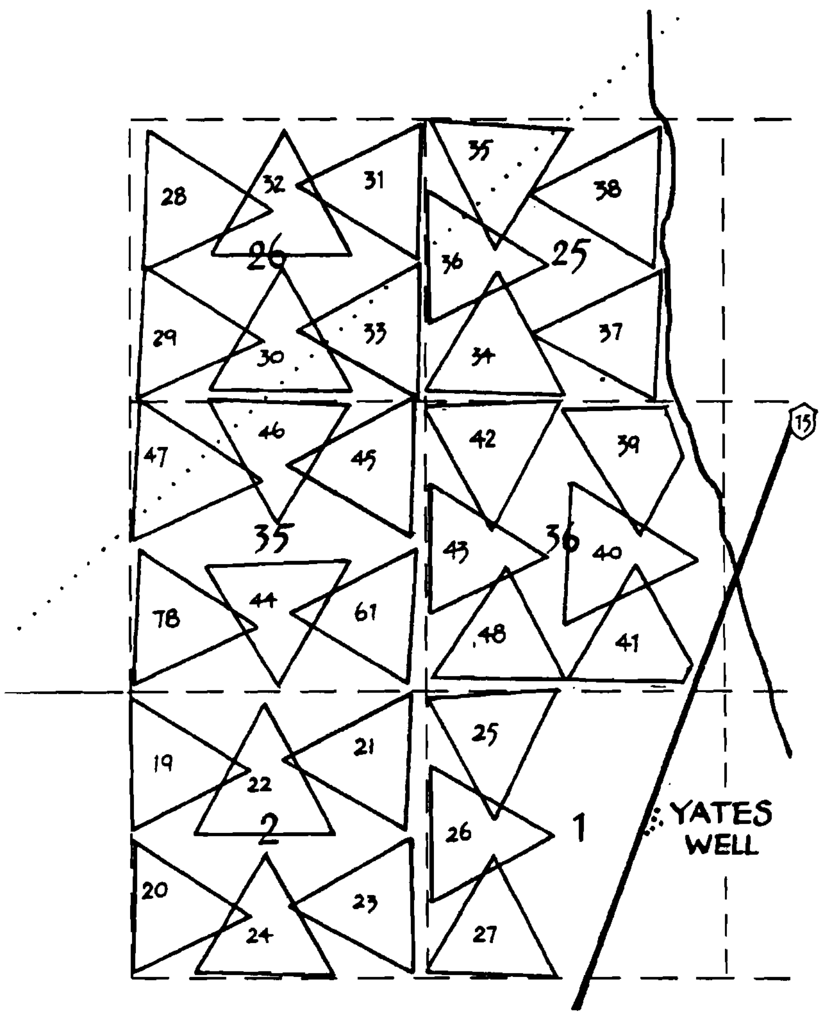

FIG. 2.—Distribution of transects examined at the power plant site during April and May, 1981.

about 21 km south of the proposed power plant site (Fig. 1). The PSP lies on a bajada at an elevation of from 900-950 m. The dominant shrubs are creosotebush and bursage. Other perennial species are typical of the creosotebush scrub community. Intensive observations of tortoises in the PSP have been conducted by Burge in 1977 and Woodman in 1979 (K. H. Berry *pers. comm.*). The density of tortoises on the plot (estimated by using 1979 sampling data and the Stratified Lincoln Ind3x) was 187/mi^2, with a 95% confidence range of 143-245 (Berry *pers. comm.*).

On 17 and 18 April, 1981, six transects within the PSP were examined. An additional six were inspected on 7 and 8 May, 1981. The May transects were laid out differently from those established in April. Distances along transects were estimated by pacing along bearings determined with a pocket transit. The inspection of a transect involved observation and recording of all observed tortoises, tortoise scats, cover sites (e.g., burrows, pallets, dens), tortoise skeletal remains, eggshell fragments, plus tracks and various depressions or excavations associated with tortoise activities. Woodrat (*Neotoma* sp.) nests and middens were examined for tortoise sign. All direct observations were recorded on a standard form (Berry and Nicholson 1979).

No scats, skeletal remains, eggshells, or tortoises were removed from the study area. However, all tortoises encountered were marked whenever possible. Notches were filed in marginal scutes according to a system developed by the Desert Tortoise Council. Notches were lined with yellow paint to facilitate later recognition. Tortoises out of reach or in fragile burrows were not marked.

The transect data collection form included much more information than is used in most analyses. The elements of most interest were counts of tortoises and their signs. An important step in interpreting signs is the adjustment or "correction" of total sign counts. The idea is that multiple signs found in one place (e.g., a cluster of scats, a group of shell fragments, a tortoise in a burrow with scats nearby, etc.) should logically be scored as a single "corrected sign." We developed a set of rules after discussions with Kristin Berry and Lori Nicholson Humphreys, which were set forth in BSAI's report to SCE (BioSystems Analysis, Inc. 1981).

Censuses of desert tortoises occupying the PSP were carried out by four biologists on three occasions in April (4-5, 11-12, 17-18) and again in May (2-3, 8-9, 15-16). Sexes (if ascertainable) and sizes were recorded for all tortoises registered. Records of animals captured and recaptured during the three April censuses were maintained and grouped in the manner described by Heckel and Roughgarden (1979). The same procedure was repeated in May, but none of the April capture-recapture experience was carried over into the May sampling. All animals registered on 2-3 May were treated as newly captured, regardless of whether they were observed in April. Data were grouped as described above. These censuses represented, therefore, two independent assessments of the PSP desert tortoise population.

Capture-recapture data were divided into three size groups: tortoises less than 100 mm in plastron length, tortoises 101-180 mm in length, and tortoises

TABLE 1. — Counts of desert tortoises and signs in four sections at the prospective site of a coal-burning power plant in Ivanpah Valley, April-May 1981.

	Sections			
	25	26	35	36
Elevation (m)	800-817	811-854	817-860	800-817
Number of transects examined	5	6	6	6
Tortoises	0	0	1	0
Mean total corrected sign (TCS)	1.80	3.57	4.83	1.33
Mean burrow sign (b)	1.20	2.17	1.50	0.50
Range (TCS)	0-4	0-7	3-10	0-2
Range (b)	0-4	0-5	1-3	0-1

exceeding 180 mm in length. Data from both censuses were analyzed using a computer program supplied by J. Roughgarden. Two analyses were made for each census, all tortoises (regardless of body size) and tortoises exceeding 180 mm in length. The analytical procedure was that described by Heckel and Roughgarden (1979). Capture-recapture data for April and May were also analyzed as described by Schumacher and Eschmeyer (1943). Pooled data for all tortoises and for only tortoises exceeding 180 mm in length were analyzed. Confidence intervals were computed as recommended by DeLury (1958).

RESULTS

Table 1 summarizes pertinent features of 23 transects examined in the four sections at the prospective power plant site. In August 1980, Nicholson (1980) examined 18 transects in these same four sections. The locations of Nicholson's transects are shown in Figure 3. For purposes of this study, the number of miles she walked was estimated from this figure, and burrows were counted in each of Sections 25, 26, 35, and 36. If total corrected sign (TCS) could not be clearly inferred (these were not mapped), it was prorated according to the proportions of transects within the area of reference. Table 2 presents a comparison of Nicholson's 1980 results with Burge's 1981 counts. Burge walked about 1-1/2 times as many miles as Nicholson, and, on an overall basis, observed about the same density of burrows. Burge recorded significantly more signs, even when totals were adjusted for distances walked.

A better way to contrast experiences of the two workers is to match transects as closely as possible. Table 3 illustrates comparisons of 13 of Nicholson's transects and a group of well-matched transects examined in 1981. Note that Table 3 also ranks observations. Rankings of this nature are compared by computing the statistic r_s (Snedecor 1956). This statistic may range from -1.0 (complete disaccord) to +1.0 (complete accord). The hypothesis tests whether a correlation exists between rankings of observers. For 13 cases, the critical r_s values for rejecting the hypothesis (at 1% level) are $>+0.661$ and <-0.661. We compute r_s as:

$$r_s = \frac{1 - 6 \Sigma d^2}{n(n^2 - 1)} \tag{5}$$

with d^2 equal to the square of the differences in rank for each pair of observations and n equal to the number of observations compared. Values of r_s for cover sites (burrows) and for TCS were 0.78 and 0.71, respectively, which reject the hypotheses tested. Hence, there is a significant positive correlation in rankings of both kinds of sign by the two observers. Both observers recorded the largest numbers of cover sites and TCS in the same areas of the study site in two independent efforts.

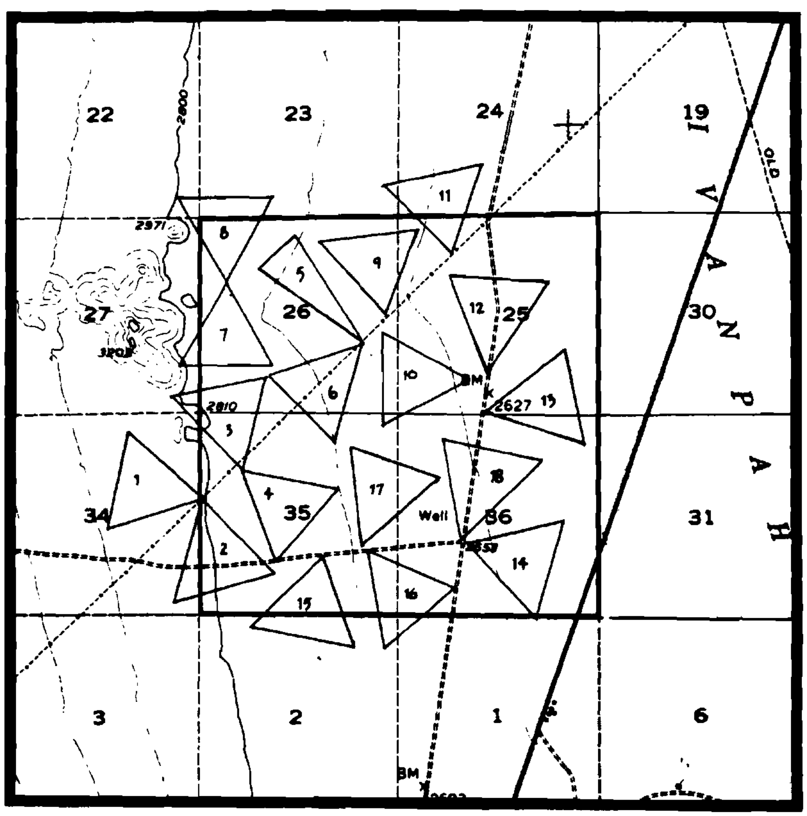

FIG. 3.—Distribution of 18 transects examined by Nicholson at the power plant site in August, 1980.

TABLE 2. — Comparisons of counts of tortoise signs at the prospective site of a coal-burning power plant in Ivanpah Valley in 1980 (Nicholson) and 1981 (Burge). Upper of each pair of values is that of Nicholson.

	Sections				
	25	26	35	36	All four
Miles walked	4.1	6.6	5.8	4.7	21.2
	7.5	9.0	9.0	9.0	34.5
Cover sites	1	9	10	1	21
	6	13	9	3	31
Total corrected sign (TCS)	1	11	14*	4*	30*
	9	22	29	8	68
Cover sites/mi	0.24	1.36	1.72	0.21	0.99
	0.80	1.44	1.00	0.33	0.90
TCS/mi	0.24	1.67	2.41*	0.85*	1.41*
	1.20	2.44	3.22	0.89	1.97

*approximated

Table 4 summarizes data collected along 12 transects examined at the Ivanpah Valley PSP during mid-April and early May, 1981. The mean number of cover sites observed in April was 7.7 (s = 3.8), while the mean TCS was 20.2 (s = 5.5). In May, cover sites averaged 10.8, and TCS 35.5 per transect. Standard deviations were 4.0 and 9.1, respectively. Live tortoises comprised almost 6% of TCS in April. Of the seven observed, five were in the open. During May, tortoises contributed less than 1% of TCS, and both tortoises observed were in burrows. Tortoise sign increased conspicuously between April and May because of marked increases in number of scats and cover sites in the latter month.

Table 5 shows the results of capture-recapture censuses conducted in April and May in the Ivanpah Valley PSP. Animals were grouped (according to capture-recapture experience) as the figures enter the Heckel-Roughgarden model:

Category 1 - Animals marked on day one.

Category 12 - Animals marked on day one and day two.

Category 2 - Unmarked animals captured and marked on day two.

Category 123 - Animals seen on all three days.

Category 13 - Animals marked on day one and later seen on day three (but not day two).

Category 23 - Animals newly marked on day two and recaptured on day three.

Category 3 - Unmarked animals observed on day three.

TABLE 3.—Counts and relative ranks of tortoise signs observed in 1980 and 1981 at the prospective site of a coal-burning power plant in Ivanpah Valley.

Nicholson transects (1980)	Burge transects (best fits) (1981)	Cover sites (and ranks)		TCS (and ranks)	
		Nicholson	Burge	Nicholson	Burge
1	5	4 (1.5)	7 (1)	5 (2)	9 (2)
2	78	2 (4.5)	3 (3.5)	2 (6)	10 (1)
4	44	2 (4.5)	2 (5)	3 (4)	5 (4.5)
5	32	3 (3)	1 (8)	5 (2)	3 (7)
7	29	1 (6.5)	5 (2)	2 (6)	5 (4.5)
8	28	4 (1.5)	3 (3.5)	5 (2)	7 (3)
9	31	0 (10.5)	1 (8)	0 (11)	3 (7)
10	34	0 (10.5)	1 (8)	0 (11)	3 (7)
11	35	1 (6.5)	1 (8)	1 (8)	2 (9.5)
12	38	0 (10.5)	0 (12)	0 (11)	0 (12.5)
13	37	0 (10.5)	0 (12)	0 (11)	0 (12.5)
14	41	0 (10.5)	1 (8)	2 (6)	2 (9.5)
18	40	0 (10.5)	0 (12)	0 (11)	1 (11)

TABLE 4.—Desert tortoise data collected along 12 transects in the Ivanpah Valley Permanent Study Plot in April and May, 1981.

Dates	Transect number	Live tortoises	Scats	Cover sites	Skeletal remains	Total observed sign	Total corrected sign
April 17-18	1	1	4	10	1	16	15
	2	2	9	8	...	19	19
	3	1	17	2	...	20	20
	4	...	9	5	1	15	15
	5	1	8	8	4	22	22
	6	2	15	13	1	31	30
Totals		7	62	46	7	123	121
May 7-8	7	...	25	4	...	29	28
	8	...	24	15	...	39	39
	9	1	12	11	...	24	22
	10	1	20	14	...	35	34
	11	...	32	12	1	45	45
	12	...	32	9	3	44	44
Totals		2	145	65	4	216	212

TABLE 5. — Results of the capture-recapture census conducted at the Ivanpah Permanent Study Plot in April and May, 1981.

Month	Size/sex categories	Capture-recapture categories						
		1	12	2	123	13	23	3
April	0-100 mm	2	0	2	0	0	0	10
	101-180 mm	2	0	8	0	0	3	10
	>180 mm/male	12	4	12	1	2	4	12
	>180 mm/female	10	3	10	1	0	1	9
	Total population	26	7	32	2	2	8	41
	>180 mm tortoises	22	7	22	2	2	5	21
May	0-100 mm	4	0	0	0	0	0	0
	101-180 mm	9	1	2	0	0	0	3
	>180 mm/male	15	3	15	0	4	1	4
	>180 mm/female	12	3	6	1	3	2	5
	Total population	40	7	23	1	7	2	12
	>180 mm tortoises	27	6	21	1	7	2	9

A total of 99 different tortoises was registered at the PSP during the April census; 75 were recorded in May (though many of these had been previously observed in April). In April and May, collectively, 138 different tortoises were observed in the PSP. Sixteen were ≤100 mm in length; 31 were 101-180 mm in length (11 males, 11 females, and nine of unknown sex); 49 were males exceeding 180 mm in length, and 42 were females greater than 180 mm. Few conclusions can be drawn from the capture-recapture data pertaining to tortoises up to 180 mm in length (Table 5). Not many were captured, and recaptures were a rare event. Capture-recapture experience of large males and females was similar. Hence, data were analyzed pertaining to the entire population and to a smaller group of male and female tortoises greater than 180 mm in length. Table 6 gives estimates for these components for April and May based on the Heckel-Roughgarden model and the Schumacher-Eschmeyer technique.

For three censuses, as carried out in April and again in May, there are eight sighting histories possible for tortoises occupying the area. These histories correspond to the seven "capture-recapture categories" in Table 5. An eighth category is represented by tortoises never seen at all. The point is to estimate the size of this last category from observed values in the other seven. We can also compare values in the seven observed cells with values expected under certain assumptions. Chi-squared tests are built into the analytical procedure. A poor fit indicates that the assumptions are not satisfied. The

TABLE 6. — Estimated numbers of desert tortoises ($n \cdot mi^{-2}$) in the Ivanpah Valley Permanent Study Plot in the spring of 1981. 95% confidence ranges are given in parentheses. Ranges for the Heckel-Roughgarden estimates are ± 2 times estimated standard deviations of estimates.

Analytical method	Dates	Total tortoise population	Tortoise population >180 mm
Heckel-Roughgarden	April	222 (144-299)	126 (80-172)
	May	151 (97-204)	101 (66-136)
Schumacher-Eschmeyer	April	233 (136-810)	131 (79-381)
	May	149 (114-212)	99 (72-159)

simplest hypothesis " . . . assumes that the samples taken on each of the . . . visits are independent of each other." That is, " . . . the probability that an animal is marked on one visit is independent of whether it is marked on another . . ." (Heckel and Roughgarden 1979:969). The values of X^2 associated with the four Heckel-Roughgarden estimates in Table 6 ranged from 2.12 to 4.85. With 3 degrees of freedom, the critical X^2 value (5% level) was 7.81. Hence, in no case was the hypothesis of independence rejected, and it was not necessary to invoke any of the other models assuming various forms on interdependence of captures.

The best estimate of the 1981 tortoise population in the Ivanpah Valley PSP is not readily apparent due to the discrepancy between the April (222-233) and May estimates (149-151). This difference may be partially interpreted in terms of the transect data. As discussed above, fewer tortoises were observed in May, and those seen were in burrows. Both the lower May population estimate and the difference in relative contributions of live tortoises to TCS in April and May would be consistent with a reduction in aboveground activity of tortoises. For this reason, the mean of the two April estimates (n = 227) is adopted as the best available representation of the 1981 population of the PSP. We must then decide whether to use April or May signs in conjunction with the April population estimate to develop predictive equations. Arguments can be advanced favoring either approach, and for the purposes of this report both relationships will be considered. If April signs are used, the density predictors are:

$$D = 29.61\ (\overline{b}) \tag{6}$$

and $$D = 11.07\ (\overline{TCS}) \tag{7}$$

If May signs are used, the equations are:

$$D = 20.95\ (\overline{b}) \tag{8}$$

and $$D = 6.31\ (\overline{TCS}) \tag{9}$$

where $\overline{b}$ is the mean number of cover sites per transect, $\overline{TCS}$ is the mean number of total corrected sign per transect, and D is the estimated density of tortoises (n/mi^2).

Nicholson (1980) divided the 4-mi^2 area of the power plant site into four zones of varying tortoise density. Estimated abundance of the tortoise was 0-10/mi^2 in Zone A, 10-20/mi^2 in Zone B, 20-50/mi^2 in Zone C, and 50-75/mi^2 in Zone D. Table 7 shows the results of matching 21 of Burge's 1981 transects with Nicholson's zones. Using the data in Table 7, we can compare results of the 1980 and 1981 investigations of the power plant site (Table 8). Except for the high densities estimated from counts of cover sites in Zone D (Equations 6 and 8), all 1981 density estimates are in good accord with Nicholson's 1980 density ranges. Figure 4 illustrates four models based on 1981 data. All of these give similar estimates when counts of sign are low (say, $\leqslant 5$). As sign counts increase, conspicuous divergences in estimates occur.

DISCUSSION

The results of this work are reassuring at one level, but raise serious questions pertaining to future investigations of densities of desert tortoises. Independent evaluations of the abundance of the desert tortoise at the power

TABLE 7.—Mean numbers of cover sites and total corrected sign (TCS) observed in four parts of the prospective site of a coal-burning power plant in Ivanpah Valley. Transects are grouped to coincide with four zones defined by Nicholson (1980).

Transect numbers 1981	Nicholson's zone	Mean numbers cover sites	Mean numbers of TCS
35, 37, 38, 39, 40, 41	A	0.33	0.83
31, 33, 42, 43, 48	B	0.60	0.63
30, 44, 45, 46, 61, 78	C	1.83	4.83
2, 4, 5, 28	D	6.33	8.67

TABLE 8.—Estimated densities (n/mi^2) of desert tortoises at the prospective site of a coal-burning power plant in Ivanpah Valley in 1980 and 1981. The 1981 estimates are based on the four models derived on pages 139 and 140.

Zones	Nicholson (1980)	Equation 6	Equation 7	Equation 8	Equation 9
A	0-10	10	9	7	5
B	10-20	18	7	13	4
C	20-50	54	53	38	30
D	50-75	187	96	133	55

plant site in 1980 and 1981 ranked the quality of habitat within the area similarly. Density estimates in various parts of the site were generally comparable.

On the other hand, the procedure tested is clearly limited in what it can tell us about the abundances of tortoises. The technique is vulnerable to error at two stages: first, in counting signs and correcting counts of signs; second, in estimating densities with which sign counts are calibrated. The kinds of problems involved in the first stage have already been referred to (e.g., observer bias, differences between years and seasons, unique characteristics of some areas affecting visibility of sign, etc.) but the quantitative effects of these sources of error on sign counts are not understood. The use of 30-day registries as estimates of "density" was another source of error, quite possibly a serious one. The situation is further confused by the use of counts of burrows (or cover sites) and total corrected counts of signs as bases for regression models, when it is clear that the two procedures lead to different results (e.g., *see* Fig. 4).

It is important to bear in mind the history of research on desert tortoises in California, and the original purpose for which the transect technique was developed. When this work began, we knew virtually nothing of the local distribution and relative abundance of the desert tortoise in any part of its geographic range. Rapid and relatively uncomplicated methods of assessing the status of the species over hundreds of square miles were needed. The transect technique served this purpose well, and Berry and Nicholson (1979) provided four classes of density ranges which could be used to rank large regions of California: $>250/mi^2$, $100-250/mi^2$, $50-100/mi^2$, and $<50/mi^2$. The technique does not err in identifying poor habitat as good habitat, but is limited in how well it can discriminate between various grades of good habitat. Furthermore, no confidence ranges can be assigned to any of the transect-count-derived density estimates.

As concerns for the protection of desert environments and wildlife resources have grown, demands for increasingly rigorous biological data have escalated. In attempting to weigh the environmental costs of building the proposed Ivanpah Generating Station, the CEC seeks (as much as is practicable) precise estimates of the numbers of tortoises occupying the 4-mi^2 plant site and the environs. Hence, the need to assess old techniques in the light of new research requirements.

We believe that better methods of estimating numbers of tortoises need to be developed. The use of the transect technique, as presently constituted, can neither generate confidence intervals for estimates nor achieve the level of accuracy currently demanded.

So what can be done? At least two avenues for future effort exist: 1) some modification and/or improvement of the line transect technique, and 2) capture-recapture analysis. Recent treatments of these two procedures are available which can serve as guides to planning, or in deciding on relative merits of the two approaches (Otis et al. 1978, Burnham et al. 1980). In theory, the line transect technique can be based on animal signs, but only if some well-defined relationship between sign and animal abundance exists, say, a 1:1 relationship between nests and individuals. In practice, line transect analyses are based on counts of animals along lines, coupled with measurements of distances and angles between the center line and observed animals. It is

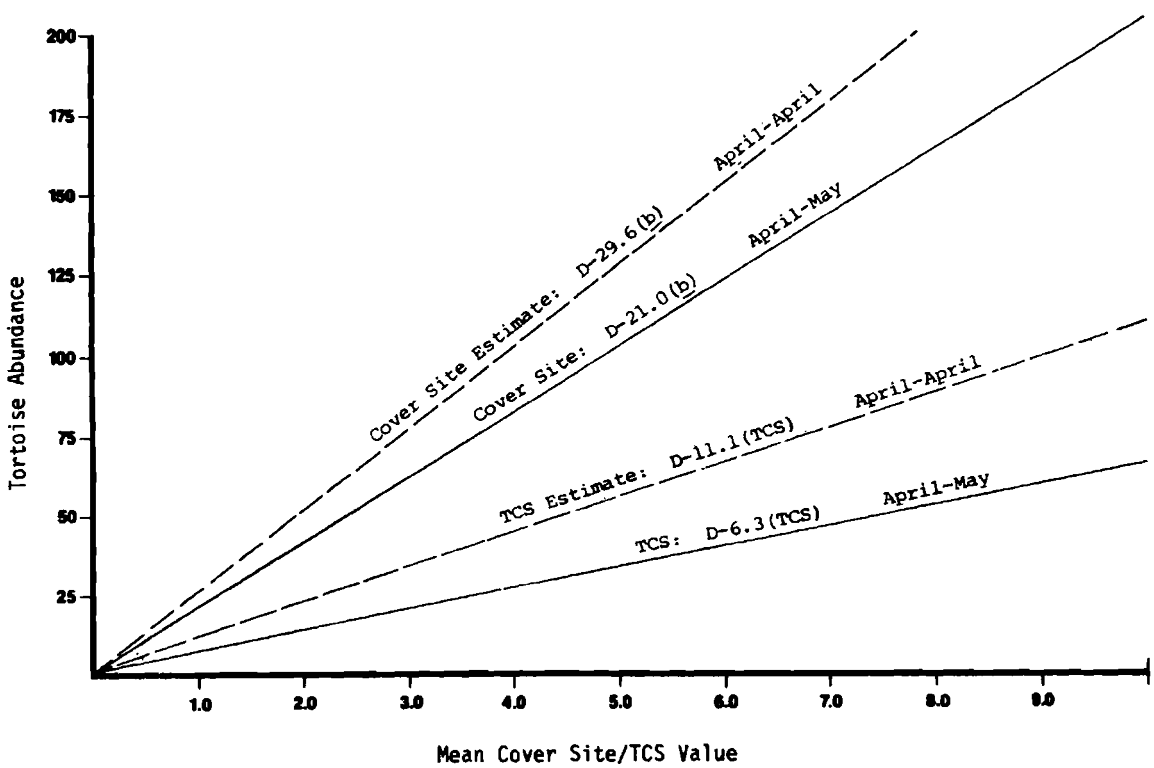

FIG. 4.—Four alternative models for estimating tortoise density during from work in Ivanpah Valley during the spring of 1981.

also necessary to assume — or determine empirically — a "detection function," which expresses the probability of an animal being observed as a function of its distance from the line (Burnham et al. 1980:15). Contrary to common belief, it is not necessary that the population of interest be randomly dispersed, nor is it necessary for all components of the population to be observed with equal ease. The detection function can be a mixture of many simple functions, where each applies to a particular element of the population. Detection functions can vary according to conditions existing at the time of a census, or even observer efficiency. The techniques described by Burnham et al. (1980) are clearly more complex than existing transect procedures. We do not argue that such procedures are the best option to pursue (e.g., the probability of seeing live tortoises along transects is low, and the power of any method is severely undermined when few animals are counted). However, the ideas discussed by Burnham et al. (1980) are an essential element in planning future studies of tortoise density.

Capture-recapture analysis is an attractive alternative because it requires neither measurements of distances, nor assumptions as to detection functions. As has been recognized, the problems lie in departures from standard assumptions underlying capture-recapture models. All of these problems were fully analyzed by Otis et al. (1978) and solutions to some of them are provided. Otis et al. dealt with "closed" populations, i.e., populations which are not depleted by deaths or emigration nor diluted by opposing processes during the study. For short-term tortoise investigations, the assumption of closure is justified. The concern of Otis et al., then, was not with the kinds of problems addressed by Seber (1965) and Jolly (1965), but with three sources of error encountered in sampling closed populations: loss of marks, errors in recording marks, and unequal probabilities of capture. In practice, the last issue is paramount. Otis et al. (1978:11) described three kinds of unequal capture probabilities: 1) variation with time, i.e., animals are more likely to be captured during one census than another, 2) unequal behavior of animals once captured vs. those never captured (e.g., trap shyness or habituation), and 3) variation in the probability of capture of different individuals. In some situations, two, or even all three, of these sources of variation may be operative. Otis et al. continued with discussions of various ways to deal with some, but not all, of these situations. In our work at the Ivanpah Valley PSP, we were able to test for only one type of departure from assumptions, viz., the probability that an animal marked during one census was independent of whether it was marked during another. In fact, our capture-recapture analysis (based on data in Table 5) is a good illustration of problems yet to be resolved. We obviously did not estimate the number of small tortoises (<180 mm) accurately, and, in fact, can draw no real inferences as to their abundance from the data acquired in April and May 1981. We accepted an estimate of 200+ tortoises in the plot principally because this figure was in agreement with earlier estimates.

This leads to a final consideration bearing on use of line transects and capture-recapture analysis as methods for estimating tortoise densities. In our view, the low probability of observing small tortoises stands as the principal obstacle to application of any method of estimating the abundance of the species. If a line transect technique is used, we must find a way to estimate individualized detection functions for the smaller size classes of tortoises.

If capture-recapture analysis is used, we must give particular attention to departures from what Otis et al. (1978) referred to as the "null case," when probabilities of capture are invariant.

ACKNOWLEDGMENTS

Craig Lyons, Norma Maes, Bernardo Maza, Philip Medica, and Arthur Vollmer conducted censuses of tortoises in the Ivanpah Valley PSP. Russell Beck, Nelson Vincent, and Thomas Moll provided assistance in the field. We thank Kristin Berry, Lori Humphreys, and Jonathan Roughgarden for valuable advice. Deborah Fitch gave secretarial assistance.

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A PRELIMINARY REPORT ON THE STATUS OF CHELYDIDRAE, TRIONCYCHIDAE, AND TESTIDINIDAE IN THE REGION OF BAJA CALIFORNIA, MEXICO

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Peninsular Baja California, Mexico, is unique in many respects, not the least of which is the dearth of information concerning the history of the region. This is particularly surprising considering the fact that it was first discovered in 1533. However, for the next century and a half, it was visited no more than 15 times by Europeans.

During this period, because of the hostile nature of both the Indians and geography, several attempts to colonize the region failed, and only one serious overland expedition succeeded (Crosby 1974).

In 1697, the Jesuits landed at Loreto and began the mission system that was ultimately to extend throughout California Alta as well. By this time, the ancestral aboriginal cultures had been severely decimated because of over 16 decades of intermittent exposure to European diseases.

During the 75 years of Jesuit occupation, subsequent to the establishment of the first mission at Loreto, a few books were written concerning the land and its inhabitants — the most comprehensive of these being "The Natural History of Baja California" by Miguel del Barco (1957), "Observations of Lower California" by Johann Jakob Baegert (1772), and "The History of Lower California" by Francisco Javier Clavijero (1789).

The first English description of the natural history of Baja California was not written until 1900, and it concerned only central Baja California (Eisen 1900). The first comprehensive scientific manuscript of the flora and fauna of Baja California was written by Goldman and Nelson after several years of intermittent exploration throughout the peninsula (Goldman and Nelson 1922).

With the exception of Harry Crosby, most historians have chosen to ignore the region because of the sparse amount of written material available (Crosby 1974). Max Moorehead, in his monumental work, "The Presidio: Bastion of the Spanish Borderlands," a tome of the history of California, chose to ignore Baja California completely (Moorehead 1975).

The entire area probably never supported more than between 20,000 and 40,000 natives prior to the initial contact with Europeans (Aschmann 1967). Once California Alta was discovered by the missionaries, the peninsula served only as an overland highway to this greener and more hospitable country north of the 32nd parallel. Unlike mainland Mexico and California Alta, the peninsula was never really colonized (Crosby 1974).

GEOGRAPHY

Baja California is a jagged finger of land extending from the southern border of the state of California to a little south of the Tropic of Cancer. It wanders irregularly south and east from lat. 32°30'N, long. 117°W at the northern international boundary and the city of Tijuana to terminate in the Pacific Ocean 1,300 km later at Cabo San Lucas at lat. 22°50'N, long. 11°W after penetrating well past the Tropic of Cancer.

The peninsula is separated from mainland Mexico by a body of water 160 km wide, usually known as the Gulf of California or the Sea of Cortêz To the west and south lies the Pacific Ocean. Baja California varies in width from 240 km at the international border in the north to 35 km at the Bahía de La Paz, 155 km above its southernmost tip. Baja California comprises an area one-third the size of California and has 3,240 km of shoreline — twice as much as that of California (Wiggins 1981).

GEOLOGY

The peninsula separated from mainland Mexico around 25 million years ago and began moving northwest. At the present time, it is approximately 720 km northwest of where it began. For the past four million years, the land mass has more or less maintained its present form (Anderson 1971).

Although the isolation of the peninsula has been relatively recent in geologic time, the separation has been complete enough to create a high degree of endemism or near-endemism of both floral and faunal elements (Savage 1959, Wiggins 1980). This is particularly true of the numerous islands surrounding the land mass (Murphy 1975).

PHYTOGEOGRAPHIC REGIONS

There is considerable variation in both floristic and faunistic elements within the 1,300 km-long peninsula. This might be expected because it is the longest well-isolated north-to-south finger of land in the world with the exception of the Malaysian Peninsula (Savage 1959). In addition, the elevation goes from below sea level to 3,096 m (over 10,000 ft) and rainfall varies between 50 mm and 750 mm (Hastings and Turner 1965). The phytogeography of the peninsula is best described in three principal vegetative zones — the Californian Region, the Desert Region, and the Cape Region (Wiggins 1959, 1981). Savage (1959) further divides the Desert Region into the Colorado Desert (in the north) and the Peninsular Desert Region. The latter is also known as the Central Desert Region (Savage 1959; Wiggins 1969, 1980).

The Californian Region can be considered an extension of the southwestern California mountain ranges and their Pacific slopes.

The Desert Region includes the eastern scarps of the northern mountain ranges, the central one-third of the peninsula with the exception of the Sierra de la Giganta, and the Cape Region.

The Cape Region includes the Sierras de la Laguna and de la Giganta, in addition to their drainages, as well as the southern mangrove forests on both seacoasts. The inclusion of the mangrove forests in the Cape Region is a somewhat arbitrary designation.

GOPHERUS AGASSIZII

The desert tortoise, *Gopherus agassizii*, occurs close to the United States/ Mexican international boundary in the proximity of the peninsula, as well as in Sonora and on Isla Tiburon in the Gulf of California (Luckenbach 1976, Dimmitt 1977, Bury 1980).

Isla Tiburón is located 8 km west of mainland Mexico and is usually considered to be part of the state of Sonora, both for political and phytogeographic purposes.

Isla Tiburón, located at the 28th parallel in the eastern Gulf of Baja California, has a resident population of *G. agassizii*. The Seri Indians have not occupied the island since 1955, and the Mexican government has had a wildlife management program there since 1967. There are no domestic livestock on the island. These very favorable conditions for the desert tortoise during recent years have apparently resulted in the high population counts found in a recent survey (Osorio and Bury 1982).

The Seri Indians considered the desert tortoise a popular food item, as do some Sonoran ranchers today. During island-hopping excursions to Isla San Esteban, 11 km west of Isla Tiburón, as well as Isla San Lorenzo, another 16 km beyond Esteban, the Seris may have carried the desert tortoise with them for food (McGee 1971). Mexican fisherman have reported the presence of *G. agassizii* on Isla San Esteban, but no confirming records exist.

G. agassizii has been listed as occurring, or as possibly occurring, in Baja California in some references, both published and unpublished (Stebbins 1966, Smith and Taylor 1966, Hunsaker 1977, Loomis and Sanborn 1976).

The species does not occur in Baja California. It is possible that prior to the cultivation and canalization of the Imperial and Mexicali valleys, it may have occurred sporadically in the northeastern peninsula. Any westward extension of the range of *G. agassizii* would be extremely difficult today because of the barriers known as "The Great Sand Dunes" east of the Mexican Colorado River and extensive agriculture on both sides of the now-dry Colorado River channel (Ives 1971).

TRIONYX SPINIFERUS

The spiny softshell turtle, *Trionyx spiniferus*, is reasonably common in the Mexicali Valley of the northern Desert Region of Baja California. This species migrated westward within the recent past and entered the Colorado River from the Gila River about the turn of the century (Miller 1946, Stebbins 1966). The aggressive *T. spiniferus* is undoubtedly responsible for the absence of *Kinoster-*

non sonoriense in the lower Colorado River and irrigation canals at the present time. No mention was made of *Trionyx* sp. in Van Denburgh (1922) or Nelson (1922); consequently, it was probably absent or rare in the lower Colorado at that time. Most of the canalization and irrigation of the Colorado River delta began in the late 1930s, enabling the spiny softshell to extend its range. *T. spiniferus* does not occur in the streams and lakes of the Pacific drainage of the northern mountains or elsewhere in the peninsula.

Some lists of the reptiles of Baja California include *K. sonoriense* (Stebbins 1966, Smith and Taylor 1966, Loomis 1976, Hunsaker 1977). An extensive search was made of the region below Yuma, Arizona, by the author without success several years ago. It is highly unlikely this species occurs in the peninsula at the present time.

Both *K. sonoriense* and *K. flavenscens* have been recorded in the Colorado River a few km north of the United States/Mexican border near Yuma, Arizona (Van Denburgh 1922). Both species appear to have become extinct in the region since then.

CLEMMYS MARMORATA

The Pacific or western pond turtle, *Clemmys marmorata*, is found only in the riparian ecosystems of the Pacific slopes of the two northern mountain ranges of Baja California Norte. It does not occur in Baja California Sur (Stebbins 1966, Smith and Smith 1979).

The vegetation of these riverine corridors is generally comparable to that of southern California and is usually identified in textbooks as the Californian Region of Baja California (Coyle and Roberts 1976).

The streams in which *C. marmorata* occur are sometimes semi-perennial at lower elevations because of the demands of extensive agriculture in their coastal floodplains.

At higher elevations and in the steeper arroyos and canyons, oak willow bosques are often several miles in extent and relatively undisturbed except for livestock grazing. The western pond turtle's range at the present time is restricted to a few of these riparian ecosystems between La Misíon to the north and San Quentín in the south, a distance of about 240 km.

Periodic flooding during cyclonic storms from the north and an occasional "chubasco" from the west or south has discouraged human invasion of several of these secluded canyons, protecting both *C. marmorata* and the endangered red-legged frog, *Rana aurora*, in the region.

During recent years, *C. marmorata* has been found in Rio San Carlos 13 km below Ensenada, as well as in Rio Santo Tomas several km east of the village of Santo Tomas in Rio San Vicente and Arroyo San Telmo. All riverine corridors are Pacific coast drainages of the Sierra Juárez.

The western pond turtle also occurs in Rio San Rafael and Rio Santo

Domingo, both of which drain the Sierra San Pedro Mártir range to the immediate south of the Sierra Juárez range.

The long-term outlook for the pond turtle is rather glum because of the gradual loss of habitat caused by human invasion and agriculture. Although a few *C. marmorata* were formerly found in the Central Desert at Misíon San Fernando, a 1978 chubasco filled the ponds below the mission with sand, more or less permanently removing the habitat. This was the only region in the peninsula where the species was known to exist in a true desert ecosystem.

CHRYSEMYS SCRIPTA NEBULOSA

The Baja California pond slider, *Chrysemys scripta nebulosa*, has rather scattered distribution in the southern half of the peninsula where it is found in the true desert. It does not occur north of the 28th parallel dividing the states of Baja California Norte and Baja California Sur. *C. scripta nebulosa*, like *C. marmorata* to the north, is only found in the riparian ecosystems of the peninsula.

Rio San Ignacio, which runs west from the town of San Ignacio located mid-peninsula, has a relatively stable population of pond sliders. A low dam 16 km west of the town was built on the river in 1927 by a rancher, Juan Lucero Arce. It has provided an excellent riparian ecosystem that is rarely visited by humans. The riverine corridor has several large natural ponds extending westward toward Laguna San Ignacio from the lake created by the dam. Most of the larger of these ponds also have turtle populations.

It has proven difficult to obtain an exact count because many of these ponds are not sufficiently clear, but estimates have been made during late spring and early summer by the author and others. The highest count obtained indicates approximately 100 *C. scripta nebulosa* exist in the 8 km extent of the ecosystem. A reasonable number of these were juveniles or subadults.

The desert through which this river flows is an ancient sea bed strewn with lava flows and no agricultural development of the area is probable, nor is there sufficient grazing opportunity for more than a few cattle. Consequently, this area should remain relatively undisturbed for many years.

Rio de la Purísima is located in the heart of the Sierra de la Giganta approximately 130 km to the south of Rio San Ignacio. Like Rio San Ignacio, it cuts through an old, lava-strewn seabed and flows leasurely toward the Pacific. There are two small towns along the river — La Purísima and San Ysidro.

C. scripta nebulosa is found along several km of the riverine corridor. The largest population is located close to the town of San Ysidro. In 1979, 23 adults were observed sunning on a flat rock adjacent to the river. There were several smaller populations in some large ponds located both above and below a low dam known as "El Zacatecas."

Rio de la Pasión is a meandering, sometimes intermittent stream that disappears into the sand after flowing westward for several km from the village of La Presa below Misíon La Pasión. Located 190 km south and east of La Purisima, the river has a resident population of *C. scripta nebulosa*. Rio de la Pasion becomes a series of ponds during periods of drought. It represents the southernmost extension of the range of the pond slider in the peninsula.

Some of the literature indicates that *C. scripta nebulosa* occurs in the Sierra de la Victoria drainages at the Cape (Van Denbrugh 1922, Loomis 1976, Hunsaker 1977, Smith and Smith 1979); this is no longer true. It has been at least a decade since *C. scripta nebulosa* has been observed by the natives and travelers in the region (Bob Van Warner, *pers. comm.* in 1976; Harry Crosby, *pers. comm.* in 1978).

In Baja California Sur, all three of the relatively isolated populations of *C. scripta nevulosa* are undoubtedly safe. Their respective ranges are quite limited, however, and there is no reasonable possibility of extension to other riverine corridors.

During periods of drought, water tables are lowered by overuse of the resources and, ultimately, some of the ponds could dry up in the Rio de la Pasion ecosystem. There are recorded periods in this region where no rain has fallen for four years (Hastings and Humphrey 1969).

During such droughts, or "secas" as the natives refer to them, livestock herds are sold and the people sometimes are forced to move on, but not before substantial damage has been done to the flora.

Sometimes a periodic chucasco will flood the arroyos and carry nearly everything in them, including most of the amphibians and reptiles, out to sea. The undependability and inconsistency of the climate has proven a limiting factor on all faunal populations in Baja California.

Although, for the present at least, these peninsular populations of turtles are reasonably secure, only in the case of *T. spiniferus* has a range been extended in recent decades. The range of both *C. marmorata* in the north and *C. scripta nebulosa* in the south is decreasing because of overuse of groundwater and declining habitat.

In Mexico, conservation programs have no political constituency and consequently are underfunded and understaffed, if existent at all. The future for conservation of natural resources is indeed bleak for all of Latin America.

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Proc. Desert Tortoise Council 1982 Symp., pp. 162-172

SOME OBSERVATIONS ON ACTIVITY PATTERNS OF CAPTIVE BOLSON TORTOISES (*GOPHERUS FLAVOMARGINATUS*)

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The Bolson tortoise is the largest and least-known member of the genus *Gopherus*. This species, restricted to dry lake-bed country in a small area near the confluence of Chihuahua, Durango, and Coahuila, was not discovered until 1959 (Legler 1959). It is highly endangered (Appleton 1978, Morafka 1979). Since 1976, a small, introduced population of adult Bolson tortoises has been living and reproducing in outdoor pens at The Appleton-Whittell Research Ranch, Santa Cruz County, Arizona. In this paper we report on the daily activity patterns of these animals, as observed from May through August 1981. The purpose of this investigation was to add to our understanding of the basic natural history of this little-known species.

STUDY SITE

The Appleton-Whittell Research Ranch includes 3,169 ha of grassland oak savannah, oak woodland, piñon-juniper, and riparian habitats, at an average elevation of 1,524 m. Ten adult tortoises were observed in two separate areas. Three females and two males were in a 0.32-ha enclosure of gently sloping bottomland with an oak hillside to the northeast and an oak-filled ravine to the southwest. The enclosure was divided approximately in half, with one male (Larry) and one female (Gertie) occupying the lower half, and two females (Jane and 90) and one male (Spry) in the upper half. During the course of the summer of 1981, three juveniles, each about a year old and of undetermined sex, were discovered in the pen. A second enclosure, about 0.4 km west of the first, was divided into two roughly equal sections, and was inhabited by five adult tortoises: one male and one female in the western part, and two females and one male in the eastern part. A hatchling was discovered in the western section of the west pen in July 1981.

Vegetation within the enclosures consisted partly of plains lovegrass (*Eragrostis intermedia*), various grama grasses (*Bouteloua* spp.), tree cholla (*Opuntia imbricata*; east pen only), prickly-pear (*Opuntia polyacantha*), annual herbs such as *Evolvulus arizonicus*, *Dyschoriste decumbens*, *Haplopappus nuttalii*, and a few small spurges (Euphorbiaceae).

Each enclosure was equipped with a cement water dish about 13 cm deep, 61 cm across, and set level with the ground.

The tortoises lived in burrows (one tortoise per burrow) proportionate to their sizes: burrow entrances were just large enough to accommodate their residents. In front of each burrow was a mound of excavated earth.

METHODS

Observations were made on five days out of seven, from 22 May to 15 August 1981, mostly from the east pen. Quantitative data on the location and activities of each animal were taken from 1 July to 1 August in the east pen only. For these data, the status of each of the five adult tortoises in the east pen was recorded on a chart bearing columns of activities, location of the animal, and weather (clouds, sun, rain), and rows marked off in 5-min intervals. At 5-min intervals for two hours in the morning and two in the afternoon, weather conditions were written into the appropriate column, and the name of each tortoise (Gertie, Jane, 90, Larry, Spry) was recorded in the columns which best described where it was and what it was doing at the instant the interval began.

Morning observations usually were made between 7:45 and 9:45, and the afternoon observations between 3:30 and 5:30. These hours were chosen based on observations made from 22 May to 1 July, in which there was a notable lack of tortoises aboveground during the middle of the day, with by far the most activity occurring during the hours cited above. From 1-15 August, various hatchlings and juveniles were watched; very little adult behavior was recorded during this time.

Observations, except those of egg laying, were made from a concealed position outside the enclosure. The maximum number of burrow entrances simultaneously visible was three: Larry's, Spry's, and Jane's. This meant that if Gertie and 90 had emerged but not climbed to the top of their burrow mounds, they could not be seen. Thus, it is likely that these two animals spent more time out of their burrows than was recorded. Detailed descriptions of egg laying were made from a position flat on the ground, about 60 cm from the tortoise.

Temperature and solar radiation data were taken from a nearby recording hygrothermograph and pyroheliometer.

RESULTS

Daily activity

The five animals in the east pen exhibited two main periods of activity each day: one in the morning and one in the afternoon. Tortoises were out of their burrows significantly more often in the morning than in the afternoon (Table 1), but once out, they spent most of their time in motionless basking. Although late afternoon emergence was slightly less likely than morning, the tortoises were significantly more active in the afternoon if they were out of

TABLE 1. — Activity patterns of five Bolson tortoises in relation to time of day and cloudiness, as observed from 1 July-1 August 1981.

	Number of observations (%)		
	Underground in burrow	Out of burrow	Chi-square
Morning (7:45-9:45)	885 (71.5)	353 (28.5)	6.97*
Afternoon (3:30-5:30)	496 (77.1)	147 (22.9)	
Cloudy	552 (80.7)	132 (19.3)	29.21**
Sunny	829 (69.3)	368 (30.7)	
	Basking	Active	
Morning (7:45-9:45)	294 (83.3)	59 (16.7)	69.36**
Afternoon (3:30-5:30)	68 (46.3)	79 (53.7)	
Cloudy	79 (59.8)	53 (40.2)	14.14*
Sunny	283 (76.9)	85 (23.1)	

*$p < .01$
**$p < .001$

their burrows (Table 1).

The animals in this study seemed to adjust their period of activity to incident solar radiation and, to a lesser degree, temperature (Fig. 1). From 1 June to 31 July, most of the instances of first morning emergence and last evening descent occurred at the same level of incident solar radiation. Similarly, most of the morning descents and afternoon emergences happened when solar radiation levels were comparable. There was relatively little activity during the middle of the day when solar radiation was highest.

The tortoises spent 74.6% of the observed time underground (Table 2). The remaining 25.4% was spent in basking (17.9%) and various activities (7.5%). Among the latter, 11 different activities were recorded, listed here in order of decreasing percentage: i) walking; ii) foraging; iii) drinking; iv) digging;

v) copulating; vi) egg laying; vii) head bobbing; viii) visiting (journey to another tortoise's burrow without aggressive or sexual behavior ensuing); ix) fighting; x) mounting without intromission; xi) flinging dirt upon descent into burrow.

Individual tortoises budgeted their time differently (Table 3). The larg-

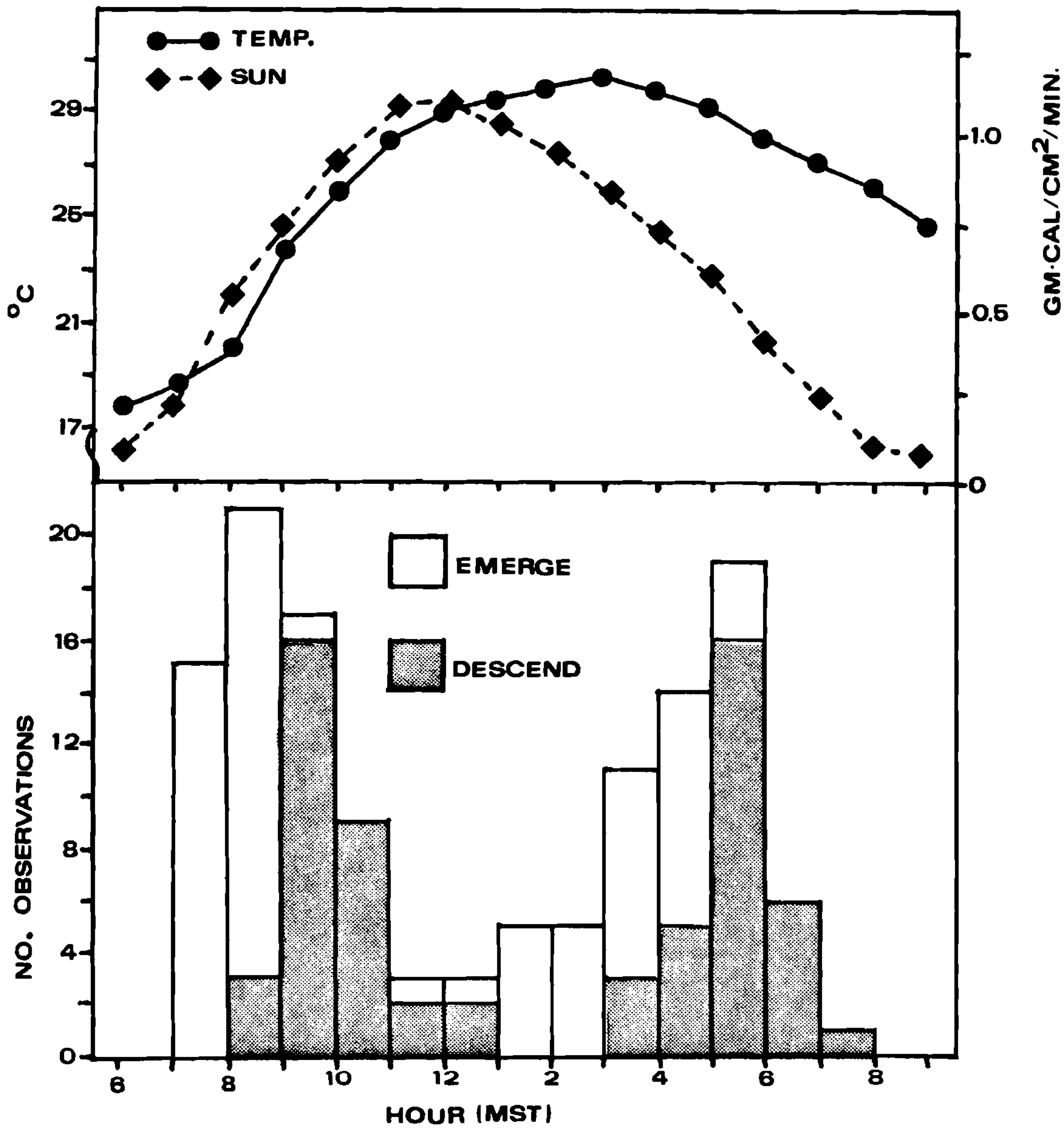

FIG. 1.—Timing of emergence from and descent into burrows by five adult Bolson tortoises, in relation to hourly fluctuations in air temperature and solar radiation.

TABLE 2. — Overall daily time budgets of five captive Bolson tortoises observed between 1 July and 1 August 1982. Numbers shown are percentages, based upon 2,101 observations taken instantaneously at five-minute intervals. Data were recorded between 7:45-9:45 a.m. and 3:30-5:30 p.m.

	Percent of time
Underground in burrows	74.6
Aboveground	25.4
Basking (inactive)	17.9
Active	7.5
Walking	2.8
Foraging	2.6
Drinking	0.7
Digging	0.6
Copulating	0.2
Egg laying	0.2
Head bobbing	0.1
"Visiting"	0.1
Aggression	0.1
Mounting without intromission	0.05
Flinging dirt	0.05

TABLE 3.—Individual daily time budgets of five captive Bolson tortoises observed from 1 July to 1 August 1981. Numbers shown are percentages, based upon 2,010 observations taken instantaneously at five-minute intervals. Data were taken be-between 7:45-9:45 a.m. and 3:30-5:30 p.m.

		Percent of time		
Animal	Sex	In burrow	Basking	Active
Gertie	F	75.0	2.0	23.0
Jane	F	75.0	16.0	9.0
90	F	89.9	8.0	2.1
Larry	M	54.0	41.0	5.0
Spry	M	73.5	22.1	4.4

TABLE 4. — Daily time busgets for each sex of five captive Bolson tortoises (three females, two males) observed between 1 July and 1 August 1981. Data were taken between 7:45-9:45 a.m. and 3:30-5:30 p.m.

	Number of observations (%)			
	In burrow	Basking	Active	Chi-square
Females	927 (82.5)	90 (8.0)	107 (9.5)	156.9*
Males	528 (65.7)	236 (29.4)	39 (4.9)	

*p $<.001$

est animal (Gertie, dominant in her enclosure) was by far the most active, while the smallest (90, subordinate in her enclosure) was notably the least active.

In this group, there was a difference in how the sexes divided their time (Table 4). Females spent more time in their burrows than males, but once out, were almost twice as active. Males basked more than females.

Effects of Cloud Cover and Rain on Activity

The tortoises were more likely to emerge under sunny conditions (Table 1), but once aboveground, cloudy conditions resulted in more activity and less basking than sunny weather (Table 1). An impending storm would stimulate them to an unusual amount of restless walking and digging. Stormy weather seemed conducive to aggressive behavior as well: all recorded fights occurred when clouds were building.

Tortoises usually did not emerge in the rain, but if they were already out, rain apparently did not inhibit activity. Individuals were seen to graze, walk, rest, and, on one occasion, lay eggs in the rain.

After a particularly heavy rainfall, one of the burrows in the west pen flooded. As we watched, the occupant (an adult male) surfaced and floated for five minutes with his head and the top of his carapace above water. He then submerged for two or three minutes, came up, and climbed out of the water onto the burrow mound.

Courtship and Reproduction

There were two mating pairs in the east pen: Spry and Jane in one enclosure (90 was never observed to participate in courtship), Larry and Gertie in the other. Larry and Gertie were the only ones actually seen to copulate: once on 11 July and once on 27 July.

Males seemed to initiate courtship by head bobbing on the female's burrow mound. The female would emerge and face the male momentarily while he continued to bob his head. She would then turn around and face down into the burrow so her posterior was elevated relative to her anterior. The male would mount, and with one pair (Jane and Spry) activity was invariably interrupted at this stage: Jane would slide down into her burrow, thereby detaching Spry. If not rejected, the male thrust and grunted while mounted on the female. This lasted for about two minutes. On one occasion (11 July), Larry slid off and, with head withdrawn, rammed Gertie's carapace posterior. He immediately remounted and thrust and grunted for an additional 30 seconds. Sometime during this encounter, ejacalation occurred, as evidenced by the wet condition of the female's hind legs and the burrow lip. (An hour leter, Gertie laid eggs during a rainstorm.) Gertie and Larry were observed to copulate again 16 days later, but for a shorter time and without ramming. Males were never observed to bite females nor to initiate courtship away from the female's burrow mound.

Egg Laying

At least five clutches were laid in the east pen between mid-May and 11 June 1981. We saw Gertie lay three clutches, and the other two females one each. On 22 May, five eggs were found in a nest on 90's burrow mound, in the shade of sacaton grass, *Sporobolus wrightii*. On 8 June, from 5:35 to 7:26 p.m., Gertie laid seven eggs in tall grass about 5 m from her burrow. Jane made a nest on her burrow mound and laid five eggs from 5:50 to 6:40 p.m. on 11 June. On 6 July, Gertie laid four or five eggs on Larry's burrow mound (which is about 8 m from her burrow), spending from 8:50 to 9:57 a.m. in the process. She laid again on 11 July. She deposited an unknown number of eggs from 5:15 to 6:45 p.m., about 9 m from her burrow, within the shade of oak trees. It began to rain heavily when she was 15 minutes into digging the nest and it was still raining when she had finished.

The nest was excavated with the hind feet only. After depositing each egg, the tortoise alternately put her hind feet in the hole as though arranging them. When the clutch was deposited, she used her hind feet to cover it with soil, and tamped down each footful of dirt. The forelegs were used to throw dirt onto the nest when it was nearly covered. By sitting on the nest and turning this way and that while covering it, the female's plastron smoothed the dirt out so the nest site was almost imperceptible.

Nest holes were about 15 cm deep, 20 cm long, very steep-sided, and roughly pear-shaped. The apex of the "pear" was under the tortoise as she dug. The topmost egg usually was under 1-2 cm of soil, with the other eggs alternating in a staggered stack beneath it.

Aggressive Behavior

Fighting occurred only between members of the same sex. Jane and Gertie fought once, the males twice. Tortoises within the same sub-enclosures were not observed to fight, except on one occasion when Jane chased 90 off her (Jane's) burrow mound. Most encounters were prefaced by sustained periods of walking, usually around the perimeter of the pens. The tortoises would eventually come upon each other, and clash through the fence separating their enclosures. The males stood up on their hind legs against the fence and tried to push each other with an upward motion, and, at the same time, flailed at each other with their front legs. They also tried to ram one another through the fence. The females also attempted to ram each other, and pushed hard against the fence. Neither one stood up as the males had done.

Juveniles fought for the possession of burrows. The two-year-olds (in a pen completely separate from that of the adults), Alpha and Beta, each had a burrow, but one seemed preferred. Beta defended it by wedging her/himself sideways across the burrow mouth while Alpha repeatedly rammed her/him. Beta would not be moved, so Alpha retreated to the less favored burrow. Two of the yearlings in Gertie's pen shared a burrow, although there were two available. On one occasion, the smaller of the tortoises blocked the entrance to the preferred burrow while the larger pushed her/him. The greater size and strength of the latter tortoise won out, and she/he pushed the former down the burrow ahead of her/him.

Adults did not defend their burrows from members of the opposite sex. On several occasions, Gertie bobbed her head at and tried unsuccessfully (she was too large) to enter Larry's occupied burrow. He made no response. Jane once entered Spry's occupied burrow for a few moments, then calmly left, unchallenged. Spry, in one instance, bobbed his head at Jane's burrow while she was out. Upon her return, she moved rapidly past him and entered her burrow.

DISCUSSION

Daily Activity

Three previous authors recorded a bimodal (morning and afternoon) activity pattern for *G. flavomarginatus*, citing avoidance of high temperatures as the reason for the pattern (Pawley 1968, Morafka 1979, Pritchard 1979). The tortoises in this study also had morning and afternoon peaks of activity each day, but Figure 1 suggests that this activity pattern may be more closely tied to levels of light intensity rather than temperature *per se*. By spending so much of their midday time underground, the tortoises reduced heat stress and dehydration, since it is both cooler and moister within the burrow (Auffenberg 1969, Morafka 1979). Contrary to Mrafka's findings (1979), which showed less intense activity in the afternoon, the five tortoises in the east pen were significantly more active in the afternoon than in the morning.

Morafka (1979) observed that walking, basking, and foraging are the three main activities of wild Bolson tortoises in Mexico. In this study, the five tortoises in the east pen spent most of their aboveground time in those same three activities: basking (17.9% of total observed time, or 70% of their aboveground time), walking (11% of aboveground time), and foraging (10.4% of aboveground time). Walking and foraging were done simultaneously, hence the similar percent values. Walking could occur without foraging, but foraging was always accompanied by walking.

Digging refers to that done by females. They would dig as though beginning a nest, then abandon the hole when it was about 5 cm deep.

Head bobbing, as described by Eglis (1962), is used in challenge, recognition, and courtship. None of the aggressive encounters observed had head bobbing as a prelude. Tortoises of both sexes bobbed their heads at each other's burrow, and at their own burrow. Head bobbing was used by males in courtship.

Females were more active than males (Table 4) because they have a wider range of activities: digging, egg laying, and dirt eating in addition to those common to both sexes.

For tortoises in general, dominance hierarchies are related to size (Brattstrom 1974). In this study, the correlation between size and dominance seemed to affect activity, as evidenced by differences in how individuals budgeted their time (Table 3).

Effects of Cloud Cover and Rain on Activity

Legler (1959) reports that in the wild, the Bolson tortoise is seen most frequently after a rainfall. Appleton (1978) suggests that rain induces or enhances digging. The results of this investigation generally confirm these observations. Tortoises probably were more active when it was cloudy because lower solar radiation reduced the danger of heat stress.

Courtship and Reproduction

The details of the sexual behavior of *G. flavomarginatus* are not well known. Legler (1961) wrote that males ram the females. Janulaw (1978) observed that a captive male bobbed his head at a female, then mounted. Appleton (1978) recorded an instance in which a male bit a female on her head and forelimbs, followed her back to her burrow, then mounted when the female was on the burrow mound.

In this study, the consistent elements of courtship were head bobbing, xiphi-plastral ramming (the thrusting and grunting described by Auffenberg 1977), and the female's posture of head lower than tail. No biting was recorded, and only once was a male (Larry) seen to ram a female (Gertie) with his gular shield.

Egg-laying Behavior

Exactly how the Bolson tortoise digs a nest and deposits eggs has not been mentioned in the literature. Information on clutch size and nest sites has been given twice: Appleton (1978) reported a clutch of seven in a nest about 13 cm deep on the female's (Gertie's) burrow mound; and Janulaw (1978) reported that a captive female laid four to seven eggs per clutch, and three clutches per year. In the latter instance, the tortoise made her nest on the burrow mound or in other dry, sunny sites.

Clutch sizes (four to seven eggs) and nest sites described in this study are quite similar to those given to previous reports, although one of Gertie's nests (near the oak tress) was made in a relatively moist area.

The tamping down of eggs as they are being deposited may damage them. In Gertie's clutch of seven, the top three were damaged: the uppermost egg was completely broken, and the next two were dented.

In order to prevent predation, we removed most of the eggs to an incubator, or, if left in the ground, covered them with a wire cage. There were mammal tracks and signs of scratching around the cages the day after the nests were made. Several times during the summar of 1981, remains of old nests that had been dug up by predators (dogs, coyotes, raccoons, etc.) were found. When one clutch was laid during a rainstorm (Gertie's of 11 July), it was left unprotected. It was not disturbed by predators, and was still intact at the end of the summer.

Aggression and Defense

Fighting between Bolson tortoises has not been previously described. Among the five adults in the east pen, it occurred intrasexually and then usually only between animals on different sides of the dividing fence. Juveniles contested burrow ownership.

When humans disturbed the burrow mounds, the tortoises blocked the burrow entrances in the same manner juveniles did when defending burrows. Adults made hissing noises when in that position. Auffenberg (1977) states that hissing may be a deterrent to predators.

Burrow Establishment

Although Morafka (1979) speculated otherwise, hatchlings do dig their own burrows. The hatchling discovered in the west pen was observed for a week, during which time it wandered great distances relative to its size. Toward the end of the week, it settled under a dead shrub and began to dig. Within two days, the burrow was large enough to completely enclose the hatchling.

ACKNOWLEDGMENTS

We would like to thank Drs. Carl Bock and Hobart Smith, of the University of Colorado, for literature, good advice, time, and patience without end.

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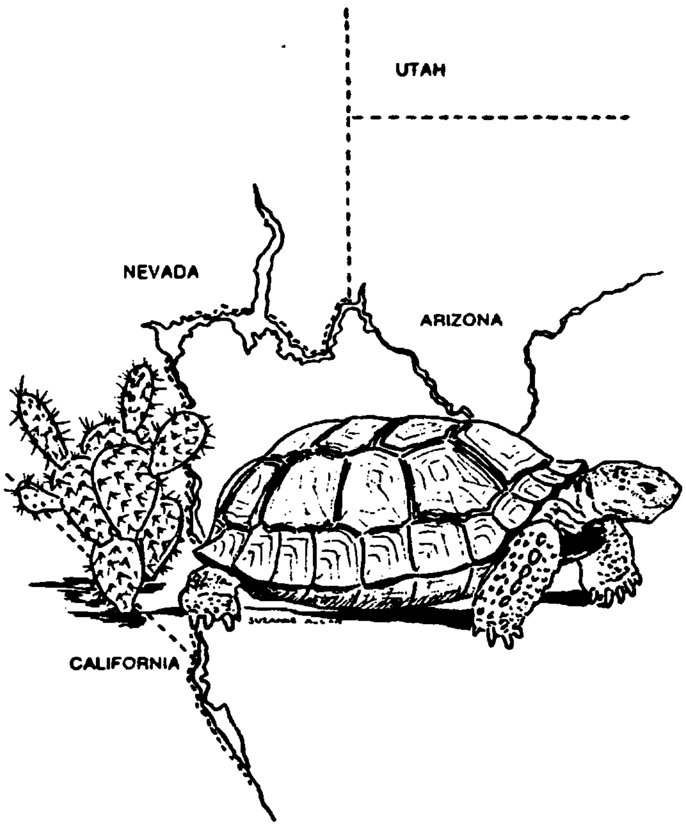

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