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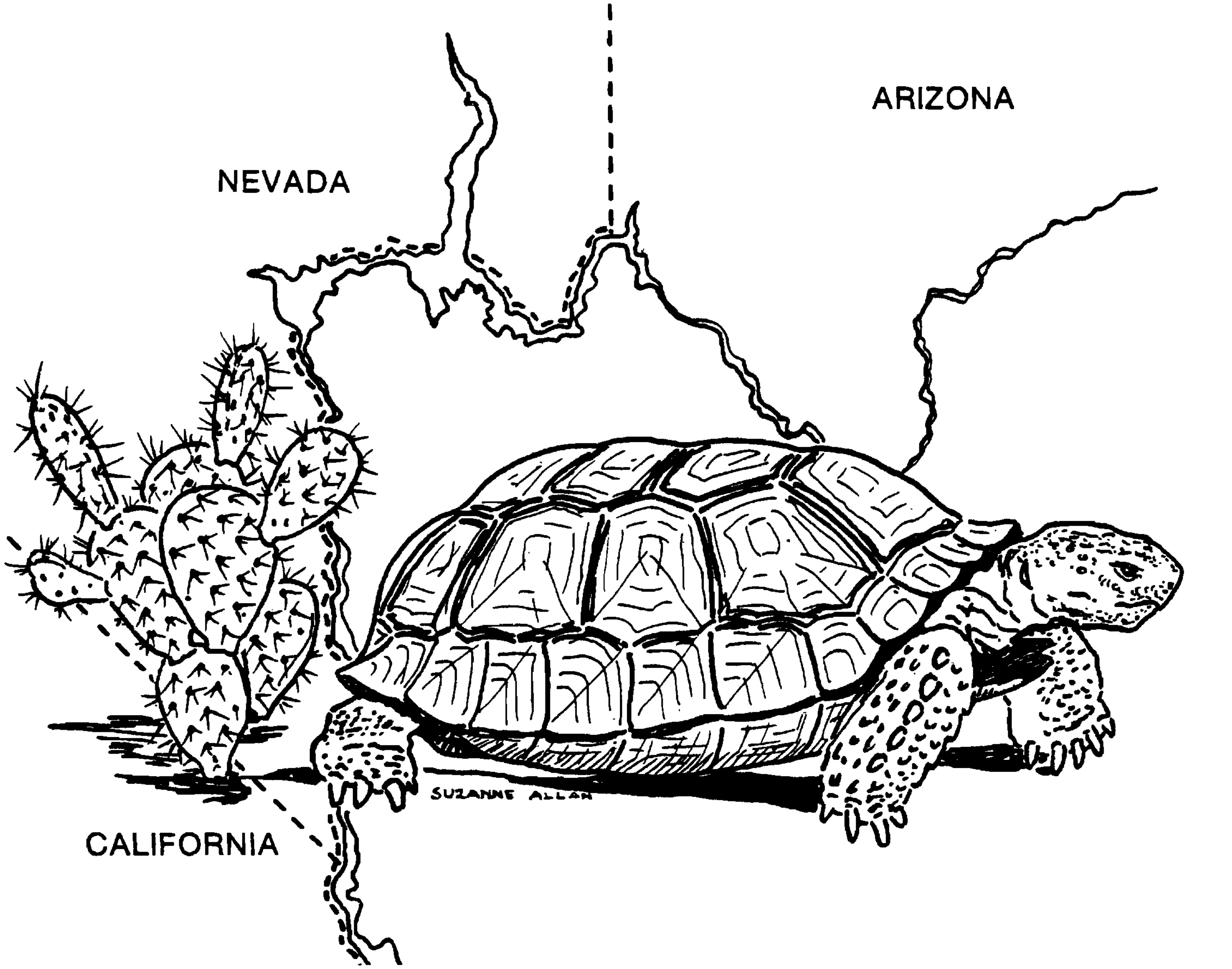
THE DESERT TORTOISE COUNCIL



PROCEEDINGS OF 1980 SYMPOSIUM

DESERT TORTOISE COUNCIL

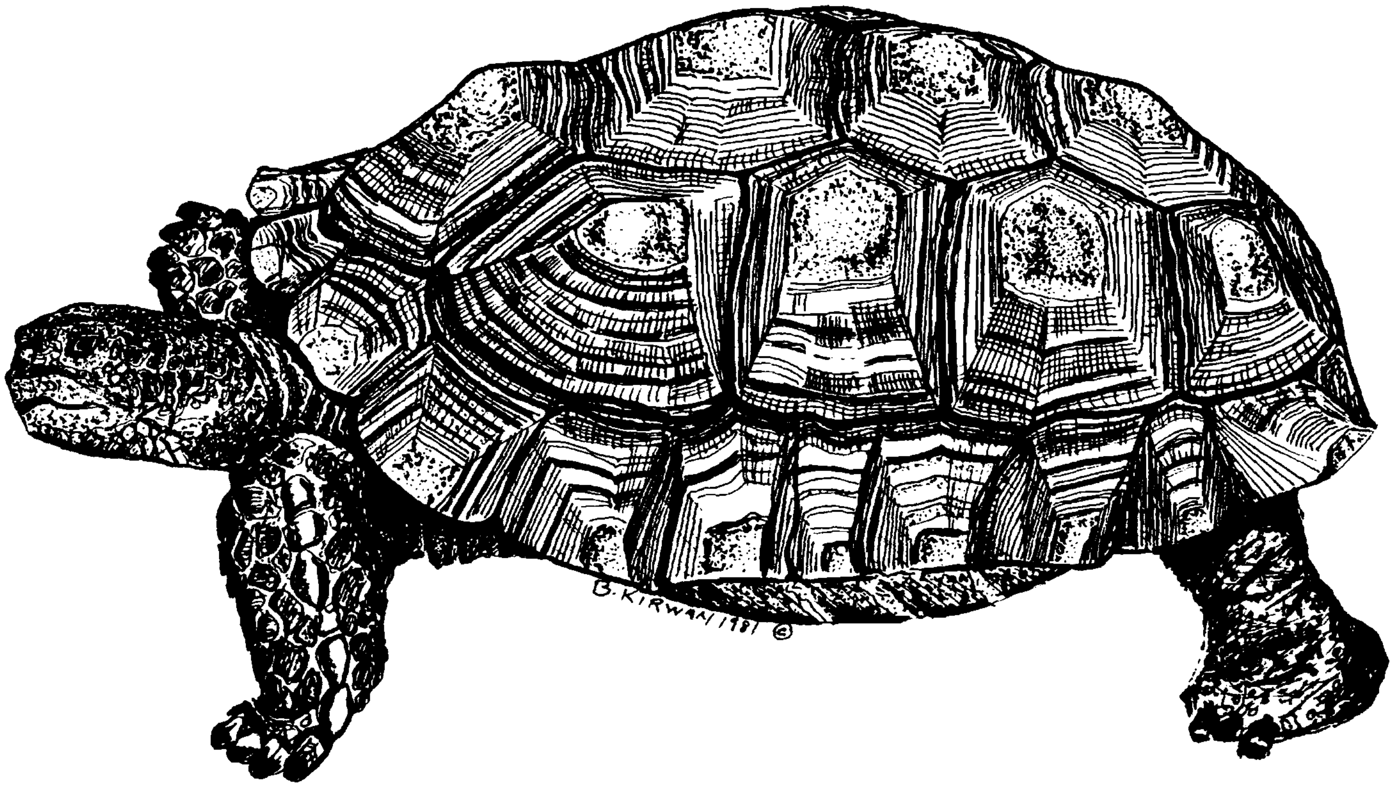
PROCEEDINGS OF 1980 SYMPOSIUM

A compilation of reports and papers presented at the fifth annual symposium of the Desert Tortoise Council, 22-24 March 1980, in Riverside, California

TABLE OF CONTENTS

Page

Papers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THE DESERT TORTOISE COUNCIL

EXECUTIVE COMMITTEE

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.

BRIEF HISTORY OF 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 organized 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 have 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.

FIFTH ANNUAL MEETING AND SYMPOSIUM

The fifth Annual Meeting and Symposium was held 22-24 March 1980 at the Holiday Inn, Riverside, California. The field trip was to the Chuckwalla Bench Area, Riverside County, California.

The Symposium was opened by the program chairman, Dr. Mark Dimmitt, followed by the keynote address by Mr. Eugene V. Toffoli, Deputy Director, California Department of Fish and Game.

An informative and entertaining after dinner program was provided by Dr. Howard G. Wilshire and John Nakata. This was a multiple slide/sound presentation entitled, "The Wheeled Locusts".

Excerpts from the Minutes of the Fifth Annual Business Meeting

The Desert Tortoise Council agreed on three major objectives for the coming year:

1. Utah Beaver Dam Slope Tortoise Population Management: The data received from the Bureau of Land Management in Utah will be analyzed and a report of comments submitted to the U.S. Fish and Wildlife Service. A meeting will be arranged with Council members and Utah to improve communications, and to offer assistance in developing management guidelines.

2. California Desert Plan: The Council will submit comments on the Bureau of Land Management's California Desert Plan. A fact sheet on the Desert Plan will be composed and sent to the Council membership to assist the members in understanding the Plan's effects on the desert tortoise.

3. Desert Tortoise Natural Area: Plans include contact with the California Department of Fish and Game and the Bureau of Land Management requesting hunting closure on the Desert Tortoise Natural Area. Letters will go to top Department of Fish and Game officials and to the Region 4 office of the Department of Fish and Game as well as the Bureau of Land Management's State Director and Riverside District.

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FIELD TRIP
CHUCKWALLA BENCH, RIVERSIDE COUNTY, CALIFORNIA

LORI NICHOLSON
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As part of the Fifth Annual Meeting and Symposium of the Desert Tortoise Council, a field trip was taken to the Chuckwalla Bench Tortoise Study Plot, Riverside County, California. Lori Humphreys, sponsored through several Bureau of Land Management contracts, has spent 100 spring and 20 fall days since 1977 studying the tortoise population on the 1.3-mi^2 (3.4-km^2) plot. She has marked 342 tortoises and collected 132 shells. Tortoise density is estimated at 259 to 311/mi^2 (100 to 120/km^2).

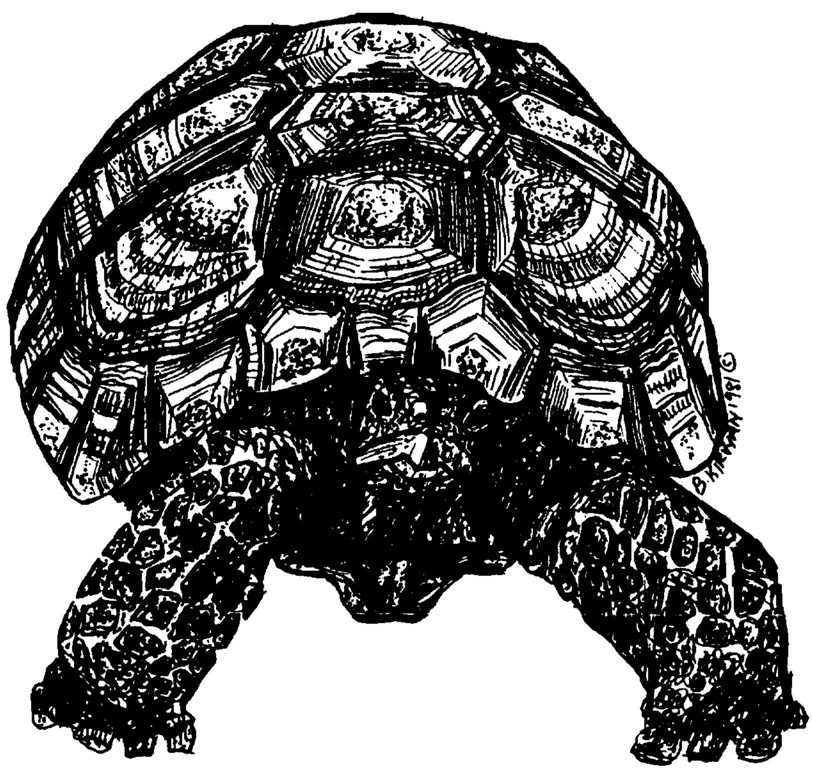
A group of 41 persons, led by Ms. Nicholson, arrived at the plot at 11:00 a.m. The weather was perfect for tortoise observations and many tortoises had been found by the lunch break. Several species of lizards, snakes, and flowering plants were also sighted. By the end of the trip, about 40 tortoises had been observed and most were marked. Seven tortoises under 3.5 inches (90 mm) in carapace length were found, including hatchling number 400, a recapture. Since its capture on 12 March 1979, this small tortoise had increased from 1.7 to 2.3 inches (43 to 55 mm) in length, and from .78 to 1.9 oz (22 to 54 g) in weight. It was only 30 ft (10 m) from the 1979 capture point.

The plot is in a rich Colorado Desert plant community dominated by creosote and burrobush. Ocotillo, white ratany, purple bush, and many cactus species are common. The wide sandy washes are lined with Palo Verde, desert willow, and smoke trees. Cheesebush, catclaw, and mormon tea are shrubs associated with these washes and smaller gullies.

The area has a long history of human use. It is intersected by the Bradshaw Road which was used as a stagecoach and cattle drive route in the late 1800's. The ubiquitous effects of General Patton's military maneuvers in the early 1940's were obvious to all: scarred land from tank treads, trash, and spent 50 mm casings. Military maneuvers probably had a heavy negative impact on the tortoise populations, as evidenced by the lack of very old adults in the population. However, thehigh proportion of young tortoises indicates that the population is recovering. Currently the area is lightly used for hunting and by off-road vehicles primarily on roads and in the washes. There are potential future threats of private land development for jojoba agriculture. Private land intermingles with public land in the area.

Those attending the field trip were Walter Allen; Kristin Berry; Allan Borden; John Brode; James Buskirk; Betty Burge; Mayo Call; Mary Croom; Barbara Dahn; Mark Dimmitt; Kenneth Dodd; Lynn Dolan; Norman Edmonston; Sidney England; Larry Foreman; Ethel

Hildebrandt; Barbara and Curtis Horton; Alex, Vicki and Sonja Jaramillo; David Kavanagh; William Laudenslayer; Lori Nicholson; Diana Pickens and son; Ted Rado; William Radtkey; Lance Sachara; Robert Sanders; Mike Segor; Paul Schneider; George Sheppard; Mae Smith; Linda Standow; Robert Turner; Al and Mary Lou Vautrin; Sally Vogel; Winton West; and Martha Young.



1979 ANNUAL AWARD: PROFILE OF RECIPIENT, MARY TROTTER

Mary Trotter has long been involved in herpetological conservation. She started and was co-editor of the Turtle Hobbyist and has been an integral force in the Desert Tortoise Preserve Committee. Mary has been an active full-time volunteer/curator in the Herpetology Department at the Natural History Museum in San Diego. Mary is a recognized expert in the raising and care of captive tortoises, and has co-authored several papers on the desert tortoise with Dr. Crawford Jackson, Jr.

Mary Trotter's association with the Desert Tortoise Council began in 1976 with the formation of the Council. She served the Council as Secretary-Treasurer for 4 years and has been a member of its publishing committee since the Council's beginning. It has been in these two positions that Mary has helped to establish the professional standing and viability of the Desert Tortoise Council. As Secretary, Mary handled the voluninous correspondence with interested peopele throughout the world. Her expertise in chelonian biology was well applied in these correspondences. She maintained the membership lists, solicited new members, and prompted those who forgot to renew. Mary's vast knowledge of herpetology and tortoise husbandry permitted her to handle this correspondence almost single-handedly.

As Treasurer, she established and maintained the Council's books. She investigated tax status options and managed the Council's funds to minimize loss of revenue through taxation.

As a member of the Publishing Committee and co-editor with Dr. Crawford Jackson, Jr., Mary helped edit the symposia proceedings, type, print, and collate all of the 1977 and 1978 proceedings. In a letter to the Council, Dr. Jackson stated, "As technical editor, I merely read and edited each paper with regard to its technical and scientific aspects. This was the easy role. By contrast, Mary had to orchestrate the entire operation, coordinating the various portions of each volume, correspond with most of the contributors via mail and telephone calls, and last but certainly not least -- retype every page of the volume, proof read it, and PRINT AND COLLATE the book! This was a staggering task, but she did it, and did it well. I am proud to have been associated with Mary in the production of the Symposia, and I hope that the membership of the Desert Tortoise Council recognizes and appreciates her outstanding accomplishment as editor." *David W. Stevens*

THE DESERT TORTOISE - AT THE CROSSROADS

EUGENE V. TOFFOLI
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On behalf of the California Department of Fish and Game, I am pleased to extend to the Desert Tortoise Council the greetings of the Director and the Resources Secretary, and to have the opportunity to address your 5th annual symposium. I would like to thank Dr. Dimmit for inviting me and to acknowledge and commend the fine contributions the Desert Tortoise Council has made to furthering our knowledge and understanding of the desert tortoise and its management, conservation, and protection. I hope the reason you are meeting in California only for the first time this year is due more to the fact that the attractions of Las Vegas have worn off than to the fear that Jim St. Amant's State car wouldn't make it any further east than Riverside.

You probably decided a year ago to meet in California in 1980, but I suspect that even then you must have known that time and circumstances would combine to make this a most opportune choice. I'm sure there is not one among you who is not aware that just a little more than a month ago the Bureau of Land Management (BLM) released its draft California Desert Conservation Area Plan and Environmental Impact Statement. By September of this year, when a final plan for management of Public Resource Lands in the California deserts is officially adopted, the fate of *Gopherus agassizi* in California will in all likelihood be irrevocably decided.

I'm sure that many of you have spent long hours reviewing that rather imposing document. And I expect the Desert Plan, as it is more simply known, and its effects on the desert tortoise, will be the topic of conversation in many quarters here this weekend. And well it should be, for the desert tortoise stands at the crossroads of its evolutionary history.

We too are carefully reviewing the Desert Plan, not only for what it means to the desert tortoise, but for its effects on all wildlife and native plants as well. The Department of Fish and Game will provide its analysis and recommendations to the Resources Secretary for incorporation with those of the other Resources Agency departments to produce the official State response. Never before has there been one land use management plan that has encompassed such a vast amount of wildlife habitat as the Desert Plan. I'm sure its significance is as apparent to you as it is to us. In recognition of its importance, the Director has instructed that it should be given careful and complete scrutiny by his staff. Although our analysis of the Plan has not been completed, I will share with you what we believe to be the management problems and needs of the desert tortoise, what we will be looking for in the Plan, and what we will be doing as a Department to fulfill those needs. But first I would like to take a few minutes to briefly review for you the role of the Department of Fish and Game in managing wildlife and how our role relates to that of Federal land management agencies, such as the BLM, and to that of organizations such as the Desert Protective Council.

Wildlife resource management, as a public trust responsibility of government, is and always has been a cooperative enterprise between State and Federal agencies and private citizens groups who attempt to influence policy or assist management.

The Department of Fish and Game's role as a wildlife management agency can be characterized by the 5 major types of management functions it carries out.

First, through the Fish and Game Commission and the Legislature, we attempt to regulate the taking of animals to the extent that natural populations can sustain harvest for sport, commercial, or scientific purposes. Our biggest challenge is to provide the best biological information possible so that laws or regulations in the best interests of the resource will be ultimately selected, despite the diverse political and economic pressures that may be brought to bear in the process. In our quest for the best biological information available we often rely heavily on the work of academic professionals, such as are to be found in the Desert Tortoise Council, and on the growing number of fish and wildlife biologists in the Forest Service and BLM, who through their own programs or in joint studies with the Department, contribute greatly to our knowledge of wildlife resources.

Secondly, we manage fish, wildlife, and their habitats where possible to try to increase the production of sport and commercially valuable species available for harvest. We also artificially produce fish and wildlife for stocking when natural reproduction is impaired or for some reason unable to sustain high levels of sport or commercial demand.

Through the Wildlife Conservation Board we carry out our third major role, that of acquiring private lands in public ownership or easement for purposes of providing fisherman and hunter access, and for protecting major game or nongame endangered species and their habitats.

A fourth major role is that of advising other agencies of government, at all levels, how they can prevent their actions or decisions from detrimentally affecting fish and wildlife, or where such is not possible, how they can compensate or mitigate for such affects. This role is largely accomplished through the CEQA and NEPA review process, although other sections of the Fish and Game Code provide additional authorities. It is primarily through this role that the review of the Desert Plan will be accomplished.

Finally, our newest, yet probably most important role is that of identifying, protecting, and restoring species that are threatened with extinction or extirpation, and preventing others from becoming so threatened.

These roles basically fulfill the intent of the Legislature, as expressed in Sections 1700 and 1801 of the Fish and Game Code and as translated into the following Department objectives:

1. To perpetuate all species of fish and wildlife for their intrinsic and ecological values as well as for their direct benefits to man.

2. To provide for the beneficial use and enjoyment of the fish and wildlife including aesthetic, educational, and nonappropriave uses.

3. To provide for diversified recreational and commercial uses of fish and wildlife consistent with the maintenance of healthy and viable natural populations.

While the primary mission of the Department of Fish and Game is the management of wildlife, BLM, as you know, is responsible for the management of Public Resource Land. A similar division of responsibility is shared between the Department and the Forest Service. We often hear, in various contexts, that the Federal Government "owns" almost half the State of California. Although some have viewed this as akin to a condition of fealty, on the whole we have been grateful that at least that portion of the Federal land managed by the Forest Service and the BLM could be regarded as somewhat "safe" habitat for fish and wildlife; relatively free from the threat of urbanization, agriculture, and modern society; forces against which fish and game laws are essentially powerless.

Historically, the Department has enjoyed a relatively beneficial, cooperative relationship with BLM. Even before the Federal Land Policy and Management Act made BLM a "multiple-use" agency, there seemed to be sufficient latitude in their mission to accommodate special fish and wildlife concerns, although protection of wildlife or habitat has never been the first priority of either the Bureau or the Forest Service.

Nevertheless, the importance of Federal land as a provider of wildlife cannot be overemphasized. The Department can prohibit the taking of desert tortoises, but protection from man's predation will do little good if the factor limiting tortoise survival is the availability of suitable habitat. We depend heavily on Federal land management agencies for assistance not only in providing suitable habitat for wildlife, but in helping control the level of exposure of wildlife to human predation. The regulation of take becomes difficult at best where the once remote areas of public land become accessible to large numbers of people and their machines. Despite their best efforts, our law enforcement officers cannot be everywhere at once.

Where special needs or circumstances have dictated, the Department and the BLM have combined forces in cooperative ventures to protect and manage wildlife and wildlife habitat on Bureau lands. A 24,000-acre reserve for the rare peninsular bighorn sheep was recently established in the Santa Rosa Mountains through such a joint venture, not to mention the considerable aid of The Nature Conservancy.

The Conservancy has also been instrumental in helping acquire inholdings within the Desert Tortoise Natural Area, a wildlife reserve known to all of you, I'm sure.

In addition to establishing preserves, the Department and the Bureau have cooperated at both the State and regional levels to conduct status surveys of rare and threatened wildlife, to prepare species and habitat management plans, and to implement special area closures or use controls in sensitive wildlife areas. Often, our respective agencies have acted at the urging of organizations such as the Desert Tortoise Council and other citizens groups. We readily acknowledge that the Department of Fish and Game lacks the manpower and budgetary resources to inventory and manage all of the diverse fauna and flora that are found on public lands. Without the scientific input and prodding of the Desert Tortoise Council, California Native Plant Society, Audubon, and others, our job would be virtually impossible and the wildlife and plants would be in far worse condition than they are now. In terms of helping to fulfill the Department's goals to protect and enhance native species, this is probably the most significant role that the Desert Tortoise Council and other wildlife special-interest groups can play.

Probably more than anyone else in recent times, Dr. Kristin Berry, first as a student-naturalist and now as the Lead Zoologist of the Desert Planning Staff, is directly and indirectly responsible for increasing by severalfold our knowledge of the status, biology, life history, and physiology of the desert tortoise and numerous other desert reptiles. Our increased knowledge of the desert tortoise has made it clearly apparent that California's largest reptilian herbivore is a seriously depleted and possibly threatened species. The challenge that is before the Desert Tortoise Council and the Department of Fish and Game is whether we can achieve our identical goals with respect to the desert tortoise; that is, to assure its continued survival as a viable component of the California desert ecosystem. However, because of the overriding importance of habitat and the ecosystem itself to the survival and welfare of a species, the BLM and the decisions it makes with respect to the Desert Plan, holds the key that will determine whether and to what degree our goal can be achieved.

It will be no easy task for the BLM to weigh and balance all of the competing and sometimes conflicting demands for management of the resources of the California Desert Conservation Area. But given the fine work of the Desert Planning Staff in identifying wildlife resources, the BLM appears to have a solid basis of information on which to allow for the needs of the desert tortoise in its recommendations and plan implementation. We have assisted the BLM wildlife staff in Sacramento in the preparation of a document titled: "Policy and Guidelines for Management for the Desert Tortoise". In its present draft form it contains management recommendations that, if followed, would significantly benefit the desert tortoise. We will rely on this tortoise "plan" together with the recently completed Desert Tortoise Natural Area Management Plan to help guide our review of the Desert Plan. But regardless of what alternative plan is ultimately adopted, the problems that will face the desert tortoise in the future are great, and we must all continue to work cooperatively if we are to achieve our objective.

Let's turn now to a discussion of the problems and needs of the desert tortoise and the Department's more immediate goals and programs for the management of this species.

On 23 August 1978, the U.S. Fish and Wildlife Service published notice that it wished to review the status of the desert tortoise to determine whether it should be proposed for listing as endangered or threatened pursuant to the Endangered Species Act of 1973. The Department of Fish and Game at that time did not offer an opinion as to the status of the desert tortoise in California, although we reported that recent studies had shown that populations had suffered a large decline from historical times. In the intervening months, the extent and magnitude of that decline had become more apparent and the factors operating to cause the decline better identified and understood. In the western Mojave Desert alone the decline has been nearly 89% since 1940.

It now appears that sufficient information may exist for the Fish and Wildlife Service to conclude its review and propose a rulemaking. Decisions made and actions taken within the next year or so may determine whether it should be listed as endangered, or if it is only threatened. Our own staff analysis of the evidence suggests that a State listing of the desert tortoise also may be warranted. Hopefully, within a year we may have a recommendation for the Fish and Game Commission.

As you know, one of the primary factors responsible for the decline of the desert tortoise has been collecting. Since the desert tortoise became protected by California statute in 1972, it has been illegal to collect them from the wild, except under permit from the Department. We believe there has been a significant reduction in the number of tortoises collected for commercial purposes since then; however, tortoises continue to be collected by unthinking individuals who seek to make them pets.

Although the tortoise adoption program is probably helping reduce the demand for wild-caught pets, there are indications that wild tortoises are suffering increasing mortality at the hands of uncaring individuals who deliberately kill and maim these helpless and protected species. It is regrettable indeed that such people have so little respect for the life that belongs to the land.

The problem of collecting and shooting is partly the result of greater public access to and use of the desert, primarily by means of off-road vehicles. ORV's also affect tortoises and their habitats indirectly by crushing tortoise burrows, destroying plants that provide food and above-ground shelter, and by possible behavioral interference from noise. Unfortunately, the Interim Critical Management Plan for ORV's, instigated pending adoption of a final Desert Plan, established several ORV "open-play" areas within prime tortoise habitat.

While the control of illegal collecting and killing is the direct responsibility of the Department, the problem is inextricably linked to the access that people have to large areas of tortoise habitat. Thus, we see a need for greater and more vigorous enforcement actions on our part, but to render that objective attainable and meaningful we need the help of the BLM in restricting human access and use in areas of desert tortoise habitat.

It has come to my attention that shooting of tortoises may be occurring in the Desert Tortoise Natural Area. If this is true and it is related to the fact that the Natural Area is open to sport hunting of upland game, we will reevaluate this provision of the Natural Area management plan to determine if it is significantly hindering the recovery of the tortoise or the management of the Natural Area.

Although cattle and sheep grazing have occurred in the California deserts for as long as 100 years, it is less certain to what degree grazing may have contributed to the decline of the desert tortoise. However, the effects of grazing on existing tortoise populations are becoming better understood, and there is growing circumstantial evidence that grazing is detrimental to desert tortoises. Under current grazing practices it is feared that depressed populations will be unable to recover on their own or will continue to decline. The habitat management plan for the Desert Tortoise Natural Area calls for the elimination of grazing. However, grazing trespass remains a problem that will take greater enforcement and stiffer fines in order to control.

The "Policy and Guidelines" for management of the desert tortoise, to which I referred earlier, contains three alternative management recommendations with respect to grazing desert-wide which, if adopted, should significantly benefit tortoise populations. In decreasing order of potential benefit these include: shifting grazing permits to areas where tortoise populations are either very low or do not exist; delaying the release of sheep and cattle in the permit areas to allow tortoises a period of undisturbed feeding during the critical period following their emergence from hibernation; and adjusting grazing allotments according to the density of tortoises present.

Although wild horses and burros are now affecting only about 20% of the tortoise's range in California, their populations are growing alarmingly and are beginning to spread into areas of prime habitat in the eastern Mojave Desert. Wild horses and burros could greatly accelerate the decline of the desert tortoise unless control measures are instituted soon.

Looming on the horizon is another major threat. Proposed leases for geothermal and oil and gas development are planned over wide areas of desert tortoise habitat. Densities of oil derricks as high as 1 per 40 acres, in combination with the access roads and support facilities that will be required, will further fragment tortoise populations. The resulting long-term impacts of these activities could be just as serious as ORV use and grazing.

There are other existing and potential uses and activities on Public Resource Lands that can adversely affect desert tortoises. Power plants and hard-rock mining tend to be limited and site-restricted so that their effects on desert tortoise populations are less pervasive and more amenable to mitigation than grazing, ORV's, and human predation.

Where development occurs on private land there is little that we or the BLM can do to prevent impacts on tortoise populations if the counties are not inclined to accept our recommendations through the CEQA review process. Agricultural development on private lands is an activity where we have the least opportunity to exert control, since no permits are required by the counties for land grading or irrigation. Yet agriculture probably has the greatest direct impact on tortoise habitat of all possible land use activities. Agriculture has serious indirect effects, also. For example, there are signs that ground water pumping Fremont Valley may be affecting native vegetation in the Desert Tortoise Natural Area.

On State-owned or controlled lands, or where State-agency projects or activities are involved, we have considerably more leverage in protecting the tortoise and its habitat through the CEQA review process. We recently advised the State Lands Commission that a negative declaration would be inappropriate for a lease application to experimentally cultivate Jojoba on a section of State-owned land in Lucerne Valley. The applicant has now been advised that an EIR would be required and that surveys will have to be conducted to determine the occurrence and status of desert tortoises and archaeological resources on the land in question. Our review of a State Lands Commission negative declaration on a proposal to release the mineral rights to some land in the vicinity of California City, near the Desert Tortoise Natural Area, also resulted in a decision by the Lands Commission to prepare an EIR. We expect the EIR to be available next month and will oppose any recommendation that will lead to adverse impacts on the desert tortoise or the Natural Area.

On a more positive note, the California Department of Transportation has been most cooperative in funding studies on the effects of desert highways on tortoise populations. These studies have been quite productive and should lead in the near future to mitigation measures, such as drift fences and undercrossings, that will benefit tortoise populations near paved highways.

I hope it has become apparent by now that the Department of Fish and Game has limited authorities when it comes to taking actions to benefit the desert tortoise. Furthermore, those actions that it can take depend ultimately for their success on the decisions and actions of others if they are to be effective. I say this not as an excuse or an apology, but so that you will appreciate the context in which our goals and programs for the desert tortoise must be applied.

The problems and needs of the desert tortoise and the Department's goals and programs to meet those needs can be summarized as follows.

First, for the problem of human predation and harrassment; the Department will intensify its enforcement efforts in the Desert Tortoise Natural Area and in other portions of the western Mojave Desert where the problem seems to be most acute. With the cooperation of the BLM we will attempt to obtain and evaluate whatever information may be available on the shooting of tortoises in the Desert Tortoise Natural Area. We will then institute whatever measures may be needed to correct the problem. We will intensify our information and education program in cooperation with BLM and other interested parties, to inform and educate the desert-using public of the plight of the desert tortoise and the need to protect it and its habitat. We would welcome the assistance and suggestions of the Council and other interested groups as to how we can make this program more effective. With respect to enforcement, some sort of "hot line" or reward system for reporting violations and obtaining convictions may be feasible.

Secondly, in conformance with the recommendations of the "Policy and Guidelines" for desert tortoise management, we will vigorously encourage and support actions by the BLM and other agencies of government that tend to reduce or eliminate access to and excessive ORV use of areas that still support desert tortoise populations. Similarly, we will encourage and support BLM efforts to modify grazing allotments and practices where benefits to tortoise and other wildlife would accrue, and will strongly urge that steps to implement control of wild horses and burros be taken immediately, pursuant to the "Policy and Guidelines" recommendations.

Thirdly, we will continue to review carefully (through CEQA and NEPA) all desert land use activities and projects, such as oil and gas leases, to help assure that options for the protection and enhancement of desert tortoise habitat are available and utilized. We will oppose those where such options are lacking.

Fourthly, we will be prepared to submit a recommendation on a proposed listing for the desert tortoise to the Fish and Game Commission, hopefully within a year. During the interim, we will be reviewing whatever proposals and data that are submitted by our Federal counterparts, the Bureau of Land Management and the U.S. Fish and Wildlife Service.

Finally, we will continue to cooperate with the Bureau of Land Management, Desert Tortoise Council, and any other agency or organization in any way necessary to achieve our common goal of assuring the continued survival of viable populations of desert tortoises in the wild in California.

As we contemplate the future of the desert tortoise at the crossroads in its evolutionary history, I'm sure we all realize that it is more than just the future of California's official State reptile that is at stake. *G. agassizi* is merely one ubiquitous actor among many playing out the drama of survival on Nature's stage. But as the tortoise goes, so will go the future of many diverse desert ecosystems and their component flora and fauna.

For millenia, the desert tortoise and its cousins have defied the vicissitudes of nature and man in some of the more inhospitable regions of the world, supremely adapted to utilize with remarkable efficiency the ingredients of life so sparingly available.

But pressures on the deserts are growing, and in California at least, they may be reaching the point where the needs of man and nature cannot be mutually accommodated. But I believe they can be. They can be accommodated if the BLM realizes that the land they hold in public trust must be husbanded in a manner deserving of that trust. With so much of the land in the California Desert Conservation Area in either single-purpose military ownership, or in private ownership, with no means presently available to prevent the latter from being overgrazed, irrigated, mined, developed, or otherwise used and abused, logic would dictate that long-term irretrievable commitments of resources be made with great caution. If the welfare of the desert tortoise and other wildlife of the desert is to be assured, then the BLM must opt to select a management alternative that is truly responsibe to the desires of the people for whom it holds the land in trust. Its own public opinion survey, conducted by a reputable national polling firm, has determined that 79% of adult Californians view more protection of wildlife and ecological values to be the greatest need in the desert. It is up to you and me and others who seek to safeguard the interests of the desert's fauna and flora to make and encourage decisions to carry out this mandate. We will have accomplished nothing if the desert tortoise and other desert species are able to survive only in isolated preserves that become, in effect, nothing more than wild animal parks.

The necessary decisions will be made much more often and much more readily if we are guided in our deliberations by Aldo Leopold's simple maxim: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise".

STATUS OF THE ARIZONA BEAVER DAM SLOPE POPULATION OF DESERT TORTOISES

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INTRODUCTION

Upon completion in 1978 of Judy Hohman's 2-year study (Hohman and Ohmart 1980), the Bureau of Land Management, Arizona Strip District, decided to continue the study of the desert tortoise as an in-house project. As biological technicial, I assumed responsibility for the coordination, continuation, and support of these studies. The following report updates and summarizes the status of the desert tortoise on the Beaver Dam Slope in Arizona. Analysis was not completed for all data collected at time of printing, therefore this is intended as only a preliminary report. Complete analysis is scheduled for 1980-81.

METHODS AND MATERIALS

The scope of the study was essentially the same as the previous two years (Hohman and Ohmart 1980). Data collection, however, was opportunistic, with an average of 1 day per week in two study areas, control and exclosure. Location and measurement of new animals, monitoring home range and movements by radio telemetry, vegetation measurements of perennial and annual species, and fecal collection for dietary analysis were of central importance for the maintenance of continuity between Hohman's work and the author. This was necessary to provide information pertaining to demographic and habitat condition trends.

Wherever tortoises were found, their locations were plotted on aerial photos, along with measurements of weight, carapace length and width, shell depth, pastron length, gular length and width, and sex of animals greater than 7 in. (180 mm) carapace length. Successive numbers were epoxied to the rear vertebral for identification purposes.

Perennial plant species composition, cover, and density were determined by line intercept (Canfield 1941) and annual forage biomass by the double-sampling technique (Wilm, Costello, and Klipple 1944).

Tortoise fecal samples were collected whenever found, provided that they were relatively fresh. The grazing system was broken in the area where the study sites are located and thus no dietary overlap could be determined.

RESULTS

In 1979, 20 additional tortoises were marked inside or along the periphery of both study areas, making a total of 93 tortoises marked over the 3-year period (Table 1). The only marked change occurred in the percentage of juvenile and adult tortoises located in comparison to each preceding year. A greater percentage of tortoises in the younger age classes were found in 1979. This substantial increase occurred primarily in the control site, where age class distribution appeared much healther than the exclosure site (Tables 2a and 2b). The increased number of young tortoises, however, was offset by a substantially smaller number of juveniles found.

After sixty-six 2-mile transects were walked at various locations during 1976-77, these two study sites were selected for having the highest frequency of tortoise sign.

In 1978, the Peterson Estimator indicated higher densities at the control (22 to 23 per km^2 or 57 to 60 per mi^2), than at the exclosure site (8 to 9 per km^2 or 21 to 23 per mi^2) (Hohman and Ohmart 1980). The density parameter also supported the healthier group occurring in the control.

No new surveys were conducted during 1979 and the addition of 20 new tortoises in both study areas indicated that previous estimates were more accurate in the upper range.

The sex ratios for the marked adult and subadult tortoises displaying sexual characteristics are summarized in Table 3. These data confirmed Hohman's findings of a biased sex ratio in favor of males in all situations. If this is an accurate description of the Beaver Dam Slope population, the sex ratio may be explained in part by high collecting pressure. This particularly affected the exclosure which is less than 1 mile south of the Woodbury-Hardy study site in Utah, where tortoises were historically collected and sold to motorists until the 1960's (Coombs 1977). Another theory is that females may sustain high mortality during stress periods of reproduction from poor range conditions made even poorer during seasons of drought (Berry 1978).

The size of home range was smaller for males during 1979 than in the two previous years (Table 4). After relocating radioed tortoises at least once per month, locations were then plotted on enlarged aerial photos and measured by the minimum polygon method (Barbour, et al. 1969) using a compensating polar planimeter. Tortoise #42 reduced his movement exactly by half -- from 12.1 acres (4.84 ha) to 6.05 acres (2.42 ha). The other four male tortoises narrowed their ranges from a mean of 68.50 acres (27.46 ha) to 28.50 acres (11.40 ha). Data for female home range size were quite limited for all years. Tortoise #61 provided the only reliable data for 1979. When compared with the 1977-78 average for three tortoises, the figures for home range were the same.

Behavior

Tortoises continued to use burrows for over-wintering within the two study sites. Of the eight radioed tortoises, five used burrows for their winter hibernacula. Tortoise #47 selected a burrow under rabbitbrush, *Chrysothamnus* sp. Throughout the active season, Hohman reported the tortoises preferred creosite hummocks and never used burrobush, *Ambrosia dumosa*, for burrowing locations. During 1979, however, tortoise #28 frequently selected a burrow under burrobush. Other previously unreported burrow locations were range rantany, *Krameria* sp., and joint fir, *Ephedra* sp.

Tortoises using these browse plants for burrow support were susceptible to trampling by larger animals. Animals using burrows near creosote hummocks for overwintering and egg depository sites were also vulnerable because the only available grasses were found in the hummocks when the interspaces between shrubs were unproductive or after the annuals cured, forcing cattle into the shrubs.

Another major difference observed in 1979-80 was the lengthened season of activity. Hohman reported tortoise activity began in April and continued into October. During this study, aboveground activity was observed on 24 October 1979, and a tortoise was sighted on State Highway 91 in late November of the same year. After 1 month of heavy precipitation on Beaver Dam Slope during January and February 1980, 3 in. (75 mm), three tortoises emerged on 29 February 1980 at midday, when ambient temperatures were approximately 70°F. On this same date tortoise #28 was discovered in a creosote burrow approximately 75 ft (25 m) from his 13 December 1979 winter home, indicating winter activity.

DISCUSSION

Until now very little information has been gathered on soil structure and soil components in desert tortoise habitat. Soil is an essential habitat factor of any subterranean species and should be considered limiting. Therefore, the following effects of grazing on soils may be critical to tortoise survival:

1. Possible increase in soil surface temperatures

2. Reduced moisture infiltration

3. Increased evaporation and runoff

4. Overall increase of aridity to a site

Another impact of grazing on desert tortoise populations is the removal of forb components during the critical spring period. Wildlife species such as the desert tortoise may have more narrow, more sensitive feeding niches than domestic animals. Some vegetation is consumed by both livestock and tortoises, as indicated in dietary overlap data (Hohman and Ohmart 1980) where as high as 60% (April 1978) similarity index occurs. This may have had a detrimental impact on the tortoise population, but the degree of impact has not been ascertained.

Both the Shivwits draft Environmental Impact Statement (EIS) and the Grand Wash Management Framework Plan (MFP) support the elimination of grazing in spring and summer from high density areas. After analysis of demographic data on several populations Berry and Nicholson (1979) have suggested that a viable population must be maintained above 50 per mi^2 (19 per km^2). Below this density, numbers approach a level from which recovery is questionable.

CONCLUSION

Tortoises seem to be irregularly distributed, corresponding to the "patchiness" of habitat throughout their range. Although the exclosure in sthis study was established to determine the grazing influence, there may be significant value also in comparison of abiotic factors, i.e. elevation (control = 180 ft or 490 m, exclosure = 2700 ft or 825 m), rainfall patterns, and soil structure, which may strongly influence habitat selection by tortoises.

A comparison of tortoise habitat both in the Arizona Strip District and elsewhere would increase our knowledge of this long-lived sensitive species. Emphasis on coordination with other concerned parties would further improve the overall condition of desert tortoises. The proposed designation of "endangered" for the "Utah population" on Beaver Dam Slope is of great interest to the Arizona Strip District. The Dixie Resource Area (Utah BLM) has initiated research in the Woodbury-Hardy and Coombs study areas and, with cooperation of field personnel, we could eliminate duplication and expedite research. Proposals have also been made to hold regular meetings for ranchers and personnel concerned with tortoise survival.

Field work and status reports will be continued. The 1980 field season will implement methods similar to previous years, as well as additional procedures, to improve the data base. A schedule of daily and monthly activities for field personnel will be used as a guide to improve the quality and quantity of data collected.

Various habitat parameters must be measured to determine environmental conditions that may limit tortoise populations.

Ground and ambient temperatures will be recorded when personnel conduct field work. Rainfall gauges should be checked monthly at each study site. Monthly vegetation transects will be run using the best available method to determine forage biomass. Utilization studies should be arranged with the range conservationist for the allotment. Cages will be placed on the Beaver Dam Slope and studies will be accomplished by personnel from both disciplines.

All tortoise fecal samples will be collected. Cattle fecal samples will be collected when Pasture 3 in the control area is grazed. Approximately 20 samples should be collected monthly. In addition, predator scats and pellets should be collected and analyzed to determine the extent of predation on tortoises.

All unmarked tortoises will be marked, and their location and physical measurements recorded. Radio telemetry will continue; new transmitters will be attached to adult females when possible. Location of hatchlings is critical to determine whether reproduction has been significant within the previous 5 years. Efforts to locate hatchlings will be concentrated in March, April, and May, using students from biology classes, Youth Conservation Corps, Audubon Society, and co-workers in the study areas to increase the likelihood of success. Weights of mature females could be monitored biweekly; any dramatic loss of weight could indicate reproduction.

Keeping the public informed may be the most beneficial approach in the long run. In so doing, management of public lands can be improved to achieve their long-term productive potential and then maintained in that condition while producing the goods and services necessary for all interest groups.

ACKNOWLEDGEMENTS

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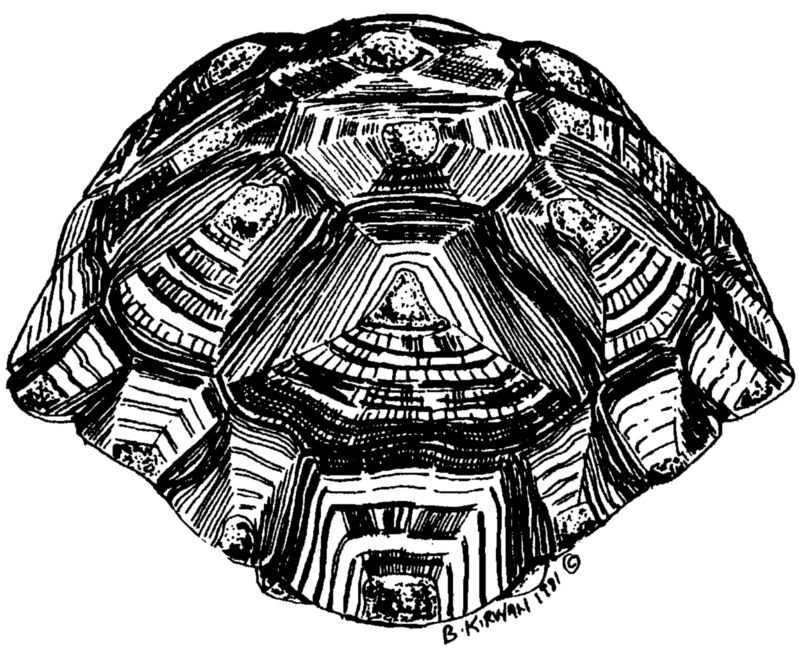

TABLE 1. Age Class and Sex of Desert Tortoises Marked at Beaver Dam Slope, Arizona

		Sex				Percent of Marked Population
		Male	Female	Unknown	Total	
Adult	A *	16	6		22	30
(214 mm)	B	3	1		4	20
SubAdult	A	5	3	14	22	30
(171-214 mm)	B	1	1	4	6	30
Juvenile	A			20	20	27
(101-171 mm)	B			4	4	10
Young	A			7	7	10
(61-100 mm)	B			5	5	35
Hatchling	A			2	2	3
(61 mm)	B			1	1	5
(						
	Total A				73	100
	" B				20	100

* A = 1977-78
B = 1979

TABLE 2a. Age Class and Sex of Desert Tortoises Observed Within Two Study Sites During 1977-78 and 1979 at Beaver Dam Slope, Arizona.*

Control

	Sex				
	Male	Female	Unknown	Total	Percent
Adult	8 (10)	5 (6)		13 (16)	25 (23)
Subadult	4 (5)	3 (4)	9 (13)	16 (22)	30 (32)
Juvenile			16 (18)	16 (18)	30 (26)
Young			6 (11)	6 (11)	11 (16)
Hatchling			2 (2)	2 (2)	4 (3)
Total				53 (69)	100 (100)

*Numbers in parentheses represent 1977-1979 observations

TABLE 2b. Age Class and Sex of Desert Tortoises Observed Within Two Study Sites During 1977-78 and 1979 at Beaver Dam Slope, Arizona*

Exclosure	Sex				
	Male	Female	Unknown	Total	Percent
Adult	8 (9)	1 (1)	-	9 (10)	45 (42)
Subadult	2 (2)	-	4 (4)	6 (6)	30 (25)
Juvenile			4 (6)	4 (6)	20 (25)
Young			1 (1)	1 (1)	5 (4)
Hatchling			- (1)	- (1)	- (4)
Total				20 (24)	100 (100)

*Numbers in parentheses represent 1977-79 observations.

TABLE 3. Sex Ratio (Male:Female) of Desert Tortoise Observed Within the Two Study Sites at Beaver Dam Slope, Arizona

Year	Location	Class	Actual	Projected
1977-78	Control and exclosuire	Adults	16:6	2.67:1
W/1979	" " "	"	19:7	2.71:1
1977-78	Control and exclosure	Adults and Subadults	21:9	2.33:1
W/1979	" " "	" " "	26:11	2.36:1
1977-78	Control only	Adults	8:5	1.60:1
W/1979	" "	"	10:6	1.67:1
1977-78	Control only	Adults and Subadults	12:8	1.5:1
W/1979	" "	" " "	15:10	1.5:1
1977-78	Exclosure only	Adults	8:1	8:1
W/1979	" "	"	9:1	9:1
1977-78	Exclosure only	Adults and Subadults	10:1	10:1
W/1979	" "	" " "	11:1	11:1

TABLE 4. Home Ranges of Adult and Subadult Desert Tortoises For 1977-79, Beaver Dam Slope, Arizona

	Adult home ranges 1977-78	1979
#28	18.40 ha (45.46 acres)	12.80 ha (32.46 acres)
#32	59.08 ha (246.00 acres)	11.14 ha (27.38 acres)
#33	23.93 ha (59.13 acres)	12.21 ha (30.00 acres)
#42	4.84 ha (11.97 acres)	2.42 ha (5.95 acres)
#47	8.43 ha (20.82 acres)	9.46 ha (23.25 acres)
$\bar{X}$ =	22.94 ha (56.69 acres)	9.606 ha (23.63 acres)

	Adult female home ranges 1977-78	1979
#30[1]	1.08 ha (2.68 acres)	No change
#39	3.66 ha (9.05 acres)	.22 ha (.55 acres)
#67	29.11 ha (71.92 acres)	11.31 ha (27.79 acres)
$\bar{X}$ =	11.28 ha (27.88 acres)	-

[1]Located 17 August 1979 over 4 miles north-northeast of her calculated home range for 1977-78.

MANAGEMENT OF DESERT TORTOISE
HABITAT ON THE ARIZONA STRIP

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I welcome the opportunity to participate in this Desert Tortoise Council Symposium to discuss the management plans of the Arizona Strip District for the desert tortoise habitat in northwestern Arizona. I will present those, along with my reasons for the management activity planned. We have a common goal of improving desert tortoise habitat. I also have a responsibility to provide for other uses of the habitat in a multiple-use management context.

The tortoise is an important and visible form of wildlife. We place a high priority on the management and protection of its habitat. We consider the population viable and do not consider its habitat threatened. However, we do see a need to follow up established studies to ensure that the habitat remains healthy and that the tortoise population remains viable.

We do not have the off-road vehicle pressure that some areas have and collecting has been reduced through protective legislation and land use changes.

A major plus for the tortoise on the Beaver Dam Slope is a land use change. Before the construction of I-15, service stations along Highway 91 not only sold tortoises to tourists but, motorists travelled slower, making the tortoise more vulnerable to collectors. The construction of I-15 in combination with a protective law has probably made collecting a minor factor now. However, we will probably be living with the effects of past collecting for a long time.

A source of potential conflict on the tortoise habitat is livestock grazing. Beginning around 1880 and until somewhere around 1930, thousands of cattle and sheep grazed across the tortoise habitat. After the Taylor Grazing Act was passed, the numbers of cattle and sheep were reduced. Sheep grazing was finally completely eliminated about 1968. Through an adjudication of grazing privileges, probably done during the 1960's, cattle numbers were limited to 2,130 for the total area. Actual grazing use over the past 5 years indicates use has stabilized at 1,767 cattle. This is approximately 350 less than their allowable number and approximately 100 less than the grazing capacity indicated by recent Bureau of Land Management studies.

In the draft environmental statement for the area, the alternatives propose stocking rates between 1,194 and 1,303 head of cattle, a reduction of 679 to 464 head of cattle below the current estimated grazing capacity. The initial stocking rate will vary depending upon what kind of grazing system is implemented on each allotment.

The reasons for the reduction below the current level are:

A. A direct allocation of forage for wildlife.

B. Exclosures.

C. Where spring grazing is allowed every year, research indicates that grazing levels must be held at a light to moderate level to allow for range improvement (40 to 50% of the current year's growth).

D. Where a rest-rotation grazing system is adopted, utilization may range from 40 to 60% of the current year's growth; but, due to a rested pasture not all of the range is available for grazing.

The range management measures we propose are adequate to provide for vegetation improvement and will leave at least 50% of the current year's vegetation production on the ground.

In addition to habitat improvement through proper range management practices, we have either already begun or are planning several actions which will specifically benefit the tortoise. These include monitoring the animals (studies already under way) and a 500-acre (203.3 ha) grazing exclosure. Proposals include a direct allocation of forage in pounds-per-acre and additional exclosures on prime habitat areas.

Studies on the Beaver Dam Slope habitat in Utah and Arizona show an improving trend in the population in general and a recent study in Arizona shows a generally healthy age class distribution. The mortality rate, however, is not consistent with the rest of the findings; we are making additional observations to determine why.

In 1948 Woodbury and Hardy estimated a 1% decline in population on the Utah study from 300 animals. By 1977 Coombs should have found some 225 animals. The 1977 population estimate was 350. Coombs estimated a 7.5% decline. If these estimates were correct, in 1980 we would have less than 180 animals in the Utah study area instead of 350 as Coombs estimates. We have identified two possible reasons for these discrepancies. There is an apparent inability to accurately age shell remains by rate of decomposition and an apparent inability to locate hatchlings. We are initiating studies to improve our capability in both areas.

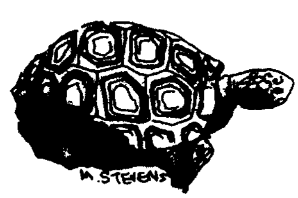
The studies show a change in population density from 152 per square mile in 1948 to 27 per square mile in 1977. This again is not consistent with an overall increase in population during that same period. Coombs expanded the study somewhat from the 1948 study area and some marginal habitat may have been included. In Arizona, Hohman found densities of 21 per square mile and 60 per square mile on two sites. Vulnerability to collecting and/or habitat quality may explain the difference. We suspect both.

The Utah studies show a change in sex ratio from 66 males to 100 females in 1948 to 236 males to 100 females in 1977. The Arizona studies also show a disporportionate ratio of males to females, an average of 167 to 100. This is hard to explain when shell remains indicate a natural mortality of 1:1. Vulnerability of one sex over the other to collecting may be a factor, the quality of the habitat, or sample size may be factors.

The Utah studies show an improving trend in age class distribution. The percentage of adult animals in the population was 90% in 1948 and 72% in 1977. Juveniles were 1% in 1948 and 9% in 1977. No hatchlings in 1948 as compared to 1% hatchlings in 1977. The Arizona studies look even better. The overall study results indicate an improving trend, leading to a healthier situation.

CONCLUSIONS

Age class and total population estimates show an improving trend in the Beaver Dam Slope desert tortoise population. Natality and mortality estimates do not support the observed improved trend. The conclusion is that the population is not in danger of extinction; but, studies should be continued to eliminate inconsistencies in the data and to provide a basis for sound habitat management.



SURVEY OF THE PRESENT DISTRIBUTION OF THE DESERT TORTOISE, *GOPHERUS AGASSIZI*, IN ARIZONA: ADDITIONAL DATA, 1979 1/ 2/

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During 1978 and 1979, 1100 miles (1750 k) of transect were walked to sample designated areas in Arizona for tortoises and their sign. Data were examined for relationships of tortoise sign presence and density to biotic communities and characteristics of topography. Throughout approximately 14,500 square miles (37550 km^2), most of the 387 sites were sampled by one, 3-mile (4.8 k) transect. Most of the area was contiguous, lying south of the Grand Canyon roughly within the area bounded by the cities of Tucson, Kingman, and Yuma. Within this region, sign frequency on flat land was 11%, on rolling land 30%, and on slopes, where 96% of the sign was found, 60%. Sign was found on grades up to 95%. On slopes, sign frequency and density were positively correlated with the apparent value of the rock formations as potential coversites (97% of coversites were under rock formations or in cavities in consolidated materials). Coversite potential values (CPV) were highest among spheroidally weathered granitic outcrops and boulders. The estimated tortoise densities are of questionable reliability because of several sources of considerable error that could not be avoided. One source of error on slopes was the non-random potential transect paths and distribution of sign -- effects of rock formations that limited free access. Limitations did not always affect tortoises and persons equally. This varied within and among sites; thus, the effectiveness of transects probably varied. The estimated densities of at least 55% of the sites with sign was $\leq$50 tortoises per square mile (2.6 km^2).

INTRODUCTION

A continuation of field work to determine the present distribution of the desert tortoise within additional designated areas in Arizona, primarily on public land, began in May 1979. As in 1978 (Burge 1979) data from the sample

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transects were examined for relationships of tortoise sign presence and density to biotic communities and characteristics of topography. Population densities were estimated within the limitations of available baseline data and designated approach.

This report covers field work performed between 17 May and 18 August 1979 and includes the combined results of 3-mile transects made during 1978 and 1979 with the exception of 12 sites north of the Grand Canyon (Figure 1). On these 12 sites, unlike sites to the south, tortoises appear to live primarily on bajadas and alluvial fans.

DESCRIPTION OF DESIGNATED AREA

The areas transected during 1978 (A and B, Figure 1) have been described (Burge 1979). The transects made during 1979 were in Area C (approximately 4,800 square miles or 12,400 km^2); also in the Basin and Range physiographic province characterized by fault block mountains. Maximum elevations of most mountain ranges were 2000-3000 ft (600-900 m). There were a few peaks 4000-5000 (1200-1500 m), but these were inaccessible. On flat land -- primarily bajadas and alluvian fans -- elevations ranged from 300 to 1600 ft (90-490 m).

Biotic communities included two major subdivisions of Sonoran Desertscrub: Lower Colorado Valley communities, dominated primarily by creosote bush, *Larrea divaricata*, and bursage, *Ambrosia dumosa*, and Arizona Upland communities, dominated primarily by paloverde, *Cercidium* sp., and cacti, *Opuntia* sp. and *Carnegiea*.

METHODS

With few exceptions, methods used during 1979 were the same as those used during 1978 (Burge 1979). For the most part, the following includes only the changes used during 1979.

Site Criteria and Advanced Plotting of Transect Sites

As a result of findings from 218, 3-mile transects made south of the Grand Canyon during 1978, the major topographic criterion for 1979 was changed. In 1978, sign frequency on flat land was 11%; sites with flat or rolling topography comprised 59% of those sampled but yielded only 5% of the sign; the remaining sign were found on hills and mountain slopes. For this reason most of the transects in 1979 were made on slopes.

A single, 3-mile x 10-yd (4.8 k x 9.1 m) transect was to be made at each of 100 sites. Sites were tentatively plotted, spacing them as regularly as possible to include each mountain range and discrete groups of hills. Subsequent on-site deletions and substitutions were made due to unforeseen access limitations or to meet other criteria enumerated previously (Burge 1979). On slopes, a transect width had to vary (≤10 yards or 9.1 m) because of the varying degree and extent of visual obstructions due to rock formations.

From data secured in 1978, tortoise sign frequency and density on slopes showed positive correlations with the coversite potential value of the slopes. Coversite potential value (CPV) is a semi-quantitative appraisal that I devised to rate the availability of surface characteristics like those associated with previously identified tortoise coversites (pallets, burrows, and dens). Coversite potential value was applied only to slopes because there, coversites were intimately associated with rock formations despite the availability of exposed soil. Unlike the typical surface of bajadas and alluvial fans, where most coversites are dug in exposed soil, the preferred substrate on rocky slopes is not evenly distributed nor is access to it free of limitations -- characteristics of the rock formations themselves. Because cover is undoubtedly a limiting factor for tortoises and because of the high positive correlation of CPV with tortoise sign frequency to density, CPV was used as an index of habitat suitability on slopes.

The CPV was based upon: 1) the abundance of potential coversites, which in turn is a function of the number of boulders, outcrops, crevices, and cavities in rocks and partially consolidated materials; 2) their functional potential as coversites; 3) the extent of negotiable access to such potential coversites; and 4) access over the slopes as a whole. The functional potential of a crevice, cavity, or boulder included contact with soil or other material that could be excavated by the tortoise, and size, e.g., single boulders >20 in (>50 cm) diameter and piles of boulders were preferred over single, smaller boulders. At the completion of a transect the CPV of the site was rated as either poor (1), fair (2), good (3), or excellent (4). However, initially, if after scanning a slope with binoculars from the base I judged the site unsuitable as tortoise habitat because of apparently very poor coversite potential, the slope was not transected. Marginally unsuitable sites usually were transected.

With few exceptions, transects began at least 1/4 to 1/2 mile (400-800 m) from unpaved roads and 1 mile (1.6 k) from paved roads.

Population Density Estimates

From the number of total sign found on the 3-mile transect at each site, a tortoise density estimate was projected proportionately using the mean sign of multiple transects on the one site of known tortoise density that was considered comparable, i.e., tortoises there lived primarily on slopes. The site was located in the Granite Hills of the northern Picacho Mountains. A density of approximately 50 tortoises/square mile (2.6 km^2) had been determined after a 2-year investigation (James Schwartzmann, pers. commun.). The results of the multiple transects at that site have been discussed (Burge 1979). Total sign included live tortoises, remains, egg shell fragments, tracks and plastral impressions (except those at coversites), mating depressions, coversites, and scats (except those in coversites or that appeared to have been excavated from inside).

The differences among groups of data were tested for statistical significance at the 5% level. Tests included Student's t-test, chi square, and Spearman's rank correlation (unless noted otherwise).

RESULTS AND DISCUSSION

In 1979, Area C was sampled by 100, 3-mile transects. Sign was found at 45 sites -- 3 of the 16 in Lower Colorado Valley communities and 42 of 84 in Arizona Upland. Total sign was 353, the mean (± 1 SD) was 7.8 ± 9 (1-44). Sign included scats, skeletal remains, egg shells, and coversites; nine live tortoises were seen. Transects were made at elevations from $\approx$700 to $\approx$3000 ft (200-900 m). Sign was found from $\approx$900 to $\approx$2200 ft (275-670 m). Nine sites were on flats, 2 on rolling topography, and 89 on slopes. Sign was found off slopes at only two sites -- near the base of slopes (where sign was found). The mean percent grade (± 1 SD) on slopes where sign was found was 50 ± 16 (5-95).

The following pertain to combined data from 3-mile transects made south of the Grand Canyon during 1978 and 1979 (Table 1). Statistical analyses pertain to values only from transects on slopes because 96% of the sign was found there and because certain comparisons among data from slopes, rolling, and flat topography would have been biased because of the intentional concentration of transects on slopes in 1979.

Sign Frequency on Slopes

Frequency Relative to Rock Types and Coversite Potential

Transect sites were described according to predominant rock type based upon U.S. Geological Survey map designations (U.S.G.S. 1969) and grouped as follows: 1) basalt, extrusive (Qtb, Qb); 2) other-volcanics -- flows and tuffs, mainly andesitic, some rhyolitic (Kv, Kr, Ka, Tvi); 3) granitic -- granite and granitegneiss (p€gr, p€gn, Mzgr, Tkg); 4) other-intrustives -- mainly andesitic and rhyolitic dikes, sills, and plugs (Tki, Ti); and 5) sedimentary -- various (Mzs, Tks). The data from the few (6) sites of other-intrusives were combined with those of other-volcanics because of their similar composition and fine-grained texture. Although extrusive basalts were also of fine-grained texture, they were considered separately because of their relative geologic youth.

Differences in sign frequencies among rock types were not significant (Table 2); however, when ranked according to CPV, rock types combined showed a positive correlation (r=1) and each rock type showed a positive correlation -- sedimentary, r=0.5 and each of the others, r=1.

For each rock type, the difference between sign frequency where CPV were low (1 and 2 combined because of small sample sizes) and where CPV were high (3 and 4 combined) could be tested with reliability only for granitic sites. The values of the small sample sizes of the three rock types other than granitic were combined. In each of the two groups, the sign frequency was significantly greater where CPV were high.

Sites with low CPV and sites with high CPV were considered separately and the differences in sign frequencies between rock types were tested using actual percentages (z-test) because of the small sample sizes. For both low and high CPV the significant differences were between the higher sign frequency of other-volcanics and each of the other rock types. Possible reasons for the significantly greater sign frequency among sites with other-volcanics (than indicated by CPV) include: 1) the few, broad categories of CPV and the low precision in rating sites; and 2) the greater surface heterogeneity on sites of other-volcanics than on sites where other rock types predominated. For example, on a site with other-volcanics judged poor as a whole, one or more small portions of the transect might have good CPV and sign.

Because sign frequency was not significantly correlated with rock type but was significantly correlated with CPV, the extent to which CPV is a function of rock type was examined. An obvious difference among rock types was that CPV of 4 (excellent) was observed only on granitic slopes (Table 2). Among all sites sampled, the frequency of sites with high CPV (3 and 4) was significantly greater among granitics and the frequency of sites with low CPV (1 and 2) was significantly less among granitics; other rock types did not differ significantly from one another in either category.

Frequency Relative to Biotic Communities or Biomes

Of the 178 transects on slopes, 159 were in two major subdivisions of Sonoran Desertscrub -- Arizona Upland and Lower Colorado Valley. The remaining 19 sites were in various communities within three other biomes: Mojave Desertscrub, Semidesert Grassland (scrub grassland), and Interior Chaparral (Brown and Lowe 1974) (Table 1). The number of sites with sign on slopes in Mojave Desertscrub, Semidesert Grassland, and Interior Chaparral were combined because of the small sample sizes. Sign frequency of this group, Arizona Upland, and Lower Colorado Valley differed significantly from a random distribution. The largest departure shown was the low sign frequency of Lower Colorado Valley.

The effects upon vegetation (potential tortoise forage) of the typically lower and more variable rainfall and higher temperatures in Lower Colorado Valley communities may have been most responsible for the significantly lower frequency of sign. Average annual precipitation in Lower Colorado Valley communities ranges from slightly more than 1 in. (2.5 cm) to slightly less than 8 in. (20 cm) (Hastings and Turner 1965); Arizona Upland, 3-12 in. (7.6-30 cm) (Shreve and Wiggins 1951), 5-6 in. (13-15 cm) near Yuma and 11-13 in. (28-33 cm) in the southeastern mountains (Lowe and Brown 1973); Semidesert Grassland, 12-16 in. (30-41 cm) (Hastings and Turner 1965), <10-15 (Lowe and Brown 1973); Interior Chaparral, 13-23 in. (34-58 cm) (Lowe 1964); and Mojave Desertscrub, 5-11 in. (13-28 cm) (Lowe and Brown 1973); however, annual precipitation is less indicative of regional differences in potential stress to vegetation than are the amounts of precipitation that occur during each of the typically biseasonal periods of rainfall and the variability within each period. For example, at Tucson, in Arizona Upland, the coefficient of variation (V) of annual precipitation is 30% -- summer precipitation, V=40% and winter precipitation, V=54%; whereas, at Yuma, in a Lower Colorado Valley region, for annual precipitation V=62% -- summer precipitation, V=95% and winter, V=75% (Hastings and Turner 1965).

Coversite potential also may have been a factor responsible for the low frequency of sign observed on slopes in Lower Colorado Valley communities. The ratio of sites with low CPV to those with high CPV in Arizona Upland was 1.2:1; in Mojave Desertscrub, Semidesert Grassland, and Interior Chaparral (combined because of their small sample sizes), 1:2.2; whereas, Lower Colorado Valley was 4:1; these differences were significant.

Sign Density on Slopes

Of the 1,656 sign observed at 106 sites, 550 (33%) were seen at 6 sites -- 65 to 126 at each site. At none of the remaining 100 sites did sign exceed 44 ($\bar{x}$ = 11.1 ± 10).

Density Relative to Rock Types and Coversite Potential

Mean sign densities were compared between rock types (Table 3). The six sites with atypically high sign totals were on granitic slopes and, even when excluded from the calculations, the mean sign on granitic slopes was significantly greater than the mean of each of the other rock types. Basalt and other-volcanics did not differ significantly but both were significantly greater than sedimentary.

Mean sign densities of the four coversite potential values for all rock types combined showed a positive rank correlation (r=1) (Table 3) and the differences between adjacent CPV-ranks were significant. For each rock type the differences between adjacent CPV-ranks also were significant where sample size was four or more.

Sites with low CPV and sites with high CPV were considered separately and mean sign densities were tested between rock types excluding sedimentary because of small sample size. Where CPV was low there was no significant difference between rock types. Where CPV was high the mean of granitics was significantly greater than the mean of basalt and the mean of other-volcanics. Comparing CPV 3, only, between rock types (Table 3) the mean sign density of granitics was still significantly greater. The possible functional relationship of granitics to high sign densities will be discussed under coversites.

Density Relative to Biotic Communities or Biomes

Two of the six sites with the highest densities were in Mojave Desertscrub communities, and two were in Interior Chaparral communities, these four comprising more than half of the sites with sign in those two biomes. The remaining 2 sites -- of the 6 with the highest densities -- were among the 89 with sign in Arizona Upland. Because of the small sample sizes from the three biomes other than Sonoran Desertscrub, their combined mean (± 1 SD) 17.8 ± 7.5 was used when means were compared, excluding the six sites with atypically high densities. The mean sign in Arizona UPland was higher than that of Lower Colorado Valley but the difference was not significant; whereas, the mean of each was significantly less than the combined mean of the three remaining biomes.

As with sign frequency, rainfall is probably a major factor responsible for the significant density differences; however, CPV, particularly the relationship of high CPV and granitics, may be at least as influential, i.e., on sites with sign, granitics were the predominant rock type on only 14% of the Lower Colorado Valley sites but comprised 61% of the Arizona Upland sites, and 100% of the remaining sites.

Frequency and Density of Specific Kinds of Tortoise Sign

Frequency and density values of each kind of sign are given in Table 5.

Live Tortoises

Most of the 57 tortoises were in cover, a few were walking or basking, one was eating the perennial herb, *Janusia gracilis*.

Environmental conditions that vary with season and time of day probably affect the visibility of tortoises more than tortoise density. The number of live tortoises observed probably would have been greater if it had been possible to transect earlier in the spring or later in the fall; 59% of the transects were made during July and August.

The maturity-size distribution of 77% adults (Table 6) is higher than in most populations from which data are available -- 33-58%. Among the exceptions is the Granite Hills population -- 69% adults (Berry 1978).

No subadults were found and the percentage of each of the three size-classes of juveniles is less than for those populations summarized by Berry (1978). Juveniles may be more eifficult to find on boulder-covered slopes than on typical bajadas; however, the low representation of classes other than adult may be an indication of declining reproductive success and/or juvenile survival. The ratio of adult males to adult females (0.9:1) was based upon only 57% of the adults, the others were too far inside burrows to sex.

Remains

The surfaces of 3,707 neotoma middens were examined; 2.7% yielded tortoise sign. Remains found on middens comprised 41%. The majority of remains were comprised of a single limb bone or shell element -- leached and/or bleached. At least 26% were relatively intact shells that probably had been exposed for ≤2 years; none was fresh. The maturity-size distribution of remains was similar to that of live tortoises -- 73% adults, 3% small juveniles and 17% large juveniles; however, subadults were represented (7%). Only 26% of adults and subadults could be sexed; hence, the sex ratio is not meaningful.

Egg Shell Groups

The fragments of 13 egg shell groups comprised the smallest percent of all sign found (1%). Low representation is understandable, for unless the nest soil is disturbed, e.g., by predators or, where the nest is at the opening of a coversite, by tortoises using the coversite, most shell fragments remain below the surface (B urge 1977*a*, 1977*b*). Nine of the groups were found at the openings of burrows. The inner surfaces of nine of the groups were eroded, indicating embryonic development; the inner surfaces of four were highly convoluted.

Scats

Scats were the most numerous sign and had the highest frequency. Neotoma middens yielded 5.4% of the scats.

The persistence, seasonality, and frequency of kinds of sign are considerations when determining the best single or combination of sign to use as an index of population density. The ratio of scats of different shades indicates relative persistence. The ratio of recent and dark scats, to those partially faded, to those faded white was 3.8 : 3.6 : 1. From my observations of exposed scats of captives, it is apparent that the time required for a fresh scat to fade completely is considerably less when the scat is exposed to precipitation than when exposed only to direct sunlight. Considering the differences in amount and timing of rainfall throughout the area sampled and the period of sampling, the length of time represented by observed scats may have differed among sites. The effect of year-to-year differences in total precipitation upon scat disintegration and upon forage availability, and tortoise activity levels could result in scat numbers that vary, not only from year to year at a given site but also in a given year between sites with the same tortoise density. Considering that scats comprised 81% of total sign, the above variables might have a significant effect upon sign totals and upon estimated tortoise densities projected from sign totals.

Thirty-two (2%) of the scats were composed almost entirely of soil; most particles <1 mm (0.04 in.) diameter. I do not know if there is a difference in the effects of exposure upon these scats and those composed primarily of plant remains. Eighteen of the 19 sites where scats with soil were found were on granitic slopes, one was on a basalt slope (Qtb). Explanations of possible significance of geophagy include use as a source of supplementary calcium (Sokol 1971). Basalts, unlike granitics, contain calcium-rich plagioclase feldspar.

Coversites

Of the 192 coversites, 8 were on the flats; 5 of these were in soil and 3 in cavities in partially consolidated wash banks. All eight were within 1/4 mile (400 m) of slopes. The remaining 184 on slopes were either in cavities in partially consolidated gravel, agglomerate or tuff, or under boulders or outcrops. Soil or rock particles usually formed the floor. Coversites were found at various locations from the base to the top of slopes. It was not unusual for neotoma middens to be found in coversites of various lengths. Coversite types included 39 pallets, 143 burrows, and 10 dens. Mean length of 127 adult-sized burrows and dens ($\leq$200 cm or 80 in.) was 95 ± 40 cm (38 + 16) (30-200). Lengths >200 cm could not be measured consistantly because of turns and obstructing rock formations.

Coversites comprised only 11% of all sign and were considered under represented because of the inherent difficulty in identifying them with certainty. Most coversite openings were of rock, lacking the characteristic half-disc shape of a coversite dug in exposed soil. Some pallets and short burrows, identified by either the presence of a tortoise or scats, showed little disturbance of the substrate and no definite tracks or shell impressions. Their appearance was like the often-numerous potential coversites. At the Granite Hills study site, tortoises frequently used superficial cover with little or no excavation, e.g., under the overhang of a rounded boulder or a rock slab. These coversites and sites like them were used after little or no excavation by black-tailed hares, *Lepus californicus*, and Audubon cottontail rabbits, *Sylvilagus audubonii*, (James Schwartzmann, pers. commun.).

Outcrops of calichified gravel and some tuffs tended to form cavities, used and improved by rodents, rabbits, and canids, as well as tortoises. Only those coversites that showed definite sign of tortoise use were included.

On slopes with sign, the frequency of coversites on granitics was 59% and on other rock types, 53%. Their respective mean densities were 3.0 ± 2.1 and 2.4 ± 1.6. The reason for the simivalues despite the significantly higher CPV and total sign densities on granitics may be that coversites among granitics are relatively more difficult to recognize for the following reasons: 1) The course granitic grus, often widespread on the surface is very poor for indicating the passage of a tortoise or that the superficial disturbance of the surface associated with the use of a site as a pallet was the result of tortoise activity; and 2) the characteristic, spheroidally weathered form of granite, e.g., rounded boulders 1-5 m in diameter and outcrops weathered to almost discrete, rounded form create low overhangs at their bases. Some of the overhangs apparently extend far enough under the rock to preclude the need of the tortoise to excavate. At the ground surface where two boulders touch, they tend to form a natural opening that sometimes leads to contiguously covered space used as a coversite without excavation (no tell-tale apron of excavated soil). Among the more extensive, massive, rounded formations, an apron of excavated soil could easily have been concealed and inaccessible.

Population Density Estimates

Some of the 189 sites without sign (Table 7) may have tortoises, but the number is probably low or use is transient. The reliability of the projected densities is questionable. For the higher densities in particular, the actual numbers are probably considerably lower. I believe that the direct and indirect effects of topography are among the responsible factors. As a rule, surfaces of rocky slopes were relatively more heterogeneous than those of flat or rolling topography, e.g., distribution of potential coversites was uneven. Also, on slopes some rock formations undoubtedly limit the free access of tortoises. Excluding secondary transport, sign would be confined to accessible areas. The differential between the effect of barriers upon tortoises and persons appeared to vary considerably among sites; yet, in many instances persons and tortoises probably were confined to the same natural access-ways. As a result, the degree of sign concentration and sampling bias probably varied among sites.

Several other factors creating large uncertainties in the population density estimates include the following: 1) There is an uncertainty of ± 25% in the population estimates of the Granite Hills (James Schwartzmann, pers. commun.), one of the baseline values used to project densities elsewhere. 2) Test transects on the Granite Hills site were few (9.7) and had a large standard deviation (8) from the mean sign (7.3), resulting in a large standard error (2.7) for the population mean. 3) Out of necessity, the assumption (very false) was accepted that the total sign from one transect at each of the other sites represented the true mean (if numerous transects had been made at each site). 4) The assumption was made that the ratio of total sign to tortoise density per square mile would not differ significantly among similar habitats (the Granite Hills site was comprised of hills and adjacent flats). However, it appears that rocky slopes in Arizona are significantly dissimilar.

No adjustment could be made for the non-random sign distribution and transect paths, or factors 3) and 4). The variables of factors 1) and 2) were applied to projected population densities. With a minimum certainty of 86%, real densities lie within a range of 9.5 times greater to 0.7 times less than the estimates given in Table 7; thus, even relative densities are unreliable.

The geographic distribution of 129 sites with sign south of the Grand Canyon (Figure 2) mainly reflects the locations of hills and mountain ranges. Most of the sites with the greatest number of sign are located in the northern portion of the sampled area at elevations between 3000 to 4000 ft (900-1200 m), associated with the higher and relatively contiguous mountain ranges -- Hualapai Mountains and hills west, south, and east of Bagdad. Throughout the area, tortoises' use of flat and rolling terrain appears to be transient. That this has always been the case remains to be determined. Where tortoises live in areas that are or have been grazed by livestock, population status and habitat condition warrant particular attention because of the observed and implied, direct and indirect effects of grazing upon tortoises (Berry 1978; Berry and Nicholson 1979). There have been livestock grazing on open range in Arizona since at least the early 1800's (Hastings and Turner 1965). If tortoises in Arizona once inhabited the flat lands as they do elsewhere throughout their range, the present use of slopes (primarily) may be related to the impact of livestock.

Cattle and/or their tracks, trails, and feces were seen at 73% of the sites which included some of the steepest slopes transected. Sign of domestic sheep were seen at <2% of the sites; burro or their sign were seen at 30%.

ORV tracks were seen at 19% of the sites; most tracks were 4-wheel and were located on the flats. At 52 sites, 1-5 tracks were seen; at 8, 6-66.

Potential predator sign was seen at 97% of the sites. No tortoise remains were found from cursory examinations of 1,552 canid scats of which less than one-half were coyote, *Canis latrans*, most were grey fox, *Urocyon cinereoargenteus*, some may have been kit fox, *Vulpes macrotis*. Of the 27 live tortoises examined, one (juvenile) showed definite signs of predation -- recent gouges and scratches on the shell, marks that could have been made by a coyote's teeth.

Of the 18 relatively intact shell remains, two showed tooth impressions and broken peripheral bones that were probably the results of mammalian predators or possibly scavengers; however, a lethal attack by a coyote may end with a completely emptied but intact shell (Berry 1972).

From a survey like the present one, a marginally self-sustaining or declining population may not be apparent or adequately represented; however, the low tortoise densities and the atypically high percentage of adults, overall, may be indications of actual decline and warrant further investigation.

SUMMARY AND CONCLUSIONS

1. Single, 3-mile transects were made at 318 sites. Flat land comprised 31% of the sites, 11% of which had tortoise sign (<2% of all sign). Rolling topography comprised 13% of the sites, 30% of which had sign (<3% of all sign). Hills and mountain slopes (up to 95% grade) comprised 56% of the sites, 60% of which had sign (96% of all sign).

2. Considering slopes only, sign frequency in Lower Colorado Valley communities of Sonoran Desertscrub was significantly less than that of Arizona Upland communities of Sonoran Desertscrub and the three other biomes. Sign density was significantly greater in the three other biomes than in either subdivision of Sonoran Desertscrub, although sign density in Arizona Upland communities was greater than in Lower Colorado Valley communities. Rainfall differences and their implied effect upon forage availability among the five biotic groups probably is a major factor responsible for the differences -- Lower Colorado Valley communities being typified by extremes of low precipitation and high temperatures. Coversite potential also may be a factor. Slope sites with low CPV were significantly more common among Lower Colorado Valley communities.

3. The cryptic location and often superficial extent of coversites among rock formations made them difficult to identify. As a result, coversites were under represented and thus were a poor index of tortoise presence, much less, density; however, the density of potentially suitable sites for cover among the rocks -- the CPV -- showed positive rank correlations with sign frequency and density and the differences between adjacent CPV-ranks were significant.

4. Sign frequency showed no significant correlation to rock type; however, sign density was significantly greater among granitic rocks. Except for granitic sites with their relatively greater number of good and excellent sites for cover, CPV would be a better indicator of tortoise presence than rock type. Also, sites with other-volcanics appear to be better tortoise habitat than indicated by their CPV.

5. The correlation of significantly higher sign densities among granitics may be a casual relationship -- the result of the characteristic spheroidally weathered forms which afford a greater number of coversite possibilities.

6. The positive correlation of CPV with sign frequency and density may be of value in predicting sites with relatively high tortoise densities.

7. Projected tortoise densities ranged from <50 to 863/square mile. The six sites with densities >300/square mile (445-863) represented only 5% of the sites with sign; however, considering the concentrating effects of microtopography upon sign distribution and transect paths, I doubt that there were as many as 300/square mile. The projections of the lower densities probably

are less in error, i.e., at least 56% of the sites with sign had low tortoise densities ($\leq$50/square mile). Actual densities, what level is critically low, and whether or not densities are declining remain to be determined.

8. The method used to estimate densities of tortoises living primarily on slopes was considered unreliable at its present, unrefined stage. Before the method is applied to slope-dwelling tortoises, further tests of its accuracy and precision should be made on several sites of different known densities and on sites with similar densities that differ in the degree of access limitations.

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TABLE 1. Sign Frequency and Density Relative to Topography and Biomes or Biotic Communities

	Biomes*/					
	SD		MD	SG	IC	All vegetation groups
	AZU	LCV				
Flats						
Sites sampled (n)	35	35	22	8	. . .	100
Frequency (%)	20	11				11
Total sign	21	8				29
Mean density**/	3 ± 1.1	2 ± 0.5				3 ± 0.7
Range	1-8	1-3				1-6
Rolling topography						
Sites sampled (n)	27	6	1	4	2	40
Frequency (%)	33	50				30
Total sign	43	4				47
Mean density	5 ± 1.2	1 ± 1.0				4 ± 1.0
Range	1-10	1-2				1-10
Slopes						
Sites sampled (n)	134	25	6	4	9	178
Frequency (%)	66	28	50	75	44	60
Total sign	1118	58	235	43	202	1656
Mean density	13 ± 1.6	8 ± 4.1	78 ± 39.0	14 ± 5.9	51 ± 19.5	16 ± 2.1
Range	1-101	1-26	18-126	9-24	18-91	1-126

TABLE 1 (Continued)

	Biomes*/					
	SD		MD	SG	IC	All vegetation groups
	AZU	LCV				
All topographic types						
Sites sampled (n)	196	66	29	16	11	318
Frequency (%)	54	21	10	19	36	41
Total sign	1182	70	235	43	202	1732
Mean density	11 ± 1.4	5 ± 2.1	78 ± 39.0	14 ± 5.9	51 ± 19.5	13 ± 1.9
Range	1-101	1-26	18-126	9-24	18-91	1-126

* SD=Sonoran Desertscrub (biome), MD=Mojave Desertscrub (biome), SG=Semidesert Grassland (biome), IC=Interior Chaparral (biome), AZU=Arizona Upland Communities, LCV=Lower Colorado Valley communities

** ± 1 SE

TABLE 2. Sign frequency on slopes relative to rock types and coversite potential values (CPV)

Coversite potential value (CVP)*/	1	2	3	4	All CPV
Granitic					
Sites sampled (n)	18	27	45	13	103
Sign frequency (%)	11	52	82	92	63
Basalt					
Sites sampled (n)	5	12	5	. . .	22
Sign frequency (%)		50	80		46
Other volcanics					
Sites sampled (n)	11	15	12	. . .	38
Sign frequency (%)	27	73	92		66
Sedimentary					
Sites sampled (n)	6	5	4	. . .	15
Sign frequency (%)	17	60	50		40
All rock types					
Sites sampled (n)	40	59	66	13	178
Sign frequency (%)	15	58	82	92	60

* 1=poor, 2=fair, 3=good, 4=excellent

TABLE 3. Sign Density on Slopes Relative to Rock Types and Coversite Potential Values (CPV)

Coversite Potential Value	1	2	3	4	Totals	4*/	Totals*/
Granitic							
Sites with sign (n)	2	14	37	12	65	6	59
Mean density**/	2 ± 1.4	6 ± 2.0	17 ± 1.8	54 ± 12.7	21 ± 3.2	16 ± 3.7	14 ± 1.4
Range	1-3	1-24	1-44	4-126	1-126	4-26	1-44
Basalt							
Sites with sign (n)	. . .	6	4	. . .	10		
Mean density		5 ± 1.2	6 ± 0.8		6 ± 0.7		
Range		2-9	4-6		2-9		
Other Volcanics							
Sites with sign (n)	3	11	11	. . .	25		
Mean density	1 ± 0	5 ± 0.9	13 ± 2.8		8 ± 1.6		
Range		1-10	1-27		1-27		
Sedimentary							
Sites with sign (n)	1	3	2	. . .	6		
Mean density	1 ± 0	1 ± 0	5 ± 2.8		2 ± 1.1		
Range			3-7		1-7		

TABLE 3. (Continued)

Coversite potential value	1	2	3	4	Totals	4*/	Totals*/
All rock types							
Sites with sign (n)	6	34	54	12	106	6	100
Mean density	1 ± 0.4	5 ± 0.9	15 ± 1.4	54 ± 12.7	16 ± 2.1	16 ± 3.7	11 ± 1.0
Range	1-3	1-24	1-44	4-126	1-126	4-26	1-44

*/ Excluding the six sites with the most sign.

**/ ± 1 SE.

TABLE 4. Sign Density on Slopes Relative to Each Biome or its Major Subdivisions; The Six Sites With the Most Sign Are Excluded

	Biomes					
	SD		MD**/	SG	IC**/	Totals
	AZU**	LCV				
Sites with sign (n)	87	7	1	3	2	100
Total sign	941	58	18	43	46	1106
Mean density***/	11 ± 1.1	8 ± 4.1	18	14 ± 5.9	23 ± 7.1	11 ± 1.0
Range	1-44	1-26		9-24	18-28	1-44

* SD=Sonoran Desertscrub (biome), MD-Mojave Desertscrub (biome), SG=Semidesert Grassland (biome), IC=Interior Chaparral (biome, AZU=Arizona Upland Communities, LCV=Lower Colorado Valley communities

** Two sites excluded

*** (± 1 SE)

TABLE 5. Frequency and Density Values of Each Kind of Tortoise Sign Found on 318, 3-mile Transects South of the Grand Canyon

	Number of sites with sign	% of all sites	% of sites with sign	Number of sign	% of all sign	Range of sign per site
Live tortoises	38	12	29	57	3	0-4
Remains	53	17	41	71	4	0-4
Scats	108	34	84	1399	81	0-118
Egg shell groups	12	4	9	13	1	0-2
Coversites	69	22	53	192	11	0-10
Totals	129	41	100	1732	100	0-126

TABLE 6. Maturity-size Class Distribution of Live Tortoises

Maturity-size class */ (mm)	Observed **/ (mm)	Number of individuals	Percent of sample
Hatchling +/			
38-47	. . .	. . .	. . .
Small juvenile			
48-99	53-85	4	7
Large juvenile			
100-179	128-168	9	16
Subadult			
180-214	. . .	. . .	. . .
Adult			
214	219-297	44	77
Totals		57	100

Adult size ranges:

12 males 226-271 (9 measurable)

13 females 219-297 (4 measurable)

19 sex undetermined (none measurable)

*/ Size=carapace length

**/ Individuals that could be reached

+/ Hatchling: no growth rings and other signs of recent hatching may be evident; size varies, e.g., 24 hatchlings measured to nearest 0.1 mm: $\bar{x}$=43.1 ± 2.3 (38-47.3)(Burge, unpublished data).

TABLE 7. Frequency Distribution of Total Sign Found on Single, 3-mile Transects at 318 Sites South of the Grand Canyon and Population Densities If Projected Proportionately Using Mean Sign Number from Multiple Transects at One Site with Known Density

Number of sign	Number of sites	Projected densities (tortoises/sq. mile)
0	189	
1-7	72	≤50
8-15	21	51-100
16-22	15	101-150
23-29	11	151-200
30-36	1	201-250
37-44	3	251-300
65	1	445
76	1	520
91	2	623
101	1	691
126	1	863

FIGURE 1. Locations of 230, 3-mile transects and 57, 1-mile transects made during 1978 (Areas A and B); and the locations of 100, 3-mile transects made during 1979 (Area C) ● = 3-mile transects with sign, O = 3-mile transects without sign, △ = 1-mile transects with sign, ▲ = 1-mile transects without sign; locations of sites where multiple transects were made for base-line values used to protect population density estimates: + for sites north of the Grand Canyon; ++ for sites south of the Grand Canyon.

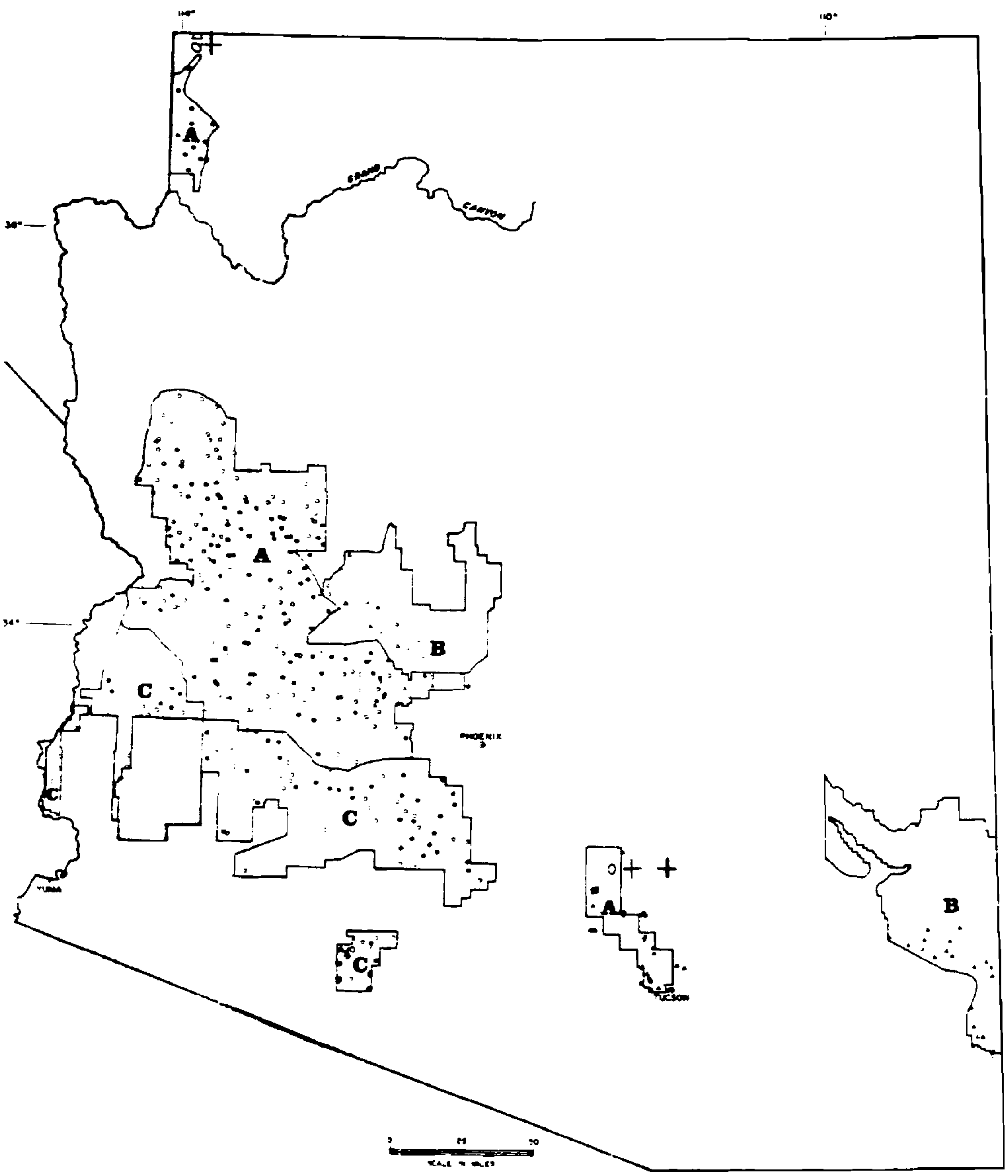
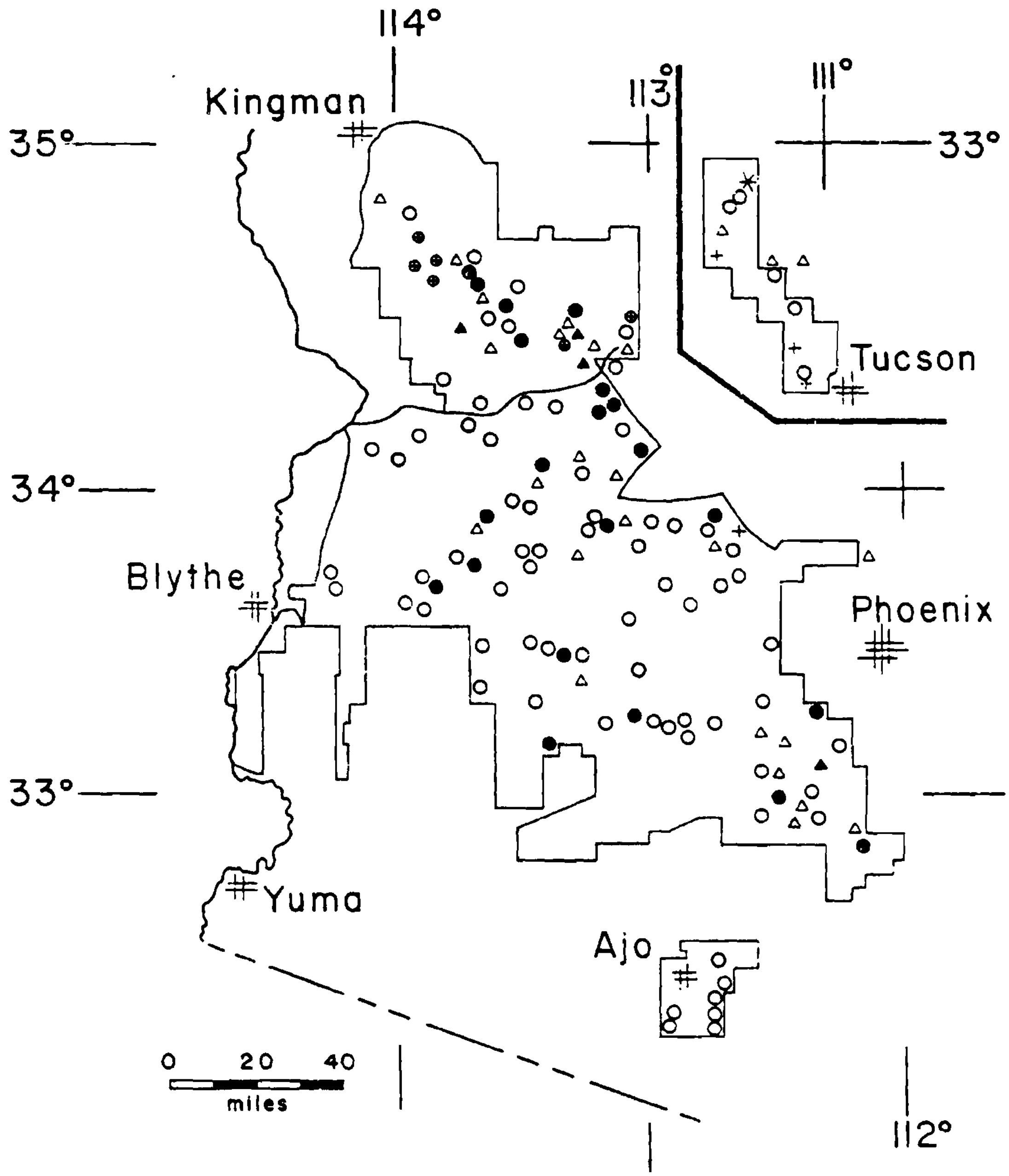


FIGURE 2. Locations of the 129, 3-mile transects where sign were found during 1978 and 1979, south of the Grand Canyon and the tentative estimates of population density ranges (tortoises/square mile): ○ = ≤50, ● = 51-100, △ = 101-200, ▲ = 201-300, ⊕ = >300. ✶ = location of the Granite Hills study site; + = locations of the 4, 1-mile transects with sign (1978).



STATE REPORT - CALIFORNIA

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The Bureau of Land Management (BLM) report for the California deserts is subdivided into six parts: 1) a summary of studies undertaken during spring 1979 at six permanent study plots; 2) a summary of studies performed in fall 1979 at seven permanent study plots; 3) studies now underway in 1980 at two previously established permanent study plots and five new ones; 4) a special baseline study in the vicinity of the interpretive center on the Desert Tortoise Natural Area; 5) a report on the potential effects of the draft Desert Plan for the California Desert Conservation Area on desert tortoise populations and habitat; and 6) the new study at Ivanpah Valley on the potential effects of cattle grazing on desert tortoises and their habitat. Jan Bickett and Tim Shields will present papers on the new 3-mi^2 (7.8-km^2) study plot focused on the interpretive center of the Desert Tortoise Natural Area. I am offering a separate paper on the draft Desert Plan. Thus only four of the six parts are discussed here.

STUDIES UNDERTAKEN IN 1979

Spring

Studies were conducted on six previously established plots, all but two of which are approximately 1 mi^2 (2.59 km^2). The study period was 60 days, twice as long as any previous BLM-sponsored tortoise study in California. The purpose of the longer time period was to gather more reliable data on densities (especially on plots with tortoise densities in excess of 100/mi^2 or 39/km^2); on size class structure and sex ratios; on shell wear and possible age through additional photographs; and on mortality, e.g. by photographing carcasses prior to collection.

Contractors were required to collect more detailed information on vegetation than in the past. They were instructed to sample annual plants using the canopy-coverage method (Daubenmire 1959) once per month for 3 months, between the 10th and 15th of each month. One hundred samples were to be taken per month. Data were collected on perennial plants using the point-quarter technique of Cottam and Curtis (1956); five permanent transects with 100 points each were established on each plot. We also hoped that more information could be gathered on the smaller tortoises, i.e. those 3.9 inches (100 mm) or less maximum carapace length MCL) with the more intensive field effort.

A brief summary of the findings on the six plots is presented below. The reader is cautioned that these data have not been reviewed carefully for consistency and accuracy, and that the results should not be considered final. A review of the raw data, methods, and analysis are underway, and results will be presented in the updated version of the draft report, "The Status of the Desert Tortoise in California" by K. H. Berry and L. Nicholson (1979).

In particular, the reader should be careful in interpreting density estimates and size class structure. Each contractor used different methods for determining density, e.g. Lincoln Index, stratified Lincoln Index, and best professional judgment. Thus there was no standard method for all plots. The size class structure was altered this year also. Hatchlings are considered to be tortoises with no growth rings; juveniles (class I) are those with one or more growth ring(s) and less than or equal to 2.4 inches (60 mm) MCL. Juveniles (class II) range in size from 2.5 to 3.9 inches (61 to 100 mm) MCL, immatures from 4 to 7 inches (101 to 180 mm) MCL, subadults from 7.1 to 8.1 inches (181 to 207 mm) MCL, and adults are greater than 8.1 inches (207 mm) MCL.

Fremont Valley, Kern County

There were 219 first encounters of unmarked or previously marked tortoises; no density estimates were offered. The size class structure of captured animals (first encounters only) was k,4% hatchlings, 0.5% juveniles (class I), 6.4% juveniles (class II), 33.3% immatures, 15.9% subadults, and 42.5% adults. The sex ratio was 0.3 males : 1.0 females for subadults, 0.7 males : 1.0 females for adults, and 0.65 males : 1.00 females for both size classes. Twenty-six shell-skeletal remains were collected, three of which were of previously marked tortoises. Two dead animals appear to have been shot, and two others were road kills. Dr. Anne M. Stewart was the investigator.

Desert Tortoise Natural Area (Section 11), Kern County

This plot is 1.1-mi^2 (2.85 km^2). There were 195 first encounters of unmarked or previously marked tortoises, and density was estimated to be about 165 tortoises/mi^2 (68/km^2). The size class structure of the captured animals (first encounters only) was 3.1% hatchlings, 3.1% juveniles (class I), 2.6% juveniles (class II), 20.0% immatures, 18.5% subadults, and 52.8% adults. The sex ratio was 0.94 males : 1.00 females for subadults, 1.02 males : 1.00 females for adults, and 1:1 for both size classes. Ninety-two shell-skeletal remains were collected, of which 48.9% were of tortoises 3.9 inches (100 mm) MCL or smaller. Three tortoises appear to have been shot. Alice Karl was the investigator.

Stoddard Valley, San Bernardino County

There were 109 first encounters of ummarked or previously marked tortoises; density was estimated to be about 88 tortoises/mi^2 (34/km^2). The captured animals (first encounters only) had a size class structure of 2.0% hatchlings, 2.0% juveniles (class I), 11.0% juveniles (class II), 15.6% immatures, 10.1% subadults, and 59.6% adults. The sex ratio was 1.6 males : 1.0 females for subadults, 1.8 males : 1.0 females for adults, and 1.8 males " 1.0 females for both size classes. Seventy-five shell-skeletal remains were collected, of which 23% were of tortoises 3.9 inches (100 mm) MCL or smaller. Two shells had bullet holes. John Barrow was the investigator.

Ivanpah Valley, San Bernardino County

There were 168 first encounters of unmarked and previously marked tortoises, and density was estimated at 220 tortoises/mi^2 (85/km^2). The captured animals (first encounters only) had a size class structure of 1.8% hatchlings, 1.2% juveniles (class I), 12.5% juveniles (class II), 27.4% immatures, 9.5% subadults, and 47.6% adults. The sex ratio was 1.5 males : 1.0 females for subadults, 1.28 males : 1.00 females for adults, and 1.32 males : 1.00 females for both size classes. Twenty shell-skeletal remains were collected, of which 10% were of tortoises 3.9 inches (100 mm) MCL or smaller. Peter Woodman was the investigator.

Chemehuevi Valley, San Bernardino County

There were 151 first encounters of unmarked and previously marked tortoises on the 2. mi^2 (5.18 km^2) plot. Density was estimated at 115 tortoises/mi^2 (44/km^2). The captured animals (first encounters only) had a size class structure of 2.0% juveniles (class I), 16.6% juveniles (class II), 29.8% immatures, 16.6% subadults, and 35.1% adults. The sex ratio was 0.56 males : 1.00 females for subadults, 0.96 males : 1.00 females for adults, and 0.73 males : 1.00 females for both size classes. Thirty-three shell-skeletal remains were collected, of which 5.9% were of tortoises 3.9 inches (100 mm) MCL or smaller. Margaret Fusari and Paul Schneider were the investigators.

Chuckwalla Bench, Riverside County

There were 266 first encounters of unmarked and previously marked tortoises, and density was estimated at 250 tortoises/mi^2 (97/km^2). The captured animals (first encounters only) had a size class structure of 0.4% hatchlings, 3.4% juveniles (class I), 11.7% juveniles (class II), 26.3% immatures, 8.6% subadults, and 49.6% adults. Sex ratios were 1.1 males " 1.0 females for adults, and 1.2 males : 1.0 females for both size classes. Ninety-four shell-skeletal remains were removed, of which 21.2% were of tortoises 43.9 inches (100 mm) MCL or smaller. Lori Nicholson was the investigator.

Contractors using the 60-day census method found higher percentages of hatchling and juveniles in general than contractors using the 30-day method in 1977 and 1978. They also found more carcasses, some of which were missed during 30-day surveys 2 years earlier. We have been examining the two different study methods closely to evaluate the differences and will discuss findings at a future date.

Fall

Several of us have wondered whether hatchlings and nests might be found more easily in fall than in spring. When funds became available in September, the BLM decided to fund 20-day surveys at seven permanent study plots in October. The field workers were to search particularly for hatchlings, small tortoises, and nests.

The results were disappointing in terms of finding hatchlings. In most cases, few or no small hatchlings and juveniles were located; percentages were far below those found in spring during the 60-day studies. In addition, male adults were found in higher proportions than in spring on some study plots. Brief summaries of the fall studies follow.

Fremont Valley, Kern County

Forty-eight live tortoises were encountered, of which 75.0% were adults, 12.5% were subadults, and 12.5% were immatures. No hatchlings or juveniles were found. The sex ratio was 2.0 males : 1.0 females for subadults, 0.8 males : 1.0 females for adults, and 0.9 males : 1.0 females for both size classes. Eighteen carcasses were collected, and 15 nests were located. The investigator was Dr. Anne M. Stewart.

Desert Tortoise Natural Area (Section 11), Kern County

Sixty-six tortoises were captured, of which 74.2% were adults, 12.1% were subadults, 9.1% were immatures, and 4.5% were juveniles. The sex ratio was 1.7 males : 1.0 females for subadults, adults, and for both size classes combined. Three carcasses were collected. Peter Woodman, the principal investigator, was assisted by Beverly Steveson and Laura Stockton.

Fremont Peak, San Bernardino County

This study area consists of two separate 1-mi^2 (2.59-km^2) plots located several kilometres apart. Only six tortoises were captured (3 adults, 2 subadults, and 1 juvenile (class II)) on both plots. However, 36 shell-skeletal remains were found. The investigator was Karen Foster.

Stoddard Valley, San Bernardino County

Fifty-six tortoises were encountered, of which 75.0% were adults, 14.3% were subadults, 3.6% were immatures, 1.8% were juveniles (class I), and 5.3% were hatchlings. The sex ratio was 7.0 males : 1.0 females for subadults, 2.7 males : 1.0 females for adults, and 3.1 males : 1.0 females for both size classes. Thirty-one shell-skeletal remains were taken. Paul Melograno was the investigator.

Ivanpah Valley, San Bernardino County

Sixty-seven tortoises were captured, of which 71.6% were adults, 16.4% were subadults, 8.9% were immatures, 1.5% were juveniles (class II), and 1.5% were hatchlings. The sex ratio was 4.5 males : 1.0 females for subadults, 1.7 males : 1.0 females for adults, and 1.95 males : 1.00 females for both size classes. Only one complete carcass was collected. Peter Woodman was the investigator.

Chemehuevi Valley, San Barnardino County

Forty-two tortoises were captured in this study, which had 4 of the 20 field days in November. Of the 42 encounters, 64.3% were adults, 16.7% were subadults, 16.7% were immatures, and 2.4% were juveniles (class II). The sex ratio was 0.4 males : 1.00 females for subadults, 1.5 males : 1.0 females for adults, and 1.1 males : 1.0 females for the two size classes combined. Two shells were taken. Paul Schneider was the investigator.

Chuckwalla Bench, Riverside County

Ninety-six tortoises were encountered; 45 were found during a storm and one day after rain fell. Of the 96 encounters, 72.9% were adults, 3.1% were subadults, 15.6% were immatures, and 8.3% were juveniles (class II). The sex ratio was 0.5 males : 1.0 females for subadults, 1.2 males : 1.0 females for adults, and 1.2 males : 1.0 females for both size classes combined. Six carcasses were collected. Lori Nicholson was the investigator.

STUDIES UNDERWAY IN 1980

Permanent Study Plots

Contracts have been awarded for continued work at two previously established permanent study plots: one of the two 1-mi^2 (2.59-km^2) plots at Fremont Peak and the plot at Goffs, both in San Bernardino County. In addition, four new 1-mi^2 (2.59-km^2) study sites have been selected within areas identified as major or minor desert tortoise habitats in California (Berry and Nicholson 1979): Kramer Hills, Lucerne Valley, and Johnson Valley, all in San Bernardino County; and Chuckwalla Valley, Riverside County. The contracts were awarded to Dr. Anne Stewart Hampton, Betty Burge, Lori Nicholson, Karen Bohuski, Peter Woodman, and Tim Shields, respectively, for these studies.

All sites are expected to have more than 50 tortoises/mi^2 (19/km^2). Studies will be 60 days long and will be similar in nature to those conducted in 1979. One major difference will be the perennial plant sampling procedure. Instead of the point-quarter technique used in 1979, belt line transects 6 x 900 ft (2 x 100 m) will be established in each homogeneous vegetation type on each plot. Each belt line transect will be subdivided into fifty 6 ft x 6 ft (2 x 2 m) quadrats. Data on annuals will be collected from twenty-five 20 x 50 cm quadrats in alternate 6 ft x 6 ft (2 x 2 m) quadrats of the belt line transect. Data on cover, biomass, and frequency will be collected for annuals.

Study of the Potential Effects of Livestock Grazing on Desert Tortoises

The BLM has funded the first year of a potentially long-term study on the effects of livestock grazing on the desert tortoise. Dr. Frederick Turner of the Laboratory of Biomedical and Environmental Science at the University of California, Los Angeles, is the principal investigator. Philip Medica and Craig Lyons are working in the field for him.

The study site is in Ivanpah Valley, San Bernardino County, in the vicinity of the Ivanpah Valley permanent study plot. Cattle have grazed the area since before the turn of the century. Two study plots, one a fenced enclosure 2.6 mi^2 (672 ha), have been established. Cattle will be removed from the exclosure, which will be the ungrazed plot, this spring.

Dr. Turner proposes to use weights of subadult and adult tortoises as a measure of their well-being and of the potential effects of cattle grazing. Seventy to eighty tortoises in the two plots will be fitted with radio transmitters so that they can be relocated and weighed at regular intervals throughout spring. An examination of weight records, particularly of females, may permit the investigators to determine number of eggs laid and to contrast reproductive effort in the two plots. The 1980 study period will be focused also on determining similarities and differences in the tortoise populations and vegetation of the grazed and ungrazed plots.

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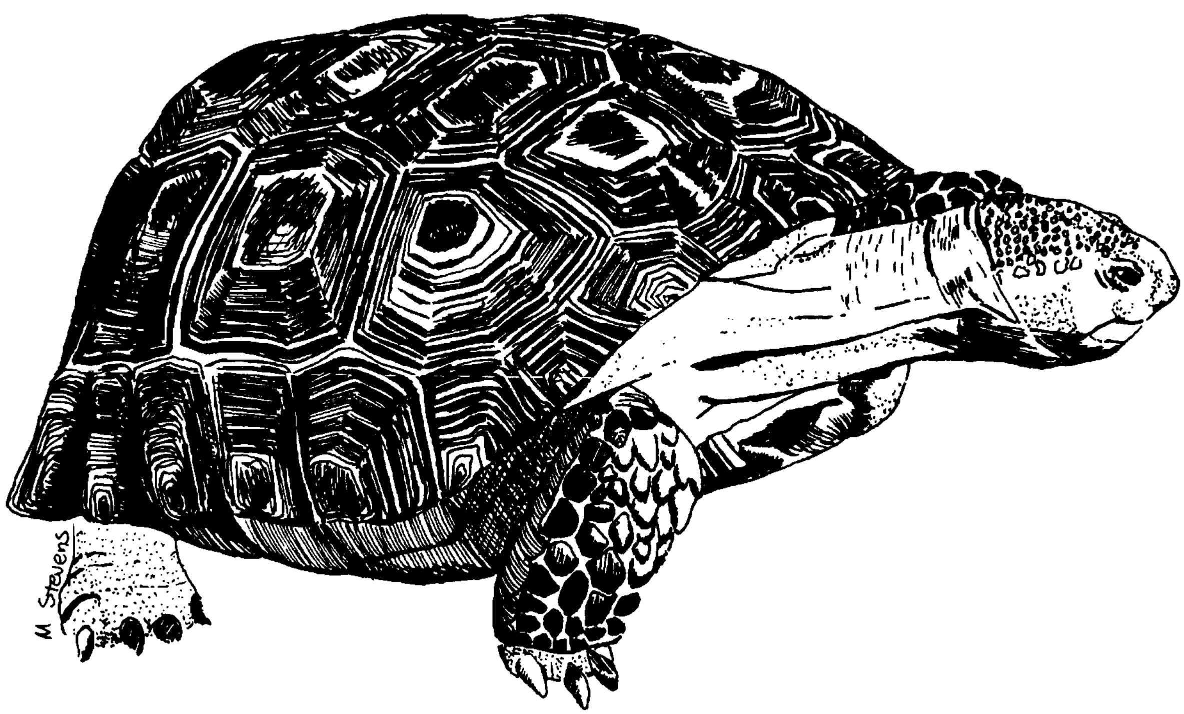

STATE REPORT - CALIFORNIA

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During 1979, Department activities to assist in the maintenance and protection of the State reptile have included land acquisition, support to the Bureau of Land Management's tortoise survey, new regulations, and the captive tortoise program.

Two recent land acquisitions -- the Boron property and the Camp Cady property -- will be managed to include habitat improvement for the desert tortoise. Both properties offer a real challenge.

The Boron property, 1 mi^2 of surplus Air Force land, has been grazed heavily by sheep and is crisscrossed by roads. However, a small tortoise population still exists there. Nine 1-mile (1.61 km) transects were walked on the property and six live tortoises, two tortoise burrows, and the remains of two dead tortoises were found. A management plan has been developed specifically for the desert tortoise.

The Camp Cady property, 2½ sections, located on the Mohave River, will be surveyed this spring to obtain data for a management plan. It is possible a portion of the land may eventually be suitable for a tortoise rehabilitation area. Frank Hoover (California Department of Fish and Game) is conducting the work on these properties.

During 1979, the Department provided $5,000 to the Bureau of Land Management to assist in conducting tortoise transects, and hopefully, we will support the Bureau's proposal to list the desert tortoise as a Threatened Species.

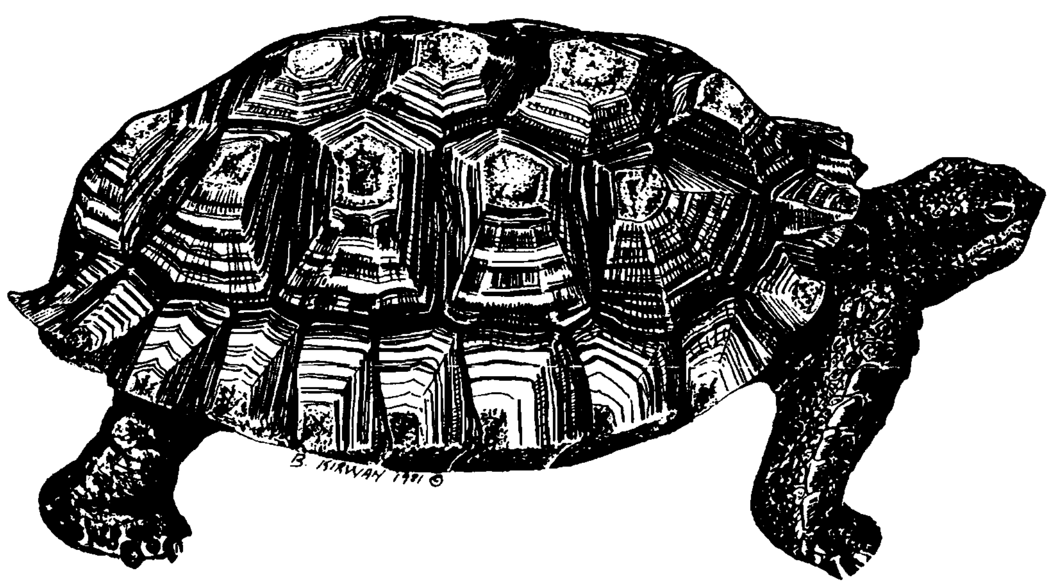
Last year I reported on our efforts to regulate the use of the State's native reptiles and amphibians in the commercial pet trade. I also requested letters of support for the proposed regulations. Because of your response and that of other people concerned with California's wildlife, the Fish and Game Commission received a record number of letters (>1000) and the regulations were approved. However, four of the commercial collectors obtained a preliminary injunction which allows them to continue collecting while the regulations are under litigation.

It is now illegal for everyone except these four collectors to collect native reptiles and amphibians for use in the pet trade. Collections can still be made, under strict regulations, for sale to approved scientific and educational institutions. Private collecting is permitted, with limits on certain species.

Two other western states have similar regulations. Arizona has prohibited the sale of native species for a number of years, and, by a recent proclamation, Utah now prohibits the sale of reptiles and amphibians, except bullfrogs and salamanders. Nevada is planning to propose regulations similar to California's within a year. It is hoped all of the states will eventually realize that commercialization of native species is wasteful and destructive and will enact appropriate regulations.

The captive tortoise program presently consists of transferring tortoises turned in to the Department of Fish and Game to Adoption Chairmen from the turtle and tortoise clubs and T.E.A.M. for placement in suitable homes. Adoption chairmen have also been authorized to pick up tortoises from zoos and humane society shelters. During 1979, 491 tortoises were adopted out.

The Department has now issued 14,700 permits for legally-acquired tortoises. We believe the permit system and the availability of tortoises through the adoption program has substantially reduced the removal of tortoises from the wild.



SPECIAL REPORT - CALIFORNIA
CALIFORNIA TURTLE AND TORTOISE CLUB

MARTHA YOUNG
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Thank you for the opportunity to tell you about the California Turtle and Tortoise Club.

For those of you who are new here today, I'd like to give you a little background information on our organization.

Our club was formed in October of 1964. We have grown since that time from just a handful of members to a present membership of over 800. We have four chapters located here in Southern California: The Orange County Chapter, The Westchester Chapter in the Los Angeles area, The Foothill Chapter in the Pasadena area, and the San Bernardino Chapter.

I have been a member of the Orange County Chapter since its beginning in October of 1975. I know the Club has helped me tremendously in gaining knowledge about turtles and tortoises and I strongly feel it has benefited many, many others.

At club meetings, which are held once a month by each of the four chapters, we have veterinarians and other experienced people speak to us. We also have care sheets available on many species of turtles and tortoises such as the desert tortoise, water turtles, and box turtles. Information is also available on hatchling care, incubation of eggs, and exotic tortoises.

Once a year each chapter has a show -- open to the public -- so that we can try to educate the public in the care of turtles and tortoises and conservation. Money is raised by the sale of turtle artifacts. This money is used for veterinarian bills, special projects, and donations to the Desert Tortoise Preserve for the purchase of additional land.

Speaking of shows -- last year at the Foothill Chapter's show a very nice gentleman came up to me with a poem he had written about the tortoise show. This gentleman didn't have any turtles or tortoises, but was fascinated with our club. I'd like to share this poem with you. It's called "Tortoise Thoughts", written by L. Jonathan Lantz and used by permission:

Tortoise Thoughts

The tortoise show so big and grand
is back by popular demand.

The tortoise is a happy beast
to which a bit of greens a feast.
It's too relaxed to stop and think
just where it'll find another drink.
Since its home is always on its back
it never hunts for an empty shack.

The tortoise folks are happy, too
they hang looser than most folks do.
They look like desert rats and such
and dig tortoises very much.

I think this poem really tells it all.

Besides education and conservation, our main activity is adoption. Each year hundreds of turtles and tortoises are turned in to us for adoption. These are turtles and tortoises found wandering in the streets, or whose owners can no longer keep them, or whose children have outgrown them. Some of these animals are sick or injured when we receive them. Each one is carefully checked over and given the necessary care before being adopted out. The "adoptive parents" are contacted and advised of the proper care and feeding of the particular animal they are going to adopt. Each desert tortoise that goes out for adoption is registered with the California Department of Fish and Game at the time of adoption.

Last summer we received a call from the Palm Springs area to pick up 150 tortoises -- these had belonged to one family who had been raising tortoises for over 40 years and could no longer take care of them. Between our four chapters and the San Diego Club we relocated these tortoises to new homes

One of our special projects included distributing care sheets to our local pet stores in hopes that they will pass them out when a turtle or tortoise is sold. We also check the condition of the turtles and tortoises they have for sale, and advise them of the proper care and housing needed.

Our monthly newsletter, The Tortuga Gazette, goes out to over 800 subscribers across the country, including 10 foreign subscribers. It features articles about turtles and tortoises, their care, medical information, and other conservation and educational material. If you would like a complimentary issue, please see me after the meeting.

Thank you for your time.

DESERT TORTOISE PRESERVE COMMITTEE REPORT

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The Desert Tortoise Preserve Committee, presently with 17 active and many contributing members, was formally organized in June 1974 with five goals:

1. TO PROMOTE THE WELFARE OF THE DESERT TORTOISE IN SOUTHWEST UNITED STATES. We are concerned with a specific situation, but are not so narrow as to ignore the desert tortoise throughout its range.

2. TO ESTABLISH A PRESERVE OR NATURAL AREA at the specific location identified by Dr. Kristin Berry, founder and advisor of our Committee. The 38 $mile^2$ (98 km^2) area is north of California City. Originally 22 $miles^2$ (57 km^2) were public land under Bureau of Land Management (BLM) jurisdiction, and 16 $miles^2$ (41 km^2) were privately owned.

3. TO PROTECT THE DESERT TORTOISE AND ITS HABITAT ON THE NATURAL AREA.

4. TO RAISE FUNDS FOR THE ESTABLISHMENT OF THE DESERT TORTOISE NATURAL AREA, FOR THE PURCHASE OF PRIVATE LAND, AND FOR FENCING. During the 6 years of its existence, the Committee has raised over $85,000 through product sales and from donations. In 1976, after the BLM received a $135,000 Congressional appropriation, used in part for fencing, the Committee shifted emphasis from fencing to land acquisition. Shortly thereafter, to facilitate land purchase, the Committee became a project committee of The Nature Conservancy. With Committee funds and Conservancy expertise, 1440 acres (5.8 km^2) have been acquired.

5. TO FOSTER AND PUBLICIZE THE USES OF THE NATURAL AREA FOR SELECTED FORMS OF RECREATION, EDUCATION, CONSERVATION, AND RESEARCH. This marks the sixth spring that the Committee has conducted group tours on the Natural Area. This is the sixth year, too, that the Committee has presented slide programs which, in 1979 alone, were viewed by a total of 3,500 people. In February 1979, the 10,000 copies of our educational booklet were included in the State Department of Education Conservation Week materials that were distributed to California schools. The Committee co-sponsored and coordinated Field Study of the Desert Tortoise, offered by University of California, Santa Barbara Extension, in April 1979. The class,

taught by Dr. Berry, will again be offered 19-20 April 1980. Recently the Committee established a quarterly newsletter which is being sent to all members, as well as other interested parties.

The Committee and friends have accomplished a great deal, but, unfortunately, far too much of our time and energy is still spent monitoring and prodding the BLM, whose land managers do not share our enthusiasm. Our accomplishments to date seem small, indeed, when compared to the tasks and problems which lie ahead:

1. The Desert Tortoise Natural Area is still not official and cannot be until the public land within the boundaries is withdrawn from mineral entry, a process that was started in 1975. With passage of the Organic Act in 1976, the process had to be changed to include Congressional involvement. Not until 1978 did the BLM resubmit the withdrawal request. In February 1980, the withdrawal was finally signed by the Secretary of Interior and is now in the 90-day period during which Congress may act against the decision.

2. To close the public land on the Natural Area to grazing took from 1972 to 1978.

3. In 1976, the BLM lost a good portion of the $135,000 Congressional appropriation by not letting the interpretive center contract on time. After constant pressure, funds were reallocated from another BLM project. The interpretive center is scheduled for completion this spring.

4. The Habitat Management Plan (HMP), as updated in the summer of 1979, is grossly inadequate. The input from the Desert Tortoise Council and the Committee, including technical corrections, was ignored. The HMP includes intentions to fence out sections where there is private land on both sides of the Natural Area boundary. The research policy, too, is not at all satisfactory. For example, the Desert Tortoise Council review of desert tortoise research proposals for the Natural ARea does not include studies done by BLM personnel of the Bakersfield District. Also, hunting is allowed in the northern part of the Natural Area in contradiction to the following statements in the HMP:

   > "The Natural Area was established to protect unique desert habitat supporting the highest known density of desert tortoises, and significant numbers of the Rare Mojave ground squirrel and other desert wildlife. This will be achieved by habitat protection and rehabilitation. The ultimate objective is to establish and maintain natural populations of native flora and fauna.

All populations of native flora and fauna in the Natural Area will be allowed to naturally fluctuate."

5. Hunting of any species is not compatible with this "ultimate objective" in principle or practice!

6. Not until recently, after continual pressure, did the BLM designate an individual to coordinate the efforts on the Natural Area.

What is the Committee's direction for 1980 and beyond? First, the public education process must be continued and intensified. Secondly, although the BLM did succeed in picking up 2¼ $miles^2$ (6 km^2) of private land this year, due to limited funding and manpower it will not be able to acquire most of the smaller parcels. We can look forward to needing millions of dollars and a great deal of time and effort to acquire the additional 11 $miles^2$ (28 km^2) of private holdings. Thirdly, we can also look forward to the need for a strong, coordinated effort to eliminate hunting on the Natural Area. Finally, a continual effort is necessary to insure proper management of the area by resource personnel.

What is our role as individuals in these future efforts -- in addition to visiting the interpretive center, conducting research on the desert tortoise, or gaining pleasure from observing wild or captive tortoises? We all derive some benefit and enjoyment from the desert tortoise. With this comes a responsibility to this species whose populations are in rapid decline. I offer the challenge to us all -- TO BECOME MORE ACTIVELY INVOLVED IN THE PROTECTION OF THE DESERT TORTOISE in the following ways:

1. Join the Desert Tortoise Preserve Committee and the Desert Tortoise Council.

2. Become or stay informed about the desert tortoise situation.

3. Put pressure on the Bureau of Land Management and the California Department of Fish and Game regarding the California Desert Plan, the desert tortoise, and other specific issues.

DISTRIBUTION AND RELATIVE DENSITIES OF THE DESERT TORTOISE IN NEVADA

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Transects were walked in 201 locations in 104 townships in Clark County as part of a survey to determine the relative density and distribution of the desert tortoise in Nevada. Tortoise densities were ≤50/mi^2 (19/km^2) for 74.3% of the area transected; only 6.9% of the transects had densities between 100 and 200 tortoises/mi^2 (39 and 77 tortoises/km^2). These higher tortoise densities were found in six locations. In one of these, Arden, the population is faced with certain reduction or possible extinction due to the expansion of Las Vegas. Tortoises were found to the limits of the county within the surveyed area with the exception of the lower Gold Butte-Virgin Mountains area.

To determine habitat supportive of high tortoise densities, vegetation, disturbance, geomorphology, substrate, and elevation were inspected. Results indicate that "preferred" areas probably: (a) lack sparse vegetation; (b) lack winter minimum temperatures below 0°C; (c) have relatively high rainfall (12 to 20 inches/yr or 30 to 50 cm/yr); (d) lack extensive disturbance, especially vehicular; (e) occur where the soil is soft to hard with gravel and/or desert pavement; and (f) are located between 1320 and 3500 ft (402 and 1067 m) in elevation.

INTRODUCTION

The Bureau of Land Management (BLM) is required to file a Grazing Environmental Statement for Clark, Lincoln, and Nye counties in Nevada. The desert tortoise, *Gopherus agassizi*, has been granted special consideration due to its "sensitive" listing. Public land in these counties is being transected to determine the distribution and relative densities of the desert tortoise. Additionally, two populations of desert tortoises, mi^2 (2.59 km^2), in Clark County were studied for 30 days during the spring of 1979 and one in Nye County will be studied during the spring of 1980. There may also be a study site in Lincoln County this spring. This report examines the transect results for 201 sites in Clark County.

METHODS

One-hundred four townships were surveyed during the fall of 1979. These included T 13S to 21S and R 63E to 70E, T 21S to 33S and R 55E to 64E, T18S to 20S in R 59E and T 16S, R 55E (Figure 1). These were chosen by Mark Maley of the Las Vegas District Office of the BLM whose selection criteria included historical sightings and areas where there was public land below 5000 ft (1524 m). My selection criteria within these townships included:

1. Accessibility
2. Maintenance of regular inter-transect spacing with two transects in all but seven townships (201 transects in 104 townships)
3. Habitat disturbance -- housing and agriculture were avoided and all but four transects were at least 0.5 mi (0.8 km) from a paved road.
4. Private or governmentally-operated land was not transected
5. Only land forms potentially habitable by tortoises were sampled, thus excluding dunes and sheer mountain slopes.

Transects were triangular, 2.4 surface kilometers in length and approximately 11 yards (10 m) wide. An attempt was made to sample habitat which maintained intra-transect homogeneity. All tortoise sign (e.g., scat, tortoises, skeletal remains, drinking and/or courtship sites, nests, burrows, and tracks) were recorded, and where appropriate, measured with respect to size and age. The standard survey form developed by Dr. Kristin Berry for transecting the California deserts was employed in transecting Clark County. Predator sign was also noted and all scats inspected for tortoise remains. Vegetation, habitat disturbance, geomorphology, and soils were assessed visually.

ESTIMATES OF RELATIVE TORTOISE DENSITY

The number of burrows per transect was determined to be the most consistent indicator from which to derive tortoise densities for the following reasons:

1. Burrows are relatively easy to sight or to detect by disturbance of soil at the burrow mouth (when located on friable soils).

2. Scat are difficult to spot because their size and color are often similar to rocks.

3. Locations of skeletal remains are altered by woodrats, *Neotoma* sp., ravens, *Corvus corax*, and carnivorous predators and the number of shells found could either be indicative of tortoise density and/or mortality. Therefore, shells are not a reliable parameter of tortoise density.

4. Tracks are difficult to sight and are ephemeral.

5. The difficulty of spotting tortoises is increased during their inactivity periods. Transects were walked during both activity and inactivity periods. Also, transient use of sites by tortoises may alter results and must be considered during interpretation.

Results from multiple transects in areas of known tortoise density, specifically the Piute Valley and Sheep Mountain study sites in Nevada (Karl 1979*a*, 1979*b*) and the Shadow Valley study site in California 17 miles (28 km) from the Clark County border (Karl 1978), plus the single transect >1 section from Burge's (1977) Arden, Nevada study site served as standards to estimate tortoise densities on transected sites of unknown tortoise density.

RESULTS

Relative Tortoise Densities and Range

Tortoise densities were low, $\leq$50 tortoises/mi^2 or $\leq$19/km^2 for 74.3% of the area surveyed (Table 1). Moderately high to high tortoise densities, $\geq$100 tortoises/mi^2 or $\geq$39/km^2, comprised only 6.9% of all transects.

Tortoise sign was found throughout the area studied, with the exception of 17 intermittent, single transects and 12 pockets of 3 to 4 transects each, where no tortoise sign was found. No tortoise sign was equated to 0 - 20 tortoises/mi^2 (0 - 8/km^2). The lower one-third of the Gold Butte-Virgin Mountains area, comprising 10 transects, also had no tortoise sign.

Habitat Delineation

Habitat was defined by vegetation, disturbance, geomorphology, substrate, and elevation. The low proportion of high tortoise density transects precluded precise determination of habitat which could support large numbers of tortoises; however, some tentative suggestions are offered.

Upper Story Perennial Vegetation

Areas with 100 to 200 tortoises/mi^2 (39 to 77 tortoises/km^2), comprising 6.9% of all transects, represented 16.5% of all transects walked through dense vegetation (shrubs separated by $\leq$1.6 ft or 0.5m). A relatively low percentage (5.9%) of the high tortoise density transects were found in sparsely vegetated areas (shrubs $\leq$66 ft or 20 m apart) and a low percentage (3.2%) of the sparsely vegetated areas had high tortoise densities. Consistent with that, a relatively small percentage (7.7%) of the transects with tortoise densities $\leq$3 tortoises/mi^2 or 8 tortoises/km^2 were walked in dense vegetation. These results indicate that sparse upper story vegetation is not supportive of large populations of tortoises. However, the sample sizes for densely vegetated areas (n=18) and sparsely vegetated areas (n=30) are low relative to those for plant communities of intermediate densities (n=232). No trends relative to tortoise density were apparent in these moderate vegetation densities.

All transects except three were walked in creosote bush scrub, *Larrea tridentata, Ambrosia dumosa,* with 2 to 8 inches (5 to 20 cm) of rain annually and temperatures between approximately 34 and 109°F (1 and 43°C) as described by Munz (1959). Also present were varying degrees of pinyon-juniper woodland, *Yucca schidigera, Y. baccata, Pinus monophylla, Juniperus* sp., *Quercus turbinella*, Joshua tree woodland *Y. brevifolia, Juniperus* sp., *Eriogonum fasciculatum, Lycium* spp., shadscale, *Atriplex confertifolia, Eurotia lanata, Grayia spinosa, Mendora spinescens, Coleogyne ramosissima,* and alkali sink communities, *Atriplex* spp., *Sueda torreyana*. The remaining three were Shadscale communities, one of which contained co-dominant *Y. schidigera* (Mojave yucca) and another co-dominant *Prosopsis* sp. (mesquite). The former had 20-50 tortoises/mi^2 (8-19 tortoises/km^2) and the remaining two had no tortoise sign.

Less than 39 tortoises/km^2 and usually less than 19 tortoises/km^2 were found in Shadscale-creosote (n=39) or alkali sink creosote (n=5) communities. Shadscale is characterized by low winter minimum temperatures, 21 to 32°F (to 0°C) and heavy soil with hardpan; alkali sink is present on poorly-drained flats with high summer maximum temperatures, 106 to 117°F (41 to 47°C) and 107 inches (3-18 cm) annual rainfall. A high percentage of transects walked through shadscale-creosote communities showed no tortoise sign, 46.2%; tortoise densities from 0 to 19 tortoises/km^2 represented 92.4%.

No tortoise sign was found in pinyon-juniper-creosote communities (n=3), the former characterized by low winter minimum temperatures to 19°F (°C), with some snow, comparatively high rainfall, 12-20 inches (30-50 cm), and mountains.

Although tortoise sign was found in Joshua tree-creosote communities (n=30), there was no apparent correlation to tortoise density. Joshua tree woodland usually has 6-15 inches (15-38 cm) of rainfall annually and low winter minimum temperatures to 21°F (°C).

Perennial grasses (e.g. *Hilaria rigida, Sporobilis* sp., *Aristida* sp., *Stipa* sp., *Oryzopsis hymenoides*) were among the dominant upper story perennials on 76 transects. No trend for increased tortoise density in these transects was apparent by examining the frequencies in each tortoise sign level. However, two transects with no tortoise sign were surrounded by transects with up to 39 tortoises/km^2; the primary difference between the single transects and their surrounding transect groups was the lack of perennial grass, specifically *Hilaria rigida* (big galleta) in the ingle transects.

Although Munz (1959) associated *Y. schidigera* with pinyon-juniper woodland, it is often found apart from the latter. Sixty-two transects through communities where *Y. schidigera* was a co-dominant species resulted in a trend toward increased tortoise density associated with *Y. schidigera*. A comparatively high percentage of these transects had $\geq$39 tortoises/km^2, 12.9% (compared to 6.7% for all transects of this tortoise density level) and a low percentage had 0-8 tortoises/km^2, 12.9% (compared to 28.3% for all transects with $\leq$8 tortoises/km^2). Also, a high percentage of the transects with tortoise densities of at least 39/km^2, 47.1%, and a low percentage of the transects with less than 8 tortoises/km^2, 12.3%, were in *Y. schidigera* communities. Consistent with that, the percentage of transects with $\leq$19 tortoises/km^2 in *Y. schidigera* communities seemed obviously low, 24.6%.

Understory Vegetation

In areas with sparse understory vegetation, only 2.6% of the transects had 39-77 tortoises/km^2. Only 5.8% of the transects with this tortoise density had sparse understory vegetation. However, no similar correlation could be made in dense communities. Possibly then, understory vegetation, unless sparse, does not affect tortoise density.

The percentage of the dominant understory vegetation which comprises tortoise forage (Burge and Bradley 1976; Coombs 1977; Berry 1978) was examined. The average percentage of the combined co-dominant, understory, forage species was slightly lower in areas of 39-77 tortoises/km^2, 61.5%, than where tortoise densities were 0-8 tortoises/km^2, 80.6%, or 0-19 tortoises/km^2, 81.5%.

Several individual forage species were analyzed. *Festuca octoflora* (fescue) and other non-brome annual grasses (co-dominant in 139 transects) comprised 82.3% of the transects with 39-77 tortoises/km^2, compared to only 52.3% and 59.7% for transects with 0-8 or 0-19 tortoises/km^2, respectively. No tortoise density trends could be related to the perennial, but low, grass, *Erioneuron pulchellum* (fluff grass), co-dominant in 74 transects. Although I have observed that legumes, especially *Lotus* spp., are favored tortoise forage, only one transect had a co-dominant legume, *Astragalus* sp., in the understory. This transect had 19-39 tortoises/km^2. *Bromus rubens* (foxtail brome), co-dominant in 77 transects, was co-dominant in a low percentage, 17.6%, of the transects with 39-77 tortoises/km^2. Only 4.0% of the transects with *B. rubens* had these higher tortoise densities. Consistent with that, the frequency of *B. rubens* in transects with 0-8 and 0-19 tortoises/km^2 was comparatively high, 49.2 and 36.2%, respectively. Four single transects with 0-19 tortoises/km^2 were bordered by transects with 19-77 tortoises/km^2 and one transect with 19-39 tortoises/km^2 was surrounded by tortoise densities of 0-19/km^2. The common feature of the lower density transects was the presence of *B. rubens* as a dominant species; it was absent in the higher density transects. The apparent decrease in tortoise density in plant communities with co-dominant *B. rubens* may be due to the latter's association with grazing (Robbins, Bellue and Ball 1951), which is counterproductive for tortoises (Berry 1978).

Disturbance

Higher tortoise densities (39-77 tortoises/km^2) were present in areas where there were old, seldom-travelled dirt roads, light cattle grazing, a paved road >0.5 miles (0.8 km) from the transect, few off-road vehicle (ORV) tracks, inoperative mines, or numerous dirt roads and trails. However, the frequencies of the individual disturbances were low, <30%, for all but cattle grazing, 64.7%, and old, dirt roads, 100%. Railroads >0.25 miles (0.4 km) distant and sheep, burro and/or wild horse grazing were present where tortoise densities were 8-39 tortoises/km^2. Heavy cattle grazing (determined by the large amount of scat and the extreme cropping of perennial grasses) and prior heavy motorcycle use occurred infrequently where tortoise densities exceeded 39 tortoises/km^2 and usually where tortoise densities were ≤19 tortoises/km^2. Tortoise densities of 8-19 tortoises/km^2 were also present where there was a house at the transect corner or 0.4 km distant and where there was prior extensive bulldozing.

Elevation

Elevations between 1320 and 4800 feet (400 and 1465 m) were transected. Tortoise sign was found between 1320 and 4600 feet (400 and 1400 m). The average elevations for transects in each tortoise density level (Table 1) did not differ significantly; however, the limits of the range, especially the upper, did vary. Tortoise densities ≥19 tortoises/km^2 were found only below 3500 feet (1067 m). The upper elevation limit extended to 4800 feet (1463 m) for 0-8 tortoises/km^2. For tortoise densities ≥39 tortoises/km^2, the lower elevation limit was 1900 feet (579 m). Densities <39 tortoises/km^2 were found to 1320 feet (402 m).

High Density Sites

There were six distinctive areas of high tortoise density with at least 39-58 tortoises/km^2 and up to 77 tortoises/km^2 (Figure 2). One of these, the Arden population, is in danger of extreme reduction or complete destruction due to the expansion of Las Vegas. At the present time, it is bordered on the north and east by private land and housing and is topographically only slightly open to the south (public land) and west (Red Rock Canyon Recreation Area). There are only 3.5 townships of habitable tortoise land at the site.

CONCLUSIONS

Habitat supportive of high tortoise densities (≥39 tortoises/km^2) probably (a) lacks sparse perennial vegetation; (b) lacks winter minimum temperatures below 0°C; (c) has relatively high rainfall (approximately 30-50 cm annually); (d) lacks extensive disturbance, especially vehicular; (e) occurs where the soil is soft to hard with gravel and/or desert pavement; and (f) are located between 1320 and 3500 feet (400 and 1067 m) in elevation (Figure 3).

The presence of high tortoise density in an area does not necessarily indicate that the habitat features of the area are able to sustain a tortoise population at the density found. It might also indicate that the density of tortoises was previously much higher and that habitat alterations are resulting in a reduction of the population.

ACKNOWLEDGMENTS

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The only combined disturbances in areas of higher tortoise densities were (1) light cattle grazing and ORV traffic with a paved road 0.5 mile (0.8 km) from the transect (3 of 17 high tortoise density transects) and (2) numerous dirt trails with inoperative mines (1 transect). No combination of extensive vehicular traffic and grazing was found where tortoise densities were $\geq$19 tortoises/km^2. No tortoise sign was found where the combination of extensive vehicular traffic, grazing of domestic stock, and refuse or agriculture within 0.2 miles (0.3 km) existed.

Geomorphology

Tortoise sign was found from valleys to mountain slopes. The frequency of higher densities of tortoises was greater on bajadas (41.2%) than valleys, foothills (23.5% each) or hills and mountain slopes (5.8%. Consistent with this, the percentage of transects walked on steep hills or mountain slopes was highest in the low tortoise density areas, 53.6%. It is possible that low tortoise sign counts were made on steep and/or rock and boulder strewn hills due to the amount of concentration expended in remaining upright on the former and the difficulty of determining tortoise coversites among the rocks. Tortoise sign may also have been underestimated in caliche washes; the many potential tortoise coversites in the banks were inspected for tortoise sign but not counted unless actual evidence of tortoises (e.g., scat, tracks, tortoises) was present.

Substrate

Tortoises were found where soils were loose to very hard, gravelly, cobbly and/or stony. (Where loose soil was present, it did not comprise the entire transect; no tortoise sign was found in the loose soil portion of any transect.) Only soft, medium hard and hard soils with slight gravel to extensive desert pavement were sites of high tortoise densities; 18.2% of the transects on hard soils had high tortoise densities, which seems obviously high compared to the percentage of all transects with high tortoise density, 6.9%. Tortoise densities $\leq$39 tortoises/km^2 were found in transects including some loose sand or cobbles and/or boulders. Only tortoise densities $\leq$19 tortoise/km^2 were found on very hard or gypsic soils. Consistent with this, transects with 0-8 tortoises/km^2 (28.3% of all transects) occupied a relatively high proportion of the transects on very hard and cobbly and/or stony soils, 66.7 and 55.6%, respectively.

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TABLE 1. Relative Densities of the Desert Tortoise in Transected Land in Clark County, Nevada

Tortoises/km^2	% of all transects
0-8	28.3
8-19	46.0
19-39	18.6
39-58	5.9
58-77	1.3

FIGURE 1. Areas transected in 1979 (///) and areas to be transected in 1980 (\\\) within the known range of desert tortoise in Nevada

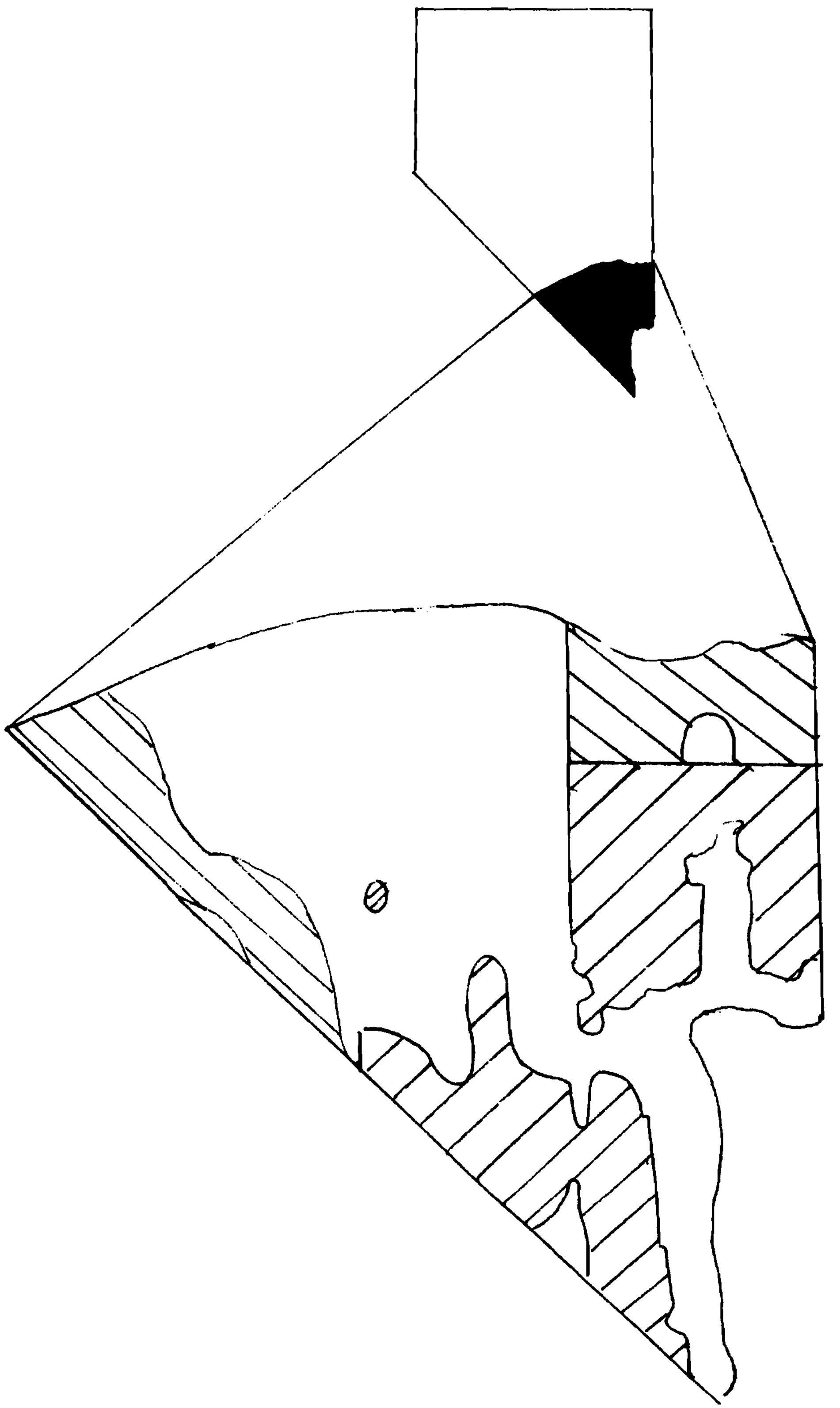


FIGURE 2. Relative tortoise densities in Clark County. Transected area lies within heavy line.

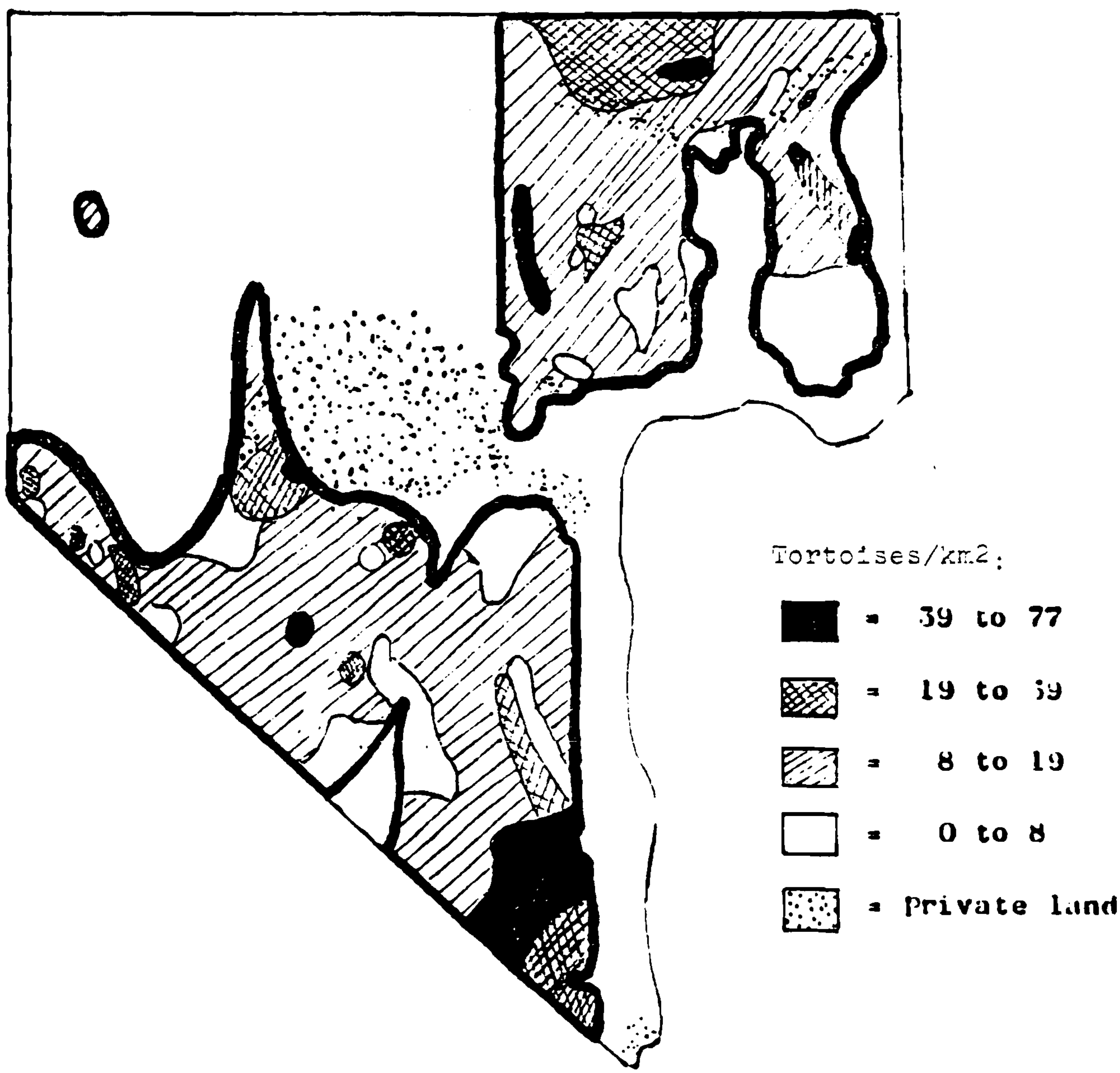
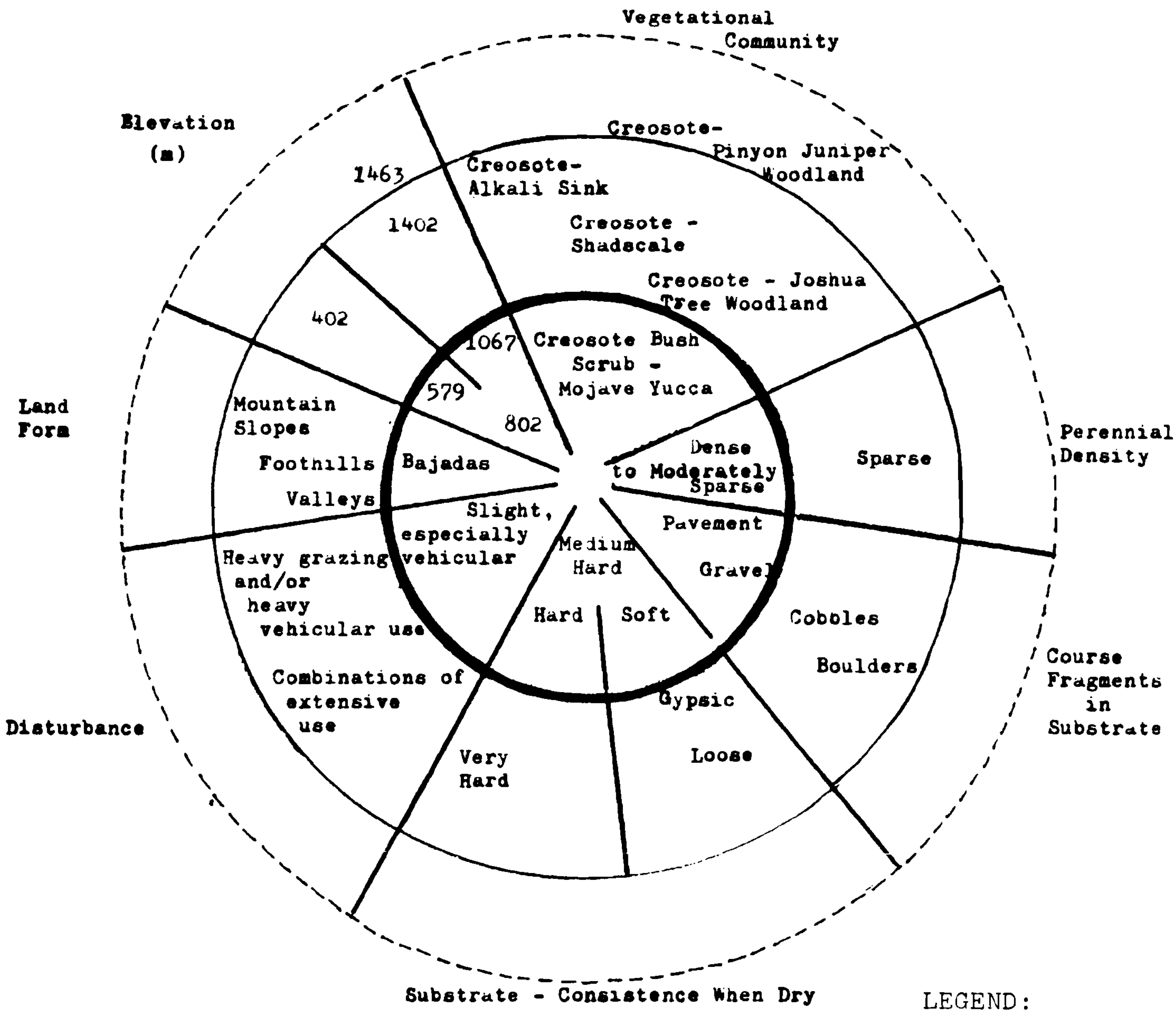


FIGURE 3. Habitat delineation



LEGEND:

Possibly supportive of high densities

Tortoises found

No tortoise sign (0-8 tortoises/km^2)

STATE REPORT - NEVADA

BOB TURNER
Nevada Department of Wildlife
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Ground surveys were conducted to determine distribution and key habitats of the desert tortoise in Nevada. Further investigation and survey work will be conducted in the spring of 1980 to determine the desert tortoise's northern distribution in the State, and its occurrence and use in various other vegetative communities. Permanent survey plots will be established in the spring of 1980. These permanent plots will be surveyed annually to collect desert tortoise trend data and other valuable data.

NEVADA LAWS AND REGULATIONS

The desert tortoise is classified as rare in the State of Nevada. Full legal protection is provided to this species by Nevada Fish and Game Commission General Regulation No. 1 and Nevada Laws NRS 501.065, NRS 503.030, NRS 503.584, NRS 503.585, NRS 503.597, and NRS 503.600.

BIOLOGICAL SURVEYS

Ground surveys were continued by Gary Herron and Paul Lucas during the fall of 1978 and spring of 1979 in an effort to determine current distribution and preferred habitats. The northeastern distribution was documented as extending into the upper portions of Pahranagat Valley (T6S, R60E), while the northwestern distribution was documented to be near Beatty (T11S, R47E) (Figure 1). Based on vegetative type, the distribution is believed to continue north a few more miles in Pahranagat Valley and to a few miles northwest of Scotty's Junction (T7S, R44E). This extension of the northern distribution will be intensively surveyed in the spring of 1980. The range extends south to Arizona and California.

A key habitat is the tortoise den, which is used for hibernation, shade, and possibly reproductive activities. The most common denning situation identified to date by our Nevada surveys is under caliche and rock formations in desert washes on bajadas. Ecological principles determined in Utah Beaver Dam Studies are probably applicable to much of Nevada (Woodbury and Hardy 1948; Coombs 1974).

Some sign was found in dens under rock boulders on hillsides or bajadas. A few dens or burrows were discovered at the bottom of washes or on sandy uplands. Desert pavement ground cover on many bajadas appeared to prevent burrow and den construction.

All observations of tortoises and sign to date were in the creosote and creosote blackbrush types, on bajadas or hills and below 5,000 ft (1525 m). Future surveys will probably document additional denning or burrow situations and vegetative types used by desert tortoise.

With Bob Turner, a nongame biologist, now assigned to Region III (southern third of the State), future work and study on the desert tortoise will be increased. Plans for 1980 include the establishment of survey plots and trend routes in southern Nevada, intensive spring surveys on the desert tortoise distribution in Nevada, and increased work with other agencies on the captive tortoise problem in Las Vegas and southern Nevada.

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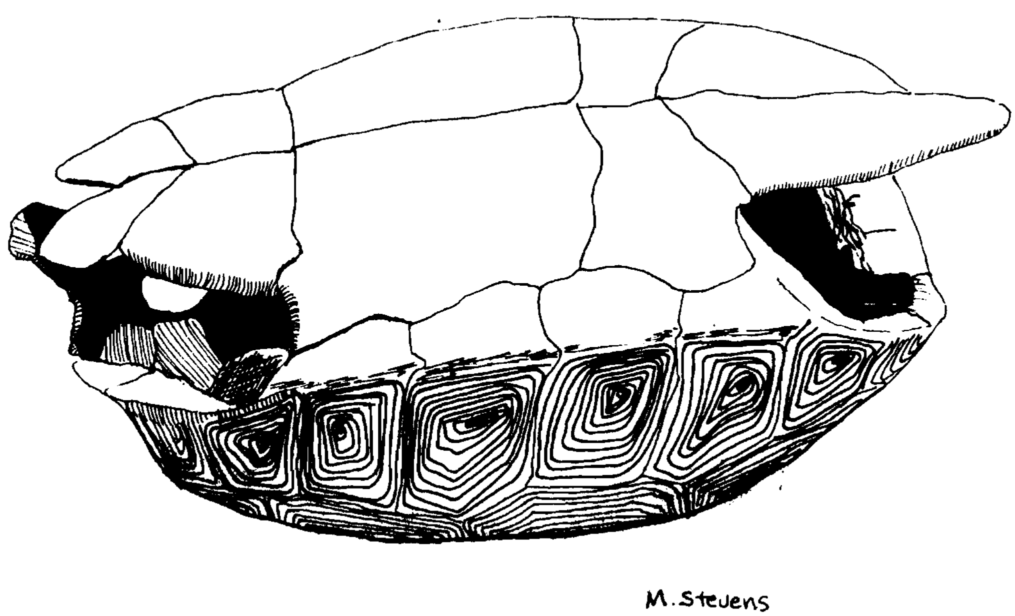

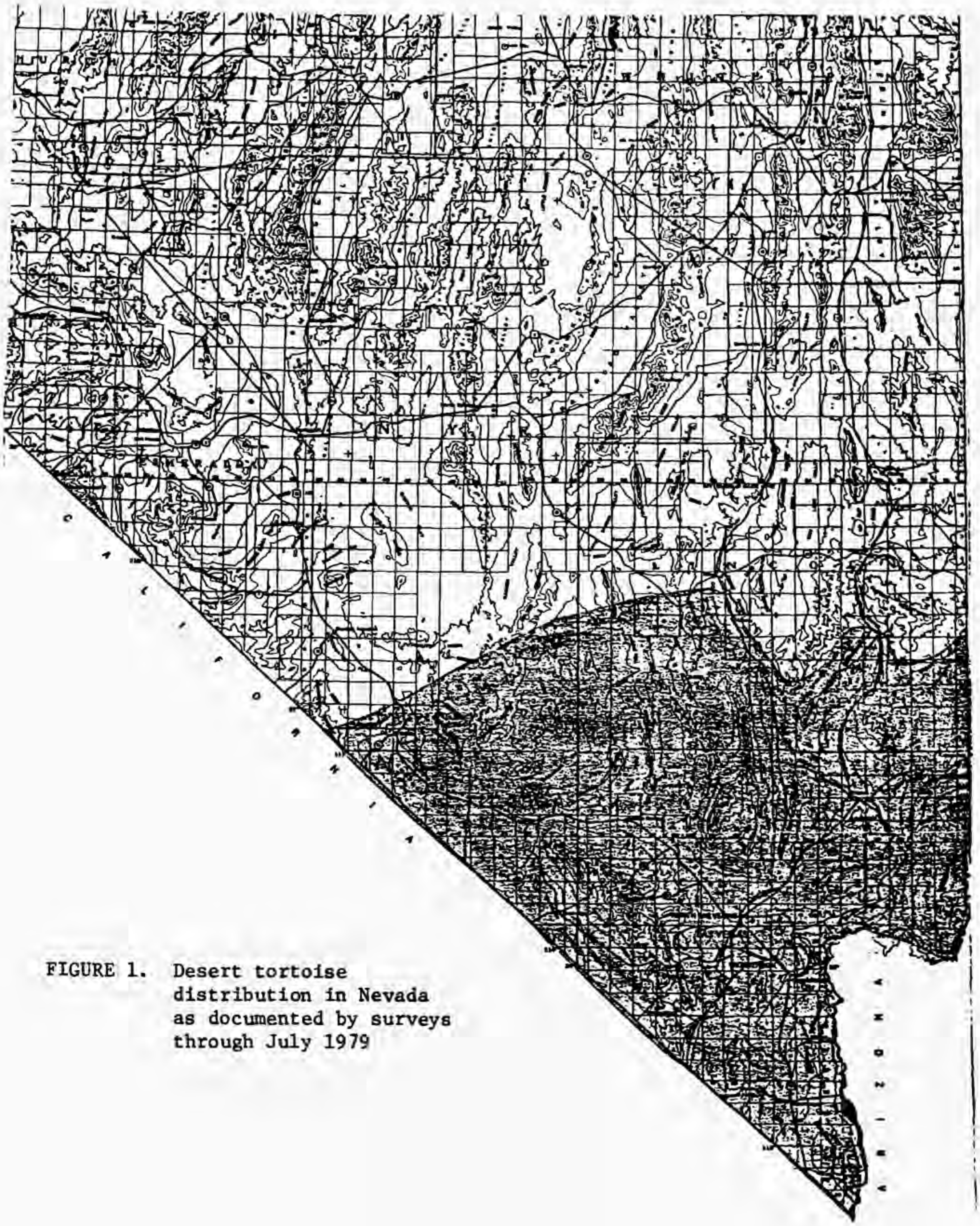

FIGURE 1. Desert tortoise distribution in Nevada as documented by surveys through July 1979

STATE REPORT - UTAH

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GENERAL DESCRIPTION

The desert tortoise, *Gopherus agassizi*, in Utah is located in the southwest corner of the State in the area known as the Beaver Dam Slope, an area of approximately 70 square miles (181 km^2). The vegetative aspect for the area is Joshua tree-creosote bush type, with a variety of annual forbs and grasses.

PRESENT MANAGEMENT OF DESERT TORTOISE AREA

A habitat management plan (HMP) has been developed for the desert tortoise area. This plan is a cooperative effort between the Bureau of Land Management and the Utah Division of Wildlife Resources. The main objectives of this plan are:

1. To establish the "Woodbury Desert Study Area" (3,040 acres or 1230 ha). This area has been fenced and will be closed to grazing, off-road vehicle (ORV) use, mining activities, oil and gas leasing, and the removal or sale of vegetation.

2. To establish a desert tortoise monitoring program. This would include an intense population study to be completed every three years. Beginning in 1980 the study would acquire data on densities, size class structure, sex ratio, production, mortality, habitat condition, den locations, and behavior. A less intense study acquiring the same kind of data will be completed on the other years. Also, a vegetative study will be conducted each year to acquire data on habitat condition and trends, production of annual vegetation, and livestock impacts on vegetation. The contract for the population study (to be completed this year) will be awarded 1 April. The vegetation studies have already begun.

3. To implement the Beaver Dam Slope Allotment Management Plan (AMP). This AMP would provide the following: On the east side of Highway 91, tortoise habitat outside of the "Woodbury Desert Study Area" would be grazed during the spring only one year out of three. On the west side of Highway 91, the tortoise area will be grazed during the spring one year out of three and then only until 30 April.

4. In those portions of the tortoise area which lie outside the "Woodbury Study Area," the following restrictions will be made:

   a. No ORV use.

   b. Oil and gas exploration or development work will not be allowed between 1 April and 1 November.

   c. No surface-disturbing activities will occur within 500 ft (152 m) of winter dens.

HOT DESERT GRAZING EIS IMPLEMENTATION

Implementation of the Hot Desert Grazing Environmental Impact Statement (EIS), and specifically the Beaver Dam Slope AMP and the "Woodbury Desert Study Area," is pending class action suit filed against the Bureau of Land Management in Federal Court.

INTERIM GRAZING MANAGEMENT

Until the time the Beaver Dam Slope AMP is implemented, an interim grazing management plan will be required. On normal precipitation years, all livestock will be removed from the area by 15 March. In years of above-normal precipitation and abundant production of annual forage, utilization checks will be made periodically and livestock will be removed at the time a conflict is thought to exist.

Managers in Utah feel that they have been responsive to the problems and needs of the desert tortoise. We want to thank you for the opportunity to outline our management objectives.

FEDERAL PROTECTION FOR NORTH AMERICAN TORTOISES: AN UPDATE

C. KENNETH DODD, JR.
Office of Endangered Species
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Washington, D. C. 20240

At last year's meeting of the Desert Tortoise Council, I presented a rather pessimistic review of the possible effects of the 1978 amendments to the Endangered Species Act of 1973 on listing candidate species (Dodd 1979*a*). In the intervening year, another set of amendments has been signed into law which add additional requirements to the listing procedure. While I do not want to go into them in detail, a summary, as it appeared in the Endangered Species Technical Bulletin of January, 1980, is presented as follows:

1. A summary of proposed regulations (rather than the complete text) and, where applicable, a map of the proposed Critical Habitat, must be published in local newspapers within or adjacent to the habitat.

2. Public meetings and hearings on Critical Habitat proposals are to be held separately (with a hearing to be held if requested within 15 days of a public meeting).

3. The time period for which emergency listing and Critical Habitat designations are effective (now applicable to both animals and plants) has been extended from 120 to 240 days.

4. A new provision requires the development and notice (with opportunity for public comment) of guidelines for the handling of petitions for listing, for priority systems for listing, and for priority systems for developing and implementing recovery plans.

5. A "status review" is now required prior to the preparation of proposals for listing.

In addition, the new amendments involve changes in the consultation and exemption process with regard to federally authorized or funded projects, abolish the Endangered Species Scientific Authority, create an independent International Convention Advisory Commission (ICAC) to advise on scientific policy as it pertains to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), reauthorize the Act for 3 years, and authorize funds to continue the program ($23 million in fiscal year 1980). Details of the 1979 amendments, which are additional and do not supercede the 1978 amendments, are presented in the Endangered Species Technical Bulletin (Anon. 1980). The entire set of listing regulations has recently been published by the Fish and Wildlife Service and the National Marine Fisheries Service (Federal Register of 27 February 1980, 45 FR 13010-13026) and will be summarized in the March 1980, Endangered Species Technical Bulletin.

The details of the requirements to implement the 1978 amendments to the Act which were outlined last year (Dodd 1979*a*) are still largely unresolved. For instance, while the Office of Endangered Species has now hired two economists to review proposed and final listing packages, the analyses themselves are prepared by biologists without economic training or familiarity with economic concepts, and there are still no guidelines as to the amount of detail required for an economic analysis. However, one bright spot is that none of the new proposals, reproposals of Critical Habitat, or final listing rules have been judged "significant" under Executive Order 12044 and, therefore, no regulatory analyses have as yet been required.

One of the main effects of the 1978 amendments to the Act was the imposition of a 2-year deadline from the time of proposal in which the Fish and Wildlife Service must list a species. If a species is withdrawn, "new and significant" information is required before it can be reproposed. On 5 March 1980, the Assistant Solicitor for the Fish and Wildlife Service issued an opinion on what would be needed to fulfill this requirement. The summary is presented because of the possible importance it has with respect to the listing of the Beaver Dam Slope population of the desert tortoise:

> "In summary, the amount and quality of new documentation required by the 'sufficient new information' standard would be expected to vary from species to species. The requisite amount and quality of additional documentation would be directly related to the factors which contributed to the failure to complete the original listing proposal within two years. If the problem resulted from a deficiency in biological data, new field studies addressing the missing information would have to be prepared. If the problem stemmed from a lack of economic analysis, additional economic data should be acquired; the acquisition of new biological information in such situations would not be as important. The hard case, of course, occurs where a proposal was not completed because of administrative problems unrelated to the adequacy of the administrative record developed in conjunction with the proposed rulemaking. The Service appears to have no choice now but to re-examine the existing biological and economic data and prepare additional documentation reaffirming the original conclusion that the species satisfied the listing criteria of Section 4(a)

of the Act. Thus, at least one new study or analysis must be added to supplement the data base of the old administrative record in order for the Service to withstand a legal challenge to its efforts to resurrect a withdrawn proposed rulemaking."

BEAVER DAM SLOPE POPULATION OF THE DESERT TORTOISE

The history of the attempts to list this population as Endangered has been presented in past Proceedings of the Council (Dodd 1978, 1979*a*). Of immediate importance is the 2-year listing deadline which must be met by 23 August 1980, or the population must be withdrawn from consideration. On 7 December 1979, the Critical Habitat of this population was reproposed in accordance with the 1978 amendments with exactly the same boundaries as in the original proposal (Dodd 1979*b*). An economic analysis which reported estimates of the economic impact of alternative management regimes which could be used in the proposed Critical Habitat was prepared by the Interior Department (Rice, Staler, and Johnson 1979).

A public meeting was held 10 January 1980, in St. George, Utah, to explain the proposal, answer public questions, and solicit information on the biology of the tortoise and the economic effects of a Critical Habitat designation on federally authorized or funded projects in the area. The Fish and Wildlife Service contracted David Stevens of the Council to present the biological basis for the proposed listing. About 130 people attended the meeting and 20 made oral comments. The people who commented were generally hostile to the proposal because of a perceived threat to grazing permittees and the community. The federal government is not popular in southwestern Utah, especially with regard to any form of regulation. Both Utah Senators Garn and Hatch recommended against the listing and requested that a public hearing be held. Accordingly, the public comment period has been reopened between 25 March and 9 April 1980. A public hearing is scheduled for 25 March 1980 in St. George, Utah.

BOLSON TORTOISE, *GOPHERUS FLAVOMARGINATUS*

The Bolson tortoise was proposed as Endangered on 26 September 1978, because of human predation, habitat modification, competition from grazing animals, and collection (Dodd 1979*a*). On 17 April 1979, it was officially listed (Dodd 1979*c*). In addition, at the CITES meetings in San Jose, Costa Rica in March 1979, the Bolson tortoise was listed on Appendix I which, among other things, prohibits commercial trade in the species (Anon. 1979).

RESEARCH

Each year, the Office of Endangered Species in Washington and its various regional offices fund a limited number of contracts for research on the status, ecological requirements, management, and recovery of listed species or species which are candidates for federal listing. The following contracts were awarded on tortoise research in 1979 and 1980:

Betty Burge - the status and distribution of the desert tortoise in Arizona ($10,000; jointly funded with the Bureau of Land Management).

David Morafka - the autecology of the Bolson tortoise ($10,000).

A FEW REMARKS

The United States is particularly fortunate to have a large number of unique and interesting amphibians and reptiles within its borders and the borders of its territories. Aside from the Vegas Valley leopard frog, *Rana pipiens fisheri*, which is of uncertain taxonomic allocation, only one species has become extinct that we know about, the St. Croix ground snake, *Alsophis sancticrucis*, last seen in the 1850's in the U.S. Virgin Islands. Our luck may not last long, however, because of the increasing habitat destruction that we witness today. Whether from overgrazing, construction of buildings and highways, mining, ORV's, or hundreds of other causes, we are fast losing a priceless heritage that future generations will never realize existed. The Endangered Species Act of 1973 was an attempt to slow this trend and, for a while, our activities progressed relatively smoothly. Even so, many of us who work directly in the program realized that the Act treated not the sources of the problem, but the symptoms. And now, even the "band-aid" has become too painful for those who do not recognize the seriousness of what we are doing to our lands and waters, but only the short-term goals of immediate profit and expediency. The Act has now been amended twice and, in spite of glowing words from politicians, it is grinding slower and slower to a position of mere legal existence for the lucky few plants and animals which made the list early. What I am saying is not that we won't continue to fight, but that the fight (and that is what it is) will be harder and harder in the future. Do not expect the federal government to protect every species which needs protection.

The desert tortoise is of particular concern because the prospects for its habitat are not good. We must plan now to forestall future serious problems. We do not need unproductive tests of political philosophy to determine which species should be protected. While we need good solid data on which to base our decisions for listing, there must come a time when enough research is completed on which to finally make a listing decision. If we err, we should err on the side of the species. That is why I disagree with Day (1979): sympathy is not good enough; it is time for action on the Beaver Dam Slope. A proposed federal listing by the Fish and Wildlife Service is not a criticism that a state, other federal agency, or individual has not necessarily done enough for a species or has done something incorrectly. This is a touchy point, but necessary to reiterate. A listing is the recognition of the plight of a species; that is what the Congress of the United States mandated and that is what we attempt to do at the Office of Endangered Species.

We all have an urgent need to educate the people and the media about the purpose of endangered species protection -- to protect species and ecosystems from extinction -- a concept so final that it can not be easily dismissed. Misrepresentation, such as that in Spencer (1979) about "...one proposal to close an area to grazing has surfaced. This is the Beaver Dam Slope area in southeastern Nevada (sic), for the purpose of protecting the desert tortoise" must not go unchallenged. The Fish and Wildlife Service has a difficult enough task explaining the Act itself without having others who can not even get their most basic facts straight "explain" it for us.

Finally, I will end this paper with a quote from John Spinks (1979), Chief of the Office of Endangered Species:

> "The most lucid comment which addresses this concept [perspectives], however, is one which was made by Aldo Leopold, who said that the first sign of intelligent tinkering is that you don't throw away any of the parts. With all of our sophistication, I think we are tinkering with phenomena that are much more sophisticated than we. Our concern is certainly for the survival of the species. It is also for the survival and well-being of mankind. It is our posture that, until our knowledge as a race, as a society, evolves to the point that we can clearly know the consequences of our action by making a species extinct, it is very, very foolish to do so."

Amen.

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THE NATURE CONSERVANCY

JUDY SURFLEET
3209 Nevada Avenue
El Monte, California 91731

The Nature Conservancy is a national conservation organization committed to the preservation of natural diversity by protecting land which contains the best examples of all components of our natural world. To date, The Conservancy and its members have been responsible for the preservation of over 1.6 million acres of forests, marshes, prairies, mountains, and islands. Over 2360 projects have been completed since the acquisition of the first preserve in 1954. Approximately 60% of the preserves are retained by Conservancy and managed by volunteer land stewards. The other 40% are transferred to universities or government agencies for management.

More specifically, the Southern California Chapter and California Field Office of Conservancy have participated in the negotiations and the acquisition of 2.25 square miles (5.8 km^2) of land in the Desert Tortoise Natural Area. In addition, members of the Southern California board have given slide programs, sold about $1,000 in merchandise, and raised several thousand dollars in donations. Our national publication, The Nature Conservancy News, devoted one entire issue to deserts, with a featured article by Dr. Kristin Berry on the Desert Tortoise Natural Area and the desert tortoise.

Lately, land acquisition and fund raising have slacked off; instead Conservancy has played another role -- applying political pressure.

Two people have contributed most significantly to this effort; Steve McCormick and Barbara Horton. Through calls and visits to Deputy Undersecretary of the Interior, Dan Beard, and the field representative of Senator Alan Cranston, changes have been made in policies concerning the desert tortoise and the Natural Area.

It is my opinion as a biologist that unless we continue our efforts to eliminate hunting on the Natural Area, create a buffer between California City and the eastern boundary of the Natural Area, as well as acquire additional habitat, we cannot expect to reverse the declining populations of the desert tortoise.

NORMAL VALUES FOR HEMOGRAM AND SERUM CHEMISTRY IN THE CALIFORNIA DESERT TORTOISE, *GOPHERUS AGASSIZI*

WALTER J. ROSSKOPF, JR., DVM
4473 W. Rosecrans
Hawthorne, California 90250

From late 1978 to early 1980, a study was undertaken to establish normal hemogram serum chemistry values for the California desert tortoise. Over two hundred animals were sampled and obviously abnormal results removed from the test group. I have concluded that my values reflect a true picture of a captive *Gopherus agassizi* in the Los Angeles area (Table 1).

The use of these values will help the veterinary practitioner and the animal scientist in monitoring clinical cases and in prognosticating the severity of disease states in the California desert tortoise. Obviously, this is of great benefit; previously there was no practical way to monitor cases except for physical exam, response to treatment, and just plain guesswork.

Several generalities were evident in my study that will help in the interpretation of results: 1) no blood parasites were found in any of the samples (in contrast to many exotic tortoise species); 2) white blood cell (WBC) counts were typically lowest after hibernation, then began to rise with warmer weather. I theorize that this is why tortoises are so disease prone while in hibernation and why they must not be allowed to hibernate while ill; 3) heterophils and basophils are very responsive to inflammatory conditions, with basophilia seen most often in chronic inflammation. Neutrophilis (rare) were most often seen in severely imflammatory conditions; 4) extremely high WBC counts are rare. Even in the face of severe infection a tortoise's WBC seldom exceeds 20,000 (in contrast to other exotic tortoises and turtles); 5) the LDH increases in many non-specific inflammatory conditions making it a valuable prognostic aid; 6) increased lymphocyte counts are often seen in chronic disease and immature lymphocytes are common in hatchlings with inflammatory disease; 7) monocytes and eosinophils are relatively rare but occasionally quite evident.

All samples were taken by cutting a toenail and using two microscope slides and from one to five capillary tubes, a very simple procedure. Most of the laboratory work was done by the Veterinary Reference Laboratory and some by the Veterinary Disease Laboratory. Both laboratories have a twice-daily pickup service and were able to do the work with minimum delay and, therefore, fewer artifacts. Hemostasis was achieved by the use of silver nitrate sticks or ferric subsulfate liquid on cotton tipped applicators.

TABLE 1. Value Ranges for Hemogram and Serum Chemistry in Normal California Desert Tortoises

506 A.M.C. OF LAWNDALE
4473 W. Rosecrans
(213) 679-0693
Hawthorne, CA 90250

☐ ROUTINE ☐ RUSH

ACCESS. NO.

HISTORY AND TREATMENT

Captives
Los Angeles area
Late 1978 - Early 1980

OWNER
Dr. Walter J. Rosskopf, Jr.

PET I.D.	SEX	AGE	SPECIES	DATE
All samples taken by microhematocrit system			*Gopherus agassizi*	3-16-80

Normal values (over 100 samples)

HEMATOLOGY	TEST RESULT	CANINE NORMAL	FELINE NORMAL	EQUINE NORMAL	CHEMISTRY	TEST RESULT	CANINE NORMAL	FELINE NORMAL	EQUINE NORMAL
CBC					30. SGOT	10-90	10–80	10–80	184–566
1. WBC x 10^3	*3-8	6.0–17.0	5.0–19.0	5.5–12.5	31. SGPT		10–80	10–80	5–30
2. RBC x 10^6	.57-1.2	5.5–8.5	5.0–10.0	6.5–12.5	32. Alk. Phosphatase		20–150	10–80	80–216
3. Hgb gm/dl		12–18	8–15	11–19	33. BUN	2-30	12–25	20–30	10–25
4. Hct %	20-35	37–55	24–45	32–52	34. Cholesterol		125–250	95–130	75–150
5. MCV fl		60–77	39–55	34–58	35. Total Protein	2.2-5.4	5.4–7.1	5.4–7.8	5.7–7.9
6. MCH pg		19.5-24.5	12.5-17.5	12.3-19.7	36. LDH	22-250	50–495	75–490	142–354
7. MCHC gm/dl		32–36	30–36	31–37	37. Bilirubin		0.1–0.6	0.1–0.6	0–2.0
8. RETIC %		0–1	0.4–6.4	0	38. Creatinine	.1-.5	1.0–2.0	0.8–1.8	1.2–1.9
9. NRBC/100 WBC		0	0	0	39. Phosphorus		2.2–5.5	1.8–6.4	2.0–5.6
DIFFERENTIAL					40. Calcium	9.0-17.0	8.6–11.2	8.0–10.4	11.5–13.3
10. Bands	0	0	0	0	41. Albumin		2.3–3.2	2.1–3.3	2.3–3.8
11. Neutrophils	0-3	0–3	0–3	0–2	42. Glucose	30-150	60–110	70–150	75–115
12. Heterophils	35-62	60–77	35–75	30–65	43. Amylase		300-1000	300–800	l.t. 100
13. Lymphocytes	25-50	12–30	20–55	25–70	44. Chloride		105–115	117–123	99–109
14. Monocytes	0-4	3–10	1–4	1–7	45. Cholinesterase		1900-3800	1900-3800	
15. Eosinophils	0-4	2–8	2–12	0–11	46. CO_2		18–20	16–20	20–25
16. Basophils	2-15	Rare	Rare	0–3	47. CPK		1–35	1–35	3–24
17. Platelets x 10^3	pres	150–700	250–700	100–350	48. Direct Bilirubin		0.06-0.10	0.05-0.15	0–0.4
18. RBC Morph—Normal					49. Fibrinogen		100–500	50–300	100–500
19. Polychromasia ☐ Occasional ☒ Slight ☐ Mod. ☐ Marked					50. Globulin		2.7–4.4	2.6–5.1	2.6–4.0
20. Anisocytosis ☐ Occasional ☒ Slight ☐ Mod. ☐ Marked					51. Lipase		0.1–3.0	0.1–1.5	
21. Spherocytes ☐ Occasional ☐ Slight ☐ Mod. ☐ Marked					52. Potassium		4.0–5.7	3.8–4.5	2.5–5.3
22. FeLV ☐ Positive ☐ Negative					53. Protime		8–11	9–13	9–12
23. FIA ☐ Positive ☐ Negative					54. Sodium		141–152	147–156	132–146
24. Sed Rate mm/					55. T-3 RIA		75–200	75–200	20–80
25. Microfilaria ☐ Positive ☐ Negative					56. T-4 RIA		1.0–4.0	2.6–5.0	1.0–3.0
26. Coombs Test ☐ Positive ☐ Negative					57. Trypsin		Positive	Positive	
27. LE Prep ☐ Positive ☐ Negative					58. Uric Acid	2.2-9.2	0–2	0–1	0.9–1.1
28. ANA ☐ Positive ☐ Negative					59. APTT		L.T. 25 seconds		
29. Brucella ☐ Positive ☐ Negative Titer ______					60. Cortisol		1–10		
COMMENTS:					61.				

*1. WBC lower during and shortly after hibernation, then rises 2. No blood parasites seen in any of the blood samples 3. Heterophils and basophils very responsive to inflammatory conditions 4. Extremely high white counts rare 5. LDH increase seen in many non-specific inflammatory conditions - valuable prognostic aid 6. Lymphocytes increase in chronic conditions

AN OVERVIEW OF DESERT TORTOISE, *GOPHERUS AGASSIZI*, ETHNOZOOLOGY

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INTRODUCTION

The use of reptiles by Southwestern Native Americans has been well recognized by the anthropological community. The degree of importance of reptiles varies considerably from tribe to tribe (Spier 1928). Reptiles were important food sources and held important roles in tribal mythology among some tribes, while to others they were either unimportant or were taboo.

The role of the desert tortoise, *Gopherus agassizi*, to Native Americans, while not covered in depth in the literature, has been important enough to have received the attention of archaeologists and ethnologists. The desert tortoise was an item of food, was a mythologic character, and, to a limited extent, was used for medicine. In some instances, tortoise bones or shells were also used as utensils or as rattles.

The distribution of the desert tortoise overlaps, to some degree, the territories of 22 tribes (Figure 1). We are not presently able to provide data on the use of the tortoise by all of these tribes, and the information presented here is not intended to represent completed research. Our intention is rather to present an overview of desert tortoise ethnozoology and to point out potential research questions of interest to zoologists and ethnologists.

PREHISTORY

Examination of faunal remains from archaeological excavations could shed light on the extent of Native American usage of the desert tortoise in instances where the ethnographic literature is deficient. Archaeological data could also provide valuable insights on the range of *G. agassizi* in prehistoric times and whether there have been fluctuations in range as a result of climatological change.

We have made no attempt to examine the massive amount of potentially relevant archaeological literature. Unfortunately, much of the recovered archaeological material has not been adequately analyzed. Campbell (1931) illustrates tortoise plastrons and carapaces recovered from formerly inhabited caves near Twentynine Palms, but includes no discussion. While the archaeological literature may contain important references to tortoise use, ethnographic data play a more important role in describing the use and relative importance of the desert tortoise to Native Americans.

ETHNOGRAPHY

Ethnographic usages ranged from food to mythology (Table 1). We have included only those tribes for which specific information was obtained during a preliminary literature search. In general, it must be noted that the ethnographic literature is highly variable in quality. A lack of references to the tortoise does not necessarily mean that the tortoise was not utilized.

Food

Subsistence usage of the desert tortoise is the best documented usage, but the indications are quite variable. Thus, it appears that the tortoise was a relatively important food for the various Yavapai groups; the eggs and bones were eaten as well as the flesh. The Yavapi believed the meat to be particularly good for children (Gifford 1932, 1936). This indicates that the Yavapai probably hunted tortoises intentionally. The tortoise was cooked in earth ovens after the plastron had been removed, and the liver was cooked on the coals. By contrast, it is recorded that the Papago ate tortoises but only when they accidentally happened across them (Castetter and Underhill 1935). The Papago ash roasted the tortoise. The plastron was opened, the viscera removed and hot pebbles inserted. Spier (1933) states that the Maricopa, Papago, and Yavapai usually roasted the tortoise in ashes, but that they were also boiled at times.

Indications are less certain, but it appears that the Havasupai may have shunned tortoises as food, along with other reptiles and amphibians (Spier 1928).

With more complete ethnographic data, would it be possible to correlate food usage of the tortoise with general regional tortoise population structure and density? Might there be more complex variables operative in established taboos on tortoise meat in certain areas, such as the perceived role of tortoises vis-a-vis floral resources?

Medicine

The only medical usage we have found was among the Yavapai, who pulverized the shells and rubbed the powder on the belly for stomach trouble. The pulverized shells were also mixed with boiled tortoise urine; the mixture was drunk as a cure for what Gifford (1936) identifies only as "difficult urination." It would be worth investigating whether the remedy was used for renal failure or obstructive conditions, and whether the biochemical characteristics of tortoise urine might indicate reasons for efficacy of the remedy.

Arts and Crafts

Differential usage of the desert tortoise is more clearly indicated in this category than with regard to its subsistence usage. Tortoise shells were used as rattles by the Cahuilla (Bean 1972), but other forms of rattles were used by the Quechan and Kamia (Gifford 1931), the Cahita (Beals 1943), and the Yavapai (Gifford 1936). The only instances of using shells for household utensils are among the Shoshonean-speaking Cahuilla (Bean 1972) and Paiute peoples (Fowler and Fowler 1971). Only among the Mojave have we found instances of the tortoise being used as an artistic motif (in pottery). Oval platters were called "kam'ota kapeta" (tortoise spoon) and were decorated with nested rectangle motifs representing the carapace markings (Kroeber and Harner 1955). A very curious fact is that no tortoise designs were found in an extensive study of Mojave Desert petroglyphs -- a geographical area where other uses of the tortoise are well-documented (Rector 1976). Is this true of rock art throughout the range of the tortoise?

Mythology

A pervasive problem in the ethnographic literature with regard to mythology is the uncertain usage of the words "turtle" and "tortoise." For example, in an obvious reference to the tortoise, Spier (1933) writes about "large mountain turtles." In some instances there are environmental references in myths strongly indicating that "turtle" refers to the desert tortoise; for example, Beals (1945) records a story, "Turtle Speaks Yaqui," in which Coyote catches Turtle with his mouth red from having eaten prickly pear fruit.

In most instances where the reference is clearly with regard to the desert tortoise, the animal is portrayed as a sort of stranger or misanthrope. Tortoise spoke Yaqui incorrectly, and frightened Coyote with false threats (Beals 1945). As a result of a fight between Badger and Desert Tortoise, the animals and people scattered and were no longer one people (Gifford 1932). After being mistreated by the Shevwits Paiute, Tortoise pronounced a curse that made people die.

A contrary view was held by the Chemehhevi (Southern Paiute) people, however. To them, Tortoise was a lesser chief, partner of the high chief, Gila Monster. Tortoise was a sacred animal, tough-hearted, symbolic of the spirit of the Chemehuevi people; in the words of Carobeth Laird (1976), the desert tortoise "expresses the Chemehuevi ideal: patience to endure, strength to survive, courage when all hope is lost."

An interesting Paiute story tells of the establishment of the tortoise in Utah:

> Turtle went to the St. George country. When he got there he said, "I am your meat, I'll stay here for you whenever you want me." -- "There was not much meat on him, we didn't want him." He (turtle) returned and said something bad that made them all die. He returned and stayed in this country, where he is now living (Lowie 1924).

CONCLUSION

Based upon our literature search, the desert tortoise played some role in the lives of most tribes living within its geographical range. There are some interesting questions about the importance of the tortoise to Native Americans, the answers to which may be contained, in part, in the archaeological literature. Another valuable source of meaningful data is the knowledge of Native American tribal elders, through ethnographic interviews. This could significantly augment existing ethnographic data.

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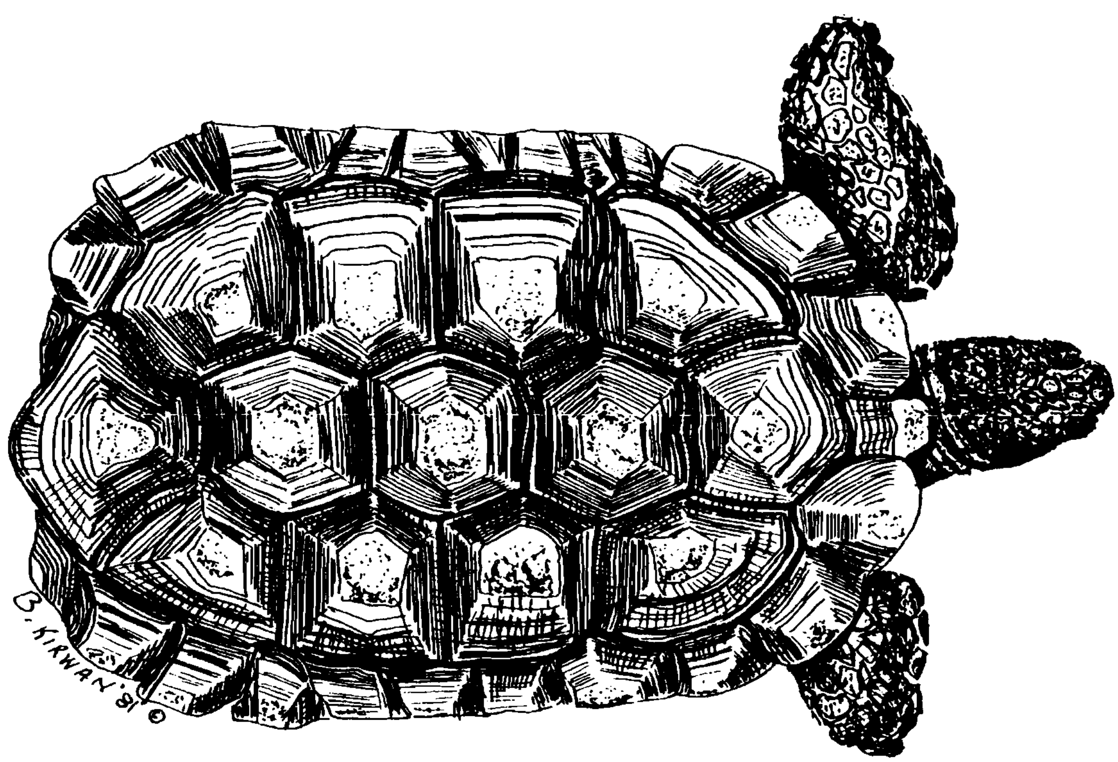

TABLE 1. Native American Utilization of *Gopherus agassizi*

Tribal Group	Food	Medicine	Arts and Crafts	Mythology	References
Paiute (including Chemehuevi)	Yes	?	?	Yes	Lowie 1924; Spier 1928; Drucker 1941; Fowler and Fowler 1971; Laird 1976
Mojave	?	?	Yes	?	Kroeber and Harner 1955
Havasupai	No(?)	?	?	?	Spier 1928
Cahuilla	Yes	?	Yes	?	Bean 1972
Yavapai	Yes	Yes	No	Yes	Spier 1928, 1933; Gifford 1932, 1936; Drucker 1941
Kamai	?	?	No	?	Gifford 1931
Quechan	?	?	No	?	Gifford 1931
Maricopa	Yes	?	No	?	Spier 1933; Drucker 1941
Papago	Yes	?	No	?	Spier 1933; Castetter and Underhill 1935; Drucker 1941
Pima	Yes	?	?	?	Drucker 1941
Cahita (including Yaqui)	Yes	?	?	Yes	Drucker 1941; Beals 1945

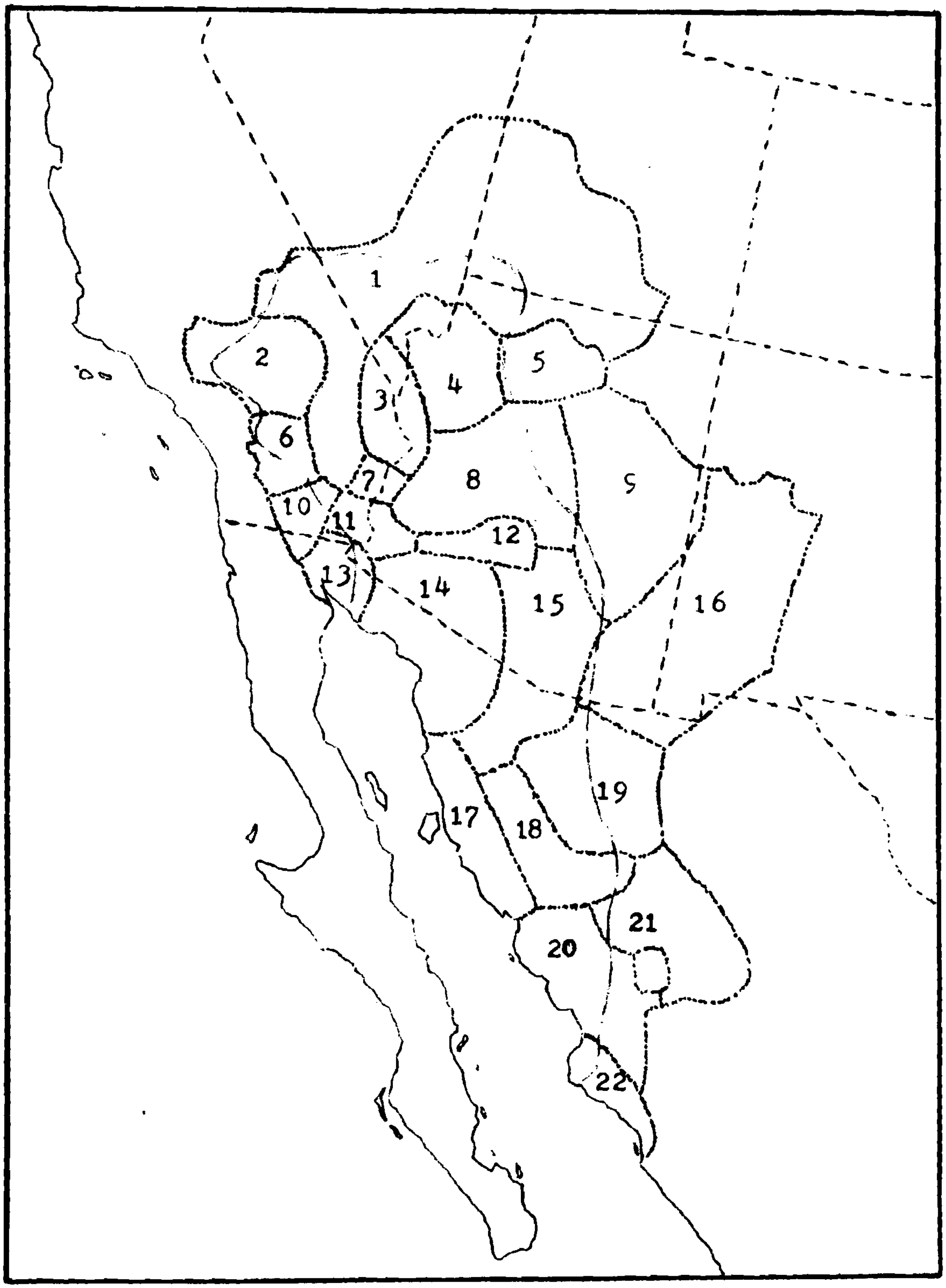

FIGURE 1. Native American tribal territories overlapping the range of the desert tortoise, *Gopherus agassizi*. Key on following page.

IMPACT OF MILITARY ACTIVITIES ON THE DESERT TORTOISE AT THE MOJAVE "B" RANGES

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Desert tortoise populations were assessed on the Mojave "B" Ranges, San Bernardino County, California, in conjunction with preparation of an environmental assessment for continued withdrawal of the lands from Public Lands. Populations were generally low (0-25 tortoises/mi^2 or 0-10/km^2). Highest densities (5-25 tortoises/mi^2 or 2-10/km^2) were recorded in Randsburg Wash Test Facility between Mojave "B" North and Mojave "B" South. Low tortoise populations were probably not due to military operations, inasmuch as populations within both disturbed and undisturbed areas were low. Military operations were, however, creating minor localized impact through habitat destruction and relocation by military personnel. High feral burro populations are the most immediate threat to tortoise populations.

INTRODUCTION

The Mojave "B" Ranges are a part of the Mojave "B"/Randsburg Wash Complex located on the China Lake Naval Weapons Center, San Bernardino County, California. The Mojave "B" Ranges are separated into two separate parcels, Mojave "B" North and Mojave "B" South, by the Randsburg Wash Test Facility. The North Range is approximately 238 mi^2 (617 km^2) and includes the southern portion of the Panamint Valley, Wingate Wash, and the southern end of the Slate Range. The South Range is approximately 253 mi^2 (657 km^2) and includes the northern portion of the Superior Valley, Eagle Crags and Pilot Knob.

Prior to 1943, the Mojave "B" Ranges were used by small mining operations and as a transportation corridor between Panamint and Death Valleys and the Antelope Valley. The Mojave "B" South

Range was used for livestock grazing and still is used, to a limited extent, today. In 1943, both parcels were withdrawn from public domain for use as an aerial gunnery range. In succeeding years a variety of evolving military activities have occurred on both ranges. Public access has been virtually nonexistent and Navy activities have been limited to relatively few target sites (a total of about 30 km^2). In 1979, the Navy withdrawal expired and WESTEC Services, Inc. was selected to prepare an Environmental Assessment document for submission to Congress concomitant with the request for an extension of the withdrawal (WESTEC Services, Inc. 1979).

As a portion of the biological assessment, both North and South Ranges were surveyed for desert tortoise, *Gopherus agassizi*, populations. Although emphasis was given to actual target sites, pristine sites also were examined as control areas. The purpose of this report is to document the status of tortoise populations in an area relatively free of human disturbance and to compare our results with surrounding desert regions. Impacts of military activities are also discussed.

MATERIALS AND METHODS

Tortoise censuses were conducted in June 1979. Populations were assessed using the same method employed by the Bureau of Land Management (Desert Plan Staff) in its desert-wide surveys. Each transect was 1.5 miles by 10 yd (2.4 km by 9 m). An observer would walk the transect and examine the 9-m swath for various tortoise signs (i.e., burrows, scat, shells, tracks, and living animals). The quantity of sign was used in conjunction with established predictive equations (Berry and Nicholson 1979) to obtain estimates of tortoise density per square mile. The immediate vicinity of each target was searched for tortoise signs, and areas within a 0.5 mile (0.8 km) radius of the targets were surveyed in order to obtain a density estimate for the target area. Additionally, tortoise transects were conducted in non-target areas in the Mojave "B" Ranges and near Christmas Canyon in the Randsburg Wash Test Facility in order to assess general tortoise population densities for the study area (Figure 1).

The Mojave "B" North Range sites were primarily in creosote bush, *Larrea tridentata*, and burrobush, *Ambrosia dumosa*, plant association. In Wingate Wash, desert senna, *Cassia armata*, was an important constituent of the creosote bush association. The dry lake area was dominated by seep-weed, *Suaeda torreyana*, and saltbush, *Atriplex elegans*. The Mojave "B" South Range sites were vegetatively more diverse, associated with topographic diversity. The Superior Valley sites were dominated by four-winged saltbush, *Atriplex canescens*, and Indian ricegrass, *Oryzopsis hymenoides*. The higher elevations consisted of a broad and variable ecotonal area between creosote bush and blackbrush, *Coleogyne ramosissima*.

RESULTS AND DISCUSSION

A paucity of tortoise activity for both ranges is evident from transect data (Table 1). Estimated tortoise densities were correspondingly low. Lowest densities (0-2/km^2) occurred in Wingate Wash and at the southern target sites on the Mojave "B" North Range. The Randsburg Wash area near Christmas Canyon had the highest tortoise densities (2-10/km^2). The remainder of the areas surveyed on both ranges were intermediate with densities ranging rom 0-8/km^2.

A desert tortoise distribution and density study was conducted by the Bureau of Land Management (BLM) throughout the California deserts (Berry 1979). Over 1,000 tortoise transects were walked between 1975 and 1979 in a manner identical to tortoise surveys conducted on the Mojave "B" Ranges, although spacing between transects was greater than that used in the present study. Greater coverage of an area allows better resolution of density estimates, which accounts for the narrower range of estimates in our study. Additionally, PRC Toups Corporation (1979) conducted limited studies in the southwestern portion of the Randsburg Wash Test Facility. Tortoise density estimates were obtained from the BLM studies for areas adjacent to the Mojave "B" Ranges, from the PRC Toups Corporation (1979) study, and from the present study (Figure 2). The overall BLM studies estimated that 33,741 mi^2 (87,389 km^2) (84.1%) of the California Desert Conservation Area has less than 8 tortoises/km^2. Only 2,969 mi^2 (7690 km^2) (7.4%) of the California Desert Conservation Area had densities greater than 19/km^2 (Berry and Nicholson 1979).

The Naval Weapons Center is at the northern portion of desert tortoise distribution in California. Local vagaries of temperature, aridity, and soil composition may account for low densities observed in the present study. In addition, feral burros, *Equus asinus*, are abundant on the Mojave "N" Range North and have accounted for substantial removal of available vegetation (WESTEC Services, Inc. 1979). Burro grazing may have accounted for a significant depletion of available food resources for tortoises.

Military activity has apparently had only minor effects on desert tortoise populations, as populations within disturbed and undisturbed areas were low. Construction of targets and roadways has certainly resulted in minor impacts to desert tortoises by vehicular mortality and habitat destruction in localized areas. Additionally, there have been instances where military personnel have relocated individual tortoises to areas less favorable for survival. As low density tortoise populations are sensitive to any removal of individuals, the minimal impact upon the population may be significant over time.

ACKNOWLEDGEMENTS

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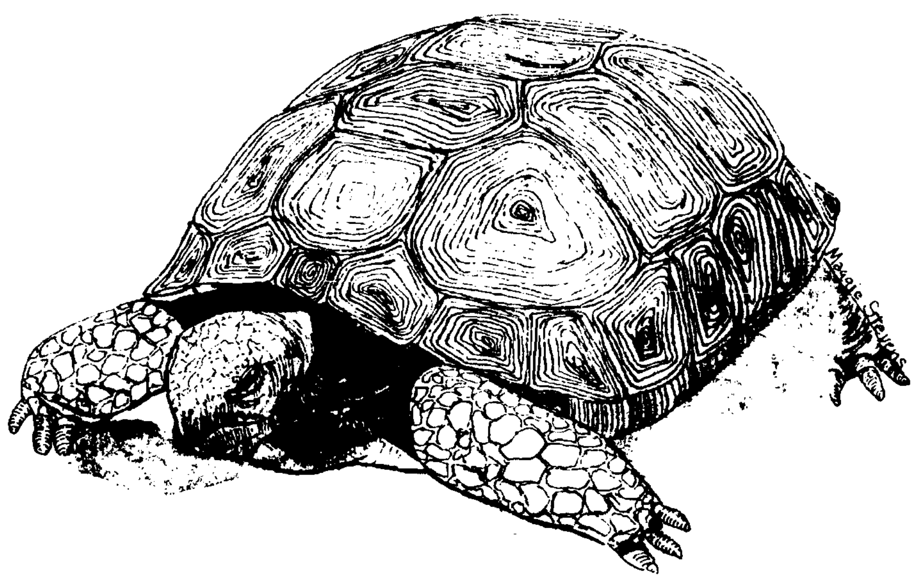

FIGURE 1. Distribution of tortoise transects on the Mojave "B" North (1-20) and South (21-40) Ranges. Transects 30, 35, and 36 were located on the Randsburg Wash Test Facility

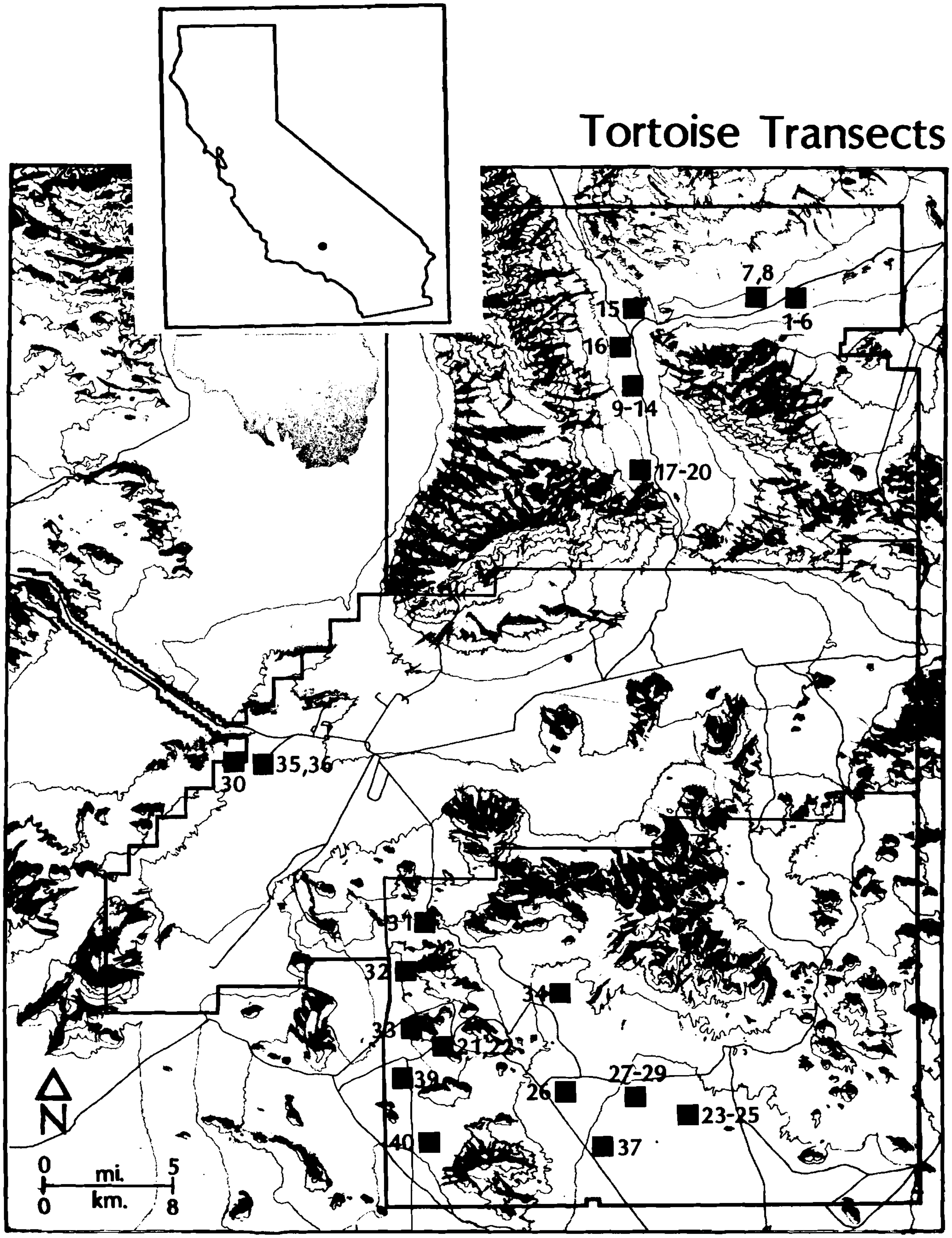

Figure 2. Tortoise densities for the Mojave "B" Ranges and surrounding areas.

Legend

Desert Planning Staff:

Greater than 200 tortoises/mi^2

100 - 250 Tortoises/mi^2

50 - 100 Tortoises/mi^2

20 - 50 Tortoises/mi^2

0 - 10 Tortoises/mi^2

WESTEC Services, Inc:

A 5 - 25 Tortoises/mi^2

B 0 - 20 Tortoises/mi^2

C 0 - 10 Tortoises/mi^2

D 0 - 5 Tortoises/mi^2

Unknown Densities

PRC Toups:

E 10 - 30 Tortoises/mi^2

FIGURE 2. Tortoise densities for the Mojave "B" Ranges and surrounding areas

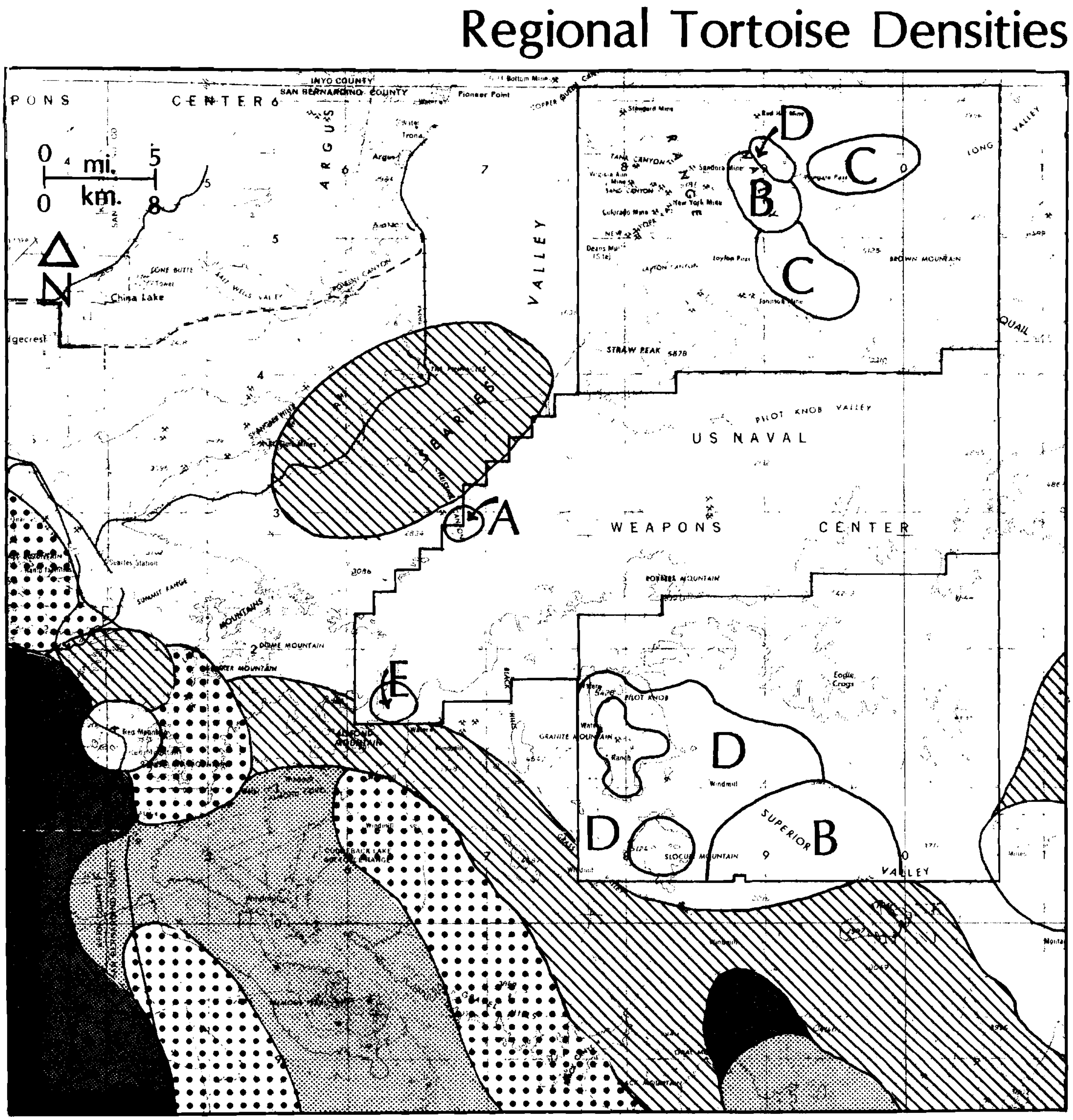

TABLE 1. Desert Tortoise Transect Data for Mojave "B" Ranges

Transect No.	Location	Total Signs Observed	Inferred Density (/mi^2)	Comments
01	Site B	0	0-5	
02	"	0	0-5	
03	"	0	0-5	
04	"	0	0-5	
05	"	0	0-5	
06	"	0	0-5	
07	"	0	0-5	
08	"	0	0-5	
09	"	0	0-5	
10	"	0	0-5	
11	"	0	0-5	
12	"	0	0-5	
13	Control	2	0-20	1 burrow, 1 scat
14	"	1	0-20	1 burrow
15	Site C	0	0-10	
16	Site D	0	0-10	
17	Sites G and F	0	0-10	
18	"	0	0-10	
19	"	0	0-10	
20	"	0	0-10	
21	PK Ranch/ Pilot Knob	0	0-10	
22	"	1	0-10	1 scat
23	Site J	0	0-20	1 juvenile found on trap lines
24	"	0	0-20	" "
25	Control	0	0-10	
26	Control	0	0-10	
27	Control	0	0-10	
28	"	0	0-10	
29	"	0	0-10	
30	Site K	8	5-25	4 burrows, 1 adult ♀, 1 adult ♂, juvenile tracks, 1 adult ♀ shell
31	PK Ranch/ Pilot Knob	0	0-10	
32	"	0	0-10	
33	"	0	0-10	
34				
35	Site K	1	5-25	1 scat
36	"	1	5-25	1 adult ♂ shell
37	Control	1	0-10	1 juvenile shell
38	Control	0	0-10	
39	PK Ranch/ Pilot Knob	0	0-10	
40	Grass Valley	0	0-10	

RECOVERY OF SOILS AND VEGETATION IN A MOJAVE DESERT GHOST TOWN, NEVADA, U.S.A.

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Recovery rates of vegetation and compacted soil were studied at the Wahmonie ghost town in southwestern Nevada. Soil in the town site has not completely recovered from compaction in the 51 years since the site was abandoned; recovery trends indicate a recovery time on the order of a century. The composition of vegetation in the town site consists of short-lived perennials whereas the surrounding undisturbed vegetation consists mainly of long-lived perennials. Comparison of the vegetation recovery in the town site with recovery in little-used streets shows that soil compaction is a major limiting factor on the vegetation of disturbed desert areas; the recovery rate of vegetation in compacted soil is too low to allow prediction of a full-recovery time.

INTRODUCTION

The Mojave Desert today is subject to several destructive land-use practices that threaten the existence of the natural plant communities. Off-road recreational-vehicle use compacts the soil (Wilshire and Nakata 1976) and strips vegetation from used areas (Keefe and Berry, 1973; Wilshire et al. 1978). Sheep grazing compacts the soil and removes shrub cover in watering and bedding areas (Webb and Stielstra 1979). Other activities causing soil disturbance and vegetation removal include mining, urban development, road guilding, and utility corridor construction (Vesak et al. 1975*a*, *b*; Wilshire 1979). These disturbances lead to accelerated wind and water erosion which cause further on- and off-site degradation of the environment (Nakata et al. 1976; Snyder et al. 1976; Gillette et al. 1979). Because most of the land disturbed during these practices is not reclaimed, determination of the amount of time required for disturbed land to recover is an important management consideration.

Several recent studies have discussed the amelioration of soil compaction with time. Orr (1975) studied grazing exclosures in South Dakota and measured significant recovery of a sandy loam after 2 years, but compacted subsurface soil had not shown signs of recovery by the end of the 4-year study. Power (1974) reported that compaction was still affecting tree growth 10-30 years after logging operations in Oregon. Blake et al. (1976) found that compacted clay loam at 12-16 inches (30-40 cm) depth had not shown significant recovery after 9 years in Minnesota. Dickerson (1976) measured significant loosening of compacted logging trails in northern Mississippi and predicted a complete recovery time of 12 years on the basis of a linear-regression model. These studies were all made in regions of greater than 20 inches/year (50 cm/year) of rainfall; no studies have been made of compaction recovery in arid regions.

Several studies have been completed on the revegetation of severely disturbed desert areas, although relatively little is known about plant succession in the Mojave Desert (Vasek and Barbour 1977). Vasek et al. (1975*a*) found substantial revegetation along pipeline corridors in the southern Mojave Desert 12 years after construction; they concluded that revegetation rates vary with site productivity but that the complete recovery time for any site would probably be in the hundreds of years. Vasek (1979) described secondary succession in the eastern Mojave Desert and found that the pioneer perennials were generally of low stature and short lifespan. Wallace et al. (1977) described natural revegetation of disturbed Great Basin desert and noted that the cover on the disturbed soil is from one-fifth to one-third of the undisturbed cover after 18 years. Wells (1961) concluded that the recovery of vegetation was slow in the Wahmonie, Nevada ghost town after 33 years and observed that a perennial bunchgrass and perennial shrubs normally characteristic of desert washes were the pioneer invaders.

Wells' 1961 study provides an important data base for recovery rates at the Wahmonie site. We report here the recovery of soils and vegetation at the Wahmonie site 51 years after it was abandoned.

SETTING

The Wahmonie townsite is located on the Nevada Test Site in southwestern Nevada at lat. 36° 49' N and long. 116° 10' W. The site has an elevation of 4330 ft (1320 m) and an average rainfall of about 7 inches/year (18 cm/year). The average January and July temperatures are 43 to 84° F (6 and 29° C), with a high temperature of 106° F (41° C) and a low of 20° F (-11° C) (R. F. Quiring, pers. comm., 1979). The townsite was built on a south-facing 3° slope of slightly dissected Quaternay alluvial fan deposits on the divide separating east- and west-draining ephemeral streams.

The alluvium was derived by erosion of block-faulted, hydrothermally altered Tertiary calcalkaline volcanic rocks (Ekren and Sargent 1965). The perennial vegetation present in the undisturbed areas is typical of middle-elevation transitional communities of the northern Mojave Desert (Randall 1972, cited in Vasek and Barbour 1977). *Larrea tridentata, Grayia spinosa, Coleogyne remosissima* and *Ephedra nevadensis* are the principal woody perennials present and *Stipa speciosa* and *Oryzopsis hymendoides* are the principal perennial grasses.

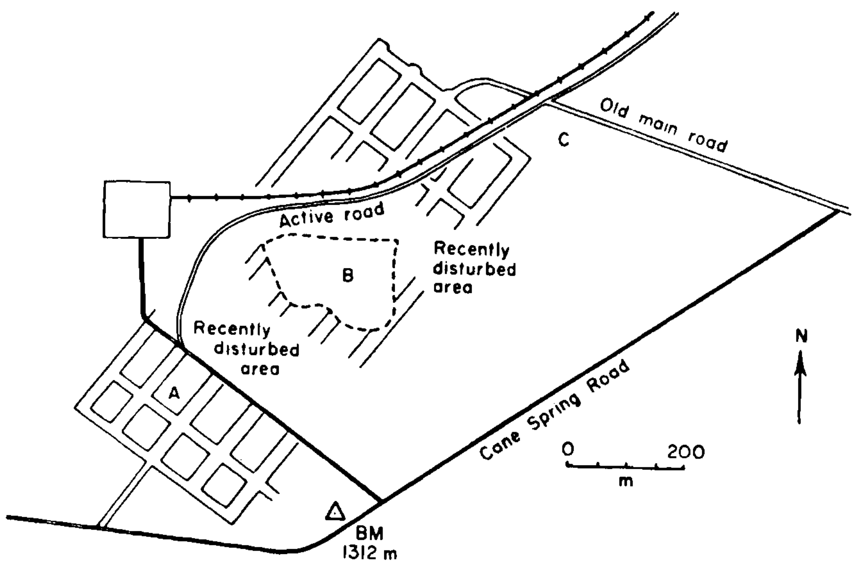

Figure 1. Map of the Wahmonie townsite, Nye County, Nevada. (A) Location of streets and southwestern control. (B) Location of abandoned townsite. (C) Location of active road, old main road and northeastern control.

Wahmonie was established and abandoned in 1928 in response to a mining boom (Paher 1971). A rectangular grid of streets and avenues 2950 ft (900 m) long and 1310 ft (400 m) wide was prepared by cutting the natural vegetation in swaths 79 ft (24 m) wide in avenues and 46 ft (14 m) wide in streets (Figure 1), but no berms are evident so soil displacement was not severe. Photographs taken during the mining boom (Paher 1971) and 1951 aerial photographs indicate that the principal settlement for the 1000 miners was the northeastern part of the site. The southwestern part of the site, prepared for sale by land speculators, was probably little used, if at all. The main avenue through town remained part of a major east-west road until about 1961 when the present paved road was established (Figure 2) and the old main road was cut off with a diversion ditch. A dirt road remains in use in the northeastern part of the townsite.

Raghaven et al. (1976) and R. H. Webb (unpublished data) showed that soil bulk densities increase logarithmically at a rate inversely proportional to the amount of applied pressure, and Bodman and Constantin (1965) reported maximum bulk densities for different mixtures of soil particles. Their results suggest that although the town site, old main road, and active road were compacted with cyclical loading of different applied pressures, the total load applied at each site probably compacted the soil to a similar high, if not maximum, density. Thus, it is possible to compare the physical properties of soil compacted to a similar high level at three different times and to study the response of the invading vegetation to the compaction. In addition, the vegetation in the southeastern streets was measured in 1961 (Wells 1961) and represents secondary succession in a little-disturbed desert soil. These attributes, and the protection given the site by virtue of its location on the Nevada Test Site, make Wahmonie a unique site for the study of soil and vegetation recovery in the Mojave Desert.

METHODS

Six study areas were established at Wahmonie in July, 1978, and May-June, 1979 (Figure 1). The ages and locations of the disturbed areas were determined from the historical record (Paher 1971), aerial photography, and Nevada Test Site records. Construction disturbances since 1961 were identified and avoided in the town site, and edge effects along roads (Johnson et al. 1976) were avoided whenever possible during the vegetation measurements. Two control areas were established because of variations in soil and vegetation across the site; the soils are coarser in the southwestern part of the town site and the vegetative composition of the undisturbed area shifted eastward from a *Larrea-Grayia* assemblage to a *Larrea-Grayia-Coleogyne* assemblage.

The soils in the study areas were sampled to determine physical properties which serve as compaction indices. Bulk densities were determined for the 0-8.7 cm depth from 57 cores taken with a thin-walled core sampler. A simple 30 degree cone penetrometer was used to measure 989 penetration depths, and a recording penetrometer (Carter 1967) was used to determine 400 penetration resistance versus depth curves. Penetration resistance is an index of soil strength dependent on density, moisture content, and structure (Baver et al. 1972). Terminal infiltration rates were measured at 23 sites using double-ring infiltrometers with a procedure described by Bertrand (1965). Rings were emplaced to a depth of 4.3 inches (11 cm), and a 3.9 inches (10 cm) falling head was applied for 2 h to determine the terminal, or approximately saturated, infiltration rate.

Three methods were used to measure perennial vegetation in the study areas. Cover was measured using the line intercept method along 970 ft (600 m) of transects in both control areas and the streets, 1310 ft (400 m) of transects in the town site, and 655 in (200 m) of transects

$$d = N - \sqrt{\sum_{i=1}^{S} n^2}$$

where d = diversity, N = total quantity of a community parameter, S = total number of species, and n = the quantity of the parameter possessed by species i (McIntosh 1967). The 'eveness' of the diversities (Hurlbert 1971) was calculated from

$$V = \frac{d - d_{min}}{d_{max} - d_{min}}$$

where V = eveness and d_{max} and d_{min} are calculated according to McIntosh (1967).

RESULTS

Recovery of Soil Properties

The soil on undissected parts of the alluvian fan have a profile consisting of 3.9 inches (10 cm) of loose, light brown, gravelly loamy sand (Figure 2) grading downward into a red oxidized zone of gravelly sand. Little textural variation occurs with depth to caliche at 24 inches (60 cm). The soil in the southwestern part of the site contains more gravel and thus has somewhat higher soil densities (Table 1), than that in the northeastern part of the site (Figure 2). Natural surfaces have a moderately well-developed rock cover between the perennial shrubs; rock cover in the disturbed areas has started to reform but does not approach that of the undisturbed area (Plate 1).

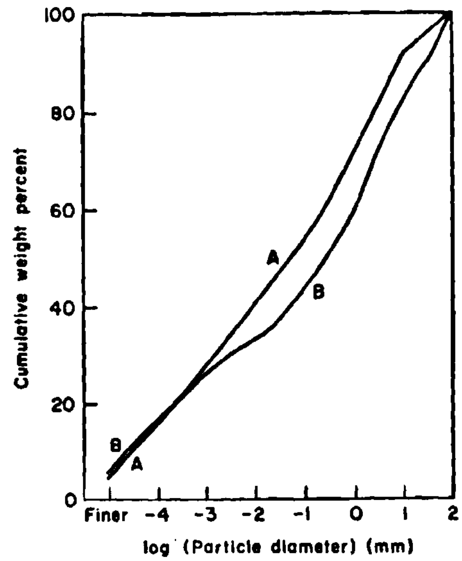

Figure 2. Distribution graph for the sizes of soil particles at the Wahmonie townsite. A, northeastern soils (0–10 cm); B, southwestern soils (0–10 cm).

The soil in the southwestern streets shows little residential compaction when compared to the adjacent control area (Figure 3(a) and Table 1), but soil in the trampled town site is still significantly compacted 51 years after abandonment. The resistance to penetration of the town site soil is significantly higher to a depth of 20 cm than that of the nearby undisturbed soil (Figure 3(b)). In addition, the bulk density is significantly higher and the penetration depth and infiltration rates are significantly lower in the town site (Table 1). The soil in the active and old main roads is also compacted (Table 1); the infiltration rate in these soils is very low compared to the infiltration rate in undisturbed soil. A 5 min rainstorm of 1.2 inches (3 cm/h) intensity caused runoff in the active road and local ponding in the old main road in early May 1979; no runoff or ponding was observed in the town site, streets, or control areas. This suggests that the erosion potential of the well-used streets and town site was high during the first years after abandonment, although the resulting erosion apparently was limited to sheetwash because gullying and other signs of severe erosion are not present.

A comparison of the soil physical properties in the active road, old main road, and town site with those of the undisturbed soil shows that the amount of recovery is time-dependent. The physical properties were modeled as a function of time since abandonment using a least-squares linear regression and a forced-fit exponential-decay curve (Table 2). The linear model depicts the fastest recovery trend whereas the exponential-decay model represents a slower yet probably more realistic trend. The inadequacy of the linear model to fit the bulk density recovery trend is evident in Figure 4; the linear bulk density recovery trend predicts a complete recovery time of 75 years, but the exponential-decay model predicts a 90% recovery time of 680 years. The other physical properties measured have predicted 90% and complete recovery times of 70-100 years (Table 2). These results should be considered only as order-of-magnitude estimates since both recovery models are derived from only four time-dependent data points.

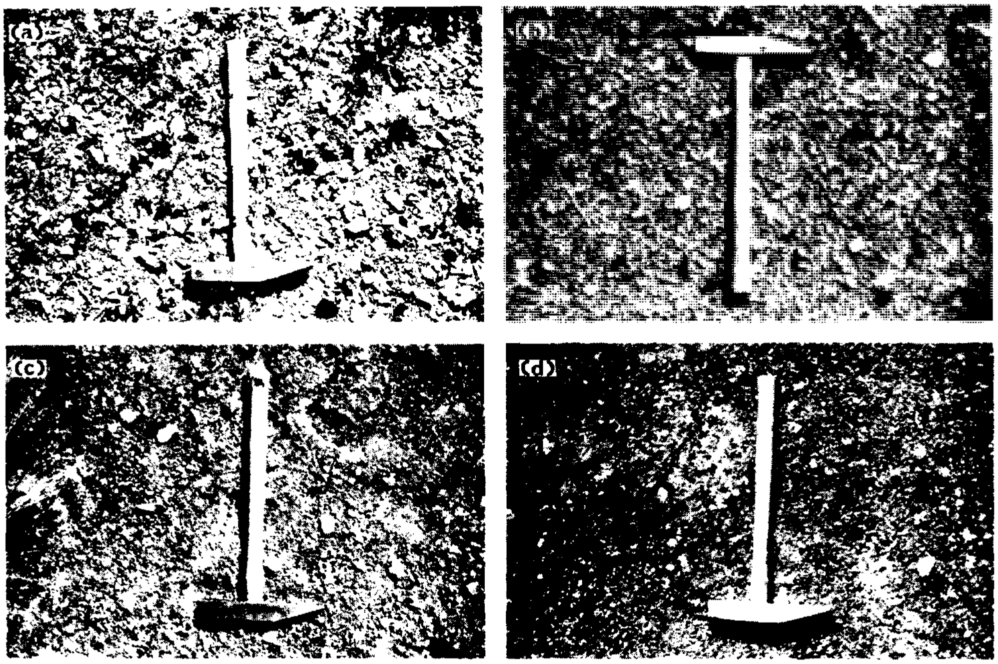

Plate 1. Photographs of rock crusts at Wahmonie. (a) Moderately well-developed rock crust on undisturbed surface, northeastern control. Hammer is 39 cm long. (b) Rock crust on disturbed surface, trampled area of the townsite. (c) Immature rock crust on disturbed surface, trampled area of the townsite. (d) Immature rock crust on disturbed surface, old main road.

Revegetation of Perennials

After 51 years the composition and quality of vegetation in the streets are still significantly different from those of the adjacent undisturbed area (Table 3). The cover of *Larrea* and *Grayia* is much less and the cover of short-lived perennials such as *Stipa* and *Hymenoclea salsola* is much greater in the streets than in the control area. As noted by Wells (1961), *Stipa* and *Hymenoclea* have greater densities in the streets, but the most striking difference is the low density of the long-lived *Larrea*, *Grayia*, *Ephedra*, and *Lycium*. The cover of *Ephedra* and *Lycium* in the streets has returned to approximately the same as in the control area, but the individuals contributing the cover in the streets are much larger. The low diversity in the streets

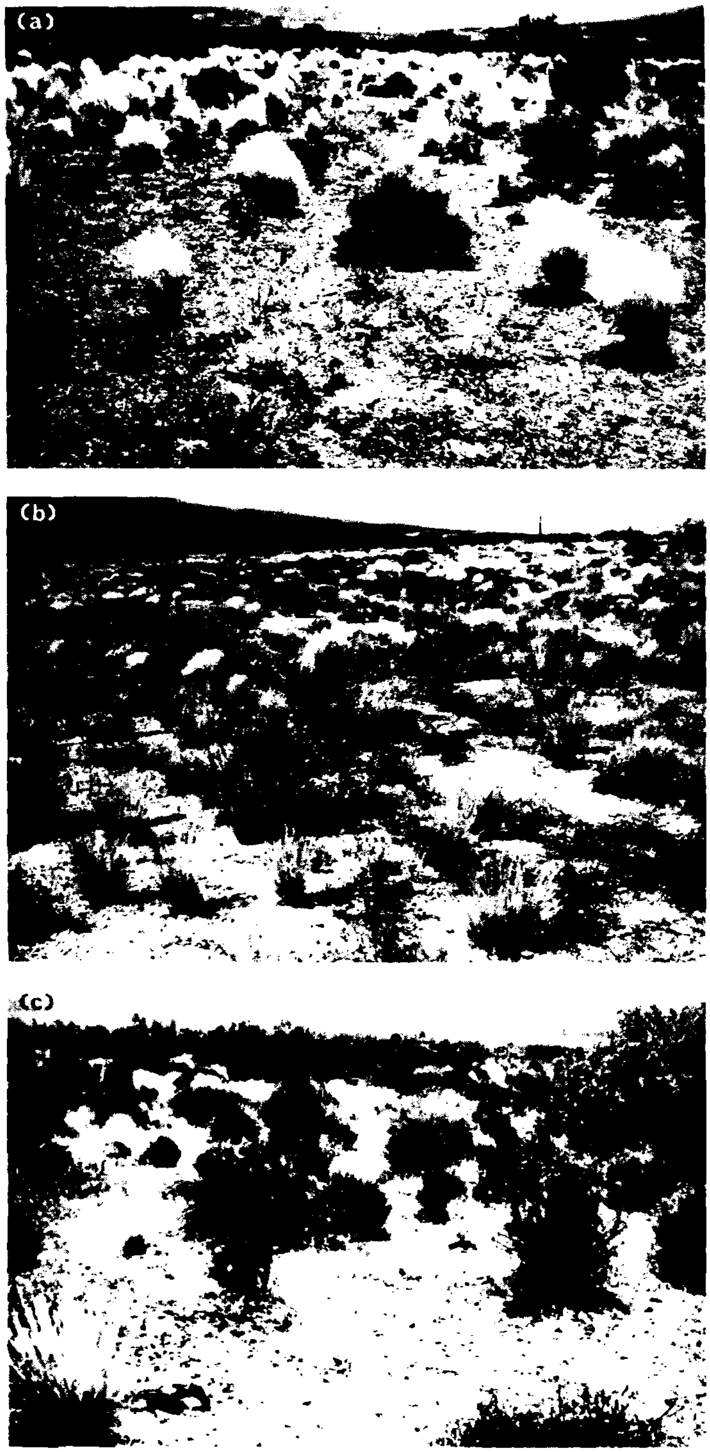

Plate 2. Photographs of vegetation in the various parts of the townsite. (a) Vegetation on old main road, abandoned 18 years. (b) Vegetation in trampled area of townsite, abandoned 51 years. (c) Vegetation in undisturbed area, northeastern control.

Table 1. *Comparison of soil physical properties in disturbed versus undisturbed areas of the Wahmonie town site. Numbers in parenthesis indicate the number of samples*

Area	Time since abandonment (years)	Bulk density (g/cm³) Mean	Bulk density Standard deviation	Penetration depth (cm) Mean	Penetration depth Standard deviation	Infiltration rate* (cm/hr) Mean	Infiltration rate Standard deviation
Southwest control	—	1·61 (10)	0·06	—	—	16·6 (4)	2·6
Streets and avenues	51	1·58 (10)	0·08	—	—	19·9 (4)	6·2
Northeast control	—	1·50 (10)	0·08	10·7 (356)	1·8	22·7 (4)	4·8
Town site	51	1·66 (10)	0·07	8·3 (326)	1·9	12·8 (3)	4·4
Old main road	18	1·71 (10)	0·08	4·7 (184)	0·7	3·4 (4)	2·0
Active road	0	1·96 (7)	0·06	1·9 (61)	0·5	2·6 (4)	1·2

* Infiltration rate under a 10 cm head after 2 hours.

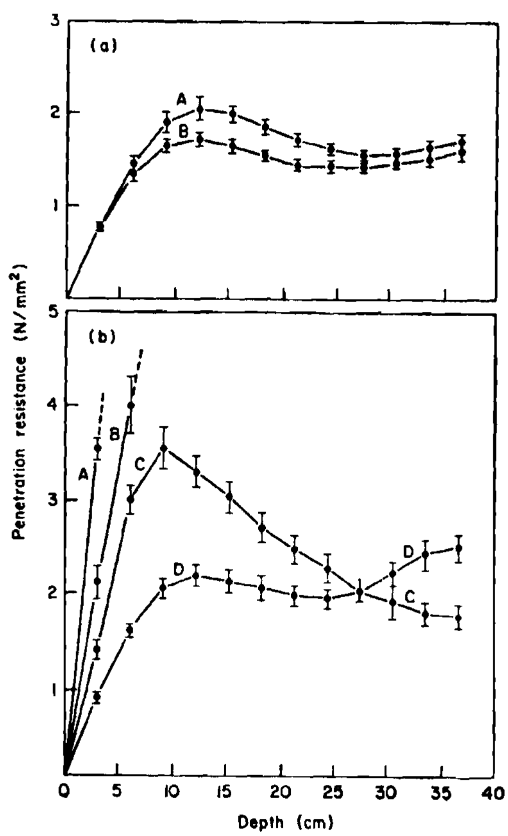

Figure 3. Penetration resistance curves for soils at the Wahmonie townsite. Bars represent standard errors for measured densities. (a) A, streets and avenues; B, southwest control. (b) A, active road; B, old main road; C, townsite; D, northwest control.

Table 2. *Summary of recovery functions for soil physical properties*

Dependent variable	ρ_0	ρ_u	a	w	90% t_r (years)
Four-parameter model, exponential decay curve					
Equation: $\rho(t) = \rho_u+(\rho_0-\rho_u)e^{-at^w}$					
Bulk density	1·96	1·50	0·343	0·286	680
Penetration depth	1·9	10·7	$4{\cdot}67\times10^{-3}$	1·45	70
Infiltration rate	2·6	22·7	$1{\cdot}66\times10^{-5}$	2·70	80

Dependent variable	b	m	r	t_r (years)
Least-squares linear regression				
Equation: $\rho(t) = b+mt$				
Bulk density	1·90	−0·0053	−0·86	75
Penetration depth	1·94	0·130	1·00	70
Infiltration rate	1·43	0·210	0·96	100

Terms: $\rho(t)$ = dependent variable as a function of recovery time, t
ρ_u = dependent variable at time = infinite (undisturbed state)
ρ_0 = dependent variable at time = 0 (active road state)
a,w,b,m = parameters of the models
r = correlation coefficient. $-1 \leq r \leq 1$ where values of $r = 1, -1$ indicate perfect fit of the equation
t_r = time requires for $\rho(t) = \rho_u$ (complete recovery time)
90% t_r = time required for $\rho(t) = \rho_u+0{\cdot}1\,(\rho_0-\rho_u)$ (90% complete recovery time)

Table 3. *Comparison of perennial vegetation in streets and avenues with adjacent control*

Perennial species	Streets and avenues Cover (%)	Density (no./ha)	Composition (%)	Southwest control Cover (%)	Density (no./ha)	Composition (%)
Larrea tridentata	1·4	25	0	9·1	350	4
Grayia spinosa	0·4	40	1	8·4	1350	15
Ephedra nevadensis	3·5	510	8	3·6	1140	13
Stipa speciosa	4·3	4160	68	2·0	3800	43
Lycium andersonii	1·4	210	3	1·7	1060	12
Thamnosoma montana	1·8	540	9	0·4	400	5
Acamptopappus shockleyi	0·2	40	1	0·4	60	1
Hymenoclea salsola	1·5	360	6	0·2	50	1
Coleogyne ramosissima	0·1	6	0	0·1	250	3
Salazaria mexicana	0·9	190	3	0	240	3
Total	15·9	6140	99	25·9	8700	100
Diversity*	94·7	1890	—	127·2	4330	—
Eveness†	0·82	0·43	—	0·72	0·70	—

* Index of McIntosh (1967)
† After Hurlbert (1971)

reflects the high *Stipa* density when compared to the low densities of other perennials; the total density in the undisturbed vegetation is distributed more evenly among the species present.

Comparison of these data with the 1961 data (Table 4) shows inconsistencies between Wells' density and composition figures and the density and composition figures shown in Table 3. Wells' data consistently show higher densities and compositions for the long-lived perennials in both the streets and undisturbed area than our data. The 1961 densities for *Larrea* and *Grayia* are twice as large as we measured and the 1961 densities of *Stipa* are low when compared to our results. These densities would indicate that the revegetation in 1979 is much less than the revegetation reported for 1961, but no on-site evidence was found to support this conclusion and the work of Shreve and Hinckley (1937) suggests that long-lived perennial densities change little over decades in arid regions. Assuming that a major decrease in perennials has not occurred, the inconsistencies could have been caused by the difference between measurement techniques (point quarter versus belt transect methods), measurement error in both studies, and/or differences in the actual sites measured in 1961 and 1979. Regardless of the cause, the inconsistencies prevent any meaningful quantitative comparison of the revegetation after 33 years (Wells 1961) with the revegetation after 51 years (present study).

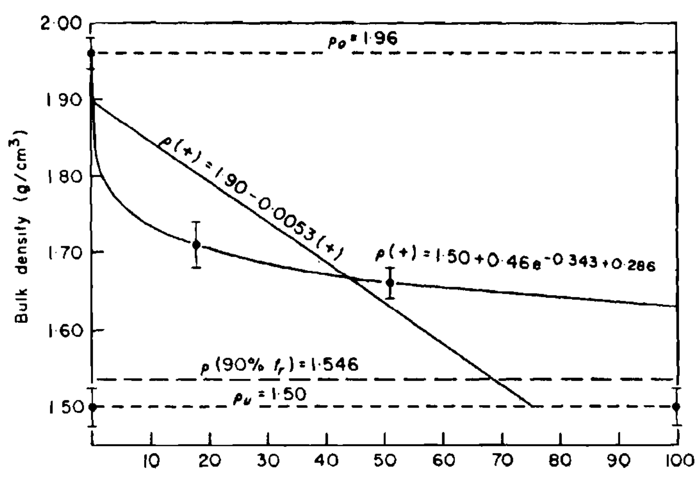

Figure 4. Recovery functions for bulk densities at the Wahmonie townsite. Bars indicate standard errors for measured densities.

The cover, density, and composition of vegetation in the old main road and town site differ markedly from those of the control area (Table 5; Plate 2). The most conspicuous difference is the almost complete absence of long-lived perennials except *Ephedra* in the disturbed areas. The surprising abundance of *Ephedra* in the old main road indicates that it was an early invader. *Oryzopsis* is also abundant in the old main road, but is only a minor constituent of the town site and undisturbed vegetation. The cover and density of the town site vegetation are much greater than that of the control area because of the large number of *Stipa* and *Hymenoclea* present. However, the diversity of cover is much lower in the disturbed areas than in the control area because most of the disturbed-area cover is contributed by only three species while five species contribute the major part of the cover of the control area.

Compaction has dramatically affected revegetation of the town site. Some long-lived perennials including *Larrea* have begun to invade the uncompacted streets (Table 3), but only short-lived perennials and *Ephedra* are present in the still-compacted town site (Table 5). These differences can be summarized in a comparison of the amount of cover contributed by different age classes of perennials (Table 6). Long-lived perennials contribute 40% of the cover in the streets but only about 3% in the town site, as compared with about 88% in the control area.

Root-crown sprouting could also have caused some of the discrepancy between the revegetation rates in the streets and the town site. The vegetation in the town site was undoubtedly totally killed by cutting and trampling, but some live root crowns could have remained in the cleared streets as Wells (1961) suggests. Vollmer et al. (1976) reported root-crown sprouting of *Larrea, Lycium* and *Ephedra* in nearby areas used by off-road vehicles; *Lycium* and *Ephedra* are the two long-lived perennials that have shown the most recovery in the streets (Table 3). Thus the revegetation in the streets may be somewhat greater than the revegetation that would occur in an initially barren, uncompacted soil.

The delay of revegetation in the town site is not unexpected in light of the findings of agricultural engineers who have studied the effects of compaction on plant growth in some detail. Lowry et al. (1970) found that the growth rate and yield of cotton were inversely proportional to the bulk density of a loamy sand; the critical limiting bulk densities appeared to be in the 5.45×10^{-7}-6.13×10^{-7} lb/mil-ft (1·60-1·80 g/cm^3) range. Taylor and Gardner (1963) found that cotton roots would not penetrate layers of higher than 3 N/mm^2 penetration resistance in a fine sandy loam regardless of moisture content, and that the limiting effect of density on growth was dependent on moisture content but clearly important in the 5.62×10^{-7}-6.13×10^{-7} lb/mil-ft (1·65-1·80 g/cm^3) range (for other references, see

Table 5. *Comparison of perennial vegetation in the old main road, townsite and adjacent control*

Perennial species	Old main road Cover (%)	Old main road Density (no./ha)	Old main road Comp (%)	Townsite Cover (%)	Townsite Density (no./ha)	Townsite Comp (%)	Northeast control Cover (%)	Northeast control Density (no./ha)	Northeast control Comp (%)
Larrea tridentata	0	0	0	0	0	0	9·5	450	6
Grayia spinosa	0	0	0	0	0	0	2·6	910	12
Coleogyne ramosissima	0	0	0	0	0	0	2·4	1630	21
Ephedra nevadensis	2·3	1450	22	0·6	310	2	1·8	1010	13
Stipa speciosa	1·2	2080	31	12·5	14,000	72	1·6	2640	34
Oryzopsis hymenoides	2·3	2400	36	0·7	740	4	0·4	490	6
Lycium andersonii	0	0	0	0	90	0	0·3	230	3
Thamnosoma montana	0	50	1	0·4	320	2	0·2	100	1
Acamptopappus shockleyi	0·1	50	1	0·2	140	1	0·1	50	1
Haplopappus cooperi	0·7	330	5	0	0	0	0·1	130	2
Hymenoclea salsola	0·1	240	4	6·7	3630	19	0	130	2
Salazaria mexicana	0	0	0	0·1	160	1	0	0	0
Total	6·6	6630	100	21·1	19,500	101	19·0	7800	101
Diversity*	30·6	3110	—	68·8	5010	—	85·7	4330	—
Eveness†	0·75	0·75	—	0·50	0·40	—	0·63	0·79	—

* Index of McIntosh (1967)
† After Hurlbert (1971)

Table 6. *Comparison of the percentage of the total cover contributed by long-lived, intermediate-lived, and short-lived perennials in study areas at the Wahmonie townsite*

	Percentage of total cover contributed by: Long-Lived*	Intermediate†	Short-Lived‡	Total
Southwest control	88·4	3·1	8·5	100·0
Streets	40·0	20·0	40·0	100·0
Northeast control	87·4	1·6	11·0	100·0
Townsite	2·8	3·3	93·9	100·0
Old main road	34·3	1·5	64·2	100·0

* Long-lived perennials are: *Larrea tridentata, Grayia spinosa, Coleogyne ramosissima, Lycium andersonii* and *Ephedra nevadensis* (?).
† Intermediate-lived perennials are: *Acamptopappus shockleyi, Salazaria mexicana* and *Thamnosoma montana.*
‡ Short-lived perennials are: *Stipa speciosa, Orzyopsis hymenoides* and *Hymenoclea salsola.*
References: Wells (1961); Vasek *et al.* (1975*b*); Johnson *et al.* (1976).

Webb and Wilshire (1978)). Since compaction in desert soils differs little from compaction in agricultural soils, these findings clearly indicate that the compaction in the town site has not only been a major limiting factor in revegetation but also is likely to continue to retard revegetation until the density and soil strength are reduced.

The order of secondary succession in Wahmonie is not consistent with respect to individual species. *Salsola iberica*, a weedy non-native annual, is present in recently constructed ditches but is absent in all of the older disturbed areas. *Hymenoclea*, long recognized as a pioneer species (Wells 1961; Vasek 1975*a*; Vasek and Barbour 1977), is abundant in recently disturbed areas in the town site but is not nearly as abundant as *Oryzopsis*, *Ephedra* and *Stipa* in the old main road (Table 5). Similarly, *Oryzopsis* has invaded the old main road but is nearly absent from the southwestern disturbed areas. The high cover of *Ephedra* in the old main road is strikingly incongruous with its cover in the town site (Table 5) and unexpected in light of its purported longevity (see references, Table 6). *Stipa* is the only pioneer consistently present in the disturbed areas, evidence indicating that the invasion of the other species is highly opportunistic and probably dependent on the proximity of established plants to the disturbed area. Generally, annuals such as *Salsola*, *Bromus rubens*, *Eriogonum deflexum* and *Astragalus* sp. are the first colonizers in disturbed soil at Wahmonie, followed by short-lived perennials such as *Oryzopsis*, *Stipa* and *Hymenoclea* and then by medium- and long-lived perennials (Table 6).

DISCUSSION

The foregoing treatment of 'recovery' and 'revegetation' uses the concept of 'recovery time' in terms of restoration of the physical properties of the soil and vegetative composition and cover to the pre-disturbance conditions. A much more limited definition of recovery, of use primarily in land-use planning, may specify complete 'recovery time' in terms of reduction of erosion rates to some specified level or revegetation to a cover that stabilizes the surface. Intermediate requirements for 'recovery' might include surface stabilization and some degree of restoration of native plant and animal populations.

The town site has recovered according to the limited definition; the total cover is higher than that in the undisturbed area (Table 4) and the infiltration rate is high considering the low annual precipitation (Table 1). In fact, the cover data in Table 5, if assumed linearly dependent on time, suggest a return to the 19% cover of the undisturbed area after 40 years. However, the town site still shows the effects of disruption in terms of the altered native plant assemblage and probable commensurate changes in wildlife populations; thus, the requirements of the limited definition are far too lenient environmentally to pronounce the town site 'recovered'.

Implicit in full-restoration 'recovery' is the assumption that soils and vegetation can recover with time to pre-disturbance conditions. Rates of soil generation in arid regions are so low (Gile and Hawley 1968; Buol and Yesilscy 1964) that the soil lost during the early years following disturbance may not be replaced for many centuries. However, the replacement may not be important ecologically if the remaining soil contains enough nutrients to sustain the initial plant growth, although data from Australia (Charley and Cowling 1968) indicate that removal of as little as 3.9 inches (10 cm) of soil in arid regions can seriously deplete reserves of nitrogen, phosphorus, and organic carbon. The hostile surface conditions of disturbed soils must be rendered more favorable to plant growth, and loosening processes must operate to ameliorate compaction. Perhaps the most important loosening process is biological activity including animal burrowing and surface loosening by invading annual and perennial vegetation. Freeze-thaw loosening, a process alleviating compaction in colder areas (Orr 1975; Balke et al. 1976), probably occurs to a limited extent at Wahmonie because of low (to 20° F or -11° C) winter temperatures, but would only be active to a shallow surface depth. Cyclical wetting and drying is a process invoked to explain upward migration of stones in desert pavements (Springer 1958; Crooke and Warren 1973); similarly, wetting and drying should also cause volume expansion in compacted soils. Dickerson (1976) showed that compacted soil in northern Mississippi followed a linear recovery trend, probably as a result of wetting and drying; however, the data shown in his Figure 7 indicate an exponential-decay recovery trend. The wetting-and-drying process would be slowed considerably in the soil at Wahmonie because of low clay content and rainfall. Furthermore, Heinonen (1977) questioned whether the bulk density of compacted soil ever returns to the pre-disturbance condition; he suggested that bulk densities have a 'normal' range and that soils may stop recovering when the density reaches the upper limit of this range.

Although the physical properties of the soils may recover to levels approximating pre-disturbance conditions, full recovery of vegetation will be difficult i possible considering the autecology of *Larrea*. Barbour (1968) noted that *Larrea* germination might be a rare event in nature, and Key et al. (1977) and Beatley (1974) found that only 2-17% and 14-35% respectively, of *Larrea* seeds from the Mojave Desert germinated under laboratory conditions. Sherbrooke (1977) reported an 88% mortality rate for first-year jojoba (*Simmondsia chinensis*) seedlings in Arizona and showed the results to be comparable with other desert species. Shreve and Hinckley (1937) reported ages of in excess of 100 years for *Larrea* individuals, and Sternberg (1976) reported ages of 1000 to 500 years for *Larrea* clumps and clonal rings in the southern Mojave Desert. These studies indicate that *Larrea* is not only difficult to germinate but once established can remain for thousands of years in the same place. Therefore, no estimates for the recovery time of the old town site can be made because *Larrea* has not yet started to invade the still-compacted soil.

There also is little evidence that the composition of vegetation invading the town site will approach that of the pre-disturbance conditions. Given the limitation of low water availability, the *Stipa* population in the town site may be able to control moisture to the point excluding long-lived perennials. Furthermore, the undisturbed vegetative composition may be in a state of flux owing to long-term climatic changes (H. B. Johnson, personal communication 1979), so the composition of the recovered and undisturbed vegetation may ultimately be radically different from the pre-disturbance conditions. These ecological considerations indicate that further recovery of the vegetation at Wahmonie will be extremely slow. If the percentages of long-lived perennials (Table 6) can be considered as a recovery index linearly dependent on time, then total recovery will require about 100 years for the streets and 1000-2000 years for the town site. However, recovery cannot be expected to follow a linear trend (Basek et al. 1975*a*) so these estimates and the Vasek et al. (1975*a*) estimate of 'centuries' are probably optimistic.

SUMMARY

Significant differences in soil properties and vegetative composition persist in the Wahmonie town site 51 years after abandonment. The recovery trend for the soil physical properties indicates a return to pre-disturbance conditions on the order of a century after disturbance, while the slow recovery of vegetation in the still-compacted town site indicates an extremely long recovery time, if the vegetation ever recovers. The long recovery times of disturbed soils and vegetation are important factors which must be taken into consideration in land-use planning for arid regions.

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THE EFFECT OF OFF-ROAD VEHICLE NOISE ON
THREE SPECIES OF DESERT VERTEBRATES

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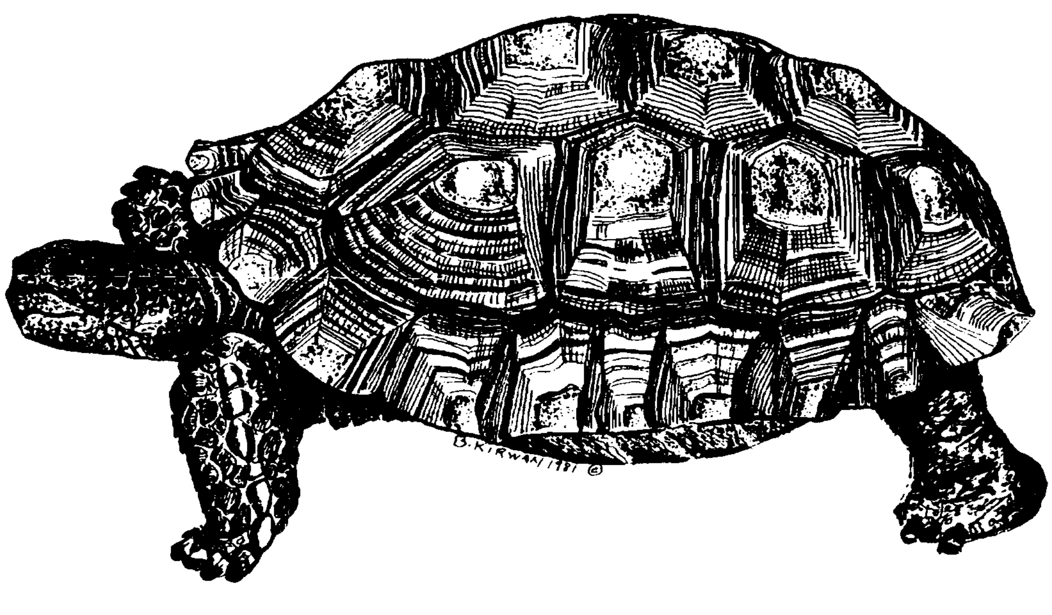
ABSTRACT

We have recently completed a three part contract with the Bureau of Land Management. The first part of that contract was to accumulate a bibliography of some 3000 references on the effect of noise on non-human vertebrates. The second part was to measure sound levels in the California desert. The third part of the project consisted of three experiemntal studies designed to test the effects of off-road vehicle noise on desert vertebrates. The results of these studies showed that the noise of dune buggies and motorcycles: (a) have definitely caused animals to go deaf with little or no recovery; (b) interferes with their ability to detect predators; and (c) causes them to behave in an unnatural manner that puts them in a situation which could result in death.



THE POTENTIAL IMPACTS OF THE DRAFT CALIFORNIA DESERT PLAN ON THE DESERT TORTOISE IN THE CALIFORNIA DESERT CONSERVATION AREA

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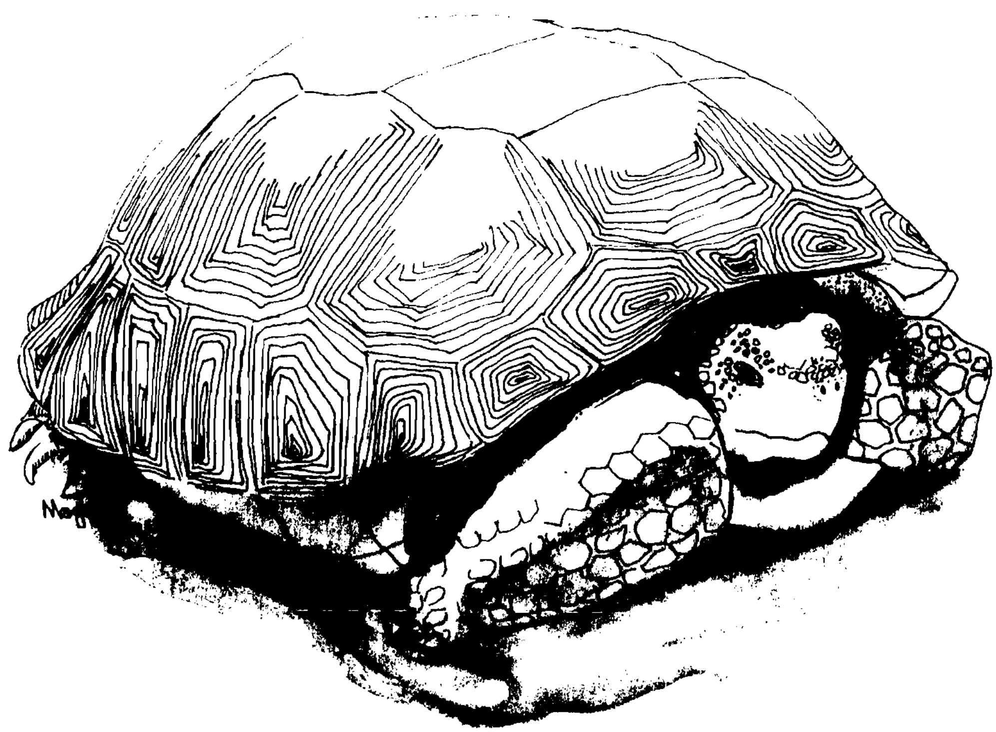
ABSTRACT

The draft California Desert Plan and Environmental Impact Statement, released on 15 February, 1980, is a 20-year management plan for the California Desert Conservation Area. After the public comment period is over May 15, the Plan will be finalized for release and implementation in September 1980. There are four alternatives: use, balanced, protection, and no action. Each alternative was evaluated for impacts on desert tortoises using data collected since 1971 and documented in a draft response entitled "The status of the desert tortoise in California" by K. H. Berry and L. Nicholson. This report describes four major population centers: 1) Fremont-Stoddard, 2) Ivanpah, 3) Fenner-Chemehuevi, and 4) Chuckwalla, as well as three minor centers: 1) Lucerne Valley, 2) Johnson Valley, and 3) Shadow Valley.

The no action, use, and balanced alternatives have the potential for extirpating the majority of breeding tortoise populations in California with the next few decades. Under the no action alternative, 58% of habitat will receive severe or high negative impacts and 42% will have no significant positive or negative impact. The high density tortoise populations (>250 tortoises/mi^2 and 100 to 250 tortoises/mi^2) will be particularly heavily impacted. Of the four major and three minor habitat areas, only the Ivanpah and parts of the Fenner-Chemehuevi are likely to survive. The use alternative potentially has the most severe impacts, with 97% of prime populations receiving high to severe negative impacts and only 2% receiving positive treatment. Under the use alternative, breeding populations in all seven tortoise concentration areas would be extirpated. The integrity of the Desert Tortoise Natural Area would be jeopardized. The balanced alternative is estimated to have high to severe negative impacts on 77% of populations and positive impacts on only 4%. Under the balanced alternative, two of four major population centers would be lost. Survival of the Desert Tortoise Natural Area as an ecosystem and as a healthy, representative tortoise population would be questionable.

The greatest level of protection would be provided through the protection alternative. Thirty-one percent of tortoise habitat would receive high to severe negative impacts, 56% would receive no substantial impact and 12% would experience positive impacts. Parts

or most of the four major population centers would be in protective land-use classifications. The minor center in Johnson Valley would be compromised. Of all the alternatives, only the protection meets Bureau of Land Management wildlife policies and the intent of the federal Endangered Species Act.



REPORT OF THE AUGUST TRIP TO THE MAPIMI BIOSPHERE RESERVE, DURANGO, MEXICO

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On Sunday, 5 August 1979, several Desert Tortoise Council members met in El Paso, Texas, for a trip to the Mapimi Biosphere Reserve in Durango. There were six of us -- Ariel Appleton, Alice Karl, Mark Maley, Lori Nicholson, Bill Radtkey, and myself. We were guests of Gustavo Aguirre Leon.

After a delay of several hours at the border because of problems with vehicle registration papers, we headed south 236 miles (380 km) for Chihuahua, where we spent the night. The next day was a 280-mile (450-km) drive to Torreon to meet Gustavo Aguirre L., Drs. Gary Adest and Michael Recht, and their students. On Tuesday, led by Gary Adest and Michael Recht, we back-tracked about 80 miles (130 km) to the little town of Ceballos, where we turned east to travel for 2 hours on dirt roads to the Reserve. We arrived in late afternoon.

The laboratory and living quarters of the Mapimi Biosphere Reserve are impressive and comfortable. The building has an inner courtyard with a garden of native plants, Bolson tortoises, and tiled walkways. Sleeping rooms, laboratory, library, and kitchen all open onto the courtyard.

We spent 3 days there. On the first day we worked in pairs to record information for Drs. Adest and Recht on tortoises recently fitted with radio transmitters. Some observations included times of emergence and retreat into burrows; food items and foragimg times; travelling; basking; rapid retreat to burrows when frightened by observers; burrow blocking behavior; and aggressive interactions underground between adults. All of us were impressed with the shyness of the Bolson tortoise compared with the desert tortoise. During the next 2 days, we attempted to find and capture unmarked tortoises on the study plot, with relatively little success. One unsuccessful member of our party spent a full morning in hiding, waiting for an unmarked tortoise to emerge from its burrow and travel far enough from its mound to allow for capture.

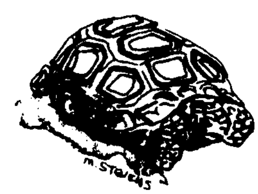
In addition to the tortoises, there were numerous hatchling Texas horned lizards, *Phrynosoma cornatum*, and short-horned lizards, *P. douglassi*. Unwary observers could easily crush the little ones. The greater earless lizard, *Holbrookia texana*, and fringe-toed lizard, *Uma exsul*, were common on the hummocks of windblown sand and mesquite. At night in the courtyard, and especially during a rainstorm, we saw dozens of Couch's spadefoot toads, *Scaphiopus couchi*, and Great Plains toads, *Bufo cognatus*.

There were a few red-spotted toads, *B. punctatus*; they were large, tan, and unspotted, unlike those found in the Mojave Desert. We saw one green toad, *B. debilis*, and one Great Plains narrow-mouthed toad, *Gastrophryne olivacea*.

The vegetation was exciting for those of us familiar only with the Mojave and Sonoran deserts of the United States. There were scattered carpets of wildflowers, some blooming shrubs, and green grass. There was creosote bush, *Larrea tridentata*; ocotillo, *Fouqueria splendens*; ratany, *Krameria* sp.; catclaw, *Acacia greggii*; whitethorn, *A. constricta*; mesquite, *Prosopis* sp.; and grey-leaved abrojo, *Condalia lyciodes*, as well as several species of cactus, mallow, and grasses. Some of the grasses were bush muhly, *Myhlenbergia porteri*; tobosa grass, *Hilaria mutica*; three-awn, *Aristida* sp.; fluff grass, *Tridens* sp.; knotroot bristlegrass, *Setaria geniculata*; Plains bristlegrass, *S. macrostachya*; and blue grama, *Bouteloua gracilis*. Several showy members of the pea, unicorn, and bignonia families were blooming.

Sheet erosion was evident in many areas on the route from the laboratory to the study site. Gullies are forming and arroyo-cutting appears to be in process in some areas. Valuable insight into the processes of water erosion in deserts might be gained by having geological experts examine the area.

The trip was a very worthwhile experience for all of us. We were impressed with the differences in behavior between the Bolson tortoise and desert tortoise and with the difficulty of studying the former species. My personal interest in effects and relationships of livestock grazing, erosion, and climate on tortoise habitat was heightened by the visit. Ariel Appleton expressed similar views. We were all grateful for the hospitality of the staff at the Biosphere Reserve and that of Drs. Adest and Recht.



ACTIVITY POPULATION STRUCTURE AND THERMOREGULATION OF BOLSON TORTOISES

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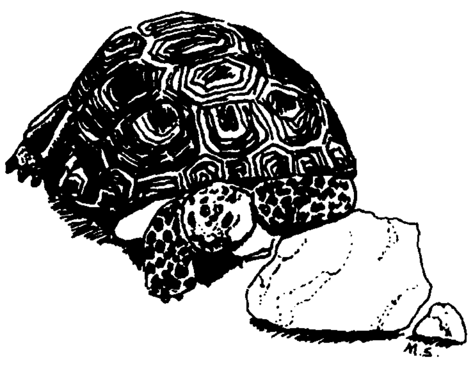
ABSTRACT

A colony of Bolson tortoises, *Gopherus flavomarginatus*, located on the grounds of the Mapimi Biosphere Reserve, Durango, Mexico, was studied during July and August 1979. Using radio-telemetry, the location, movement pattern, activity phasing, behavior, and deep body temperature of six individuals was observed. Solar radiation (Langleys), humidity, sun and shade temperatures of air and soil, and the temperatures of representative burrows were simultaneously monitored.

Home ranges of one male and one female adult tortoise were estimated at 3 acres (1.2 ha) and 3.4 acres (1.4 ha) by measuring the area contained within actual linear movement polygons. These data were compared with other *Gopherus* species. Bolson tortoises frequently covered long distances during movements. The mean distance moved by four tortoises was 333 yd (304.5 m) with a range of 93.5-692.5 yd (85.5-633 m). Multiple burrow occupancy in all size and sexual combinations was common. The number of burrows used or visited ranged from two to four per tortoise. Tortoises were active throughout the day, with peak activity bimodally occurring at 0900-1000 hours and 1600-1700 hours CST. Mean body temperature maxima were correlated with peak activity periods.

The mean body temperature of all tortoises recorded at all times of the day from 26 July through 13 August was 87.5°F or 30.8°C (N=427). The variability of body temperatures is attributed to variation in behavior and concomitant exposure. Heating rates of free-ranging tortoises were significantly higher than cooling rates and the attainment of body temperatures of 104°F (40°C) or greater while foraging was common. Locomotion and foraging bouts appear limited by thermal constraints at this time of year.



A BEHAVIORAL STUDY OF CAPTIVE BOLSON TORTOISES, *GOPHERUS FLAVOMARGINATUS*, AT THE RESEARCH RANCH, ELGIN, ARIZONA

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ABSTRACT

I spent July and August of 1979 at The Research Ranch in southeast Arizona to observe a breeding colony of Bolson tortoises being developed under the care of Ariel Appleton. The tortoises occupied a 0.74 acre (0.3 ha) enclosure in bottomland below Ariel Appleton's house. The enclosure is in a flat, grass meadow with an oak dotted hillside to the east, and occasional oaks to the western border.

Before 18 June, the pen was divided into two sections. Two males, Spry (MCL=12.6 inches or 319 mm) and Potent (13.6 inches or 246 mm) and one female, Jane (14.0 inches or 356 mm), occupied the west section. A male, Larry (12.6 inches or 319 mm) and female, Gertie (15.0 inches or 380 mm) were in the east section. Each tortoise was established in its own burrow. On 18 June, the east pen was divided in half to make room for five additional tortoises that were being moved in from an enclosure on another part of the Ranch. These had been numbered with yellow paint and marked with holes in the marginal scutes, for a previous study. The only male of the five was 01 (11.0 inches or 279 mm), and the four females were numbered 07 (12.2 inches or 310 mm), 08 (14.3 inches or 364 mm), 11 (13.0 inches or 330 mm), and 90 (13.1 inches or 333 mm).

The numbered tortoises spent most of their time pacing along the fences, although all were occasionally seen feeding and drinking water. They accepted a metal animal travel crate as a shelter, and later, a bird blind added for additional shelter was also accepted. The tortoises would spend occasional nights under clumps of sacaton grass.

Most activity took place in the mornings and later afternoons. Much of the mid-day, unless the weather was cool, was spent under shelter There was some activity during light rain, but the tortoises would seek shelter if the rain became very heavy. They were especially active in the morning after a storm.

Aggression between females of the numbered tortoises was common. In most cases, while pacing the fence, a larger tortoise would ram a smaller one out of its way.

Aggression between tortoises of the two different pens was also common. Spry spent much of his time pacing his east fence, looking into the pen with the numbered tortoises. He fought through the fence with 01 many times and would try to ram any of the females that came by. A couple of times he rammed at the numbered tortoises' shelter, even though none of them was inside.

All of the female numbered tortoises were courted by 01. He bobbed his head at any of them that he came across. He would follow them, head bobbing, circling, and occasionally biting. He also mounted every female, but no successful matings were noted. Every time, the female would move away and 01 would slide off.

Seven successful matings occurred between Gertie and Larry. In four of these, Gertie was the initiator. She would go to Larry's burrow while he was out foraging, and block the entrance. When Larry returned, he was confronted by Gertie, and would start bobbing his head. Gertie would come up and turn around on the slope of the burrow, allowing Larry to mount her. Copulation usually lasted 5 to 10 minutes.

Spry courted Jane several times by head bobbing on her porch and occasionally by chasing her to her burrow. She responded only twice by coming out and allowing him to mount. Both times, she moved back into her burrow before copulation occurred.

Potent head bobbed on Jane's porch on five occasions, but received no response from Jane.

Spry and Potent were the only two males together in a pen. Spry seemed to be dominant over Potent. Whenever he saw Potent out of his burrow, he would chase him back in. Spry would then head bob on Potent's porch. On eight occasions, Potent would then slowly head down into his burrow until Spry slid off. Potent was usually found out of his burrow during the warmer part of the day, when most of the other tortoises were under shelter, possibly to minimize contact with Spry. Even a week after Potent was removed from the pen, Spry was seen bobbing his head on the porch of Potent's deserted burrow.

On 16 August, six of the tortoises were moved to a new enclosure. Located on an open area, the 4.0-acre (16-ha) pen is oval and is divided into two parts. Female 07 and male 01 were put in the east section, while females 90, 11, and 08, and Potent were put in the larger west section. Seven plywood shelters were placed throughout the enclosure to provide shelter and to encourage burrow digging. Fresh water was provided.

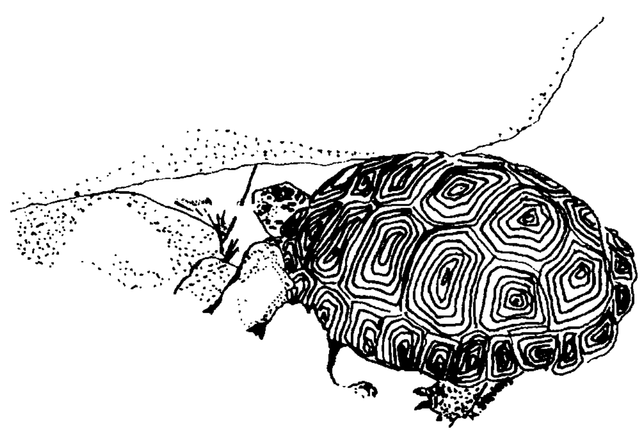
The first reaction of all the tortoises to the new area was to pace the fences. All were watched carefully for signs of stress and were regularly put into shade. Each tortoise was put in a shelter during the late evening in hopes that they would learn to stay there during the night. They would sometimes wander off and find a place for themselves.

Since the weather was unusually warm, with little rain, we (Ariel and I) began loosening the soil and starting burrows under the shelters. We also watered various areas with sprinklers every day and poured extra buckets of water on our "burrow starts".

Activity patterns were similar to what they had been in the temporary pen, with mid-days usually being spent under shelter. All of the tortoises were seen feeding.

Little courtship activity was observed in the new pen. 01 bobbed occasionally at 07 and chased her, but never mounted. Potent rammed each of the females in his pen at least once, but never showed any courtship behavior.

During the last week of August, both 01 and 07 started burrows under their respective shelters. I had to leave the ranch at the end of August, but according to Ariel, all of the tortoises did dig burrows except for Potent, who ended up sharing a burrow with 08 for the winter.



BOLSON HATCHLINGS AT THE RESEARCH RANCH, ELGIN, ARIZONA

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In early July 1979, three eggs were uncovered on the apron fronting the burrow of the bolson tortoise named Jane in the northwest enclosure below my house. The apron soil, compact and rocky, had previously been lightened with the addition of sterile steer manure and sand.

Jane, who established her burrow in the summer of 1976, is a mature, relatively light colored tortoise on loan from the Institute of Ecology in Mexico. She weighs approximately 20 pounds (9 kg). She subsists on native plants in the .3-acre (.1-ha) enclosure, mainly plains lovegrass, several species of grama, and occasional forbs.

I placed her eggs in an incubator constructed with the advice of Mary Trotter and her son, John, of San Diego, from a styrofoam food container, setting the temperature at 90°F (32°C). The first hatchling, weighing 1 oz. (28 gm), appeared on 3 September, the second, weighing just under an ounce, 2 days later. The third egg did not mature.

The hatchlings (Alpha and Beta) were placed in the incubator in bowls greased with vaseline until their yolk sacs were absorbed, then on waxed paper within a large carton about 3 ft (1 m) long, which provided choices of light and temperature. As soon as the yolk area on the plastron had healed, the wax paper was removed so they could move more easily on the rougher cardboard surface. A heat light was placed over one end; a cardboard center divider, resting on a reptile heat brick, provided a shady side with heat as well as a lighted side. At the end opposite the light, a small heat pad was placed under one area of the carton. Straw was placed at the cooler, darker end. The temperature choices ranged from about 70° to 80°F (21 to 27°C). Hatchlings had observable location preferences, which varied from day to day.

First foods offered were finely minced summer and yellow squash, squash blossoms, young green beans, dandelion leaves, cauliflower, and cabbage. Initially the hatchlings were inept at feeding and showed only slight interest but finally started to take some nourishment within a week of hatching. I was not satisfied with their response to chopped food and, anxious to transfer them to a native plant diet, since the latter had proved most satisfactory for the adult tortoises under my care. Flats of native grasses and native dichondra were planted, placed in part sun and the hatchlings introduced to them with good success, namely a more enthusiastic and determined effort to forage. At this time, fresh scats of the adult tortoises were offered and eagerly accepted. Water was made available, in which they liked to sit as they drank, frequently urinating in the saucer. After the first month, uric acid crystals were excreted from time to time after profuse drinkin.

They foraged well in the flats, which were ringed with a 6 inch (15 mm) high metal lawn edging, but the confined space seemed frustrating to them so 6 ft by 2.5 ft (2 m by .9 m) plots of grasses and dichondra were planted in the vegetable garden, ringed with the lawn edging and covered with glass and clear plastic to create a hot frame for warmth during the cool fall and winter months. Alpha and Beta were placed there when the temperature in the frame had reached 70°F (21.°C) or more, to feed and exercise for 2 or 3 hours. Squash blossoms were offered when available and Paladac, Vionate, and calcium powder were sprinkled sparingly on the food. Alpha showed a preference for broad leafed plants and Beta for the grasses.

Alpha would stay at one eating site for a considerable time, interspersing eating with lengthy rest periods. Beta frequently moved from one site to another. Alpha tended to bite off large pieces of leaf and to work them slowly into the mouth by chewing. By contrast, Beta would chomp off a single bite which was chewed and swallowed before taking another. Both had occasional difficulty making contact with what they were attempting to eat, snapping repeatedly at a blade or leaf without changing the head or neck angle or the length of thrust and with no apparent attempt to correct for previous misses. Eventually they would become frustrated and move on to a new site. There appear to be certain heights and angles at which they forage best, which differed between the two.

The hot frame pens had a considerable open dirt area on which they could exercise and the size of the area minimized "fence pacing". At 2 months, several small sow bugs were introduced and were snapped up as soon as they uncoiled and started moving. However, subsequent offerings were not eaten. Scent seems important in their selection of appropriate forage. Feeding on growing plants exercised the muscles of their necks and forelimbs, which were braced as they tugged at a leaf or blade.

On very cold days, when it was not possible to take them outside, the only readily accepted food was lettuce, primarily romaine. The leaf was weighted down with a stone. They slept the majority of the time while in the carton, seeming, as they grew, to prefer the cooler, shadier areas of that enclosure. I did not make food constantly available as these tortoises would not be feeding at all during winter in a natural environment. In fact, growth rings on Alpha and Beta seemed to be developing almost too rapidly. I recorded weights, lengths, and widths for each hatchling from late October 1979 to September 1 80

(Table 1). The adults in my care cease foraging in early fall and don't resume serious eating until late spring even though they will be up basking at the burrow mouth on warm days, with occasional trips to water. Observations on adult weight loss during the winter show an average of about 0.5 lb (227 gm) for tortoises weighing from 10 to 20 lb (5 to 9 kg).

The hatchlings could not right themselves if overturned, which happened during an occasional clash, and this, if typical, must account for much early attrition in the wild. Adults have little difficulty in this regard, so it will be interesting to see when this ability develops in the young ones.

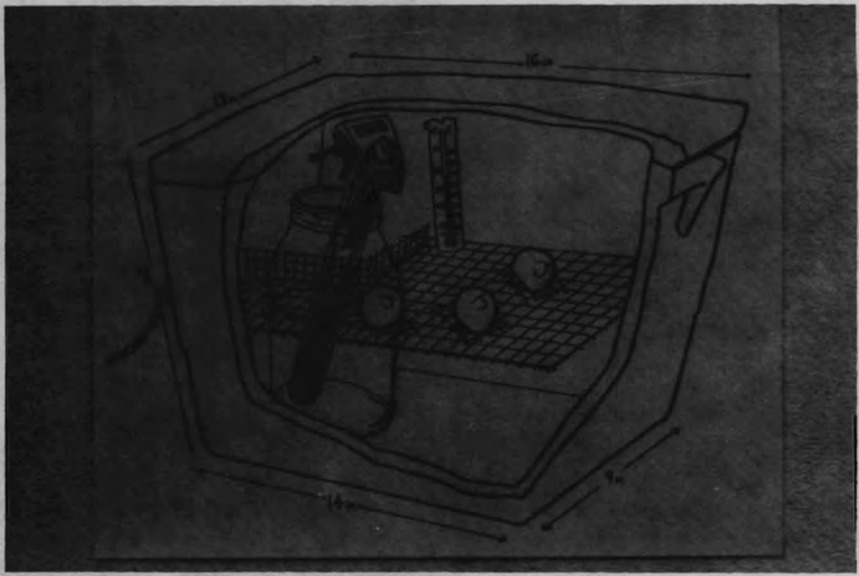
TABLE 1. Weights and Measurements from October 1979 to September 1980

	Length	Width	Weight
31 October 1979			
Alpha	59.0 mm	50.2 mm	2 1/8 oz.
Beta	57.4 mm	47.6 mm	2 7/8 oz.
15 March 1980			
Alpha	77.6 mm	60.4 mm	3 1/4 oz.
Beta	64.8 mm	56.7 mm	2 7/10 oz.
1 September 1980			
Alpha	81.4 mm	70.3 mm	4 3/4 oz.
Beta	76.8 mm	66.2 mm	4 oz.

Both hatchlings were introduced in May 1980 to a covered pen of 20 ft (6 m) in diameter near the adult tortoise area, containing established native forbs and grasses. At first they were left out only during daylight hours. They soon commenced digging individual burrows in dampened soil and when these appeared deep enough for shelter, they were left in the pen permanently. They entered hibernation in the fall and appeared to be in good condition through December.

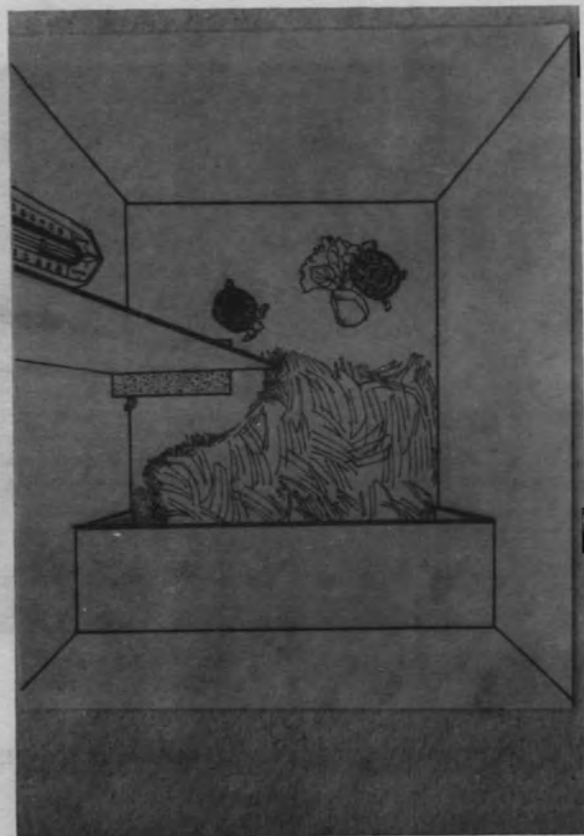
ACKNOWLEDGEMENTS

My deep appreciation goes to Kyoko and Bill Landon for their devoted care of these first hatchlings during my frequent absences and for their skillful photography, drawings, and assistance in setting up living and feeding areas.

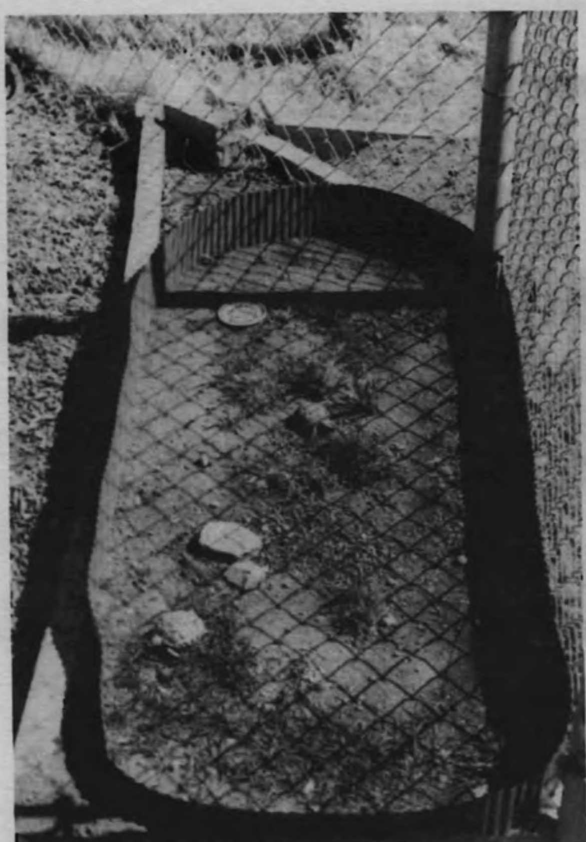


Incubator constructed from styrofoam food container

Size of hatched eggs in relation to 25¢ piece.



Cardboard carton --
winter home for
hatchlings.



Outside feeding area--
planted to dichondra and
native grasses.

A METHOD FOR DETERMINATION OF POPULATION STRUCTURE AND DENSITY OF THE DESERT TORTOISE

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Seven of the 12 quarter sections comprising the Desert Tortoise Natural Area-Interpretive Center tortoise plot are within the Natural Area boundaries. One of these, through a combination of factors, was much more intensively searched than the other six. The population structure from this intensively covered area differed dramatically from the results for the other quarters within the Preserve. The proportion of young tortoises and the overall density were much higher.

The observed differences are ascribed to the difference in search time between the different sub-plots. If the results from the more intensively studied section are more accurate, this suggests a modified approach to the assessment of these population parameters should be used. Basically, this approach involves controlled application of different amounts of search time to different sub-plots to observe the effects of an added increment of coverage on population structure estimates. A method to conduct this experiment is described and its possible use for broad-scale population structure investigation is briefly discussed.

INTRODUCTION

Possibly the two most important indices of the wellbeing of a wild population are population structure and density. The accurate determination of these statistics is vital to the effective management of a population. When dealing with a threatened species like the desert tortoise, *Gopherus agassizi*, the importance of reliable population parameter estimation is obvious.

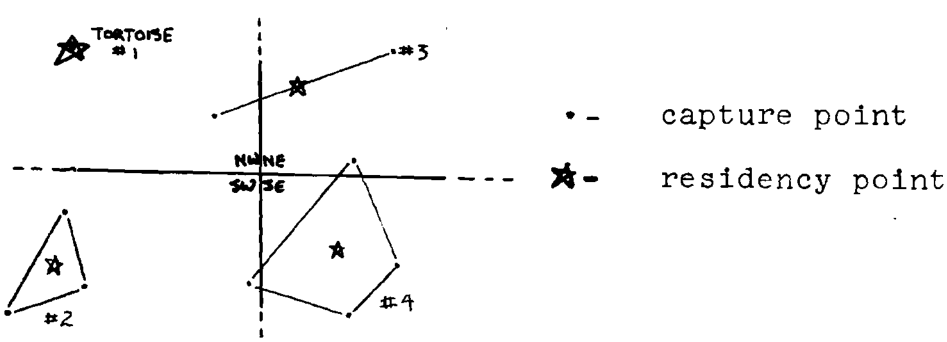
The results obtained during work at the Desert Tortoise Natural Area-Interpretive Center (DTNA) site during the spring of 1979 suggest a practical and straightforward method of achieving such accurate population information within the context of the single season study plot approach.

METHODS

Of the 12 quarter sections comprising the plot, 7 were inside the boundary fence of the DTNA. One of these seven, the southeast quarter of section 34 (hereafter referred to as SE 34) received much heavier search coverage than the others. Several factors contributed to this situation. Tour groups visiting the Preserve entered via the gate at the southeast corner of the quarter. The great majority of their time was spent in SE 34 searching for and finding tortoises. On their excursions they were accompanied by the researcher responsible for the area, who recorded all the encounters for inclusion in the study results. The researcher also crossed this quarter section twice every time she visited another portion of her mile^2 plot. Finally, friends of the researcher visited her on the site and helped her in her searching, further increasing the coverage of her plot relative to the rest of the study site. By examining capture records and field notes, it is roughly calculated that SE 34 received two times as much coverage as the average for the rest of the plot.

Accurate records were kept of the location of each encounter and from these a capture map was generated. For analysis purposes each tortoise was assigned residency to a quarter section by the following rules: if the animal was found only once, it was considered a resident of the quarter where the capture occurred; likewise, if all the capture points of a tortoise found more than once fell within the same quarter. If the animal was encountered more than once and in different quarter sections, the "average" location of its capture points was estimated and this point determined its residency (Figure 1).

FIGURE 1. Residency determination



This obviously crude method was necessary to divide the population for quarter-by-quarter comparison. In the case of SE 34, all but two of the tortoises were caught solely within the boundaries of the quarter so little averaging was needed.

RESULTS

A quarter-section by quarter-section tabulation of population structure and density was made from the capture map (Table 1). With the exception of SE 34, all the DTNA quarters showed very similar results. As such, in the tables which follow, these quarters are combined for the purpose of comparison with SE 34.

TABLE 1. Results for Three Different Sub-plots of the DTNA-IC Study Site

Size-age class	MCL (mm)	SE 34 #	SE 34 %1/	DTNA-SE 34 2/ #	DTNA-SE 34 2/ %	Total DTNA #	Total DTNA %
Hatchlings, J1	(60)	7	10.77	4	1.24	11	2.84
J2	(60-99.5)	9	13.85	10	3.10	19	4.91
Immature	(100-179.5)	18	27.69	75	23.29	93	24.03
Sub-adult	(180-208.5)	6	9.23	50	15.52	56	14.47
Adult	(209)	25	38.46	183	56.85	208	53.75
Total		65	100.00	322	100.00	387	100.00

1/ Percentage of total for sub-plot

2/ Values for DTNA excluding SE 34 results

Obviously, the most striking result is the much higher proportion of small tortoises encountered in SE 34. Of 11 hatchling and J1 tortoises found in the 7 quarters within the natural area, 7 were found in this single quarter section. A high proportion of the J2 animals observed were likewise found in this quarter.

One further result is pertinent. This is the effect of size on capturability. The average number of encounters (the sum of initial capture and any subsequent recapture) were recorded for 4 size groups (Table 2). The size classes used were suggested by natural breaks in the data. Encounter number increases with increasing size.

TABLE 2. Average Number of Encounters Per Individual Tortoise for Different Size Classes Within DTNA Sub-plot

Size class (mm)	Number of individual	Average number of encounters per individual
40-129.5	55	1.35
130-199.5	93	1.88
200-279.5	207	2.66
280	30	3.50

DISCUSSION

The excess coverage of SE 34 and the analysis presented above were not designed into the study procedure for the plot. As such, interpretation of results of this basically "uncontrolled" experiment must be cautious. Given their striking nature, however, these results are suggestive and warrant comment.

It seems reasonable to explain the differences in observed population structure and density between SE 34 and the other six quarter sections within the Preserve to the added increment of search time the former received. Assuming that the tortoises on the whole are rather sedentary over the course of a single season (an assumption supported by the movement results obtained), the majority of resident adults and sub-adults were caught and marked fairly early in the study. Thereafter, encounters in these age groups were mostly recaptures and thus didn't alter population structure results. The entire plot received a degree of search coverage adequate to accurately sample the adults and sub-adults.

For the smaller age-size classes the story is different. The effect of the added search time in SE 34 is vividly reflected in the heightened proportion of small tortoises in this quarter's tally. Because they are less easily seen, it is evident that more searching is necessary to adequately sample the smaller age-size classes. I would suggest that the results for SE 34 show the influence of an amount of search time more nearly sufficient to accurately sample all age classes. The estimated population structure for SE 34 is undoubtedly much more realistic than that for the rest of the plot.

The above discussion does not deny the possibility of patchy distribution of young tortoises. It is possible that the real density of these small animals is higher in SE 34 than elsewhere on the plot. Given the dramatic differences obtained, though, it seems unlikely that this could be solely responsible.

IMPLICATIONS

SE 34 received intensive coverage. The other quarter sections within the Preserve were subjected to an amount of search time more typical of the normal 60-day tortoise plot. Considering the results, this implies that the average 60-day treatment of a 1 mi^2 plot may yield results that significantly underestimate both population density and the proportion of small tortoises within the population. As accurate estimates of these characteristics are essential for good management, the following research approach is suggested for investigation of tortoise population structure.

Preliminarily, the program requires several conditions. The plot should be relatively homogenous environmentally. An accurate method of mapping capture location is essential. Very good results were obtained at DTNA-IC using aerial photographs. Using these in conjunction with careful staking of the plot at 100-m intervals allowed very accurate mapping. Finally, discipline on the part of the investigator is needed. A system of recording the amount of search time spent in each portion of the plot must be set up. The program calls for controlled and different amounts of search time being applied to different sub-plots. This requires both accurate accounts of where search time is spent and accurate transect walking. To avoid bias in the results, consistency of search style is also necessary.

The square mile plot could be divided into sixteenths. Perhaps four of these could be randomly chosen to receive an added increment of search time. These sub-plots, totalling one quarter of the area investigated, should receive at least twice the coverage of the rest of the plot.

With this approach, it would be possible to assess the effect of an added increment of search time on population structure over a large area from short-term studies.

This approach is obviously limited to ecologically very similar plots but could allow relatively efficient and accurate population structure assessment for whole populations.

A COMPARISON OF THREE METHODS OF POPULATION ANALYSIS OF THE DESERT TORTOISE, *GOPHERUS AGASSIZI*

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Desert tortoise field studies rely on analysis of a mark and recapture ratio for estimating population densities. Three methods of analyzing this ratio, the Lincoln Index, the Stratified Lincoln Index, and the Schnabel Method are compared, using data from the same tortoise population. The biological significance of the variation in estimates are discussed and violations of the basic validating assumptions of each technique are pointed out. The Schnabel Method and the Stratified Lincoln Index are presented as alternatives to the widely used Lincoln Index but both violate their conditions for validation. It is suggested that density estimates be computed in terms of numbers of adults and sub-adults per unit area with estimates for the smaller size classes reserved for relative comparisons with other areas to assess the reproductive health of the population.

INTRODUCTION

In the spring, and again in fall of 1979, I had the fortunate opportunity to work for Dr. Kristin Berry on the Bureau of Land Management's (BLM) Chemehuevi Valley permanent tortoise study plot. The purpose of the work was to obtain quantitative data on the density, age structure, and sex ratios of the tortoise population. These data have been reported to the BLM California Desert Plan Program (Fusari and Schneider 1979; Schneider 1979). This site was also studied twice in previous years by Cook (1977) and Nicholson (1978) and the accumulation of these data has allowed this comparison of population analysis techniques. Since a population estimate was one of the primary objectives of the study, I wanted to be sure that it was accurate. It was my dissatisfaction with the initial analysis technique and estimate that prompted this study.

The field work consisted of a mark and recapture census on a 1.8 mi^2 (4.7 km^2) plot. The mark-recapture ratio was then analyzed using the Lincoln Index and two variations, the Stratified Lincoln Index (Overton 1971) and the Schnabel Method (Harless and Morlock 1979).

With 3 years of data, it was possible to use the Lincoln Index for 13 different estimates by designating one period as the capture period and another as the recapture period (Table 1). The estimates vary considerably from 208 (116/mi^2)

to 322 (179/mi^2) with overall confidence limits between 81 (45/mi^2) and 536 (298/mi^2). The variation and the wide confidence limits make these estimates of limited value. The reason for the variation is violation of the validating assumptions of this technique rather than sampling error.

Under normal conditions, desert tortoise field studies cannot meet the prerequisites of the Lincoln Index. To begin with, the method is designed for a single marking period and a single recapture period. With this study, given the size of the plot, the distribution and activity patterns of the tortoises, and human limitations, less than 5% of the estimated population was found during any day of the study, with a mean less than 1%. With this low capture rate, it is necessary to conduct a cumulative census.

The Schnabel Method is a variation of the Lincoln Index that is designed for use with a cumulative census. In this method, a daily record is kept of the total number of tortoise encounters, the number of recaptures, and the number marked. Using the formula, basically the same as the Lincoln Index, estimates are computed for every day of the census. In this study, the daily estimates were then averaged after they had apparently leveled off.

Using this method, the resulting estimates are lower than the estimates using the Lincoln Index for comparable time period (Table 2). The confidence ranges for this method are also quite small, giving an apparently more reliable population estimate. However, this method does not account for immigration and emigration or differential probability of capture. The effects of immigration and emigration can be seen when comparing the estimates from progressively longer censuses. The estimate from spring 1979 data is the lowest figure and as the time period is increased, the resulting estimate increases. This indicates that, during a short period of study, the chances of significant movement of tortoises on and off the site would be minimal and as the period of study increases, so would the likelihood of immigration and emigration. Thus, as more unmarked tortoises moved onto the site and marked tortoises left the study site, the ratio of marked to unmarked tortoises would decrease, resulting in an increased estimate.

It is important to note that the population density probably remains constant as immigration and emigration are balanced. Only the ratio of marked to unmarked tortoises changes significantly. The results of the computations using these methods do not reflect the size of the population at any given time but rather, the number of tortoises that use the site over the period of time analyzed. This probably represents those tortoises that have a portion of their home range within the study area. Thus, those tortoises with all or most of their home range within the study area have a higher probability of being captured than those tortoises whose home range only overlaps a little with the study plot.

Assuming that tortoises don't shift their home ranges over time, the number of tortoises that could be encountered would have an upper limit effected by mortality and natality only.

The Lincoln Index and Schnabel Method both assume that the probability of capture is equal for all members of the population. As shown above, this does not hold when working with desert tortoises. Size class also effects the probability of capturing a tortoise. Smaller tortoises are harder to see, seem to have reduced activity periods, and have smaller home ranges than larger tortoises (Shields 1979). The effects of these differences give adults, marked or unmarked, a higher probability of being captured. With this higher probability of being captured, the recapture rate of adults for this study (>70%) is also higher than for juveniles (<16%). This tends to lower the population estimate.

Further evidence of differential capturability is seen within the size classes. During March 1979, 20 adult and sub-adult tortoises marked 1977 or 1978 were encountered. These tortoises comprised 51.3% of the adults and sub-adults found that month. However, these 20 tortoises represent only 19% of all adult and sub-adult tortoises found during 1979. The disproportionate number of 1977-78 tortoises encountered in March indicates a higher capturability of these tortoises. Those tortoises with the highest capturability would tend to be encountered first and small samples would heavily favor them. The reasons for the differential capture probability are linked to differences in home range (size and amount of range within the site) and activity patterns.

The Stratified Lincoln Index accounts for differences in capturability between the size classes but cannot correct for differences within the size classes without considerably more data. In this technique, sub-populations are analyzed separately and, with matrix algebra, corrections are made for individuals changing sub-populations. When the population can be divided into sub-populations in which the probability of capture is basically uniform, this technique computes the probability of capture rates using the recapture rates for the sub-populations. From this, the technique estimates the size of the different sub-populations.

In desert tortoise studies the population sample can be divided into size classes and the population of each size class estimated. The resulting estimates using the data from the Chemehuevi site are higher than the estimate for the same time period using the Lincoln Index or the Schnabel Method. More importantly, the analysis gives estimates for each size class, which vary considerably from the sample. The estimate for the juvenile size class is much higher than the sample, due to the low recapture rate. This is also true of the immature size class. The adult and sub-adult estimates, on the other hand, show slightly less tortoises than actually were found during the entire study. This may show the effects of immigration and emigration as the sample represents those tortoises that were on the site over the entire period of study, the estimate is for the 60-day period in the spring only. When 1977 and 1978 data are added, the estimate increases considerably and is well above the sample for all size classes. Given the above, then the estimate for the shorter time period would more closely reflect true density.

As stated above, the high estimation of juvenile tortoises is a result of the low capture rate. While this indicates that the sample has not begun to approach the actual numbers of juveniles within the study area, the small sample size, and the lack of understanding of the habits of these small tortoises prevents complete acceptance of this estimate. Should further studies support these findings, then population dynamics could be based on estimates using this technique.

The estimate yielded by the Stratified Lincoln Index for adults and sub-adults is exactly that of the Schnabel method for the same time period. This time period, spring 1979, has proved to be the most useful period for analysis. The marking period was designated as the first 30 field days and the recapture period the last 30 days. This minimized the effects of immigration and emigration and yielded a high recapture rate. Even with the Lincoln Index, this period's analysis had the smallest confidence range. The Schnabel method yielded the lowest estimate for this period (194) with the Stratified Lincoln Index giving the highest estimate for this period (303).

While a continuous short study period minimizes the effects of immigration and emigration, it does not yield sufficient data for the juvenile size class. For this reason, I recommend that density be computed for adults and sub-adults over a one-season study period. These size classes are the reproductive potential of the population and as such, density estimates are quite important. The smaller size classes are harder to census and inclusion of data from these tortoises compromises the accuracy for the large size classes. The population density of the small size classes are important in that they indicate the reproductive success of the population and are indicative of the population's future. To assess these factors, the size structure of the population sample or estimates yielded by the Stratified Lincoln Index can be compared with other populations with similar data. If through improved techniques the population of small tortoises can be accurately sampled, then estimates using the Stratified Index can be tested.

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TABLE 1. Lincoln Index Estimates

Capture period	Recapture period	Population estimate (per mi^2)	Confidence limits (per mi^2)
1977-78 67[2/]	1979 S[1/] 35/151[3/]	288 (160)	199,401 (111,223)
1977-78 67	1979 S and F 39/171	295 (164)	211,401 (117,223)
1977-78 67	1979 F 13/42	216 (120)	113,374 (63,208)
1979 S 151	1979 F 22/42	287 (159)	178,437 (99,243)
77, 78, 79 S 183	1979 F 26/42	296 (164)	190,433 (106,241)
1977 32	1979 F 6/42	224 (124)	81,521 (45,289)
1977 32	1979 S 15/151	322 (179)	176,536 (98,298)
1977 32	1979 S and F 17/171	322 (179)	184,517 (102,287)
1978 36	1979 F 7/42	216 (120)	85,467 (47,259)
1978 36	1979 S 20.151	272 (151)	164,420 (91,233)
1978 36	1979 S and F 22/171	280 (156)	173,424 (96,236)
1977-78 67	1979 March 20/62	208 (116)	125,321 (69,178)
79 S 1st half 93	79 S 2nd half 44/102	216 (120)	155,289 (86,161

1/ S=spring F=fall

2/ Number of tortoises marked

3/ Number of tortoises previously marked/number of tortoises checked for marks

TABLE 2. Schnabel Method and Stratified Lincoln Index Estimates

Schnabel Method Estimates

Age class	Time period	Population estimate	Confidence limits	Density
all	Spring 1979	194	164,233	108/mi^2
all	Spring and Fall 1979	210	180,247	117/mi^2
all	1977-78 Spring 1979	234	201,273	130/mi^2
all	1977-78 Spring and Fall 1979	241	209,276	134/mi^2
adults and sub-adults	Spring 1979	93	75,113	52/mi^2
adults and sub-adults	Spring and Fall 1979	98	84,120	54/mi^2

Stratified Lincoln Index

Capture period	Recapture period	Age class estimates	Population estimate	Confidence limits	Density
1st half Spring 1979	2nd half Spring 1979	110 juveniles 100 immatures 29 sub-adults 64 adults	303	224,409	168/mi^2
1977-78	1979 Spring	162 juveniles 147 immatures 59 sub-adults 82 adults	450	118,628	250/mi^2

A BRIEF UPDATE ON THE CALTRANS FENCE-CULVERT FEASIBILITY STUDY

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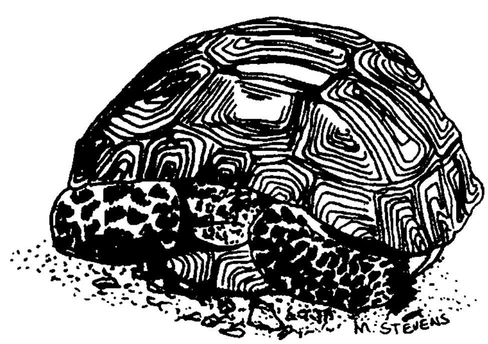
In 1979 a brief paper was presented at the Desert Tortoise Council Symposium. In the paper we described a study being conducted by CalTrans on the feasibility of using a fence-culvert system to avoid the increases in desert tortoise mortality associated with roads. This is a very brief update on the progress of that project.

Our site is in the western Mojave desert approximately 8 miles (12.9 km) south of Barstow, California. The tortoise population there is large (approximately 200/mi^2 or 518/km^2) and appears to be very healthy having good size and age class ratios as estimated qualitatively.

The experimental system was constructed in April 1979 and consists of a 450 ft long, 15 to 20 ft wide, double fence made of 18-inch high chicken wire. Crossing it at right angles, 150 ft from each end, are two, 3 ft diameter culverts. In addition we constructed a set of three, 15 ft diameter, circular pens with small (2 to 3 ft diameter) culverts interconnecting them.

Briefly, we have found that: (i) Tortoises will cross the culverts. They do a lot of nosing and hesitating at first but do move into the culverts and eventually through them. Indeed, they use the culverts as retreats as temperatures climb during the day. There seems to be some reluctance to cross culverts with a very small diameter, close to body or burrow size, during activity periods. (ii) Tortoises will spend a lot of time "fighting" the chicken wire fences. We would hypothesize that there is a conflict in the sensory inputs offered by the fences. Visually, the way appears open but physically the animal is blocked. In the spring of 1980 we will be testing other types of fencing to clarify this situation. (iii) We believe that the tortoises near the experimental fences are learning the position of the fences and culverts and will adjust their paths of travel to allow for the blockades presented by fences. This is of great encouragement to us and we will explore this further in the spring of 1980.

Next year we will present a full report of our data and recommendations concerning tortoises, fences, culverts, and roads.



TORTOISE POPULATIONS ON THE SECOND COMMUNITY OF CALIFORNIA CITY

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Desert tortoise populations were assessed within the Second Community of California City in conjunction with preparation of an environmental impact report for relinquishment of surface entry rights by the State of California. Tortoise densities fluctuated significantly throughout the study area, although densities exceeding 200 tortoises/m^2 (77 tortoises/km^2) were recorded. Areas of low tortoise densities were apparently due to habitat destruction by sheep grazing, road grading and off-road vehicle use. Implementation of the proposed action would increase development pressure in the Second Community, resulting in loss of desert tortoise habitat on site and indirect impact to the adjacent Desert Tortoise Natural Area.

INTRODUCTION

Under contract to the California State Lands Commission, WESTEC Services performed environmental studies on the approximately 28,000-acre (11,300-ha) Second Community of California City, Kern County, California. The State Lands Commission currently owns surface entry rights for mineral extraction on approximately 15,000 acres (6070 ha) of the privately-owned community lands. The current developer of California City has applied to the State Lands Commission for relinquishment of the State's right of surface entry to the approximately 6070 ha. Relinquishment of these surface entry rights could facilitate residential development of the Second Community.

The Second Community is virtually unpopulated. However, it has been extensively disturbed through construction of roadways in association with mass land sales, grazing, and through heavy off-road vehicle use. As technical assistants to the State

Lands Commission, WESTEC Services prepared an environmental impact report on the State's proposed action (WESTEC Services, Inc. 1980). A portion of this study included surveys to document the status of the desert tortoise on Second Community Lands and to analyze potential impact of development on the desert tortoise within the Second Community and on the adjacent Desert Tortoise Natural Area (Figure 1).

MATERIALS AND METHODS

Twenty-five transects were surveyed in early November 1979 (Figure 2). Each transect was 1.5 mile (0.93 km) long by 10 yd (9.04 m) wide and was walked in a triangular fashion with 0.5 miles (0.31 km) on a side. Tortoise transects were chosen at random and included some areas disturbed by sheep, motorcycles, and road grading. Tortoise signs were used as an index of density, using the method of Berry and Nicholson (1979).

There were three basic plant communities on the study site: 1) creosote bush community; 2) shadscale community; 3) Joshua tree community. Community designations follow those of Munz (1974) and Thorne (1976). Three subsets of the creosote bush community were identified: a) creosote bush, *Larrea tridentata*, and burrobush, *Ambrosia dumosa*, association; b) pure stands of creosote bush; and c) creosote bush with a high density of perennial species. This latter association was dominated by creosote bush, burrobush, and goldenhead, *Acamptopappus sphaerocephalus*.

There is an existing network of graded roads prepared for eventual subdivision (Figure 2). In addition to the roads, concrete culverts and other diversion structures are present in all drainage courses. A much-used campground is present at Galileo Hill and serves as a base camp for recreational vehicle operators. Motorcycle trails are found virtually everywhere throughout the Second Community area. In addition, domestic sheep have grazed the area. Webb (1979) estimated that 60 to 68% of perennial plant above-ground biomass was removed by sheep grazing.

RESULTS AND DISCUSSION

The desert tortoise, *Gopherus agassizi*, occurred throughout the study area with densities ranging from 10 to 200 tortoises/mi^2 or 4 to greater than 77 tortoises/km^2. (Table 1). Although densities fluctuated significantly throughout the study area, some trends were apparent (Figure 3). The southern portion of the study area contained tortoise densities between 30 and 100 tor-tortoises/mi^2 (12 and 39 tortoises/km^2). The central portion contained higher densities of 100 to 200 tortoises/mi^2 (39 to 77 or more tortoises/km^2). Tortoise densities within the northern portion ranged between 10-200 tortoises/mi^2 (4 and 77 tortoises/km^2).

In previous studies conducted in 1977, Berry and Nicholson (1979) estimated tortoise densities to be greater than 77 tortoises/km^2 throughout most of the Second Community area. Densities in the northeastern portion of the study area were estimated up to 96 tortoises/km^2 by Berry and Nicholson (1979). In general, the present study may indicate a decline in the tortoise population over the past 2 years. However, some differences in densities may be attributed to differences in survey methods. The earlier survey generally avoided highly disturbed areas whereas the current survey routes were selected randomly.

Areas within a 10-mile (16-km) radius of the Second Community have generally high tortoise densities. The Desert Tortoise Natural Area has the highest reported densities, over 96 tortoises/km^2 (Berry and Nicholson 1979). Furthermore, Berry and Nicholson speculated that tortoise densities above 19 tortoises/km^2 represent viable populations. Therefore, most areas within the Second Community study have significant populations.

Desert tortoise populations may be declining in the Second Community area. This decline may be due to collections by the public, vehicular mortality, grazing, and general habitat degradation due to grazing and off-road vehicles. The large variation in densities within the study area may reflect this general habitat degradation.

Relinquishment of the State's right to surface entry on Second Community lands would result in increased potential of development of these lands. This development would result in loss of significant desert tortoise populations within the Second Community.

In addition to on-site losses, development of the Second Community would indirectly impact the Desert Tortoise Natural Area through increasing tortoise collection on the periphery, increasing the potential for unauthorized off-road vehicle use within the area, as well as a potential for dogs and on-road motor vehicles to increase tortoise mortality.

ACKNOWLEDGEMENTS

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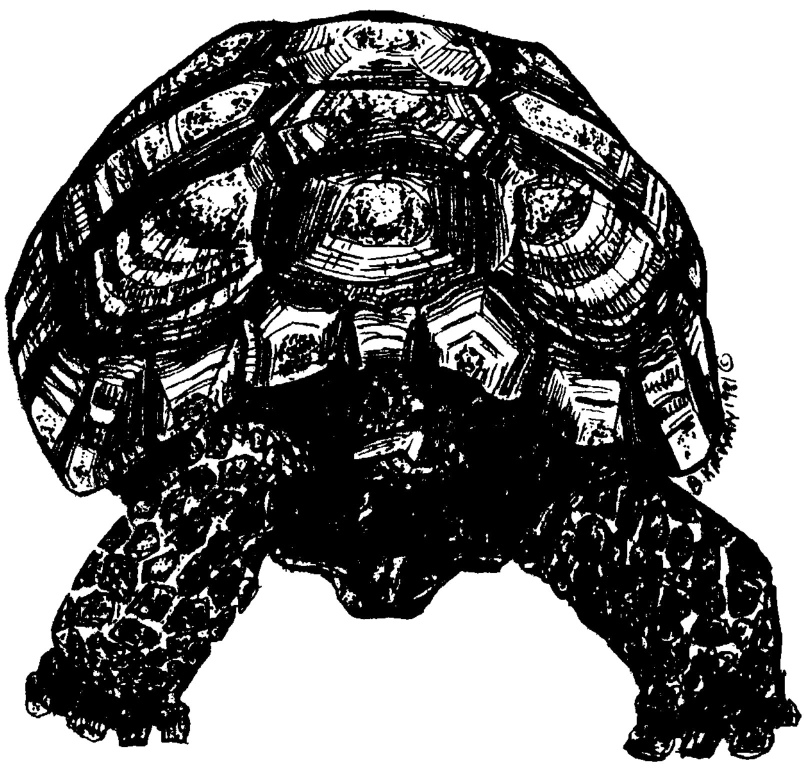

FIGURE 1. Regional map of the Second Community of California City and surrounding areas

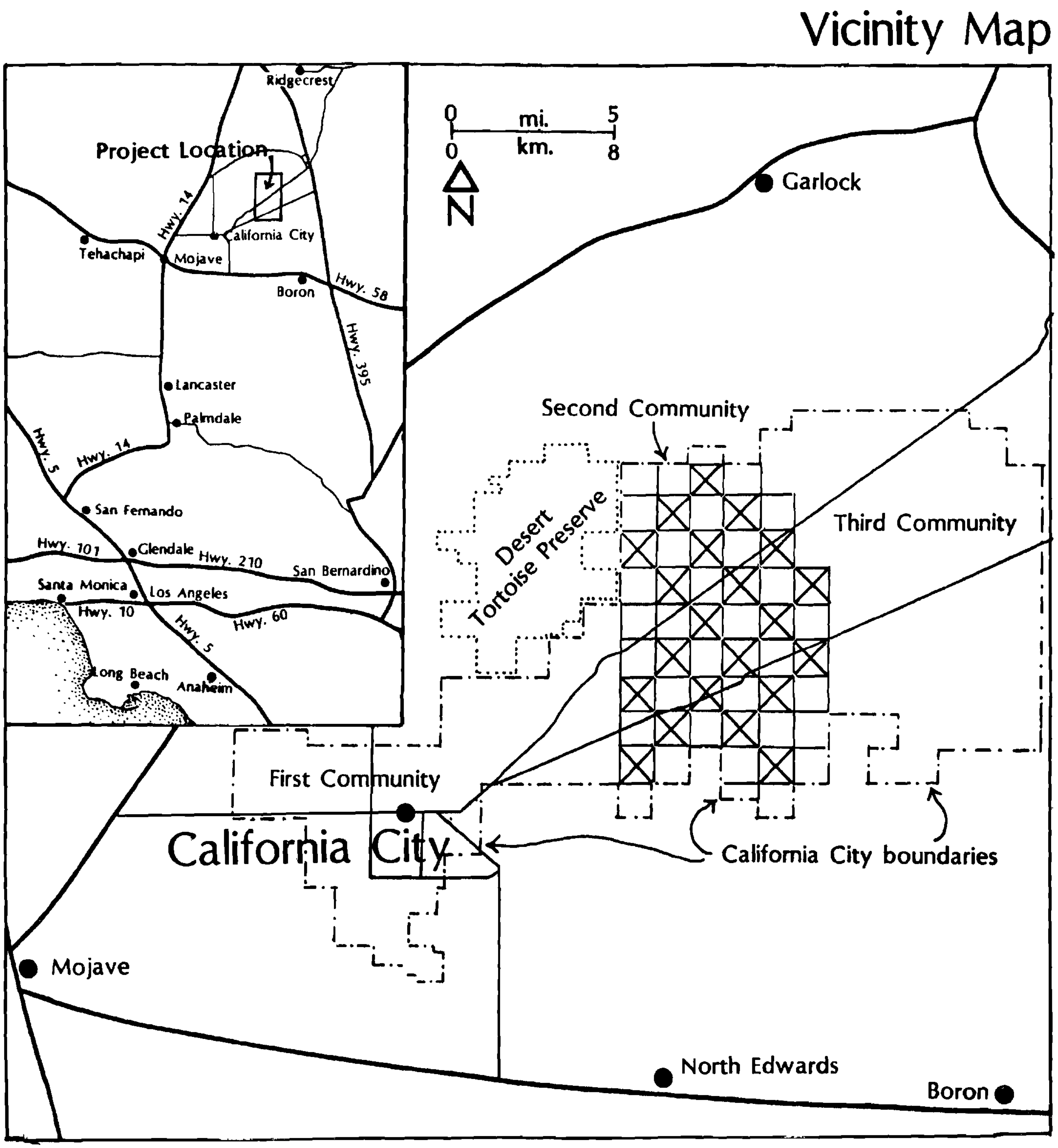

FIGURE 2. Map of the Second Community of California City and locations of tortoise transects

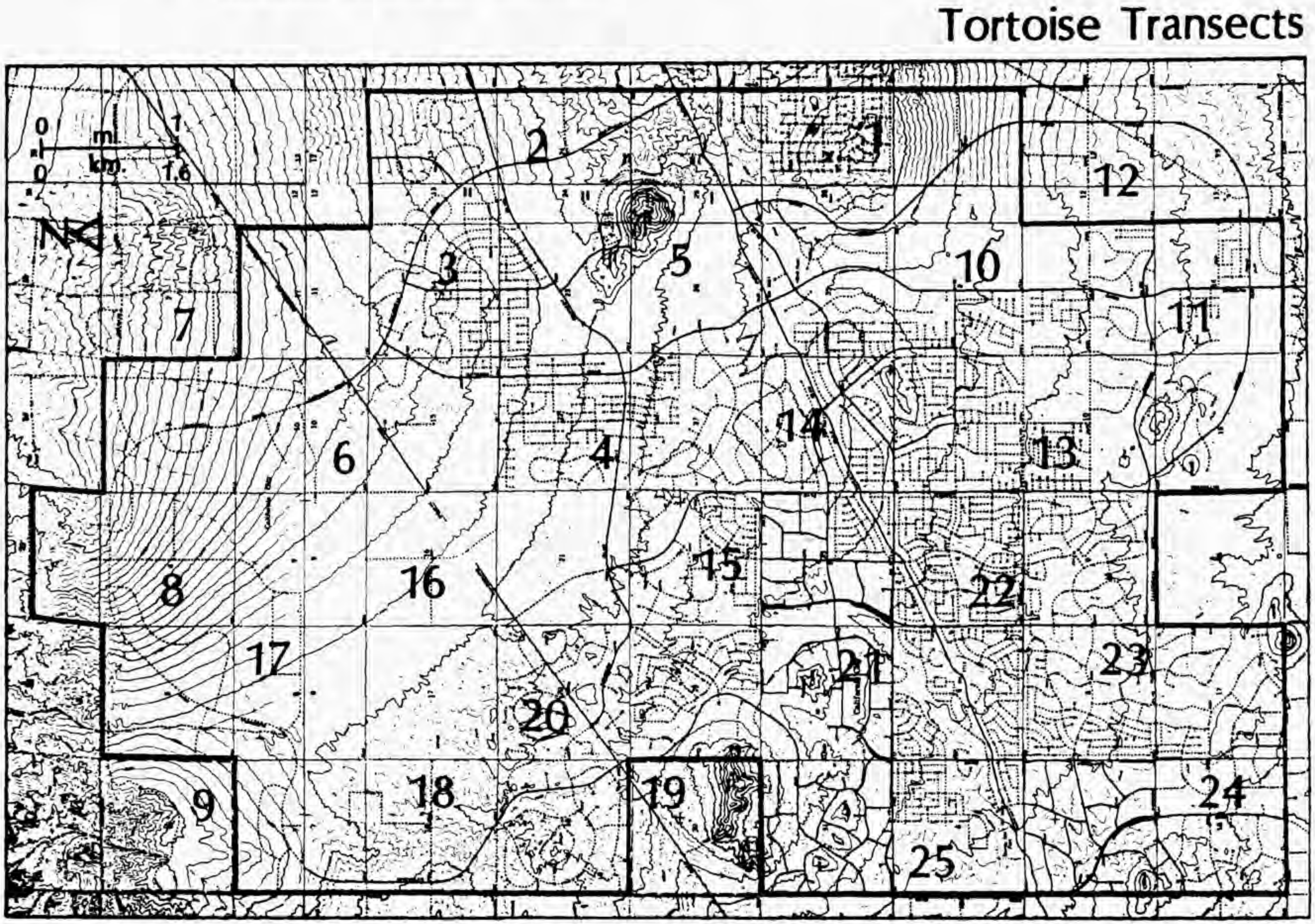

Figure 3. Tortoise densities on the Second Community of California City.

Legend

Greater than 77 tortoises/km^2

39 - 77 Tortoises/km^2

12 - 39 Tortoises/km^2

4 - 12 Tortoises/km^2

FIGURE 3. Tortoise densities on the Second Community of California City

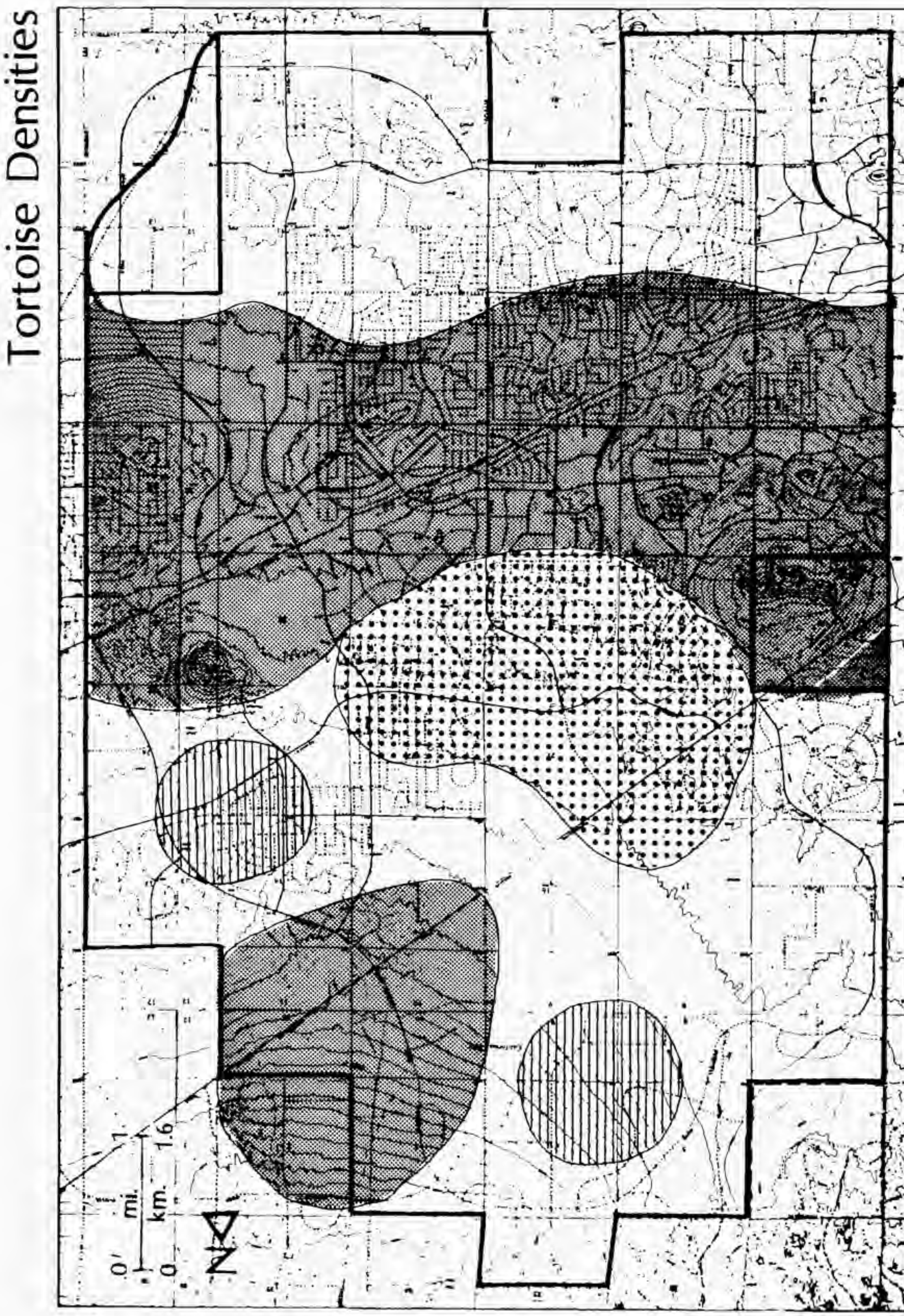

TABLE 1. Tortoise Transect Results

Transect Number	Area Quarter	Total Sign	Number of Burrows	Number of Scats	Live Tortoises	Shells
1	SE	12	6	6	0	0
2	NE	9	2	7	0	0
3	NE	2	0	2	0	0
4	NE	31	7	22	1	1
5	NE	11	4	7	0	0
6	NE	19	7	10	2	0
7	NE	14	6	7	1	0
8	NW	5	0	7	0	0
9	NW	9	0	9	0	0
10	SE	20	4	12	2	2
11	SE	4	3	1	0	0
12	SE	5	1	4	0	0
13	SE	4	1	3	0	0
14	SE	10	6	2	0	2
15	SW	17	9	7	0	1
16	NW	8	1	7	0	0
17	NW	6	2	3	0	1
18	NW	11	1	9	0	1
19	NW	15	4	11	0	0
20	NW	28	7	18	1	2
21	SW	17	6	11	0	0
22	SW	13	6	6	0	1
23	SW	11	4	6	0	1
24	SW	10	3	7	0	0
25	SW	28	3	24	0	1

A BASELINE STUDY OF THE DESERT TORTOISE, *GOPHERUS AGASSIZI*, AT THE INTERPRETIVE CENTER SITE, DESERT TORTOISE NATURAL AREA

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ABSTRACT

During March, April, and May, 1979, Timothy Shields, Anthony Rigoni, and I conducted a baseline study of the density, age structure, sex ratios, and other parameters of a population of desert tortoises at the Desert Tortoise Natural Area, Interpretive Center site. The site is located approximately 6 miles (9.7 km) NNE of California City in eastern Kern County, California. Each person was responsible for 1 mi^2 (2.59 km^2). The data were pooled for analysis. Seven of the 12 quarter sections studied are inside the fence of the Preserve and the other 5 outside, so that the population characteristics of tortoises living in a protected area could be compared to those living in areas also used by humans.

Drainage throughout the area is generally toward the southwest from the highest point, 2620 ft (799 m), at the northeast corner to the lowest, 2425 ft (739 m), in the southwest corner. The drainage is steeper in the northern part of the site, and becomes gentler at lower elevations.

The vegetation is predominately creosote bush-burro bush scrub, with variations in species composition in response to different drainage and substrate conditions. One notable exception is bunchgrass dominated vegetation located in a band of very sandy soil across the southern quarter of the site.

Crossing through the southeast corner of the site is the large Randsburg-Mojave dirt road, heavily used by recreationists, especially on weekends. Gravel extraction from the large wash in the southern part of the site has occurred on 0.07 mi^2 (.182 km^2). This area also serves as a popular campsite for off-road vehicle users. Motorcycles are used extensively on the area outside the fence.

During the study, 590 tortoises were encountered. The density of tortoises on the entire study area was estimated at 231/mi^2 (89/km^2). Inside the fence was 260/mi^2 (100/km^2) and outside, 191/mi^2 (73/km^2). The difference could be the result of reduction of the productivity of the unprotected land as a result of surface disturbance due to ORV activity, gravel extraction, and grazing. Death of tortoises on Randsburg-Mojave Road and under the wheels of off-road vehicles, and the removal of tortoises for pets are also factors.

The population of tortoises is divided into five standard age or size classes based on mid-carapace length: Hatchling (40-60 mm), Very Young (60-100 mm), Immature (100-180 mm), Sub-adult (180-210 mm), and Adult (>210 mm). In comparing the percentage of each class inside and outside the Preserve fence, it was found that the smaller size classes are essentially equal, but there is a greater relative percentage of large tortoises inside the Preserve.

Analyzing sex ratios both inside and outside the Preserve shows sub-adult males outnumber females, with the inside ratio close to 1:1, while the ratio outside approaches 2:1. Similarly, the adult male:female ratio is higher in the unprotected areas. The average adult male size is larger inside the Preserve than outside.

The removal of large, territorial males from outside the Preserve could account for these patterns. Larger tortoises are easier to see and are therefore more susceptible to collection. Following their removal, smaller males could move to the land outside the Preserve where they would encounter less aggression, and would more easily be able to establish territories.

Feeding habits were based on direct observations of feeding tortoises. Scats were not analyzed. Based on 170 feeding observations, tortoises were found to utilize 24 plant species. The major species utilized were *Lotus* sp., *Erodium cicutarium*, and the annual grass, *Schismus barbatus*. Because frequency of use of most species was very low, tortoises probably utilized many more species of flowering annuals than these observations indicate.

Evidence of growth of tortoises during the season of study was observed as early as 20 March. When tortoises were recaptured throughout the season, they were remeasured (MCL only) and reweighed. A measurable growth was exhibited by 81 tortoises.

Soft ticks were observed on six adult females, six adult males, and one immature tortoises or 2.2% of the total 590 tortoises examined. Ticks were usually found on the marginal scutes and varied in number from 1 to about 70 on a single tortoise.

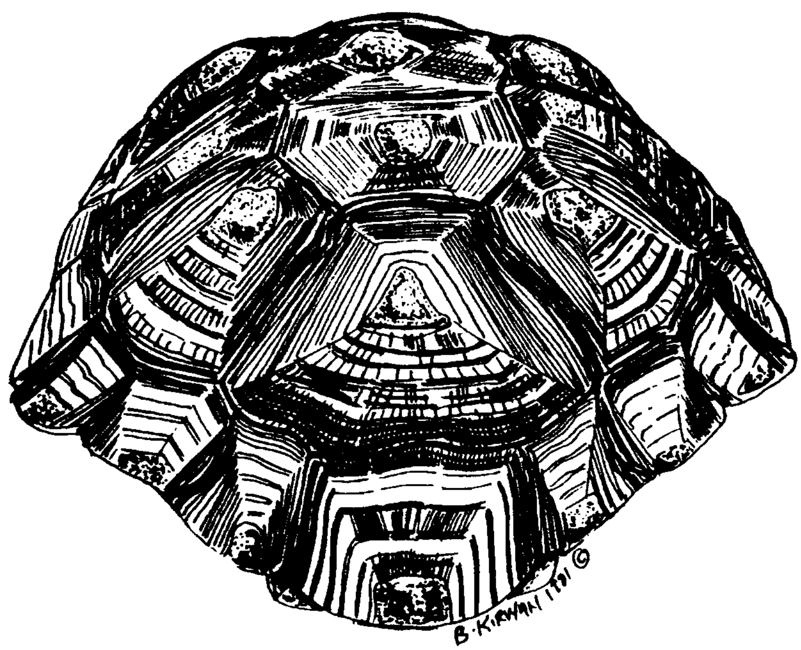
Eight acts of aggression between tortoises were noted during the season. Three of these involved two males, four involved two females, and one involved a male and a female.

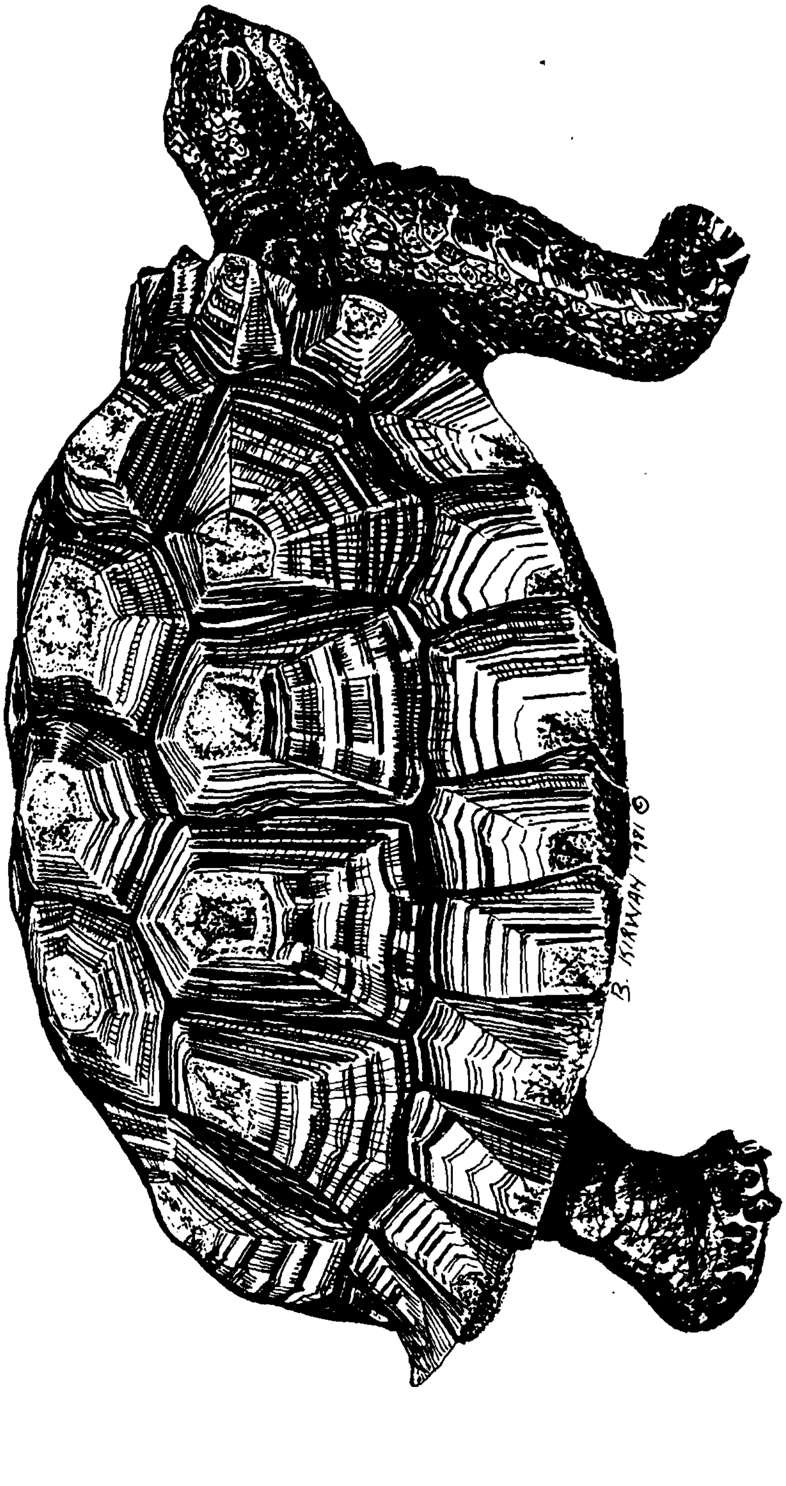
Courtship between tortoises was observed on 13 occasions. Six of these involved complete courtship, mounting, and copulation sequences. A typical courtship involved the following:

The male approached the female, bobbing his head. The female usually tried to move away. The male followed, circling around her, head bobbing, then biting and butting. When the male mounted, he curled his tail around the back of the female's carapace to her cloacal region. As copulation occurred, the male continuously pawed the female's carapace and made grunting sounds with each thrust. Timing and exact behavior varied among individual tortoises. Eight male-female pairs were observed sharing burrows.

Remains of dead tortoises were identified as accurately as possible as to size and sex. Analysis of age structure indicates that the hatchling and very young individuals are the most vulnerable. If a tortoise survives this early period, it is likely to survive into old age.

The Interpretive Center site should be an important site for future population and behavioral studies.





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