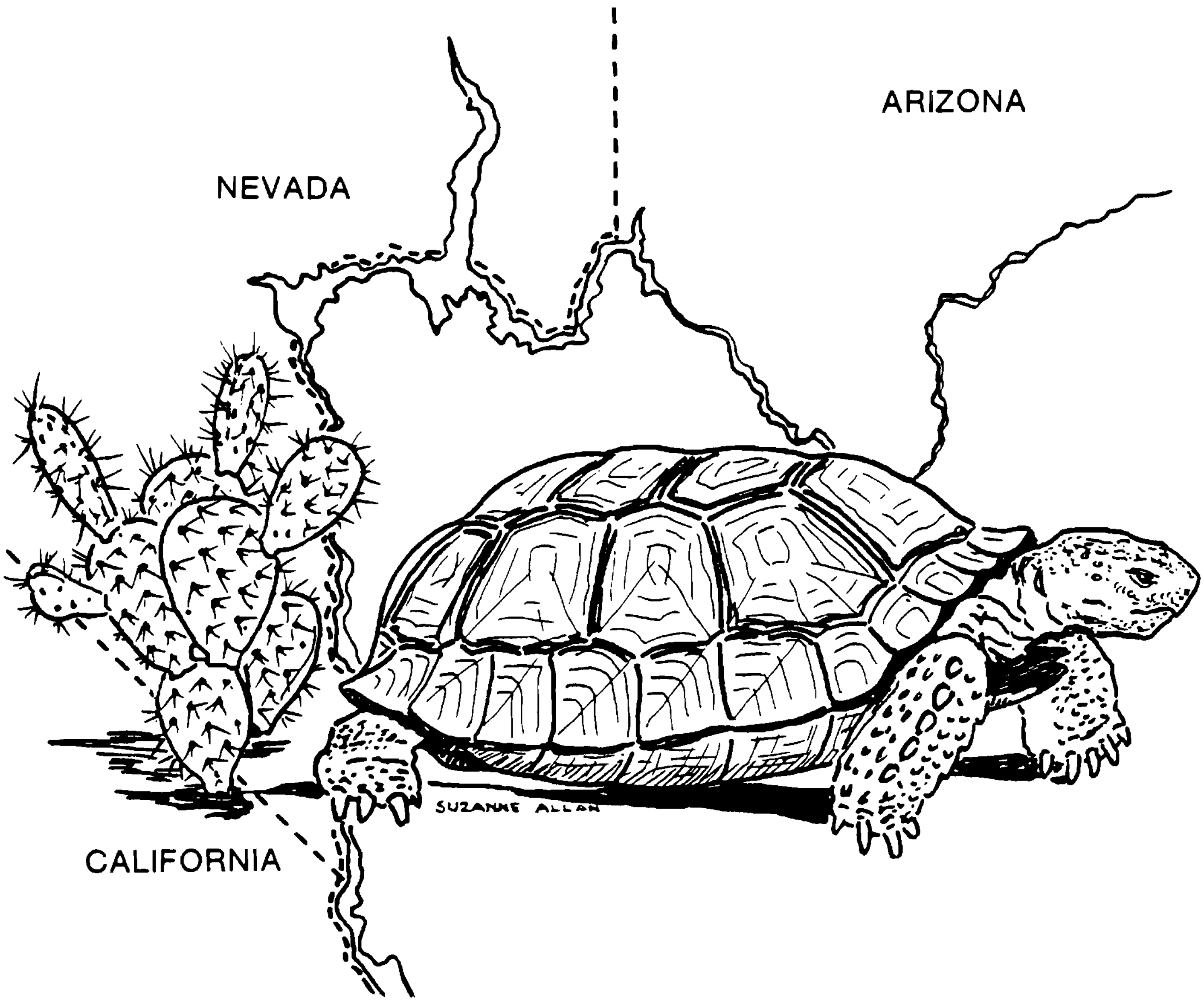
THE

DESERT TORTOISE COUNCIL



PROCEEDINGS OF 1981 SYMPOSIUM

DESERT TORTOISE COUNCIL

PROCEEDINGS OF 1981 SYMPOSIUM

A compilation of reports and papers presented at the sixth annual symposium of the Desert Tortoise Council, 28-30 March 1980, in Riverside, California

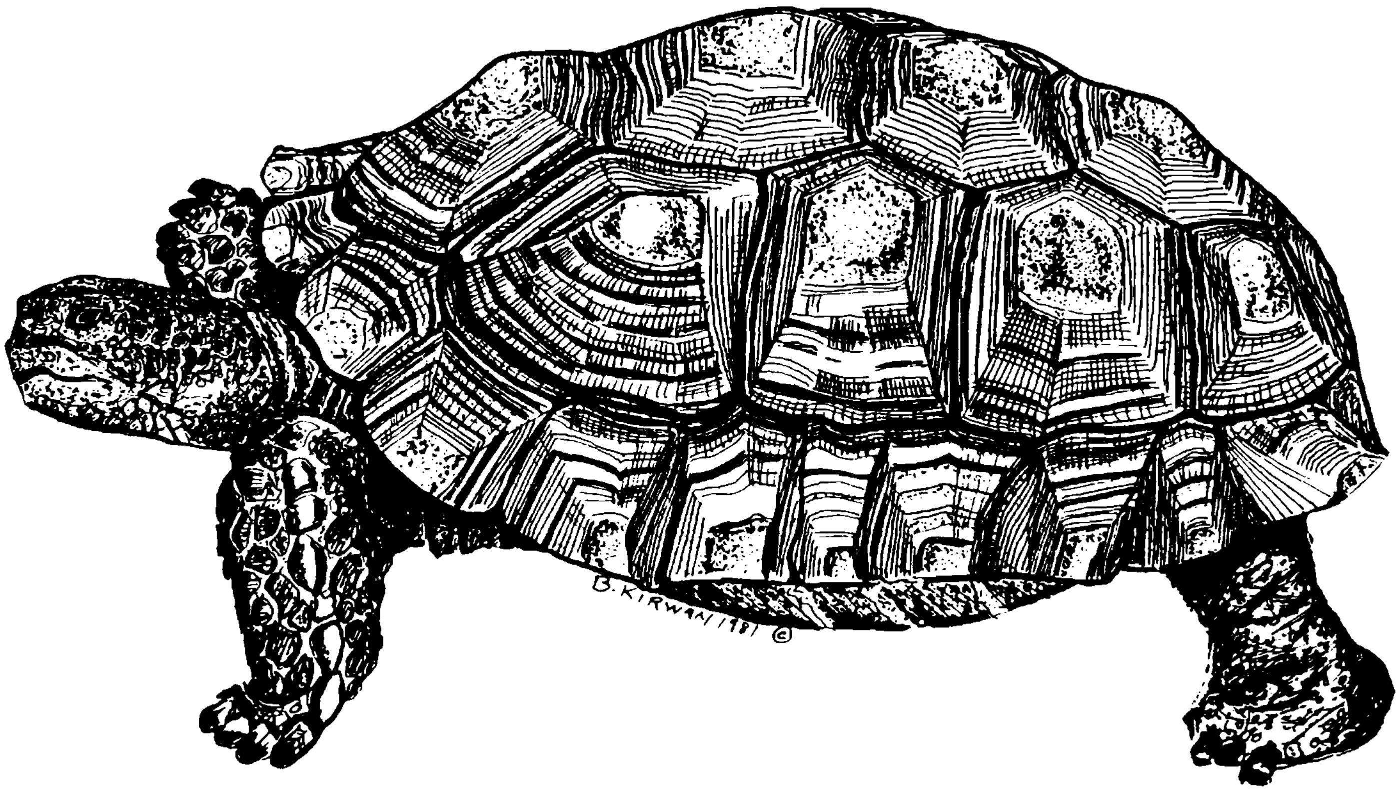
DESERT TORTOISE COUNCIL

TABLE OF CONTENTS

Page

Page

Desert Tortoise Council


B. KIRWAN 1981 ©

DESERT TORTOISE COUNCIL

EXECUTIVE COMMITTEE

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

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

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

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

The objectives of the Council are:

1. To serve in a professional advisory manner, where appropriate, on matters involving management, conservation and protection of desert tortoises.

2. To support such measures as shall work to insure the continued survival of desert tortoises and the maintenance of their habitat in a natural state.

3. To stimulate and encourage studies on the status and on all phases of life history, biology, physiology, management and protection of desert tortoises, including studies of native and exotic species that may affect desert tortoise populations.

4. To provide a clearinghouse of information among all agencies, organizations and individuals engaged in work on desert tortoises.

5. To disseminate current information by publishing proceedings of meetings and other papers as deemed useful.

6. To maintain an active public information and conservation education program.

7. To commend outstanding action and dedication by individuals and organizations fostering the objectives of the Council.

MAJOR ACCOMPLISHMENTS OF THE DESERT TORTOISE COUNCIL IN 1980

DAVID W. STEVENS
Southern California Edison Company
Environmental Affairs
P.O. Box 800
Rosemead, California 91770

A primary objective of the Desert Tortoise Council is to help ensure that viable populations of the desert tortoise exist in their native habitat. To date, one goal to meet this objective has been to preserve the Utah Beaver Dam Slope population. To satisfy this goal, the Desert Tortoise Council, from its inception in 1975, has worked toward having this population listed as Endangered by the Office of Endangered Species. On August 20, 1980, the Beaver Dam Slope population was officially listed as Threatened and thirty-five square miles of the Beaver Dam Slope were designated as Critical Habitat.

Council efforts during 1980 in support of this listing are outlined below.

1. Presentation to the public at the U.S. Fish and Wildlife Service's St. George, Utah Public Meeting regarding the Desert Tortoise Council's proposal to list the population as endangered.

2. Review and evaluation of all St. George, Bureau of Land Management data applicable to management of the Beaver Dam Slope for the desert tortoise. A report of findings was then submitted to the Office of Endangered Species.

3. A meeting was held with personnel of St. George area Bureau of Land Management and Utah Division of Wildlife Resources to discuss current management practices and desert tortoise studies on the Beaver Dam Slope. A report of findings was made to the Office of Endangered Species.

The listing of the Beaver Dam Slope tortoise population offers protection through the Endangered Species Act. Any proposed action requiring federal approval that may adversely impact this population or its critical habitat may be denied by the appropriate federal agency. The Act also..."makes it illegal for any person subject to the jurisdiction of the United States to take, import or export, ship in interstate commerce in the course of commercial activity, or sell or offer for sale this species in interstrate or foreign commerce. It would also be illegal to possess, sell, deliver, carry, transport, or ship any such wildlife which was illegally taken." Special permits are available, however, for scientific purposes or to enhance the propagation or survival of the species.

Other major activities of the Council during 1980 were:

1. Review and comment on the "Parker 400" motorcycle race and the Johnson-Parker race. Both races have the potential for significant impact to the desert tortoise.

2. The environmental statement for the Shivwitz Resource area was reviewed and comments sent to the Bureau of Land Management.

3. A $50.00 contribution was made to the Sierra Club for development of a 30-minute film on the environmental problems associated with feral burros. In the film, Dr. Kristin Berry will review the impact these animals have on the desert tortoise.

4. Considerable time and effort were spent reviewing and commenting on the proposed Desert Plan. This plan has the potential of permitting significant levels of adverse impact on desert tortoise populations and their habitat. Of particular importance is the need to protect the now high density populations in the Fremont-Stoddard area, Ivanpah Valley, Fenner-Chemehuevi area in Chuckwalla Bench.

The following two resolutions were passed at the business meeting of the Sixth Annual Meeting and Symposium:

RESOLUTION CONCERNING THE PRESERVATION OF ASH MEADOWS

WHEREAS the Desert Tortoise Council is vitally concerned with the preservation of key portions of the North American deserts, and

WHEREAS urban and agricultural development within the North American deserts are rapidly encroaching upon natural habitats within this area, and

WHEREAS Ash Meadows (Nye County, Nevada) lies east of Death Valley and contains endangered species of plants and fishes, is widely acclaimed as an area of biological endemism unique in the United States and equalled in only one other location in North America (Mexico), and

WHEREAS Ash Meadows is of enormous current and future value to the people of the United States and to the world scientific community, and

WHEREAS Ash Meadows is currently threatened by subdivision and residential development, and

WHEREAS such development would be destructive to the flora and fauna and other natural values heretofore described,

BE IT RESOLVED that the Desert Tortoise Council, meeting at Riverside, California, on March 28-29, 1981, does hereby request that every effort be made by the several responsible public agencies to place Ash Meadows in public ownership, using available means of exchange or purchase, and be it further

RESOLVED that legislative means of acquisition be thoroughly investigated, and that Senator Alan Cranston be exhorted to bring to hearing S. 41, the Desert Pupfish National Monument Bill, and be it further

RESOLVED that copies of this resolution be forwarded to Senator Alan Cranston of California, to Senators Paul Lexalt and Howard Cannon of Nevada, to the Secretary of the Interior, to the Directors of the U.S. Fish and Wildlife Service and Bureau of Land Management, and to the Director of the Nevada Department of Wildlife.

RESOLUTION CONCERNING THE ENDANGERED SPECIES ACT

WHEREAS the Congress of the United States passed and President Richard M. Nixon signed the Endangered Species Act of 1973 after finding that:

(1) various species of fish, wildlife, and plants in the United States have been rendered extinct as a consequence of economic growth and development untempered by adequate concern and conservation;

(2) other species of fish, wildlife, and plants have been so depleted in numbers that they are in danger of or threatened with extinction;

(3) these species of fish, wildlife, and plants are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people;

(4) the United States has pledged itself as a sovereign state in the international community to conserve to the extent practicable the various species of fish or wildlife and plants facing extinction;

and

WHEREAS the purposes of this Act were stated "to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purpose of the treaties and conventions set forth in subsection (a) of this section";

and

WHEREAS the policy of Federal agencies were defined in this Act such that "It is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purpose of this Act";

and

WHEREAS species of animals and plants are today being increasingly threatened by habitat alteration and careless development, unsound land management practices, vandalism, overcollection, and from a multitude of other causes;

and

WHEREAS the Desert Tortoise Council is particularly concerned about the viability of populations of the desert tortoise, *Gopherus agassizi*, a species which may warrant Federal protection under provisions of the Act;

BE IT RESOLVED that the Desert Tortoise Council, a professional organization composed of individuals concerned with the survival of the desert tortoise and the viability of the ecosystem on which it depends, expresses the following concerns about the Endangered Species Act of 1973 and its administration:

1. The Act must be virorously enforced for the protection of endangered and threatened species.

2. Amendments which would weaken the scope and protection afforded to listed and proposed species of fauna and flora must be vigorously opposed.

3. Cuts in the budget of the Cooperative Agreement Program under Section 6 of the Act must be restored to assist the States in the management of resident endangered and threatened species.

4. Habitat acquisition funds to acquire lands for the protection of endangered and threatened species must be restored and augmented.

5. Attempts to slow down the listing process, and thus deny protection under the Act's provisions to species that are endangered or threatened must be opposed.

6. Attempts to reorganize the Branch of Biological Support in the Fish and Wildlife Service's Office of Endangered Species which would eliminate the biological expertise for both the Endangered Species Program and the listing process, must be opposed as detrimental and contrary to the purposes of the Act and the wish of Congress.

7. The USFWS must maintain its authority for Sections 2 and 7 consultation abilities in order to have objective evaluations of federal actions for jeopardy opinions. Some federal agencies currently are not consulting the USFWS as required under the ESA.

ATTENDEES - SIXTH ANNUAL MEETING AND SYMPOSIUM*

Dr. Gary A. Adest
Department of Biology
University of Calif. San Diego
La Jolla, CA 92093

Walter Allen
Calif. Turtle and Tortoise Club
Weschester Chapter
10456 Circulo de Zapato
Fountain Valley, CA 92708

Keith R. Anderson
Calif. Dept. of Fish and Game
245 West Broadway Suite 350
Long Beach, CA 90802

Ariel Appleton
The Research Ranch
P. O. Box 44
Elgin, Arizona 86511

Jennifer Babcock
Golden Valley Ecological Society
639 W. Bullard, Apt. 105
Clovis, CA 93612

Steven Baker
29 Bayshore Avenue
Long Beach, CA 90803

Charles Bayless
Southern Calif. Edison Co.
Environmental Affairs
P. O. Box 800
Rosemead, CA 91770

Jeanne Bellemin
623 Avenue C
Redondo Beach, CA 90277

Elinor Benes
Depat. of Biological Science
Calif. State University-Sacramento
Sacramento, CA 95819

Dr. Kristin Berry
Bureau of Land Management
Desert Plan Program
3610 Central
Riverside, CA 92506

Doris and Paul Bickett
569 Center Lane
Santa Paula, CA 93060

Jan Ellen Bickett
719 19th Street
Sacramento, CA 95819

K. A. Booth
Bay Area Turtle Society
30 Shasta St.
Orland, CA 95963

Alan Borden
Bureau of Land Management
1747 Cliffrose Drive
Lake Havasu City, AZ 86403

Jeanne Breneman
1747 Cliffrose Drive
Riverside, CA 92507

John M. Brode
Calif. Dept. of Fish and Game
1416 9th Street
Sacramento, CA 95814

Alice Broderick
Calif. Turtle and Tortoise Club
San Bernardino Chapter
3515 Sepulveda Avenue
San Bernardino, CA 92404

Barbara Brydolf
Calif. State University-L.A.
3273 Vosburg Street
Pasadena, CA 91107

Betty Burge
Bureau of Land Management
2207 Pardee Place
Las Vegas, NV 89104

Betty Caldarelli
T.E.A.M.
14051 Harvest Ave.
Norwalk, CA 90650

Tom Campbell
1928 E. Cornell
Fresno, CA 93713

Susan Celano
8160 Diana
Riverside, CA 92504

Vivian W. Cerda
Calif. Turtle and Tortoise Club
San Bernardino Chapter
5325 Bardwell Avenue
Riverside, CA 92506

Ed Chatfield
State Lands Commission
1807 13th Street
Sacramento, CA 95814

Jennifer Cherniss
2491 Ellsworth #52
Berkeley, CA 94704

Daniel P. Christensen
Calif. Dept. of Fish and Game and
Golden Valley Ecological Society
639 W. Bullard #105
Clovis, CA 93612

Michael P. Coffeen
Utah Dept. of Wildlife Resources
656 S. 300 Eent of Wildlife
Cedar City, UT 84720

Cindy and Ted Cordery
Bureau of Land Management (Ted)
4321 N. 31st Drive
Phoenix, AZ 85017

Mary and Roderick Croom
Calif. Turtle and Tortoise Club
Westchester Chapter
2119 S. Harvard Blvd.
Torrance, CA 90501

Bruce L. Deuley
8008 Quimby Avenue
Canoga Park, CA

Dr. Mark Dimmitt
Arizona-Sonora Desert Museum
4331 N. Oxbow Road
Tucson, Arizona 85705

Dr. C. Kenneth Dodd
National Museum of Natural History
Smithsonian Institute, Division of
Reptiles and Amphibians
Washington, D. C. 20560

Mark W. Dodero
San Diego Society of Natural History
6210 Tooley Street
San Diego, CA 92114

Ike Eastvold
Highgrove, CA

John A. Edell
Calif. Dept. of Transportation
3060 Indian Creek Drive
Bishop, CA 93514

Norman Edmonston
Desert Tortoise Council and
Calif. Turtle and Tortoise Club
San Bernardino Chapter
P. O. Box 2220
Pomona, CA 91766

John R. Ekhoff
Calif. State University-Long Beach
10912 Chestnut Street
Los Alamitos, CA 90720

Sidney England
915 Fullerton Avenue
Corona, CA 91720

Jay M. Feldman
9557 Terrace Place
Des Plaines, IL 60016

Anne Fetzer
San Diego Museum of Natural History
P. O. Box 1390
San Diego, CA 92112

Alice Karl
21126 Chatsworth
Chatsworth, CA 91311

Thomas Kato
3401 Wible Road
Bakersfield, CA 93309

David Kavanaugh
Calif. Turtle and Tortoise Club
9549 Gidley
Temple City, CA 91780

Steig Klein
2441 Hasta #21A
Berkeley, CA 94704

Beverly Kohfield
2434 N. 6th Street
Fresno, CA 93703

Beverly and Tom Lackey
Calif. Turtle and Tortoise Club
Westchester Chapter
22816 Murlin Place
Canoga Park, CA 91807

Fred La Rue
Living Desert Preserve
P. O. Box 1775
Palm Desert, CA 92260

June Latting
320 Maravilla Drive
Riverside, CA 92507

Nancy Lewis
Calif. Turtle and Tortoise Club
500-1/2 S. Orchard Drive
Burbank, CA 91506

Craig Lyons
UCLA Biomedical and Environmental Lab.
1167-B E. Hialea
Las Vegas, NV 89109

Neil McGurty
575 Armsley Square
Ontario, CA 91762

Judith Markwood
4001 Fair Oaks
Sacramento, CA 95825

Bernardo Maza
Reynolds Electric Engineering
1467-B E. Hialeah Drive
Las Vegas, NV 89109

Philip A. Medica
UCLA Biomedical Environmental Lab.
P. O. Box 495
Mercury, NV 89023

Emmie and Douglas Miller
Calif. Turtle and Tortoise Club
Orange County Chapter
33211 Caribbean Way
Dana Point, CA 92629

Larry Minden
238 Younglove Avenue
Santa Cruz, CA 95060

Mary Beck Moser
Summer Institute of Linguistics
Huntington Beach, CA

Kimberly A. Nicol
2946 Mullens Drive
Richmond, CA 94806

Dr. Robert Ohmart
Dept. of Zoology
Arizona State University
Tempe, AZ

Daniel C. Pearson
Southern Calif. Edison Co.,
P. O. Box 800
Rosemead, CA 91770

Harvey Fischer
Los Angeles Zoo
5333 Zoo Drive
Los Angeles, CA 90027

Betty and Warren Forgey
Desert Tortoise Preserve Committee
P. O. Box 307
Boron, CA 93516

Joan L. Fortino
4360 Joslin Court
Riverside, CA 92505

Rochelle Fried
Calif. Turtle and Tortoise Club
Orange County Chapter
3701 Hermosa Place
Fullerton, CA 92635

Madeline Genizerbst
Calif. Turtle and Tortoise Club
San Bernardino Chapter
7057 Barton Street
San Bernardino, CA 92404

David Germano
258 Burnham Road
Oak View, CA 93022

Gerald Greene
7932 Mary Ellen Avenue
North Hollywood, CA 91605

Dr. Anne M. Hampton
Biological Research Associates
P. O. Box 11627
Tahoe Paradise, CA 95708

Sally Helm
San Diego Turtle and Tortoise Society

Mark Hoffman
Santa Monica College
Life Sciences Dept.
Santa Monica, CA 90405

Judy P. Hohman
U. S. Fish and Wildlife Service
4518 W. Desert Hills Drive
Phoenix, AZ 85304

Sandy Holly
Calif. Turtle and Tortoise Club
Orange County Chapter
5211 Dovewood
Huntington Beach, CA 92649

Frank Hoover
Calif. Dept. of Fish and Game
15378 Bird Farm Road
Chino, CA 91710

Dr. Barbara K. Hopper
The Nature Conservancy
P. O. Box 266
Woodland Hills, CA 91365

Major Ron Huff
U. S. Air Force
Carson City, NV

Lori and Ken Humphreys
6590 De Anza
Riverside, CA 92506

Jackie Jacobsen
184 Brown
Claremont, CA 91711

Alex Jaramillo
Calif. Turtle and Tortoise Club
San Bernardino Chapter
9635 Lombardy Avenue
Fontana, CA 92335

Shelly R. Johnson
Pasadena City College
2265 Paloma Street
Pasadena, CA 91104

Terry B. Johnson
Arizona Natural Heritage Program
30 N. Tucson Blvd.
Tucson, AZ 85716

Yatta and Dave Josephe
Los Angeles Aquarium Society
11640 Mayfield Avenue
Brentwood, CA 90049

Steve Juarez
CWESA
1425 N. Vagedes
Fresno, CA 93728

Diana Pickens
T.E.A.M.
16720 Dubesor Street
La Puente, CA 91744

Tony Recht
6957 Hazeltine Ave. #2
Van Nuys, CA 91405

Norman Roberts
2810 Hidden Valley Road
La Jolla, CA 92037

Georgia and Dr. Walter Rosskopf
Animal Medical Centre of Lawndale
4473 W. Rosecrans Blvd.
Hawthorne, CA 90250

Lance Sahara
1160 Third Street
Gilroy, CA 95020

Evelyn and Jim St. Amant
Calif. Dept. of Fish and Game
245 West Broadway, Suite 350
Long Beach, CA 90802

Robert Sanders
San Bernardino County Museum
129 Sir Dimas
Riverside, CA 92507

Marc Sazaki
Calif. Energy Commission
Serrano Road
Sacramento, CA 95825

Paul B. Schneider
P. O. Box 570
Prescott, Arizona

George P. Sheppard
Bureau of Land Management
Arizona Strip District
Box 1272S
St. George, UT 84770

Timothy Shields
Bureau of Land Management
1147 Bedford Street
Santa Paula, CA

Robert B. Spicer
5333 E. Pt. Lowell Road
Tucson, AZ

Linda Standow
Calif. Turtle and Tortoise
Club-Orange County Chapter
Costa Mesa, CA

David W. Stevens
Southern California Edison
Environmental Affairs
P.O. Box 800
Rosemead, CA 91770

Beverly Steveson
Desert Tortoise Preserve Committee
418 Brookhaven Drive
Bakersfield, CA 93304

Dr. Glenn R. Stewart
Biological Sciences Dept.
Calif. State Polytechnic University
Pomona, CA 91768

Laura Stockton
Desert Tortoise Preserve Committee
6201 Wible Road #66
Bakersfield, CA 93309

Peggy and H. A. "Cap" Strano
Calif. Turtle and Tortoise Club
Orange County Chapter
405 W. Berry
Anaheim, CA 92805

Judith Surfleet
The Nature Conservancy
3209 Nevada Avenue
El Monte, CA 91731

Linda Swantz
Calif. Turtle and Tortoise Club
Orange County Chapter
405 W. Berry
Anaheim, CA 92805

Jean and Howard Tanner
14323 Erie Road
Apple Valley, CA 92301

Roy K. Tate
Victor Valley Museum
9270 8th Avenue
Hesperia, CA 92345

Bruce Trotter
800 Kines Road
Newport Beach, CA 92663

Mary Trotter
San Diego Natural History Museum
1835 Klauber Avenue
San Diego, CA 92114

Nancy Tufts
45 Ridgecrest Road
Kentfield, CA 94904

Dr. Frederick B. Turner
UCLA
711 Kingman Ave.
Santa Monica, CA 90402

Robert Turner
Nevada Department of Wildlife
4804 San Sebastian Avenue
Las Vegas, NV 89121

John W. Wear
11390 Center Drive
Colton, CA 92324

John F. Westermeir
WESTEC Services, Incorporated
6118 Brookhollow Drive
Santa Ana, CA 92705

Leslie White
Ralph M. Parsons Co.
P. O. Box 162
La Puente, CA 91747

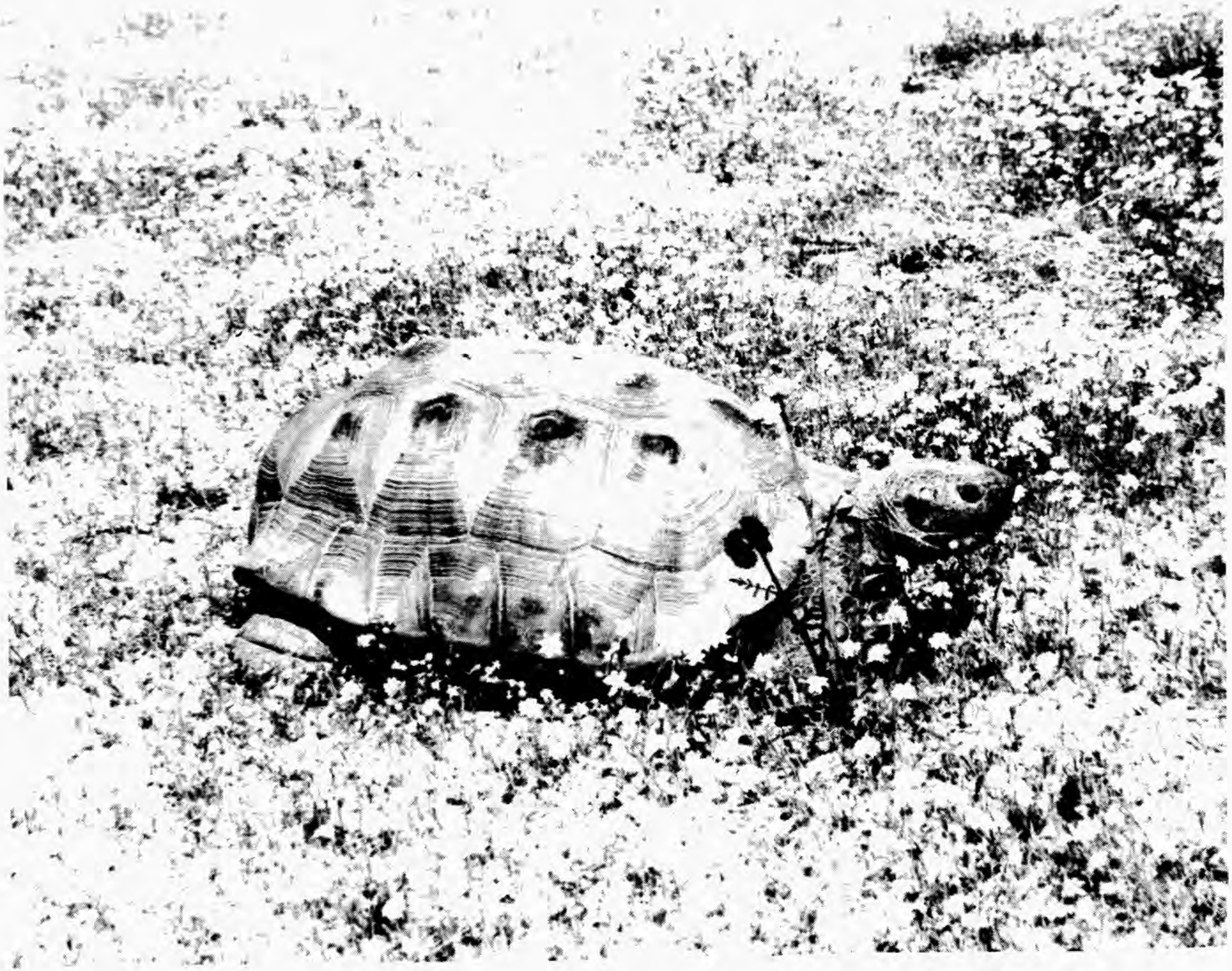
Darrell Wong
Calif. Dept. of Fish and Game
407 W. Line Street
Bishop, CA 93514

Peter Woodman
4414 Eleventh
Riverside, CA 92501

Martha Young
Calif. Turtle and Tortoise Club
Orange County Chapter
10245 La Hacienda, Apt. C
Fountain Valley, CA 92708

Genevieve Zerbst
233 E. 17th Street #23
San Bernardino, CA 92404

*NOTE: Addresses listed may be home addresses and may not reflect an individual's professional affiliation.



Frank Hoover and Dr. Ross Hardy

1981 ANNUAL AWARD: PROFILE OF RECIPIENT, DR. ROSS HARDY

FRANK HOOVER
California Department of Fish and Game
15378 Bird Farm Road
Chino, California 91710

The recipient of this year's Desert Tortoise Council award for outstanding achievements on behalf of the desert tortoise goes to an individual to whom both tortoises and those interested in the welfare of tortoises owe a great deal. His interest in desert tortoises goes back I don't know how many years--at least to the point where my biggest interest was trying to figure out how to get my big toe out of my mouth. His early work resulted in a paper published in the April 1948 edition of Ecological Monographs and concerned the tortoises in the Beaver Dam Slope in Southern Utah. It is still considered the classic desert tortoise study. The tortoises still surviving from that study constitute the oldest marked population of these animals and are very likely the oldest marked population of vertebrates in the United States.

As interesting and important as this work was, it had a more far-reaching benefit than I'm sure any of the researchers would have dreamed of. At our annual symposium in 1978 Jim St. Amant and other Council members were talking to Ken Dodd of the Federal Endangered Species Office about Federal listing of the Beaver Dam Slope population of desert tortoises. Ken felt the listing was possible but mentioned the objection that the population had no distinguishing characteristics. It suddenly struck Jim that most of the tortoises there had been permanently marked in this early study and that the population could be defined by the many marked tortoises still existing there. This was acceptable to Ken, and as you probably know, the Beaver Dam Slope population of desert tortoises was ultimately Federally listed as Threatened. This prior marking of these tortoises therefore was one of the deciding factors in getting this declining population listed.

Many of you have probably figured out that the individual being discussed is Dr. Ross Hardy. It gives me particular pleasure to present this award since I was a student of his at Long Beach State College (now known as California State University, Long Beach). Dr. Hardy moved there back in the college's very earliest years. I remember him telling about how he used to teach in a makeshift classroom in an apartment's garage, as I recall, and the students had to crane their heads around pillars to see the blackboard. Both the college and Dr. Hardy have come a long way since then. His achievements have been many and varied but he always maintained an interest in tortoises.

In token of the Council's appreciation of his interest and achievements, the Desert Tortoise Council Annual Award for 1981 is hereby presented to Dr. Ross Hardy.

THE MX MISSILE PROJECT

MAJOR RON HUFF
U.S. Air Force
Carson City, Nevada

I get asked to speak to all the different groups that have an interest in the different areas the MX is going to touch, and it touches just about every environmental area and socioeconomic area that you can think of. I have been in the Air Force for 15 years and you have a tendency when you've been in an organization that long to forget there's other areas, other disciplines, and other ways of living. And that's been an experience for me.

I hope that the discussion this morning on the MX smissile system will add to your education and I would urge that if there's anything I don't cover, please bring it up and I'll do the best I can to try and answer the questions.

This morning I'm going to talk about the system itself, and I'm going to do it in three different ways. First of all I'm going to discuss the need for the system because if there's not a need, the $33.8 million dollars and the destruction a project like this could bring to a deployment area is not worthwhile. But we will talk about the real need -- why we do need this system. We'll talk about what the system is and bring everybody up to date on where we are today.

I will emphasize right from the beginning that the decisions for deployment of MX -- or if we're going to build it or where we're going to build it -- have by no means been made. They will not be made until later on this year. The Air Force has been directed by the current administration to progress ahead while the decision-makers take a relook at everything that has gone on in the past. They want us to progress ahead as if we were going to go ahead and deploy the system.

First of all, when I talk about the need, we go back a little bit and talk about the stratetic policy of this country. The national strategic policy is based upon what we call a system of deterrants. Deterrants is a concept whereby we maintain the strength through the capabilities of our weapons systems that we are able to absorb a first-strike attack by an aggressor nation and maintain the capability for the survival of those forces and have the capability to inflict an unacceptable level of damage on any potential aggressor nation.

During the course of the talk this morning I'll probably talk about the Soviet Union because they are probably our foremost aggressor at this point. But when we talk about that deterrants, when any aggressor nation knows that they cannot unilaterally disarm us in the first strike, then they are not going to initiate that first attack and therefore nuclear war is averted. When we talk about the policy of deterrants, you have to maintain the type of forces that have the capabilities to provide that survivability and the retalitory capabilities.

We have done that through what we call the nuclear triad -- the strategic nuclear triad. All the triad is, really, is a diversification of forces. We do not put all our eggs in one basket and rely on one particular system to provide for that deterrant quality or that deterrant capability. The triad is based on three different systems: the manned bomber, the submarine-launched ballistic missile, and the land-based intercontinental ballistic missile. The diversification has given us the deterrant capability and has kind of evolved since the late 1950's as the systems were brought on line. It kind of evolved and we have taken a look at it and have seen that really the three different types of system offer us two unique types of capabilities.

First of all we're talking about a system such as the triad where the systems have unique capabilities, unique qualities, and present problems to the Soviet Union in that they are unable to put all their technological effort into defending one system. In other words, they cannot put everybody in technology to try and defend against the land-based ICBM because if they do that then they're only going to take care of that one system and the other two systems are still going to cause some problems. So it prevents them from seeking and obtaining technological breakthroughs that would render our forces useless. In other words, that they could strike us and we would not have a retalitory capability left.

The other unique feature that has kind of evolved out of the triad is that since we do have diversification (there are three separate systems), if the Soviet Union should achieve a technological breakthrough in one particular area, then we are not defenseless at that point. We still have the other two legs of the triad in tact in providing us with the deterrant capability to deter us against an aggressive nation starting a nuclear war.

The kind of situation we have found ourselves in today and one of the reasons the Air Force is advocating that we need a new land-based ICBM, and the MX, which I will describe later, is the system we need to deploy, is that the Soviets have achieved a technological breakthrough in their land-based ICBM. They have spent a considerable amount of money and put a considerable amount of effort into increasing the capabilities of their intercontinental ballistic missiles, whereby at this point in time they have put our ICBMs at a risk that we feel that on a first attack by the Soviet Union, they would have the capability of destroying at least 90% of our ICBMs on the ground. To combat that situation, we re proposing to build the MX, which would give us an increased land-based capability and also would maintain the triad.

We have long known that technology being what it is that sooner or later the Soviets would have the capability to destroy our land-based ICBMs and we have undertaken studies since the early 1960s to try and find out what we could do to maintain the land-based leg of that ICBM. The surprise to us and to our intelligence community is, we weren't expecting them to do it until the mid 1980's so we felt we had plenty of time to get a new system on board and deployed. What the Soviet Union did, though, is during the decade of the 1970's they outspent us by somewhere around $250 billion dollars in national defense. Seventy billion dollars of that ws in their ICBM system.

During that same time period just look at the strategic forces across the board. We're talking about three types of systems: the submarines, the manned bombers, and the ICBM. In the area of submarines we have proposed and are building right now the Trident submarine. We have had some problems with the Trident submarine and currently we do not have any in operation. During the decade of the 1970's the Soviet Union built and deployed two new submarine launch ballistic missiles. In the area of manned bombers, the triad in the

U.S. depends on the AGB52. Now the B52 has been around since the early 1950's. Now in some situations you will find pilots flying the same aircraft today that their fathers flew. So we do not have a current manned bomber in the system developed for deployment. During the decade of the 1970's the Soviets built and deployed the Backfire bomber, which is a controversial bomber, whether or not its intercontinental in degree. We feel that it is. They built it and they currently have another bomber under research and development. In the area of ICBMs which is really what we're talking about today -- it's what MX is -- during the decade of the 1970's we deployed the Minute-man Three missile and in 1976 we shut down the assembly line for Minute-man Three so we currently do not have any new systems being built or deployed. During the 1970's the Soviets still deployed three ICBMs and they currently have four ICBMs under research and develoment and we would expect that they would deploy them later on in the 1980's. The only effort we have currently going on in that field is the MX missile system.

So, as you can see, during the 70's they put a considerable amount of effort in their strategic systems while we were practicing detante. It would appear that looking back on that decade it was a one-sided detante. While we were standing still and not doing anything, they were proceeding ahead. And that is the position we find outselves in today.

As I stated earlier, when we look back in the early 60's we saw that sooner or later technology would be available that a fixed-site system would become vulnerable. In other words, our Minute-man systems are a fixed site. There's one missile in each site. The Soviet Union knows the exact location of each one of our missiles. They have obtained the technology that they needed for their guidance systems and warheads so that they are able to accurately target and destroy those fixed locations. To counter that and to maintain a land-based system we are proposing to the Department of Defense and to the administration that the MX missile system be deployed on land. When we looked at all the different alternatives of deploying a new ICBM we looked at other areas other than the land system. We looked at sea base alternatives, we looked at air and mobile type alternatives in addition to land mobile systems. Altogether we looked at some 35 different altenatives to deploying the new systems.

What we have currently come up with is a concept of deploying a system that achieves survivability through two ways, through deception and mobility. The deception concept is kind of unique in that the survivability factor of MX is dependent on your being able to hide the missile and keep the Soviet Union from knowing the exact location of the missile itself, whereas the fixed site Minute-man may sit vulnerable. If we can come up with a way of deploying a new missile system on land and keeping the Soviet Union or any other aggressive nation from knowing the exact location of it, we feel we can achieve a certain degree of survivability and maintain a retalitory recurrent capability. So MX itself is like a shuttle gate. In other words, you move that system around and you try to hide the system from the Soviet Union so they cannot accurately destroy it.

Now let me go ahead and describe what MX is, the concept we see. It's really two different components. One is the missile itself and the other is the deployment mode and the basic mode. Now the missile itself is an advance over current technology of the Minute-man but it's not that technologically risky for us to go ahead and build it. It's somewhat larger than Minute-man.

It's a 4-stage solid propellant missile. It carries 10 nuclear warheads instead of the 3 that the Minute-man Three carries and the one that the current Minute-man Two, and it is also a merge capability. We can individually target the 10 warheads to 10 different targets in the Soviet Union. We should have that capability right now with the Minute-man Three missile. The main technology advantage of the new missile over the Minute-man is the new guidance system that has been developed for the MX which makes it extremely more accurate than the Minute-man. The real heart of the system is the baseing.

And that, if you have been following the MX at all, is the area where we have the most concern expressed. Because to achieve the deception that we need for survivability, we're talking about taking the system of 200 missiles and deploying them in 4,600 different locations or a possibility of 4,600 locations. We're talking about an extremely large area for deploying the system. The baseing mode I won's discuss right now. I'll just discuss the one that te Air Force has proposed to Congress and the Administration and is the proposed alternative in the draft EIS.

We would like to locate the system in Nevada-Utah. The system itself would cover somewhere around 10,000 square miles of those two states with approximately 70% of the system in Nevada and 30% of it in Utah. As stated, there will be 4,600 different shelters involved in the system. Two hundred missiles will be rotated through those 4,600 centers or shelters in a manner that you cannot accurately detect which one of those shelters the missile is in. We would have two Air Force bases associated with the deployment area. One Air Force base would be built in the Coyote Springs area which is in Nevada 60 miles north of Las Vegas. There other would be built in Utah, and currently we are looking in the Milford, Utah area. There would be approximately 9,000 miles of new road built for the new system. Fifteen hundred of that would be paved road, the other 7,500 miles of road would be compacted gravel or other natural surface area roads. The system would require withdrawal of approxiimately 25 square nautical miles of land from public use. As I stated earlier, we're going to put the system over approximately 10,000 square miles. All of that area would be open to the public except for the specific locations of the shelters and the main operating bases.

To get down to the basic component of the system, each one of the shelters where a missile could possibly be locatd would be a 2-1/2-acre site. It would be fenced off by barbed wire fence. There would be a security system inside that 2-1/2-acre shelter area which would detect any unauthorized intruders and thereby we would have to respond with security forces if anybody ws on the site. And that allows us to secure just that single area and let the other area around the shelter be open to public use such as mining, grazing and whatever activity is going on right now. There would be 23 of those shelters associated with ech missile. Those 23 together we call a cluster, and you would have one missile for every 23 shelters. That missile would be rotated around once or twice a year throughout that cluster. So you have the possibility of it being in one of 23 different locations.

Now the trick, and I guess the heart of the system, is being able to move that missile around that cluster in such a manner that if you were standing right next to it you would not be able to tell which shelter that missile was being put and which shelter the dummy missile was being put. The whole basis of the system depends on deception. You have to hide that missile.

If they know the exact location of all 200, they can avoid the other 4,400 targets and go right after the 200 and destroy those 200 MX missiles and we're left in the same situation we are right now. So the heart of it is being able to adequately deploy that missile in a manner that they cannot derive the exact location.

What we're doing right now is going through all the different tests of looking at missiles, looking at all the support equipment it takes to run a missile and see what kind of electronic signatures it gives off, what kind of ink signatures it gives off and trying to duplicate the exact signatures of the missile itself in every one of the 22 other shelters in that specific cluster. To date we have been able to successfully do that so we feel encouraged that we will not have any problems in that area of trying to hide the system.

When we talk about the 4,600 different shelters associated with the MX systems, the people in Nevada and Utah always say it is 4,600 different targets that the Soviets are going to aim for. What that does is gives them 4,600 targets that they have to aim for to destroy 2,000 of our weapons. Given the amount of weapons that they currently have in their inventory and are projected to have in their inventory, we do not feel that they would take the risk of utilizing a significant number of their weapons (estimated 1/2) to destroy 2,000 of ours. And that itself is going to be a deterrant factor. They would not take the risk of utilizing that many weapons to go after only 2,000 of ours. So the deterrant is there not only in the number of weapons that they have to expend to destroy a limited number of ours but also in the fact that a considerable number of ours will indeed survive even if they went on a 1 on 1 attack and we would maintain the retalitory capabilities to inflict an unacceptable level of damage upon them.

When we looked at the size of the system we naturally looked at where we wanted to deploy the MX. We're going to build a system that's going to take 10,000-15,000 square miles, and that's what we looked at initially; where in the U.S. do we deploy the system? We set up several different criteria. One of them was constructability; we had to have at least 50 feet of water, 50 to bedrock to construct the system. Because the system is sensitive to detection, we wanted to maintain at least 200 miles from any foreign border or coastal area where a foreign country could set up sensors and maybe try to detect the exact location of the missile itself. There were several other environmental and socioeconomic criteria that were also set up.

What we came up with was six geotechnically suitable areas within the U.S. that we felt we could adequately deploy the system. It was kind of in a horseshoe area. It ran from the northern portion of Nevada down through Nevada into the Mojave Desert area in California, down through southern Arizona in the Yuma area, up through Texas, New Mexico, and into Colorado and Wyoming-Nebraska area. We applied the more significant operational criteria on it and we narrowed it down to two choices of where we thought we could deploy the system and Nevada-Utah became the Number one choice for deployment of MX with Texas-New Mexico the alternative location. In the Environmental Impact Statement, we have also included an option of putting half the system in Nevada-Utah and half the system in Texas-New Mexico. The drawback to that, as we stated in a report to Congress, is it costs about $3-1/2 billion more to split the system up because of duplication of facilities. And in the Texas-New Mexico area there is a considerable amount of private land that we would have to purchase whereas in Nevada-Utah about 99% of the system will be put on federal land.

When we looked at that system and said we want to put it in Nevada-Utah we immediately recognized several problems in the environmental area and socio-economic area. During the course of construction in a peak year we're talking about employing 90,000 people. Construction workers, their dependents, indirect employment and other people are going to naturally come along with a project of this size. We're talking about putting 90,000 people into the employment area in both Nevada and Utah, and when you talk about the population of the current counties op there -- they have a population together of somewhere around 25,000 people right now -- you're talking about severe impacts on their way of life, on the economy of the area, on the services of the area, the scools, fire department, law enforcement, and just about every other area you want to think about that goes along with the normal services of the community combined. If you're not familiar with that part of the country, let me tell you that if you live in a community with 5 or 600 people out there it's considered a pretty large town. They just cannot stand the types of growth that we're talking about bringing in there.

The only real area of economic affluence that has the capability to absorb this type of growth is the Las Vegas Clark County area and we're trying to determine the best way to deploy the system to get as much of the impact of the system down into Clark County, down to the Las Vegas area and keep it away from the upper rural areas. Because of that, until decisions are made as to what we can actually do with the system, the efforts that we have going on right now are considerable in both the planning for those services and the environmental areas.

We realize that in addition to socioeconomic impacts there's going to be a significant environmental impact. The desert tortoise that you're all interested in is going to be impacted in the Coyote Springs main operating base area. That is according to the Fish and Wildlife people where we got the data to do our environmental impact statement as a primary habitat area for the desert tortoise. And we're going to propose to put a base just about right in the center of the area so we need to begin looking at how we can minimize the type of impacts to the desert tortoise.

Water in Nevada-Utah is a significant problem. In a state where year after year they've wondered whether they're going to have enough water to get through for living, for livestock grazing and other activity that goes on here, there's concern there about the Air Force coming in and utlizing the existing water that they have -- taking it away from the current uses for the construction of the facilities.

In the water area we've been able to work with the State water people. We have made the commitment that we will abide by State water law and if the State says there's not enough water there, they're not going to issue us a permit and we're not going to get the water. We have done a considerable amount of exploration on our own in water to find additional water sources. And we've been able to come up with what we feel is more than the amount of water we need to construct the system. And after we develop those sources for construction we will be able to turn that additional water back over to the Stae and the State would have more water at the end of the index than they do now.

The mining people are concerned that they're not going to be able to carry on with their activities. Although we see that any additional activities that are going on right now can exist with MX in those areas outside of the fence, it's hard for them to udnerstand that we can secure a system and still allow that type of activity. We're looking at ways right now, working with the mining people, of assuring them that they can continue their operation. One of the things they're finding over there is there may be an abundance of strategic metals which we in the Department of Defense need to develop these systems, and that we're running out of and the sources in 3rd world countries like South America and South Africa, are becoming more and more unstable and we don't want to put a dependence upon that. We're interested in keeping the mining interests open.

Grazing is also another problem in several of the different environmental areas. Right now we're talking to the experts in those areas to try to understand what we can do to accmmodate both systems, and get the views of the experts that we can incorporate in the deployment of this system so that when we do put it in we know that we can't put it in without an impact. There's got to be an impact. There's going to be an adverse impact. Our goal is to try to talk to the people that live in the area that are vitally concerned with those areas and get their ideas so we can minimize the impact to the maximum extent possible when we put that system in.

The status of the system right now, as I mentioned in the beginning, is that we do not have a decision on whether we're going to deploy the system or not. That decision will probably be made in August at the completion of the EIS process. Currently we are in the middle of that. We will start public hearings in Nevada-Utah, Texas-New Mexico next week. The comment period for the EIS will terminate, at which time we'll take all the comments on the Draft EIS, respond to the ones of subsitive nature, include that data in the final EIS, and that document will be used by the President to make two decisions. That will be first of all, where to deploy the system and within that area of deployment where the two operating bases will be. We expect that decision to be made sometime in August. At that point we will begin to get a decision to go ahead and do it. We will begin range land withdrawal procedures through the BLM, and currently we are scheduled to begin construction on the system about a year from today. In spring of 1982 we hope to have the main operating base built and the first 10 missiles operational by 1986, with the entire system completed by late 1989.

That's basically the system. I will remind you that the system itself is going to cause problems. We realize that and it's through talking to people like you, getting your input into the Air Force in what you think we need to do and sitting down and talking to us, that we're going to be able to get the system put in or say we're going to get it put in to everybody's satisfaction but we will address as many problems as we can and try to accommodate as many problems. The Air Force realizes that systems like this cause significant problems and I guess if it was up to the majority of people you talked to in the Service as well as everybody else, we would just as soon not have to do this. It's a system that we feel we need for national defense. The Country needs it because of the Soviet threat. The alternative to not building an MX or not building a system such as MX is to not challenge the Soviet Union in their aggression and let them proceed on down the road and let us be stuck with the consequences. In our responsibility as the Air Force and under our charter in the strategic area, we don't feel that is an option that this Country can afford to take.

DESERT TORTOISE STATUS REPORT
STATE OF ARIZONA - 1981

GEORGE PAT SHEPPARD
Bureau of Land Management
Arizona Strip District
196 E. Tabernacle
St. George, Utah 84770

There are four Bureau of Land Management (BLM) districts in Arizona and each is responsible for managing desert tortoise habitat:

1. Safford District has the least amount of habitat, with occasional tortoise sightings south of Dripping Springs Mountains. Sightings have also been made near Winkleman, Arizona, and south along the San Pedro drainage. This is probably the eastern extreme of desert tortoises in Arizona.

2. Phoenix District has the greatest extent of range for desert tortoises. The habitat extends southward into Mexico, east toward the San Pedro, northwestward following the Upper Sonoran Life Zones, above Black Canyon City, south of Prescott, running north to the Colorado River along the bench of the Grand Wash Cliffs and in the foothills west to the river.

   Betty Burge has done extensive inventory work, running transects in several locations throughout the State. Paul Schneider was contracted by BLM in 1980 to conduct studies in several locations in central Arizona. He will be presenting his findings at these meetings.

3. Yuma District has tortoises located in the foothills east of the Colorado River and also on the creosote bajadas and the desert drainages. Yuma District is responsible for the management of the areas impacted by the Parker 400 race. It is run when there is little or no tortoise activity, but concern for the habitat exists. Coordination is conducted with various agencies about these concerns.

4. The Arizona Strip District, located in the extreme northwest corner of the State, has several locations where desert tortoises can be found; Beaver Dam Slope, Virgin Mountain slopes, and all of the lower deserts south of the Virgin Mountains and west of the Grand Wash Cliffs. These areas are continuous with tortoise habitats in Utah and Nevada. Resource management decisions will not be made in these areas without total consideration given to desert tortoise requirements.

With respect to grazing, prior to implementation of allotment management plans, transects are conducted in the respective area to determine tortoise sign frequency from which densities are projected. In areas of moderate-high density, protection of tortoise habitat will be accomplished by three methods:

a. Fencing

b. Adjusting grazing systems

c. Placement of livestock waters 2 miles or more from these critical areas.

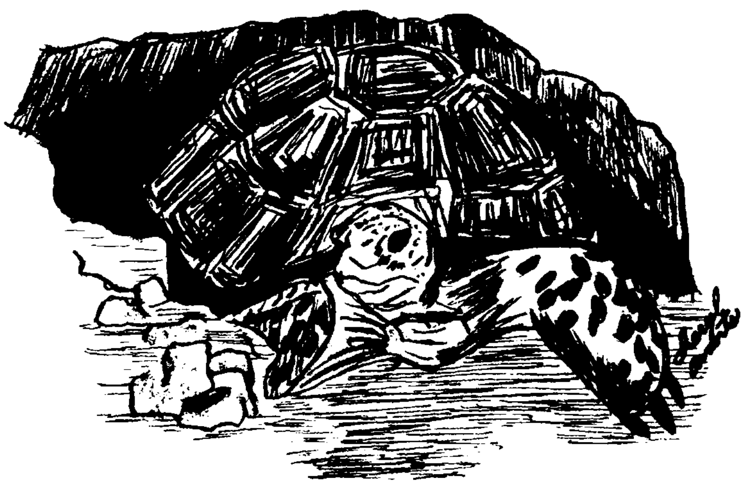
The Shivwits Resource Area has been designated foroff-road vehicle ORV use in the Federal Register, effective 26 September 1980. Beaver Dam Slope and the Virgin Mountain Slopes are restricted to designated roads. The remaining low desert areas are designated to limit ORV's to existing roads.

Our modified fire suppression plans should reduce impacts of mechanical suppression techniques.

On Beaver Dam Slope the studies are now in the 5th year. Research in this area will hopefully continue to improve the information on livestock-tortoise competition. These data are presented elsewhere in these proceedings.

As in the other three districts, we must continue to be mindful of continuing impacts to tortoise habitat. Seismic exploration has increased throughout the State. Pipelines, catchments, telephone lines, and mining operations continue in tortoise habitat. The greatest impact to tortoise habitat on the Arizona Strip is just over the horizon. The Allen-Warner coal slurry line and 345-kv will cut directly across Beaver Dam Slope tortoise area for about 10 miles.

Needless to say, it will take extremely careful management of our public lands to improve conditions for tortoise populations.



DESERT TORTOISE POPULATION OF THE BEAVER DAM SLOPE IN NORTHWESTERN ARIZONA

GEORGE PAT SHEPPARD
Bureau of Land Management
Arizona Strip District
196 E. Tabernacle
St. George, Utah 84770

Data was collected over a 4-year period, 1977-1980, covering a variety of aspects of desert tortoise, *Gopherus agassizi*, ecology in northwestern Arizona. A study was designed for the first 2 years to determine densities, age and sex structure, feeding habits, reproduction, and home range. Dietary overlap of desert tortoises and livestock was also analyzed (Hohman and Ohmart 1980). During the following 2 years of study, habitat and population conditions continued to be monitored.

This paper is a summarization of the data collected from all 4 years. Since the original findings were reported by Hohman and Ohmart (1980) refinement of field techniques and an increased sample size has furthered the understanding of conditions as they exist on Beaver Dam Slope in Arizona. I must reemphasize that this paper is an evaluation of the existing habitat and population conditions. Therefore, I have avoided the effects of livestock grazing as the findings are inconclusive. Populations of a long-lived animal like the desert tortoise are difficult to evaluate from only 4 years of field work. However, we now have baseline data from which the scientific community can continue to monitor as to the trend of this population(s).

Data from 2 study sites revealed marked animals totalling 30/km^2 (77/mi^2) and 16/km^2 (41/mi^2). There was a strong correlation with precipitation and forage production of the tortoise's primary food items, plantain, *Plantago insularis*, and filaree, *Erodium cicutarium*. Dietary overlap of tortoises with cattle was highest in the April grazing period each year. after the annual forage cures in May, cattle shifted dramatically to perennial species such as winterfat, *Ceratoides lanata*, for forage. An exception was observed in May 1978 when cattle diet was 45% filaree and 45% Mediterranean grass, *Schismus* sp.

Abiotic factors and range management may have an equal influence on habitat and population conditions of the desert tortoise.

INTRODUCTION

The desert tortoise, *G. agassizi*, is a long-lived reptile inhabiting communities in the lower Sonoran and Mojave deserts. Because tortoises are long-lived, slow-moving, and possess low yearly recruitment rates (Berry 1978), populations can be drastically affected by actions that alter their environment. Desert tortoises are also dependent on annual forbs and flowers for meeting nutritional needs (Berry 1978). The effect of livestock grazing on tortoises has received attention in recent years by several authors (Berry 1978; Hohman and Ohmart 1980; Turner *et al.* 1980: and is believed to have been a major contributor to the decline of this turtle in the West. Studies on various tortoise populations (Coombs 1977; Burge and Bradley 1978; Woodbury and Hardy 1978) indicated declining trends.

This paper addresses tortoise population and habitat conditions from data collected over a 4-year period, 1977-1980. With relatively little or no information existing concerning this tortoise population, the data presented here are essential to monitor the trend of conditions with future studies. This is not to say that assessment of conditions cannot be made at the present. On the contrary, by using sound ecological principles and life history information, management recommendations and conclusions can and must be drawn.

METHODS

The Beaver Dam Slope lies in the western foothills of the Beaver Dam Mountains of northwest Arizona and southwest Utah. The total area of 233 km^2 (90 mi^2) is bounded by Beaver Dam Wash to the west, the Beaver Dam Mountains to the north and east, and the Virgin River to the south. Less than 50% of the slope is in Arizona (104 km^2 or 40 mi^2). The area is a broad alluvial fan ranging in elevation from 823 m (2,700 ft) at the Arizona-Utah border to 549 m (1,000 ft) at the Virgin River.

Two areas with the highest frequency of tortoise sign were determined from preliminary transects (Burge 1979; Hohman and Ohmart 1980. These areas lie in the elevational extremes of Beaver Dam Slope, Arizona (Figure 1) and were the focal point of this study. The control site is in Section 27 of Township 41 North, Range 15 West, Gila and Salt River Base Meridian. The exclosure site is in Section 34 and the west edge of Section 35, Township 42 North, Range 15 West. This site, slightly less than 2.5 km^2 (1 mi^2), was fenced to exclude livestock.

Judy Hohman, a master's candidate from Arizona State University, Tempe, Arizona, conducted the first 2 years of the study (Hohman and Ohmart 1980). I conducted the final 2 years. Field efforts were not consistent in relation to time of day, length of time spent per day, days per month, or areas of concentration within each study site (Table 1). Hohman and I; however, used similar enough field techniques to allow data comparison.

Identification numbers were assigned to each captured tortoise and applied in two ways. Epoxied tags were fixed to vertebra 5 for rapid field identification. Adult, subadult, and immature animals also had permanent marks notched in the marginal scutes, using a file. Juvenile and hatchling tortoises were not notched because delayed ossificationof the shell makes them susceptible to injury. The tortoise number and standard shell measurements (Berry, unpubl. data) were then recorded on data sheets. Sex was determined using four characteristics: gular forks, shape of plastron, development of chin glands, and shape of tail. These were displayed primarily in adult and subadult size classes. If a younger animal showed signs of a developing sexual

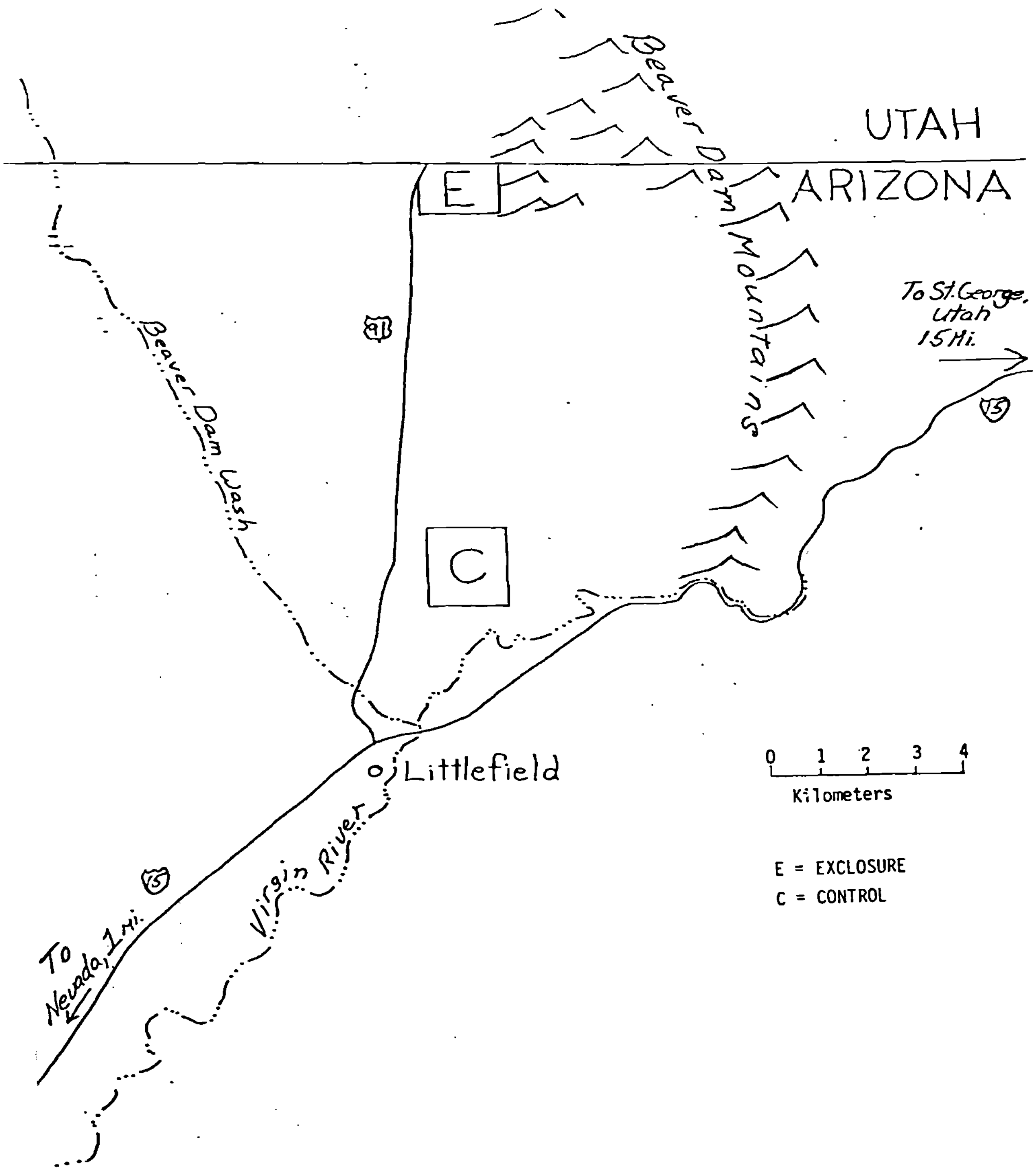


FIGURE 1. Desert tortoise study areas on Beaver Dam Slope, Arizona

TABLE 1. Number of Field Days on Beaver Dam Slope, Arizona, 1977-1980.

	Number of Field Days Per Year			
Month	1977	1978	1979	1980
February	3	1	1	1
March	5	0	0	1
April	15	10	1	5
May	9	16	5	11
June	21	20	5	9
July	7	19	5	5
August	13	19	7	1
September	2	0	1	5
October	2	1	3	1
November	0	1	0	1
December	2	0	1	0
Totals	79	87	29	40

characteristics, this fact was recorded but not applied to sex ratios of the population. Exceptions to this occurred when growth rates of recaptures allowed for positive sex determination (Tables 2, 3, and 4). Tortoises were also sorted into size classes (Berry 1980).

Radio-location of adult tortoises was accomplished using the same methods and equipment used by Schwartzmann and Ohmart (1976). Efforts were made weekly to locate radio-tagged tortoises during their active season with a few exceptions (Table 1) and monthly in the winter to note any changes. Location of nonradioed tortoises also provided information on individual home ranges; home ranges were mapped with three or more captures. Locations were plotted using the minimum polygon method (Barhour *et al.* 1969), and the aerial distance determined by compensating polar planimeter.

Tortoise and cattle fecal samples were collected for monthly and annual dietary analysis and percent dietary overlap.

Eleven line transects were established randomly in the control plot and 14 in the exclosure. Transects were located so adequately sample vegetation types in both washes and flats. The technique was the modified line intercept (Canfield 1941) and provided information on perennial plant species composition, relative cover, and density. Above-ground biomass of annual forbs and grasses was measured by the double sample technique (Wilm *et al.* 1944). Sixteen mini-plots (20 cm X 100 cm frame) were used per transect in 1977-1978 but reduced to 10 plots for 1979-1980. Transects were run each month for several in 1977-1978 and once per year in 1979-1980 during the late May-early June period.

TABLE 2. Size Class Distribution and Sex Ratio of Desert Tortoises on Beaver Dam Slope, Arizona, 1977-1980*

	1977	1978	1979	1980
	(M) - (F)	(M) - (F)	(M) - (F)	(M) - (F)
Juvenile I (MCL $\leq$60 mm)	1	1	1	0
Juvenile II (MCL 60-100 mm)	6	1	5	5
Immature I (MCL 101-140 mm)	4 (1)	7	1	6
Immature II (MCL 141-179 mm)	(1) 6 (1)	(1) 6	5 (3)	(1) 4 (3)
Subadult (MCL 180-207 mm)	(2) 8 (1)	(2) 6	(1) 3 (1)	(1) 4 (2)
Adult I (MCL 208-240 mm)	(5) 7 (2)	(6)10 (4)	2 (2)	(5)10 (5)
Adult II (MCL $\geq$241 mm)	(4) 5 (1)	(4) 5 (1)	(3) 3	(7) 8 (1)
Total	37	36	20	37
Sex ratio	12:6	13:5	4:6	14:11

* Numbers include 12 peripheral animals found adjacent to the study areas

TABLE 3. Size Class Distribution and Sex Ratio of Desert Tortoises in Control Site, Beaver Dam Slope, Arizona, 1977-1980

	1977	1978	1979	1980
	(M) - (F)	(M) - (F)	(M) - (F)	(M) - (F)
Juvenile I (MCL <60 mm)	1	1	-	-
Juvenile II (MCL 60-100 mm)	5	-	5	4
Immature I (MCL 101-140 mm)	2	6	1	3
Immature II (MCL 141-179 mm)	3	(1) 4	3 (2)	-
Subadult	(1) 5 (1)	3	(1) 3 (1)	1 (1)
Adult I (MCL 208-240 mm)	(4) 5 (1)	(4) 7 (3)	2 (2)	(1) 2 (1)
Adult II MCL >241 mm)	(2) 3(1)	(3) 3	(2) 2	(2) 3 (1)
Total	24	24	16	13
Sex ratio	7:3	8:3	3:5	3:3

TABLE 4. Size Class Distribution and Sex Ratio of Desert Tortoises in Exclosure Site, Beaver Dam Slope, Arizona, 1977-1980

	1977	1978	1979	1980
	(M) - (F)	(M) - (F)	(M) - (F)	(M) - (F)
Juvenile I (MCL <60 mm)	-	-	1	-
Juvenile II (MCL 60-100 mm)	-	1	-	1
Immature I (MCL 101-140 mm)	1 (1)	-	-	3
Immature II (MCL 141-179 mm)	(1) 2 (1)	3	2 (1)	(1) 3 (2)
Subadult (MCL 180-207 mm)	1	(1) 1	-	(1) 2 (1)
Adult I (MCL 208-240 mm)	(1) 1	(3) 5 (1)	-	(2) 6 (4)
Adult II (MCL >241 mm)	(2) 2	(2) 2	-	(4) 4
Total	7	12	3	19
Sex ratio	4:2	6:1	0:1	8:7

RESULTS

Population Condition

From 1977 through 1980, a total of 130 tortoises were marked on Beaver Dam Slope, Arizona. These animals were primarily from the two study sites (Table 2). Twelve animals were located outside the study areas (Table 2) but were not included in the actual figures for the control and exclosure (Tables 3 and 4). The number of marked animals varied between the two study sites markedly; $16/km^2$ $(41/mi^2)$ while the control had $30/km^2$ $(77/mi^2)$.

The number of animals found throughout the course of the study in all size classes remained stable. No significant difference existed between the years within any given size class (one-way ANOVA, $F_{3,24} = 1.4634$, $P < .05$). Furthermore, the number of animals in each size class was not significantly different from other classes regardless of the year (one-way ANOVA, $F_{6,21} = 2.20$, $P < .05$). When the relationship between age class and years was tested, no significant correlation was found (two-way ANOVA, $F_{18,28} = 0.70819$, $P < .05$). It was assumed that no significant changes were occurring with this population and that numbers remained stable. Through all 4 years and all size classes, there was no significant difference from the expected 1:1 sex ratio ($X^2 = 3.294$, $.05 < P < 0.1$).

Habitat Condition

Creosote-bursage was the predominant vegetation association in both study areas. The exclosure had a higher diversity of perennial plant species. Nine species were found in the control and 16 were found in the exclosure. The higher elevation, soil composition, and more extensive drainages dissecting the site could contribute to this increased species composition. Bursage, *Ambrosia dumosa*, burrobrush, *Hymenoclea salsola*, and bladder-sage, *Salazaria mexicana*, were the dominant species in the exclosure washes. In the control, winterfat was associated with creosote-bursage.

Production of the desert tortoises' primary food item, plantain, at the control site, was low during May 1977 (19 kg/ha) but climbed the following year to an abundant level (288 kg/ha). Above-ground biomass of plantain decreased in 1979 (95 kg/ha) but increased once again in 1980 (146 kg/ha) in the exclosure. Substantial increases in production were recorded also for the annual grasses, Mediterranean grass and foxtail brome, *Bromus rubens*. Both grasses peaked at their highest levels during 1979, particularly foxtail brome in the exclosure (1,825 kg/ha). This high level of production appeared to be a delayed response to the unusually high annual rainfall in 1978 (36.37 cm). Stylocline, *Stylocline micropoides*, a selected food item of tortoises when available, was abundant in 1978 (220 kg/ha for May) and was present in the tortoise diet only during that year, 6.4% in April and 13.3% in May. Other plant species showing intermittent periods of high use were filaree and milk-vetch, *Astragalus* sp. In 1979, Indian ricegrass, *Oryzopsis hymenoides*, showed heavy use in July (23.93%), August (11.65%), and September (53.54%). Galleta, *Hilaria rigida*, was found in the diet only during October 1979 (49.75%). Winterfat was the preferred shrub in the control showing late summer consumption. Ratany, *Krameria parvifolia*, the preferred exclosure shrub, showed heavy spring use in May 1979 (95.42%). Plantain was the overall preferred food item from the dietary analysis. The consumption of plantain

Dietary Overlap

Dietary overlap data were provided for 1977, 1978, and 1980 (Appendices A-F). Plantain overlap was higher in April than May for all years. Tortoise and cattle use of winterfat was at the highest level in May 1977 when annual production was low during drought. In 1980, cattle shifted from high use of foxtail brome to almost exclusive dependence on winterfat in May.

Total percent dietary overlap for all species and years revealed food preferences were most similar during April, reaching a high of 59.9% in April 1978. Plantain, filaree, and Mediterranean grass were the three primary plant species contributing to the high overlap. Filaree and Mediterranean grasses made up 90% of the cattle diet in May 1978. Overlap was low in 1980 dropping to a negligible amount of 2% in May.

These data revealed preference of annual forbs and grasses by cattle in the early spring. After the annuals cured (date varies annually with moisture, approximately 1 May), cattle shifted dramatically to shrubs. With frequent and irregular periods of low precipitation, annual forage production was low, tortoises shifted to alternate food items. This shift was apparent each year in late summer months, when tortoise use of perennial shrubs and grasses increased significantly, as noted above.

Production of foxtail brome and Mediterranean grass increased in the 2 years following the heavy rains of 1978, probably due to the increased seed crop preceeding theinitial moist year and/or the timing of winter-spring rainfall with respect to seed germination. Unfortunately, cattle did not graze in the control site in 1979 when the largest production was realized. The following year remained high in production of these annual grasses, resulting in 39.16% relative density of foxtail brome in the diet of cattle for April 1980. These plants were of varying importance for both cattle and tortoises. During 1977 when plantain production was lowest, tortoise use of Mediterranean grass and foxtail brome was highest. The food item preference reversed when plantain production increased in the following years. Dietary overlap of this annual forb was highest when the crop of annual grasses was low in 1977. Cattle shifted to higher use of Mediterranean grass and foxtail brome when the production of grasses increased in 1978-1980, thereby reducing dietary overlap somewhat, particularly in 1980. Combined dietary overlap was highest in April 1978 as a result of the mutual use of plantain and filaree. Forage biomass (kg/ha) of plantain was significantly correlated (control: $r = .955$, $P < .05$, exclosure: $r = .984$, $P < .05$) with the amount of precipitation for both study sites. Filaree correlation with rainfall was also statistically significant ($r = .935$, $P < .10$) in the control study site.

Home Range

Home range values (Appendix G and H) fluctuated for both males and females as the forage biomass varied each year. Male tortoise home range had a high correlation with the production of both plantain ($r = .947$, $P < .10$) and filaree ($r = .983$, $P < .05$). Female tortoise home range similarly had a significant correlation with the production of plantain ($r = .932$, $P < .10$) and filaree ($r = .985$, $P < .05$). The correlation coefficient (r) is high enough in all four tests to expect the relationship of increased desert tortoise home range with increased forage biomass of these two key species.

DISCUSSION

Although dietary overlap data exist, the degree of competition remains a problem. The question remains: what are tolerable levels of utilization by cattle in the low desert areas before the availability of forage for tortoises drops too low to sustain a healthy, reproducing population? A higher percent overlap was found during drought conditions, which may be a critical period for tortoises (Berry 1978) and also a period when most signs of mortality have been recorded (Hohman and Ohmart 1980).

Annual grasses could be a buffer, reducing dietary overlap, but the role of annual grasses may only be of benefit when forage production is high. My data support this hypothesis and suggest that competition may limit the success of tortoises on the slope. Frequent use of annual forbs and/or grasses by cattle occurred each year in April. April is the time of emergence and initial activity of tortoises, a time when physiological responses affecting growth and reproduction are most likely influenced.

Home range and forage biomass production data were found to be highly correlated. As a K-selected species (low birthrate, low mortality, low recruitment, and low population turnover), this type of strategy would tend to increase an individual's personal resource success (the "K" strategist: MacArthur and Wilson 1967; Pianka 1970, 1972; Hairston, *et al.* 1970). This strategy could also increase the chance of encounters that could theoretically increase reporoduction. The home range data and the number of sexually mature females per study site (control, n=9; exclosure, n=5) may be an important factor to consider when reproductive potential is analyzed. Unless increases occur in the number of females represented in the adult age class, reproduction could remain negligible.

In summary, forage vailability affects both the physiological and behavioral response of desert tortoises. Consider the following conditions:

INFLUENCING FACTORS--------->	FORAGE AVAILABILITY------->	BEHAVIORAL RESPONSE
High winter-spring precipitation		Increased tortoise activity
Reduced grazing competition		Increased male/female encounters
No surface disturbance	ABUNDANT	Increased reproduction
Fire (long-term)		
	VS.	
Drought		Decreased activity
Increased grazing competition	REDUCED	Fewer male/female encounters
ORV destruction		Decreased reproduction
Fire (short-term)		

The continuing of adverse factors over several years could reduce the numer of tortoises through loss of habitat. Furthermore, the combining of these factors with other human disturbances, such as collecting, road construction, and off-road vehicle damage to habitat and animals, could reduce a population to below recoverable levels. This situation exists on Beaver Dam Slope. Overgrazing by sheep and cattle in the late 1800's persisted for an extended period of time until at least 1950. Overgrazing, combined with drought, fire, heavy collection pressure, and road kills, has impacted this population over the past century. A long-lived, K-selected species like the desert tortoise, cannot recover quickly, if at all, from these adverse impacts. Extremely careful management and protection will be needed to improve the health of this population.

CONCLUSION

Should grazing continue in tortoise habitat after 1 April, particularly in drought years? This resource conflict is not exclusively limited to grazing competition. Trampling of burrows and creosotebush mounds disturb the protective cover sites (Sheppard 1981 field notes). Egg shell remains were found in 1981 at the entrance to three creosote burrows in the control site. Cattle grazing in and around these mounds, where most forage grows, has adversely impacted existing or potential tortoise habitat. Eliminating cattle grazing after 1 April would remedy this problem. An alternative recommendation to reduce this impact would be a "rest-rotation" system within an allotment, using two, three, or four pastures, resting one completely for a full year.

I have tried to carefully assess habitat conditions and the response of tortoises to these conditions. Any further interpretation of the data presented here on the Beaver Dam Slope population would be speculative. The continuing destruction of desert tortoise habitat throughout its range made necessary some discussion of historic and present disturbances to the habitat to appreciate the factors working against the health of this species. The population characteristics of age structure, sex ratio, densities, and natality are interrelated and the health of the Beaver Dam Slope tortoises in Arizona depend on the quality of existing habitat. Precipitation was found to be of extreme importance in influencing tortoise survival. Therefore, abiotic factors must not be separated from management decisions. Spatial and temporal distribution of tortoise food resources affecting activity cycles equaly depend on habitat management. The climatic, physical, and biological environment all influence the food resource distribution and abundance. Land managers are responsible for the biological environment: the habitat.

ACKNOWLEDGEMENTS

J. Hohman, through her pioneering efforts during the first 2 years, paved the way for the completion of this study.

I would like to extend my deepest appreciation to D. Schaffer for the statistical assistance provided for the analysis of the data. Critical reviews by B. Jones, F. Turner, K. Berry, and K. McGinty were instrumental, providing valuable comments in review of the draft manuscript. J. Morgart, N. Middlebrook, and P. Schneider also made numerous suggestions on the manuscript.

T. Gardner provided the typing that was essential for completion of the project. Discussions with R. Ray and B. Booker during various phases of the study were valuable. I am grateful to the Arizona Strip District, Bureau of Land Management, for providing the opportunity to conduct this project and for B. Templeton's and K. Moore's continuing support.

REFERENCES

Barbarou, R. W., M. J. Harvey, and J. W. Hardin. 1969. Home range movements and activity of of the eastern worn snake, .
Ecology 50(3):470-476.

Berry, K. H. 1978. Livestock grazing and the desert tortoise. Trans. of the 43rd North American Wildlife and Natural Resource Conference. pp. 505-519.

--------. 1980. State Report-California, Pages 61 to 67 *in* K. Hashagen, ed. Proceedings of the 1980 Symposium, Desert Tortoise Council, Riverside, California.

Burge, B. L., and W. G. Bradley. 1976. Population density, structure, and feeding habits of the desert tortoise, *Gopherus agassizi*, in the low desert study area in southern Nevada. Pages 51-75 *in* N. Engberg, S. Allan and R. Young, eds. Proceedings of the 1976 Symposium, Desert Tortoise Council, Las Vegas, Nevada.

Burge, B. 1979. A survey of the present distribution of the desert tortoise, *Gopherus agassizi*, in Arizona. U.S. Dept. of the Interior, Bureau of Land Management. Contract number YA-572-CT8=108. 70 pp.

Canfield, R. 1941. Application of the line intercept method in sampling range vegetation. J. Forestry 39:388-394.

Combs, E. M. 1977. Wildlife observations of the hot desert region, Washington County, Utah, with emphasis on reptilian species and their habitat in relation to livestock grazing. Report to U.S. Dept. of Interior, Bureau of Land Management, Cedar City, Utah. From Utah Div. of Wildl. Resour.

Hariston, N. G., D. W. Tinkle, and H. M. Wilbur. 1970. Natural selection and the parameters of population growth. J. Wildlife Management, 34:681-690.

Hardy, R. 1945. The influence of types of soil upon the local distribution of some mammals in southwestern Utah. Ecol. Monogr. 15:71-108.

Hohman, J., and R. D. Ohmart. 1980. Ecology of the desert tortoise, *Gopherus agassizi*, on the Beaver Dam Slope, Arizona. U.S. Dept. of the Interior. Bureau of Land Management. YA-510-PH7-54. 46 pp.

MacArthur, R. H., and E. O. Wilson. 1967. The theory of island biogeography. Princeton, N.J., Princeton Univ. Press. 203 pp.

Pianka, E. R. 1970. On r and k selection. Amer. Natur., 104:592-597.

________. 1972. r and k selection or b and d selection? Amer. Natur., 106:581-588.

Turner, F. B., P. A. Medica, and C. L. Lyons. 1981. A comparison of populations of the desert tortoise, *Gopherus agassizii*, in grazed and ungrazed areas in Ivanpah Valley, California. Report to U.S. Department of Interior, Bureau of Land Management on Contract No. SS00012/UCLA, CA 95-1A1-1211.

Schwartzmann, J. L., and R. D. Ohmart. 1976. Radio-locating free-ranging desert tortoises, *Gopherus agassizii*: Maximizing transmitter range and longevity. Pages 577-578 C. G. Jackson, Jr. and M. Trotter, eds. The Desert Tortoise Council: Proceedings of the 1977 symposium, March 24-26; Las Vegas, Nevada. Available from: Desert Tortoise Council, 5319 Cerritos Avenue, Long Beach, California 90805.

Wilm, H. F., D. F. Costello, and G. E. Klipple. 1944. Estimating forage yield by the double-sampling method. J. Am. Soc. Agron., 36:194-203.
Woodbury, A. M., and R. Hardy. 1948. Studies of the desert tortoise, *Gopherus agassizii*. Ecol. Monogr., 18:145-200.

APPENDIX A. Percent Relative Densities of Plant Species Found in Diets of Desert Tortoises and Cattle and Percent Dietary Overlap for April 1977, Beaver Dam Slope, Arizona (Hohman and Ohmart 1980)

Plant species	Tortoises	Cattle
Forbs		
*Plantago insularis** (wooly plantain)	46.9	33.6
Medicago sativa [1] (alfalfa	0.3	--
Oenothera/Camissonia (primrose)	--	0.1
Lotus sp. (lotus)	16.6	--
Allionia incarnata (windmills)	4.3	--
Lupinus sparsiflorus (lupine)	0.8	--
Typha sp.	--	8.9
Shrubs		
*Ceratoides lanata** (winterfat)	0.3	24.4
Acacia greggii (catclaw)	--	1.7
Larrea divaricata (creosote bush)	2.3	--
Hymenoclea salsola (cheesebush)	--	16.2
Annual grasses		
Bromus sp. *[1] (brome)	11.5	6.3
Schismus sp.[1]	17.0	--
Sedges		
Scirpus olneyi (bulrush)	--	8.8
TOTAL	100.0	100.0
PERCENT DIETARY OVERLAP	40.2	

* Percent dietary overlap

[1] Introduced

APPENDIX B. Percent Relative Densities of Plant Species Found in Diets of Desert Tortoises and Cattle and Percent Dietary Overlap for May 1977, Beaver Dam Slope, Arizona (Hohman and Ohmart 1980)

Plant species	Tortoises	Cattle
Forbs		
*Plantago insularis** (wooly plantain)	29.6	3.9
Erodium cicutarium *[1] (filaree)	20.2	0.6
Erigonum sp. (desert trumpet)	0.6	--
Abronia villosa (sand verbena)	0.4	--
Amsinckia sp./*Cryptantha* sp. (fiddleback/forget-me-not)	0.6	--
Lesquerella gordoni (beanpod)	0.4	--
*Medicago sativa*l [1] (alfalfa)	0.2	--
Astragalus sp. (locoweed)	--	--
Bowlesia incana (bowlesia)	--	--
Oenothera/Camissonia (primrose)	--	0.2
Shrubs		
Sphaeralcea sp. (globe mallow)	8.1	--
Ceratoides lanata (winter flat)	11.2	84.1
Acacia greggii (catclaw)	0.1	--
Krameria parvifolia (little-leaved ratany)	--	0.3
Larrea divaricata (creosote bush)	--	0.2
Annual grasses		
Bromus sp. [1] (brome)	1.3	2.8
Schismus sp. [1] (schismus)	0.8	2.6

APPENDIX B. (continued)

Plant species	Tortoises		Cattle
Perennial grasses			
Erioneuron pulchellum (fluff grass)	2.7		--
Hilaria rigida (big galleta)	0.7		2.8
Cynodon dactylon [1] (Bermuda grass)	--		1.4
Cacti			
Opuntia sp. (opuntia)	0.2		--
Sedges			
Scirpus olneyi (bulrush)	--		0.6
Unknowns			
A	11.1		0.1
C	11.8		--
TOTAL	100.0		100.0
PERCENT DIETARY OVERLAP		18.6	

* Percent Dietary Overlap

[1] Introduced

APPENDIX C. Percent Relative Densities of Plant Species Found in the Diets of Tortoises and Cattle and Dietary Overlap for April 1978, Beaver Dam Slope, Arizona (Hohman and Ohmart 1980).

Plant species	Tortoises	Cattle
Forbs		
*Plantago insularis**	48.8	33.6
*Erodium cicutarium** [1]	16.8	17.4
Astragalus sp.	0.9	--
Stylocline micropoides	6.4	--
Oenothera sp./*Camissonia* sp.*	0.1	0.1
Medicago sativa	0.1	--
Lotus sp.	0.1	--
Eriogonum sp.*	9.3	1.1
Amsinckia sp./*Cryptanthas* sp.*	0.5	8.3
Chaenactis sp.	0.1	--
Eucnide urens	0.1	--
Lepidium lasiocarpum	0.1	--
Baileya multiradiata	1.0	--
Shrubs		
Ambrosia dumosa	--	1.8
Sphaeralcea sp.	0.1	--
Hymenoclea salsola	0.1	--
*Ceratoides lanata**	0.3	4.6
Salvia sp.	0.1	--
Larrea divaricata	--	0.1
*Acacia greggi**	0.3	0.4
Annual grasses		
Bromus sp. *[1]	3.9	1.1

APPENDIX C. (continued)

Plant species	Tortoises	Cattle
Schismus sp.*[1]	6.6	28.8
Cacti		
Opuntia sp.	2.8	--
Unknowns		
A	--	1.9
C*	1.4	0.9
TOTAL	100.0	100.0
PERCENT DIETARY OVERLAP	59.9	

* Percent Dietary Overlap

[1] Introduced

APPENDIX D. Percent Relative Densities of Plant Species Found in the Diets of tortoises and Cattle and Percent Dietary Overlap for May 1-15, 1978, Beaver Dam Slope, Arizona (Hohman and Ohmart 1980).

Plant species	Tortoises		Cattle
Forbs			
*Plantago insularis**	40.0		2.3
*Erodium cicutarium**[1]	4.9		45.3
Astragalus sp.*	3.0		0.9
Stylocline micropoides	13.3		--
Eriogonum sp.*	0.2		0.4
Amsinckia sp./*Cryptantha* sp.	--		0.7
Chaenactis sp.	2.5		--
Lepidium lasiocarpum	--		0.4
Shrubs			
Krameria parvifolia	--		0.1
Hymenoclea salsola	--		0.3
*Ceratoides lanata**	6.1		0.4
Salvia sp.	0.1		--
Bebbia juncea	0.1		--
*Larrea divaricata**	0.5		0.2
Tamarix chinensis	0.1		--
Annual grasses			
Bromus sp.*1	2.8		1.4
Schismus sp.*[1]	13.6		45.2
Perennial grasses			
*Hilaria rigida**	0.1		0.9
Catci			
Opuntia sp.*	16.7		0.5
TOTAL	100.0		100.0
PERCENT DIETARY OVERLAP		24.5	

* Percent Dietary Overlap

[1] Introduced

APPENDIX E. **Percent Relative Density of Discerned Plant Fragments from Desert Tortoise and Cattle Fecal Samples and Percent Dietary Overlap for April 1980, Beaver Dam Slope, Arizona**

Plant species	Tortoises	Cattle
Forbs		
Plantago insularis	76.06	2.92
Erodium cicutarium	11.44	0.73
Anemone sp.	0.88	----
Shrubs		
Krameria parvifolia	0.22	----
Sphaeralcea sp.	----	5.22
Ceratoides lanata	8.05	26.68
Ephedra nevadensis	----	1.45
Annual grasses		
Bromus sp.	1.81	39.16
Perennial grasses		
Hilaria rigida	0.22	8.38
Oryzopsis hymenoides	0.44	5.22
Agropyron sp.	0.22	3.69
Aristida sp.	----	0.73
Poa sp.	----	1.45
Sitanion sp.	----	1.45
Cactus		
Unknown	0.22	----
Legume		
Unknown	0.44	----
Unknown	----	2.92
Total	100.00	100.00
Percent dietary overlap	14.39	

APPENDIX F. Percent Relative Density of Discerned Plant Fragments from Desert Tortoise and Cattle Fecal Samples and Percent Dietary Overlap for May 1980, Beaver Dam Slope, Arizona

Plant species	Tortoises	Cattle
Forbs		
Plantago insularis	92.22	0.22
Erodium cicutarium	0.53	----
Astragalus sp.	2.30	----
Shrubs		
Krameria parvifolia	0.13	----
Sphaeralcea sp.	0.13	----
Ceratoides lanata	----	96.91
Ephedra nevadensis	----	0.43
Annual grasses		
Bromus sp.	1.84	1.56
Perennial grasses		
Hilaria rigida	0.96	----
Oryzopsis hymenoides	0.68	----
Agropyron sp.	0.13	0.22
Agrostis sp.	----	0.22
Cactus		
Unknown	0.68	----
Legume		
Unknown	0.40	----
Unknown	----	0.44
Total	100.00	100.00
Percent dietary overlap	2.00	

APPENDIX G. Home Ranges of Adult Desert Tortoise for 1977-1980, Beaver Dam Slope, Arizona

Adult Male Home Ranges

#	1977	1978	1979	1980	Status
28	--------------	18.40ha(45.46ac)	12.80ha(32.46ac)	6.09ha(15.03ac	Removed
32	0.42ha(1.04ac)	99.17ha(244.96ac)	11.14ha(27.38ac)	10.97ha(27.10ac)	Removed
33	3.13ha(7.74ac)	23.20ha(57.31ac)	12.21ha(30.00ac)	10.81ha(26.69ac)	Removed
42	--------------	4.84ha(11.97ac)	2.42ha(5.95ac)	1.97ha(4.86ac)	Active
47	--------------	8.43ha(20.82ac)	9.46ha(23.25ac)	1.61ha(3.97ac)	Removed/Injured
72	--------------	----------------	----------------	0.96ha(2.36ac)	Active
60	--------------	----------------	----------------	3.83ha(9.47ac)	Active
49	--------------	----------------	----------------	22.20ha(54.84ac)	Active
115	--------------	----------------	----------------	0.34ha(0.83ac)	Active
34	--------------	----------------	----------------	6.74ha(16.66ac)	Active-Missing
$\bar{x}$ =	1.78ha(4.39ac)	30.81ha(76.10ac)	9.61ha(23.81ac)	6.55ha(16.18ac)	

APPENDIX H. Home Ranges of Adult Desert Tortoise for 1977-1980, Beaver Dam Slope, Arizona

Adult Female Home Ranges

#	1977	1978	1979	1980	Status
30	1.08ha(2.68ac)	*	No change	<0.40ha(<1.0ac)	Removed
39	-------------	3.66ha(9.05ac)	0.22ha(0.55ac)	--------------	Lost
61	-------------	29.11ha(71.92ac)	11.31ha(27.79ac)	2.61ha(6.45ac)	Active
69	-------------	---------------	1.26ha(3.11ac)	0.29ha(0.71ac)	Active
94	-------------	---------------	---------------	7.81ha(19.29ac)	Active-Missing
95	-------------	---------------	---------------	9.05ha(22.35ac)	Active
104	-------------	---------------	---------------	--------------	Active-Missing
108	-------------	---------------	---------------	0.68ha(1.68ac)	Active
78	-------------	---------------	---------------	0.13ha(0.32ac)	Active
$\bar{x}$ =	1.08ha(2.68ac)	16.39ha(40.49ac)	4.26ha(10.48ac)	3.00ha(7.40ac)	

*Female desert tortoise moved 4.3 linear miles from May 1978 to 17 August 1979 when relocated. Presumed movement to have taken place over spring-summer 1978 due to lack of radio contact during this period.

THE STATUS OF THE DESERT TORTOISE IN ARIZONA RELATIVE TO CONSERVATION ACTIVITIES BY THE NATURE CONSERVANCY AND THE ARIZONA NATURAL HERITAGE PROGRAM

TERRY B. JOHNSON
Arizona Natural Heritage Program
30 North Tucson Boulevard
Tucson, Arizona 85716

I would like to thank Steve Gallizioli of the Arizona Game and Fish Department and Kristin Berry of the Bureau of Land Management for the opportunity to participate in this conference. I am here to represent (unofficially) the Arizona Game and Fish Department (AGFD). Due to severe limits on out-of-state travel, the AGFD could not officially send one of its employees, yet Steve Gallizioli and I felt very strongly that someone should be here to represent them, even if only unofficially. Steve sends his personal regrets that he could not be here.

For several reasons, it seemed appropriate for me to come. I represent the Arizona Natural Heritage Program, which is a cooperative effort of the Game and Fish Department and The Nature Conservancy. All three groups are interested in the current and future status of the desert tortoise in Arizona and throughout its range. In order to make intelligent decisions for future actions by these various groups, we need to know more about the desert tortoise and its population status throughout its range and in local areas, especially in Arizona. We need to know who is active, who is collecting information, and how to go about putting that information together to present a balanced perspective. Many of you I've spoken to before but had never met. This is always one of the benefits of meetings such as this -- meeting the people who are actively involved in areas of mutual interest.

The Arizona Natural Heritage Program, which I coordinate and serve as one of the staff zoologists, is in the second year of its 2-year pilot period. In September 1981, contingent upon legislative approval, the program will be incorporated into the AGFD as a nongame and endangered species branch. Presently, our program has a staff of six. The new branch would have State responsibility for monitoring the desert tortoise, its population, and its protected status in Arizona. In order for us to make the best decisions possible, we need to have well-documented information on the desert tortoise, not just in Arizona, but throughout its range, so that its Arizona status can be interpreted in the proper perspective.

The Heritage Program is now reviewing the distributions and population status of some 700 species of plants and animals. These species are the very rarest of Arizona's native flora and fauna, those species with such limited distribution or small populations that their continued presence in the State could be affected by local disturbances. They are a significant part of the natural heritage that gives Arizona its unique character. The desert tortoise is one of those species. In the next 6 months, the Heritage Program biologists will make recommendations to State and Federal agencies and to The Nature Conservancy as to which of these species are most in need of immediate conservation action. We will designate, based on all locality and population status information available to us, specific localities where protective measures such as establishment of natural areas or outright land acquisition, could be implemented most effectively. To do this, we will need your knowledge, advice, and full cooperation.

STATE REPORT - CALIFORNIA

KRISTIN H. BERRY
Bureau of Land Management
1695 Spruce Street
Riverside, California 92507

The Bureau of Land Management (BLM) report for the California deserts is subdivided into five parts: 1) a summary of studies undertaken during spring 1980 at seven permanent study plots; 2) work underway now in 1981 on two permanent study plots; 3) an analysis of data collected to date on all permanent study plots; 4) a study of the effects of sheep grazing on the Kramer plot; and 5) a study in Ivanpah Valley on the effects of cattle grazing on desert tortoises. Lori Nicholson Humphreys and Ken Humphreys will present the report on the Kramer-sheep grazing study separately (see this volume), and Dr. Frederick Turner, Philip Medica, and Craig Lyons will present the Ivanpah study in a paper entitled "A Comparison of Populations of the Desert Tortoise, *Gopherus agassizi*, in Grazed and Ungrazed Areas in Ivanpah Valley, California (see this volume).

STUDIES UNDERTAKEN IN 1980

Studies were conducted on two previously established 1-mi^2 (2.59-km^2) plots and five new plots of the same size. The previously established plots are Goffs and Fremont Peak in San Bernardino County; the five new plots are Kramer, Johnson Valley, Lucerne Valley, and Upper Ward Valley in San Bernardino County and Chuckwalla Valley in Riverside County. With the exception of the Fremont Peak plot, the studies were the 60-day censuses described in the 1980 Symposium Proceedings of the Desert Tortoise Council (Berry 1980). The Fremont Peak plot received 30 days of study. The information presented below is preliminary in nature; a review of the data has not been completed and errors are possible. The reader should be cautious in interpreting figures for density (several methods were used) and size class structure. The size class structure remains the same as last year. 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) maximum carapace length (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.

Analysis of population data for all permanent study plots in California is nearing completion. The results will be presented in an updated version of the draft report, "The Status of the Desert Tortoise in California" by K. H. Berry and L. Nicholson (1979). The new report is entitled "The Status of the Desert Tortoise in the United States" by Berry *et al.* and should be available in 1982.

Fremont Peak, San Bernardino County

One of the two 1-mi^2 (2.59-km^2) plots at Fremont Peak was sampled in a 30-day census. There were 43 first encounters of unmarked or previously marked tortoises; no density estimates were provided. The size class structure of captured animals (first encounters only) was 4.6% hatchlings, 6.9% juveniles (class II), 27.9% immatures, 13.9% subadults, and 46.5% adults. Sex ratios were 0.5 males : 1.0 females for subadults, 1.86 males : 1.00 females for adults, and 1.36 males : 1.00 females for both size classes. Twenty-five carcasses were collected, two of which appeared to have been shot. There was one road kill. The plot was grazed and used for bedding and watering by a herd of 800 sheep. Dr. Anne Stewart Hampton was the investigator.

Kramer, San Bernardino County

There were 147 first encounters of unmarked tortoises on this new plot. Density was estimated at about 170 to 180 tortoise/mi^2 (66 to 69/km^2). The size class structure of the sample was 6.1% juveniles (class I), 11.6% juveniles (class II), 24.5% immatures, 15.6% subadults, and 42.2% adults. Sex ratios were 1.30 males : 1.00 females for subadults, 0.94 males : 1.00 females for adults, and 1.02 males : 1.00 females for both size classes. One hundred one carcasses were collected, three of which showed evidence of having been shot. A herd of about 1000 sheep grazed the plot. Lori Nicholson and Ken Humphreys were the investigators.

Lucerne Valley, San Bernardino County

There were 117 first encounters of live tortoises on this new plot; two died during the study period. Density was estimated at 138 tortoises/mi^2 (53 km^2). The size class structure of the 115 captured animals (first encounters only) was 3.5% hatchlings, 1.0% juveniles (class I), 12.8% juveniles (class II), 14.8% immatures, 13.0% subadults, and 55.7% adults. The sex ratios were 2.75 males : 1.00 females for subadults, 1.0 males : 1.0 females for adults, and 1.2 males : 1.0 females for both classes. Seventy-one carcasses were found. One juvenile was crushed by a vehicle, and two other tortoises were shot. The investigators were Karen Bohuski and Peter Woodman.

Johnson Valley, San Bernardino County

There were 83 first encounters on this new plot. Density was estimated at 109 tortoises/mi^2 (42/km^2). The size class structure (first encounters only) was 8.4% hatchlings, 1.2% juveniles (class I), 10.8% juveniles (class II), 14.5% immatures, 9.6% subadults, and 55.4% adults. Sex ratios were 0.61 males : 1.00 females for subadults, 1.27 males : 1.00 females for adults, and 1.17 males : 1.00 females for both classes. Sixty-four carcasses were recovered; five tortoises had been crushed by vehicles. The courses for four motorcycle races crossed this area. Peter Woodman and Karen Bohuski were the investigators.

Goffs, San Bernardino County

There were 297 first encounters on this plot, which was first censused in 1977. Density was estimated at 251 individuals/mi^2 (97/km^2). The size class structure of the population (first encounters only) was 2.0% juveniles (class I), 6.7% juveniles (class II), 28.3% immatures, 8.8% subadults, and

54.2% adults. Sex ratios were 1.9 males : 1.0 females for subadults, 1.5 males : 1.0 females for adults, and 1.5 males : 1.0 females for both classes. Nine shell-skeletal remains were taken. Betty L. Burge was the investigator.

Upper Ward Valley, San Bernardino County

There were 142 first encounters on this new plot. Density was estimated at 160 tortoises/mi^2 (62/km^2). The size class structure of the population (first encounters only) was 2.8% hatchlings, 2.8% juveniles (class I), 19.0% juveniles (class II), 17.6% immatures, 12.0% subadults, and 45.8% adults. The sex ratio was 1.12 males : 1.00 females for subadults, 1.83 males : 1.00 females for adults, and 1.65 males : 1.00 females for both classes. Seventeen shell-skeletal remains were found. Alice Karl was the principal investigator.

Chuckwalla Valley, Riverside County

There were 84 first encounters on the plot. Density was estimated at 110 tortoises/mi^2 (2/km^2). The size class structure of the population (first encounters only) was 1.2% juveniles (class I), 25.0% juveniles (class II), 19.0% immatures, 14.3% subadults, and 40.5% adults. Sex ratios were 0.83 males : 1.00 females for subadults, 0.94 males : 1.00 females for adults, and 0.91 males : 1.00 females for both classes. Twenty-three carcasses were collected; many small and fragmented pieces of bone were also observed but not collected. This plot has a history of military activities.

STUDIES SCHEDULED FOR 1981

Permanent Study Plots

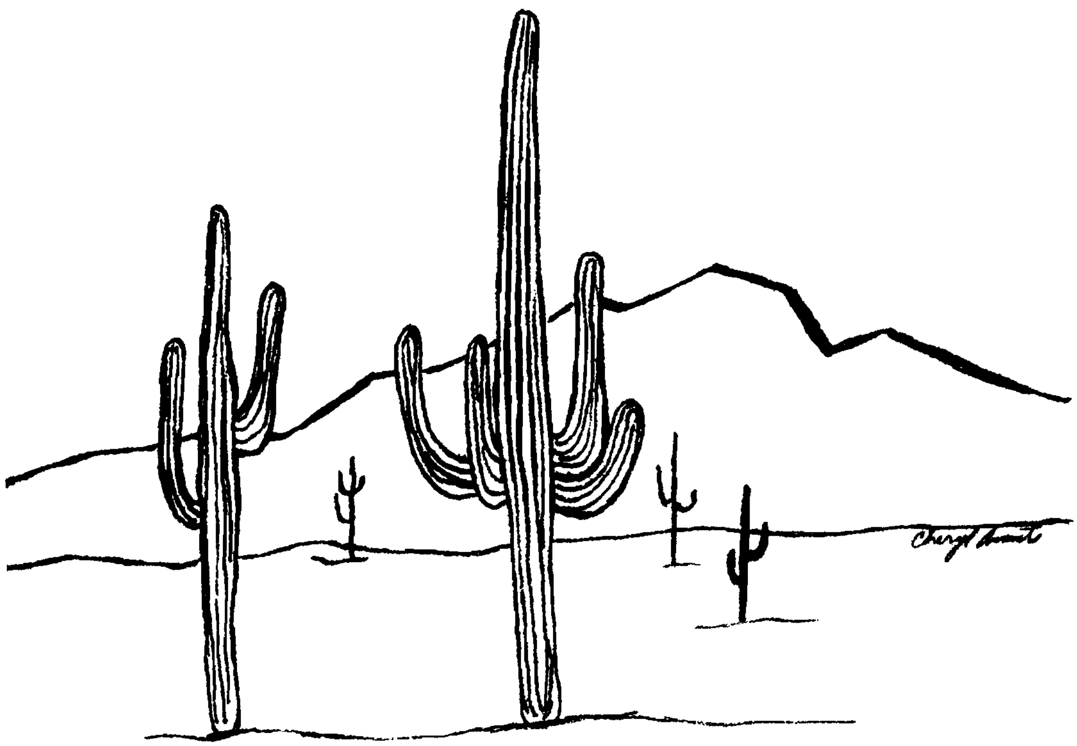
Contracts have been awarded for continued work on two permanent study plots, the first in Fremont Valley in eastern Kern County and the second in Stoddard Valley in San Bernardino County. Tim Shields will work at Fremont Valley and Peter Woodman at Stoddard Valley. These two plots have been sampled intermittently since 1976 and 1977, respectively. The methods are basically the same as those described in the 1980 State Report for the 60-day study (Berry 1980). There is one significant difference: contractors no longer will be required to prepare written reports summarizing their findings. Instead, they will fill out computer data sheets for eventual data storage, retrieval, and analysis. This computer data sheet is called "Card 1" and contains information that will be used in analysis of such parameters as size and age class structure, sex ratios, density, distribution, and growth.

Analysis of Data Collected at Permanent Study Plots

During the last 5 years, the BLM has sponsored studies at over two dozen permanent study sites in California. About 5,000 tortoises have been marked and over 1,000 carcasses have been collected. The data base is massive. We decided that 1981 is the year to prepare these data for computer storage, retrieval, and eventual analysis. Several contracts have been awarded to accomplish this objective. Examples of some projects are: 1) preparation of "Card 2," a computer data sheet for coding information on tortoise behavior (e.g. daily and seasonal activity, use of burrows, foraging behavior and food habits, interactions with other tortoises and animals, etc.); 2) coding of all existing behavioral data collected from 1977 to the present on Card 2; 3) design of "Card 3," the computer card for recording information on the carcasses; 4) coding of all tortoise remains collected since 1971 for Card 3 and assignment of the approximate time since death at the moment of collection; 5) analysis of data on disintegration of shell-skeletal remains; and 6) assignment of shell wear classes to each of approximately 5,000 tortoises for which 35 mm slides are available. I will be working very closely with the contractors on these projects, some of which were initiated several years ago.

REFERENCES

Berry, K. H. 1981. State Report - California, p. 61-67, *in* K. A. Hashagen, ed, Desert Tortoise Council: proceedings of the 1980 symposium: March 22-24, Riverside, California.



STATE REPORT - CALIFORNIA

FRANK HOOVER
California Department of Fish and Game
15378 Bird Farm Road
Chino, California 91710

In 1980, at the request of Dan Christenson, a biologist in the Department of Fish and Game's Fresno office, a contract was initiated through Fresno State University to hire a person to monitor and evaluate hunting and shooting on the Desert Tortoise Natural Area near California City. Funds came from the Department's Decal Program, which provides funds for management of nongame species. Tom Campbell was hired to do this work. He started working last October and the contract will run through next June. There are hopes to get more funds so the work could extend for three calendar years. Tom will give a detailed account of his activities and findings tomorrow so I won't go into that here but I understand he has expanded the job to include keeping tabs on the area's fences and doing general public relations work.

The Department's "Progress Report on the Experimental Rehabilitation of Captive Desert Tortoises", which was published in the Council's 1978 Symposium Proceedings was published separately last year by the Department of Fish and Game as a Regional Information Bulletin.

During 1980, the Department issued 1,805 permits to possess live tortoises. This is down from the 2,061 permits issued in 1979. It is too early to determine if this is a trend or just a natural fluctuation. The Department has issued a total of 16,261 tortoise permits.

The number of tortoises turned in to the Department by the public has drastically declined in the past few years. Apparently there haven't been any newspaper articles concerning tortoises. Whenever that happens and they mention the legality of owning these animals, people apparently misunderstand and assume tortoises cannot be legally possessed and we're flooded with them. In 1980, we only received 13 tortoises. Since it is our current policy to give these tortoises to appropriate clubs for adoption, 12 of the 13 were given to the Orange County Chapter of the California Turtle and Tortoise Club, which was next on our list. I brought the thirteenth one here and, if anyone can give it a good home, they are welcome to it.

During 1980, the Department reviewed and commented on a number of proposed projects in the desert that would impact tortoise populations. These have mostly been proposed jojoba plantations on state lands. Unfortunately, most of the ones I've seen were in the south Lucerne and Johnson valleys area. The tortoise population in that general vicinity is going to be decimated by planned off-road vehicle free play areas. With the cooperation of the State Lands Commission, we have been able to block these developments so far but I feel they will be a continuing problem.

SUMMARY OF A REPORT FOR THE CALIFORNIA DEPARTMENT OF TRANSPORTATION AND RESULTS OF A BRIEF SURVEY OF DESERT TORTOISES OCCURRING ALONG I-15 SOUTH OF BARSTOW, CALIFORNIA

MARGARET FUSARI
College Eight
University of California, Santa Cruz
Santa Cruz, California 95064

STEPHEN M. JUAREZ
1425 North Vagedes
Fresno, California 93728

GLENN R. STEWART
Biological Sciences Department
California State Polytechnic University, Pomona
Pomona, California 91768

and

JACK EDELL
Caltrans District 09
Bishop, California 93514

In the summer of 1980 a final report was presented to the California Department of Transportation summarizing the findings of a 2-yr desert tortoise study. The study evaluated the feasibility of using barrier fences and culverts to pass tortoises under roads. The objective was to suggest ways to reduce mortalities caused by cars. This report summarizes the conclusions and recommendations and provides the details of a survey conducted in the spring of 1980 along I-15 south of Barstow, California.

SUMMARY AND DISCUSSION

Use of Culverts by Tortoises

We found that tortoises will make use of culverts to cross barriers. Tortoises were hesitant at first but became familiar with the culverts and used them, sometimes as preferred routes of travel. We found no evidence of any hazards involved in such use. Some animals did not use the culverts, but the restoration of a substantial part of the gene flow across roads is far superior to the assumed current situation in which mortality could severely restrict the interbreeding of populations on opposite sides of heavily traveled roads.

Use of Barrier Fences

On the basis of our experiments, we suggest that a barrier fence (minimum height = 16 to 20 inches or 40-50 cm), placed along roads, would deter desert tortoises (and probably other small animals as well) from going onto the roadway. We recommend hardware cloth fencing of half or quarter inch mesh to avoid problems of fence-fighting and to prevent tortoises getting their heads caught in a larger mesh fencing. We did not observe evidence of such harm in our observations. Some animals may dig under the fence unless it is buried; however, the cost of burial might be prohibitive and we feel that a partially effective barrier would still prevent significant mortalities.

The installation of a fence-culvert system, which allows crossing via culverts and prevents access to the road itself, will serve not only to protect populations of the desert tortoise from decimation by the construction of new roads, but could also serve to restore many areas of usable habitat to the desert tortoise along currently existing roads and freeways.

Population of Tortoises Found Adjacent to I-15

On 24 April 1980, from 1400-1500 Pacific Standard Time, 16 students from a University of California, Santa Cruz environmental studies class, natural history of amphibians and reptiles, walked a 0.25 mile (400 m) wide belt transect along the west side of I-15 south of the Sidewinder Road exit, from the freeway access fence west and 0.5 mile (800 m) along the freeway. All tortoises found were identified by sex, size class, and location on the transect (Appendix I). These animals were notched according to the standard system adopted by the Desert Tortoise Council and used by the Bureau of Land Management (BLM).

A total of 25 tortoises was located. The sample is small but clearly shows that tortoises of all sizes and both sexes are present adjacent to I-15 (Table 1) and hence subject to impact.

TABLE 1. Size Classes of Tortoises Found on Freeway Transet 24 April, 1980

Size class	Carapace length	N	%	M	F	U
Hatchling	0 - 60 mm	1	4	-	-	1
Juvenile	61 - 100 mm	1	4	-	-	1
Immature	101 - 180 mm	12	48	7	2	3
Subadult	181 - 214 mm	3	12	3	-	-
Adult	214 mm	8	32	5	3	-
	Totals	25	100	15	5	5

Nicholson[1/], under contract with BLM, has data which show that tortoise population densities increase with distance from the road with the greatest effects seen within 0.5 mile (800 m) of the road. These effects are most pronounced on newly paved roads but Humphreys[2/] has data in preparation which show with older roads, the reductions in density may extend farther and that an equilibrium may not be established even after 40 yr. These works indicate that for 40-year-old roads, approximately 60% of the original tortoise population may have been lost from the 1.0-mile strip surrounding the road.

If mortality could be stopped, many thousands of square miles of tortoise habitat could be reclaimed. For example, according to a report being prepared by Berry and Nicholson[3/] there are 2,066 miles (3325 km) of road intrusion into areas designated as Desert Tortoise Critical Habitat Zones. These intrusions consist of 302 miles (486 km) of primary highway, 174 miles (280 km) of other paved road, 247 miles (397 km) of main dirt road, and 1,343 miles (2160 km) of other dirt road. If we consider that a 1-mile (1.6-km) stretchof road could yield 2 mi^2 (5 km^2) of restored habitat, then there are 4,131 mi^2 (10,700 km^2) of habitat that could be protected by the complete fencing of roads in these critical habitat zones. If only the primary roads were fenced, 604 mi^2 (1564 km^2) of critical habitat would be restored to the desert tortoise.

These figures represent only BLM designated Critical Habitat Zones. Similar figures could be obtained for all desert tortoise habitat. The reclaimed habitat could be used for the release of tortoises which have been held captive either as pets or for medical reasons. In particular, the release of some adults of breeding age could hasten the recovery of roadside populations.

RECOMMENDATIONS

We recommend a pilot project be undertaken along the I-15 freeway, from the Sidewinder Road exit south to the Hodge exit. A 16-20-inch (40-50 cm) barrier fence could be attached to the existing freeway fence, with runways down to all of the existing culverts. Then, if the culverts were kept clear of windblown brush and other debris, the tortoise population along the freeway could be marked and monitored by a series of periodic transects run parallel to the freeway on both sides. This would yield long-term data on the status of the roadside populations and would provide specific information on the effectiveness of the system. An alternative location for a pilot project would be one of the roads in the Critical Habitat Zones described by the BLM or in an area of known desert tortoise occupancy where road construction is planned.

1/ Nicholson, L. In prep. The effects of roads on desert tortoise populations. Report to the Bureau of Land Management, Riverside, California, in partial fulfillment of contract #CA-060-CT8-000024.

2/ Humphreys G. In prep. Differential equations and desert tortoises. Bureau of Land Management, Riverside, California 92506.

3/ Berry, K. H. and L. Nicholson. In prep. The status of the desert tortoise in California. Bureau of Land Management, Riverside, California 92506.

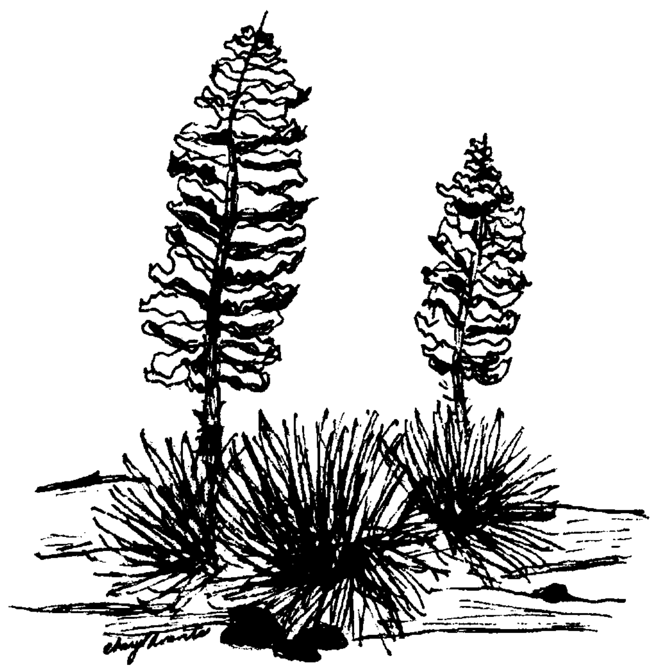
Dr. Kristin Berry, of the BLM Desert Planning Staff, recommends that roads in highly crucial habitat be fenced on a priority basis, using the information available through her office. We recommend that a qualified person be commissioned to produce such a plan.

Finally, we urge that this plan be implemented as soon as possible to protect populations of the desert tortoise adjacent to roads and freeways. As pointed out by Luckenbach (1982), human use of the desert has incresed dramatically over the years and can be expected to increase more. It would be only logical to assume that the impacts on tortoise populations will increase as well unless positive action is taken.

REFERENCES

Luckenbach, R. A. 1982. Ecology and management of the desert tortoise (*Gopherus agassizii*) in California. *In* Bruce Bury, Ed., North American Tortoise Conservation and Ecology, U.S.D.I. Fish and Wildlife, Wildlife Research Report 12, Washington, D.C.

Nicholson, L. 1978. The effects of roads on desert tortoise populations. pp. 127-129 *in* M. Trotter and C. G. Jackson, Jr., Eds., Desert Tortoise Council Proceedings, Las Vegas, Nevada.



APPENDIX I. **A List of Desert Tortoises Found on April 24, 1980, on a Transect Extending for One-half Mile South of the Sidewinder Road Exit of I 15 on the West Side of the Freeway Fence**

Number	Size class	Sex	Car (mm)	Remarks
200	I	M	180	Mating by Sidewinder Road
201	I	F	180	exit from U.S. 15
202	SA	M	190	.1 mile west of fence
203	A	M	215	.2 mile west of fence
204	I	?	110	.2 mile west of fence
205	J	?	80	at fence
206	SA	M	210	at fence
207	I	M	155	.1 mile west of fence
208	A	F	245	v. worn, in burrow
209	A	F	220	at burrow, laying eggs
210	I	M	150	in burrow
211	I	?	140	in burrow
212	A	M	230	at fence
213	I	M	170	in burrow
214	A	M	250	in burrow
215	I	F	145	in borrow
216	I	M	170	at burrow mouth, 2x nuchal
217	A	M	260	at burrow
218	I	M	140	.2 mile west of fence
219	A	M	215	.1 mile west of fence
220	SA	M	190	at burrow
221	A	F	220	in burrow
222	I	?	150	in burrow
223	I	M	160	in burrow
224	H	?	49	near Sidewinter Road exit

ELECTRIC ENERGY DEVELOPMENT IN CALIFORNIA AND PROTECTION OF THE DESERT TORTOISE: CAN BOTH GOALS BE MET?

MARC SAZAKI
California Energy Commission
1111 Howe Avenue
Sacramento, California 95825

I am pleased to be here today speaking about electric energy development in California, particularly the California desert area, and how efforts are being undertaken to meet the State's electrical energy needs while adequately protecting natural resources such as the desert tortoise.

I will first present a brief review of the creation of the California Energy Commission and the scope of its legislative mandate. Next, I will discuss the regulatory framework through which the Commission certifies thermal power plants. Then I will describe cases the Commission has acted on which I think will interest you because they involve desert sites. Finally, I will explain why natural resource groups such as yours should maintain an awareness of the development of alternative energy technologies which may not be under the California Energy Commission's jurisdiction.

In 1974, the California Legislature passed the Warren-Alquist Act creating the State Energy Resources Conservation and Development Commission. The Commission, commonly called the California Energy Commission (CEC), is the result of the Legislature's efforts to establish and consolidate the State's responsibility for energy resources, for encouraging, developing, and coordinating research and development into energy supply and demand problems, and for regulating electrical generating and related transmission facilities. In ensuring that a reliable supply of electrical energy is maintained at a level consistent with the need for such energy for protection of public health and safety, for promotion of the general welfare, and for environmental quality protection, the Commission uses a two-phased power plant certification process.

Power plants greater than 50 MW and utilizing such energy sources as geothermal heat, fossil fuels, and nuclear fuel must be certified by the Commission. During the first phase of the process, a party interested in building a thermal power plant must file with the Commission a Notice of Intent (NOI) to submit an Application for Certification (AFC).

Receipt of a NOI document begins a 12-month process in which various factors must be accomplished at given intervals until a final decision is reached. Within the first month, staff must determine if the data in the submittal are adequate for evaluation. Comments from appropriate local, regional, state, and federal agencies are sought to assist in making this determination. Because of the strict regulatory timeframe, it is essential that staff receive these comments quickly. If data are inadequate, the NOI is rejected and if the applicant chooses, the document can be revised and resubmitted. When data are adequate, informational hearings are held within a month of the acceptance of the filing. The informational hearings allow the applicant to describe the proposed project and respond to initial public inquiry. Also, through the first 4 months staff may request additional information from the applicant and the Commission may convene technical workshops to clarify information and identify and discuss potential issues. No sooner than 15 days after the informational hearings, adjudicatory hearings must be held to identify issues for adjudication, issues which may be eliminated from further consideration in the notice proceedings, and issues which should be deferred to the certification proceedings. Adjudicatory hearings followed by a final report, final report hearings, and decision must be completed before the close of the process.

Prior to submitting an AFC for a project, the NOI must be approved with, in most cases, at least two alternative project sites.

An applicant decides which NOI approved site will be proposed for site certification. The AFC must contain among other things, a detailed description of the design, construction, and operation of the proposed facility. Also, available site information including maps and descriptions of existing ecological conditions must be included.

By statute, a decision on an AFC must be made within 18 months of filing the application, unless the Commission and applicant agree to a longer period. As with the NOI, the Commission and its staff assess data adequacy of the submittal. After an AFC filing is accepted, staff meetings and workshops can be conducted as necessary prior to the start of evidentiary hearings which take place 3 to 8 months after acceptance. While the certification process is conducted, the Commission, as lead agency, must prepare a project EIR. The draft EIR must be completed before the eighth month begins and final EIR certified before a decision is issued.

One noteworthy factor built into the certification process is monitoring. The Commission establishes a monitoring system to assure that any facility certified under the AFC process is constructed and is operating in compliance with air and water quality, public health and safety, and other applicable regulations, guidelines, and conditions adopted or established by the Commission or specified in the written decision on the application. This system helps assure that environmental concerns are not overlooked after project approval.

Public participation is encouraged during both the NOI and AFC proceedings through the Energy Commission's Public Adviser Office. Staff in this Office are available to assist the public in developing the most effective ways in which an individual's or group's interest may be represented during either process. One useful item provided by the Public Adviser is a "Project Workbook and Public Adviser Guide". This booklet is available for various projects that are under Commission power plant siting review. It contains information regarding the regulatory process, physical features of the proposed project, issues under contention, a list of Commission staff assigned to the case, and a list of government agencies that have received a copy of the submittal under review, and a list of libraries holding copies of the submittal.

Two current power plant proposals that should be of interest to the Desert Tortoise Council are Southern California Edison's Lucerne Valley Project and California Coal Project. Lucerne is at the AFC review level. Although further analysis is presently postponed, Lucerne is located 32 miles southeast of Barstow in the Upper Johnson Valley. The 1290 MW power plant proposed as a gas turbine peaker, is adjacent to an area identified in BLM's Desert Plan Final

EIS as supporting a distinct desert tortoise population. Incidently, BLM's desert planning staff was at one time considering proposing this particular tortoise habitat area as an area of critical environmental concern. Now the area is in an unrestricted motorized vehicle play classification. It is possible that restricting access to the uitility's property surrounding the power plant will reduce effects of uncontrolled ORV activity on tortoises and their habitat. If you would like more information on the status of the Lucerne AFC proceedings, please contact the Commission's Public Adviser.

The SCE California Coal Project, a 1500 MW, coal-fired power plant, has received NOI approval for the Ivanpah site. This site is located beside Interstate Highway 15 about 3 miles from the Nevada state line. The original Ivanpah proposal included a well field to supply water needs. As described, up to 143 wells could eventually be drilled, covering as much as 40,000 acres. Considering this and the related features necessary for developing the well field such as access roads, well pads, pipelines, and pump power distribution facilities, the Commission's staff believes that if the well field is built, the resident desert tortoise population would sustain unacceptable impacts. Considering staff analysis and Dr. Berry's testimony during the adjudicatory hearings, the Commission decided the Ivanpah site could not be approved with the well field. As an alternative to the well field plan, which it seems Southern California Edison proposed in good faith to satisfy state water use policy, the utility now proposes to supply the plant's water needs by bringing fresh water via pipeline. The water pipeline will be installed adjacent to existing roads as much as practicable. This alternative appears acceptable from a biological prospective and will be examined thoroughly during AFC proceedings.

Other desert sites considered in the NOI proceedings were Boron, Cadiz, and Rice. Boron is unacceptable because of the incompatibility with previously established military uses essential to national defense. Cadiz and Rice are conditionally approved pending submittal of additional air quality information in a special pre-AFC filing. All four desert sites are acceptable for synfuel-fired combined cycle and boiler facilities.

Considering electric energy development of the scale just discussed, and the open planning process through which it is reviewed, I believe there is a fair chance of protecting the desert tortoise when development takes place in the desert area. Other forms of electricity production, such as wind farms, solar, and geothermal, have siting potential in the desert and could effect the desert tortoise. Since these forms of development are outside the Commission's official review process because of their small size, it's hard at this time to predict what the level of impact on the desert tortoise will be. I recommend groups such as yours maintain constant vigilance by forming committees to follow specific types of development. Also, be prepared to provide your expertise as needed. Most of all, keep the lines of communication open by responding to agency requests for your comment and input and contacting the various agencies to express your concerns about development activity.

STATE REPORT - CALIFORNIA

E. W. CHATFIELD
California State Lands Commission
1807 13th Street
Sacramento, California 95814

This report will describe the Commission, its land management functions, and some current projects in land consolidation and exchange.

BACKGROUND

Public ownership of land by the State can be traced to the date of California's admission into the Union in 1850. Under the "Equal Footing" doctrine, California was admitted to the Union with the same rights, sovereignty, and jurisdiction as the original states. Accordingly, title to all tide and submerged lands and the lands beneath inland navigable waters was vested in the State by the Constitution.

Excluding the beds of all naturally navigable waterways, and tide and submerged lands, the State's jurisdiction, at one time, embraced over 8.8 million acres (3.6 million hectares) of "dry" public domain land. In the intervening years, however, the majority of such lands have been sold as provided by law, to provide aid for California's public school system.

In 1938, the Legislature established the State Lands Commission, successor to the Office of the Surveyor General, and the Division of State Lands in the Department of Finance, to manage and supervise these lands. The Commission structure was adopted in response to allegations concerning mishandling of public assets by the single executive appointed at that time as the Chief of the Division. It was decided that having two constitutional officers elected on a statewide basis, and one appointee from the Governor, to manage and control the State's land holdings would prevent future mishandling.

In effect, the Commission acquired a stewardship of State lands. These lands consist of sovereign lands -- those which California acquired by virtue of her sovereignty, and proprietary lands -- those which were acquired by grant. Sovereign lands include all tide and submerged lands underlying the Pacific Ocean and extending from the mean high tide line seaward for 3 nautical miles and those submerged lands underlying the beds of navigable inland waterways. Proprietary lands include those acquired from the Federal Government by virtue of a legislative grant and include school lands, the 16th and 36th sections of each township or lands granted in lieu thereof, and swamp and overflowed lands. Some of the sovereign lands are also referred to as "granted lands" because the administrative control of these lands has been transferred by the Legislature to local public agencies.

The Commission is composed of two elected officials, Kenneth Cory, the State Controller, and Mike Curb, the Lieutenant Governor; and one gubernatorial appointee, Mary Ann Graves, the State Director of Finance. The Commission currently is landlord for more than 4.5 million acres (1.8 million hectares) of land belonging to the people of the State, compared to some 44 million acres (17.8 million hectares) owned by the Federal Government. Of this total, over 600,000 acres (245,000 hectares) represent vacant State school lands, as well as an additional 716,000 acres (290,000 hectares) of land in which the surface rights were sold, but the mineral rights were retained.

The Commission is assisted by a staff of approximately 250 specialists in mineral resources, land management, boundary determination, petroleum engineering, and natural science. Public meetings are held each month in the State Capitol, at which time interested groups may address the Commission.

The lands under the Commission's jurisdiction are managed under a multiple land use concept. Unlike its State agency counterparts, the Commission, as a major State landowner, is not obligated to lease, sell, or dispose of its lands. The Commission's lease considerations are geared toward maximizing the statewide public benefit from the use of such lands in a manner consistent with environmental protection and enhancement. Along with this, enabling legislation charges the Commission with the stewardship of the public trust for commerce, navigation, and fisheries. The Commission, therefore, is the designated custodian to protect and safeguard the public's rights pursuant to this public trust. Functionally, it is divided between Minerals and Land Management.

MINERALS MANAGEMENT

Old beds of meandering rivers, and their present beds, are sources of sand and gravel; by dredging, navigation channels are cleared. Salt is mined from State lands in the San Francisco Bay area, and oil and gas from beneath State-owned lands both onshore and off, chiefly in Southern California. Geothermal energy comes from beneath State lands in Napa and Sonoma counties. All of these activities produce royalties, presently about $500 million annually in non-tax revenue to the State. Most of these activities are supervised by our Long Beach staff.

LAND MANAGEMENT

Surface management is a more descriptive term; these 4 million acres, or 6,300 square miles (1.6 million hectares) are comprised chiefly of sovereign lands; that is, lands vested in the State at statehood for commerce, navigation, and fishing. The Commission derives some income from these as well, about $1.5 million annually. Examples are revenues from waterfront development, marinas, anchorages, and individuals leasing State lands for private piers and boathouses.

But not all our work results in income. The public's use of navigable waters must be protected and enhanced, according to the trust under which we hold these tide and submerged lands. Access to and over navigable waters sometimes has to be won in court for many public uses.

The School Lands, granted to the State by Congress in 1853, are so called because the grant was to fund the common schools in this state by their sale, lease, or development. Some 600,000 (245,000 hectares) of the 5.5 million acres (2.2 million hectares) originally granted remain unsold, largely in the

Northeastern and Southeastern California deserts. Timber sales, grazing leases, and some agricultural and mineral leases are the main economic activities on school lands. Since 1969, a moratorium on the sale of these lands to the public has halted disposal pending an inventory and classification of these lands and their environmental values. Never having been funded by the Legislature, the inventory remains to be done, and the moratorium on sale remains in effect.

CURRENT PROJECTS

Our management of school lands is made difficult by their scattered distribution and by their being inholdings inside various Federal agencies' lands. Therefore, one of our present projects is to seek exchanges of our scattered parcels with such agencies for one or more large contiguous blocks elsewhere in California with resource management potential. Too, we are entitled to over 100,000 acres (40,500 hectares) of the school land grant which has never been granted to California for various reasons. Another project, presently our highest priority in school lands management, is to select a contiguous block of BLM land in lieu of that entitlement as well.

One possible area for such accumulation by in-lieu selection or exchange with the Bureau of Land Management is Johnson Valley; others are the Caliente Range, Mendocino County, Trinity County, and the Eagle Lake area in Lassen County.

We are now exploring a possible exchange in the desert to benefit the desert tortoise; land of high tortoise density or habitat quality may be exchanged for more developable lands of less importance to the desert tortoise. Dr. Berry is discussing this proposal with us at present.

Trespass control is another function we address; various unauthorized and damaging activities on State lands are being worked on with mixed success. Off-road vehicle damage is a thorny problem from many aspects.

People create problems, and people solve them. Among the array of possible alternative solutions to these problems, creative problem-solving can usually provide some outcomes that achieve what each of the participants needs out of a transaction. The Commission and its staff, under the network of counterbalancing laws, policies, and public needs facing California's land managers, are working to be part of these solutions.

CALIFORNIA TURTLE AND TORTOISE CLUB

MARTHA YOUNG
California Turtle and Tortoise Club
10245 La Hacienda Ave., Apt. C
Fountain Valley, California 92708

I'm here to tell you about the California Turtle and Tortoise Club. We've been busy the last year, but first I want to tell you a little about our Club in case you aren't familiar with it.

We are an educational and conservation club that was formed in 1964. We have four chapters here in Southern California, with a possible fifth chapter in Northern California holding its first meeting next month. At these meetings we discuss our turtles and tortoises and any problems we may be having. We have speakers such as veterinarians and other people interested in turtles and tortoises.

Our monthly newsletter, The Tortuga Gazette, goes out to over 800 members across the country, including 10 foreign subscribers. It features articles about turtles and tortoises, their care, medical information, and other conservation and educational material.

Each chapter of the Club has an annual show or exhibit where we display our turtles and tortoises and offer educational literature. Money is raised through donations and sale tables where turtle artifacts are sold. This money is used to pay veterinarian bills and for our special projects that we have during the year.

Our main goal is to educate the public in the proper care of captive turtles and tortoises.

As I said before, we have been busy the last year. We've been working on updating our care sheets and adopting out turtles and tortoises. The adoption program is our main activity. Turtles and tortoises are turned in to us to be placed in new homes. These are animals that people can no longer keep for one reason or another. We try to find the best possible home for them. Following is the Orange County's adoption report for the past 2 years:

October 1978 thru October 1979 - Adopted Out

Desert Tortoises		Turtles	
Hatchlings	14	Berlandiers (Texas)	7
Sub-adults	11	Box (assorted)	6
Females	22	Water (assorted)	21
Males	46		

Total: 127

October 1979 thru October 1980 - Adopted Out

Desert tortoises

Hatchlings	22
Sub-adults	14
Females	28
Males	39

Turtles

Berlandiers (Texas)	4
Hermanns (Greek)	6
Box (assorted)	23
Hatchling	7
Water (assorted)	19
Hatchling	39

Total: 201

On 11 September 1980 something very exciting happened. A woman from Garden Grove, California called me and said her desert tortoise's eggs were hatching and there were two tortoises in the same egg. The hatchlings were joined at the egg sac. I took them to Dr. Strathman at Orange-Olive Veteranarian Hospital, where he successfully separated them. There was a big difference in their size and there wasn't much hope for the smaller one, but as of this date both are doing great.

I've brought a friend along with me today. This is Harry. He's a male California desert tortoise. Harry has had a very tragic life. Last September some friends of Westchester club members were out in the desert and saw Harry sitting on the road. They decided to move him out away from the road so that he wouldn't be hit by a vehicle.

Well, it was too late, he'd already been run over. Harry's shell was cracked in several places, he was bleeding badly and the maggots were having a field day. The people knew it was illegal to remove a California desert tortoise from the desert, but in this case it had to be done. Harry was given to club members who took him to Dr. Rosskopf on 2 September. I picked him up from Dr. Rosskopf on 4 September. The California Department of Fish and Game was notified that I had Harry. At that time Harry was an extremely wild tortoise. I picked him up from the vet on 4 September but I didn't see his head until 24 September. Medication was applied to the damaged area and the bandage was changed twice a day. Because Harry was so wild I couldn't get his head out to force feed him so he existed on injections of aminoplex and the antibiotics needed to fight his infection. Harry had to be kept in the house to avoid further infection. Each day I would offer him food with no avail. On 12 November 1980 Harry ate on his own for the first time. Gradually he became friendly. On 2 December 1980 Harry's shell was fiberglassed.

This is Harry's second outing. Last November he attended a Desert Plan meeting in San Bernardino.

Harry is adjusting well to captive life. But there's one sad thing. Perhaps there was a "Harriet" or "Henrietta" out in the desert that was his mate. He'll never see her again, but time heals all things--Harry now has a new love and her name is "Burma". That seems to present a small problem too because "Burma" is a Burmese brown tortoise!

Harry and I would like to thank you for giving us your time and attention.

DESERT TORTOISE PRESERVE COMMITTEE REPORT

LAURA STOCKTON
6201 Wible Road, No. 66
Bakersfield, California 93309

The Desert Tortoise Preserve Committee appreciates being a part of the Desert Tortoise Council Symposium Program, both in presenting this report and in displaying materials.

At the last Symposium I closed with a challenge to all of us to become actively or more actively involved in desert tortoise protection. While each of us makes a mental checklist of personal involvements, I will give a brief accounting of the involvements centered around the Desert Tortoise Natural Area. I will be speaking for the 19 active, 69 contributing, and 12 sustaining members of the Committee and for the countless project supporters. I will also touch upon the resource agency involvements. This report will be categorized to correspond with the five major goals of the Desert Tortoise Preserve Committee:

1. TO ESTABLISH A PRESERVE OR NATURAL AREA. The Desert Tortoise Natural Area is official! After 5 years of being processed back and forth through the various levels of the Bureau of Land Management and the Department of the Interior, the Secretary of the Interior signed the withdrawal from mineral entry during February 1980. This was a major prerequisite for official designation. The waiting period during which Congress could negate the withdrawal ended in July. Meanwhile the Bureau of Land Management, confident that Congress could stick with the decision, held the official dedication of the Natural Area and the Interpretive Center on 26 April 1980. The ceremony was preceeded by guided tours led by Desert Tortoise Preserve Committee members. The 300 people who attended the ceremony were addressed by such dignitaries as Deputy Secretary of the Interior Dan Beard and Congressman Bill Thomas. Following the ceremony, Secretary Beard informed us that we should be proud of our role in establishing the largest nongame preserve in the United States.

2. TO PROTECT THE DESERT TORTOISE AND ITS HABITAT ON THE NATURAL AREA. As you know, the California Desert Plan in draft and final form required careful analysis. Using some of the information compiled by the Desert Tortoise Council and materials compiled by Committee members, we made a concentrated effort to inform individuals of the situation and to motivate them to comment on the Plan. We appreciate those who joined us in commenting on the Plan. Although the Plan details have yet to be released, it appears that the Natural Area will be managed as an Area of Critical Environmental Concern. The Plan implementation will require close monitoring on our part.
In June 1980, the State Lands Commission released the Environmental Impact Report on the Great Western Cities application for State relinquishment of surface entry rights on 1400 acres (467 hectares) of the Second Community of California City. The Second Community not only contains a sizable desert tortoise population, but also directly borders 4 miles (6.4 km) of the eastern boundary of the Natural Area. In spite of notice to both the Council and the Committee that each would receive a copy of the EIR upon

release, neither organization received it until phone requests were made close to the comment deadline. Both the Committee and the Council requested a 3-mile (4.8-km) buffer area and a physical barrier between the Natural Area and the Second Community developments. The California Department of Fish and Game requested that the State retain the surface entry rights due to potential wildlife damage. The State Lands Commission voted to relinquish surface entry rights on 30 October 1980, with less than a token measure to protect wildlife. That is, that Great Western Cities will deed to the Bureau one section of land. While this may help in acquiring private holdings within the Natural Area through exchange, it does nothing to protect the wildlife of the Natural Area from local dogs, children, and vehicles. Also, it does nothing to save the tortoise population of the 48-mi^2 (124 km^2) of the Second Community. These procedures and subsequent contact with the State Lands Commission indicate that the process was not competently handled. Our best chance of affecting the situation now is to be ready for the same process with regard to the Third Community. The Committee will be closely following the progress of the application for the Third Community and will be requesting your letters of concern at the proper time.

A major protection problem discussed in the 1979 Committee Report was hunting. The Committee is looking forward to the findings and recommendations of Tom Campbell, under special contract with the Department of Fish and Game.

3. TO RAISE FUNDS...FOR LAND ACQUISITION. During 1980 over $7,000 was grossed on products. We have added a new "Natural Area" tee shirt. The $4,500 donated during this same period includes $600 donated by the Westchester Chapter of the California Turtle and Tortoise Club (CTTC). Both the Westchester Chapter and other local chapters of the CTTC have continually and actively supported our efforts.

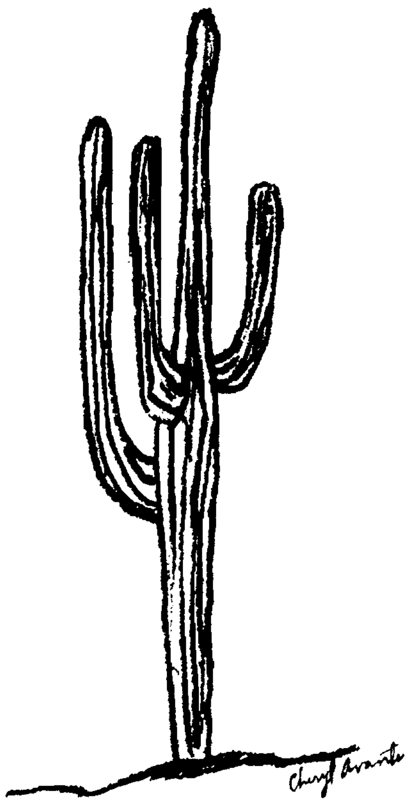
   The Bureau is currently working on a land exchange for Section 31, a key section on the western boundary of the Natural Area. The Committee will invest $12,000 in the process to equalize the land values. After this exchange, 11 highly divided sections of private land will remain to be acquired. We must all realize that it is much more difficult to "sell" the desert and the desert tortoise as a priority conservation problem than it is to "sell" a more lush and wet area. It takes very special techniques and salespersons to convince people of the subtle beauty, natural diversity, and fragility of the desert and of the immediate need to invest time and money into its protection.

4. TO FOSTER AND PUBLICIZE THE USES OF THE NATURAL AREA FOR SELECTED FORMS OF RECREATION, CONSERVATION, AND RESEARCH. During 1980, 3000 people attended 56 programs given on the desert tortoise and the project. Also, over 200 people were given guided tours of the Natural Area, not to mention the countless individuals who visited the Interpretive Center and explored the nature trails on their own. The Committee drafted preliminary nature trail guides for three loop trails, which were temporarily posted by the Bureau for the dedication. The Bureau has recently permanently posted the trails and will be printing finalized trail guides soon.

   Again during 1980, the Committee co-sponsored "Field Study of the Desert Tortoise" offered through University of California, Santa Barbara Extension, taught by Dr. Kristin Berry.

5. TO PROMOTE THE WELFARE OF THE DESERT TORTOISE IN SOUTHWESTERN UNITED STATES. Although our concentration is on the situation at the Natural Area, we found it important to comment on and solicit comments on the desert tortoise situation throughout the California desert with regard to the Desert Plan process. If the protection of the other three major desert tortoise populations in California is going to be as minimal as it appears, the Desert Tortoise Natural Area may well represent the best hope for survival of the desert tortoise in California.

This brief report does not adequately reflect the time, effort, and frustrations of individuals directly involved. Nor does it adequately reflect your efforts during the past year toward the survival of the desert tortoise. Yes, we all have a major investment in the future of the desert and the desert tortoise. We must increase this involvement; we cannot afford to do otherwise.



Guided tour of the Natural Area

Sheep grazing on
Desert Tortoise Natural Area

Stockton

STATE REPORT - NEVADA

KEMP CONN
District Manager
Bureau of Land Management
Las Vegas District
P. O. Box 5400
Las Vegas, Nevada 89102

This report is designed as a direct response to questions directed to this district in the Desert Tortoise Council's letter of December 31, 1980.

Question: What are your efforts to study populations in the areas identified in earlier inventories as possibly having tortoise populations with densities of > $50/mi^2$ ($130/km^2$); what are your efforts to obtain data on actual density, size class structure, mortality, sex ratios, etc?

Answer: There are no efforts underway this fiscal year. The District workload includes implementation of the Ash Meadows Habitat Management Plan (HMP) for the Warm Springs pupfish and the Mormon Mountain for bighorn sheep, development of the Virgin Mountain HMP for reintroduced bighorn and the Virgin River HMP for the endangered woundfin, as well as considerable involvement in the planning process for Clark County.

Question: What are your efforts to better delineate the areas with moderate to high densities (areas with $50/Mi^2$) by increasing denisity of strip-transects?

Answer: Again no efforts are underway to accomplish this for the same reasons as above.

Question: What are the 1981 priorities for studies of the desert tortoise and Annual Work Plan?

Answer: One study is planned for initiation this fiscal year. This is a diet quality and diet overlap study for desert tortoise and cattle in the spring. It is planned to use fecal analysis and proximate analysis methods. The area for this study is undetermined at present.

Question: What is the status of the Environmental Assessment concerning off-road vehicle designation in Clark County, Nevada, and elsewhere in the District?

Answer: The Environmental Assessment concerning off-road vehicle designation in Clark County is being postponed until Coordinated Resource Management Planning has been completed for the new Management Framework Plan being prepared for Clark County. It is expected that the Environmental Assessment for off-road vehicle designation in

Clark County will be completed as part of the 1982 Annual Work Plan. Also, an ORV Plan is being prepared for Lincoln County. The Environnmental Analysis Report for this plan is expected to be completed in fiscal year 1982.

Question: What considerations are being given to the desert tortoise Clark County Environmental Statement for livestock grazing?

Answer: Inventory data from the 1979 desert tortoise survey and the existing conflicts with oil and gas, roads, livestock, and off-road vehicles has been presented as a part of the Unit Resource Analysis for Clark County. The Management Framework Plan Recommendations which would address the protection of the desert tortoise is being prepared by district wildlife specialists.

Considerations specific to tortoise include:

1. Closures and restrictions to ORV events in area of high tortoise density.

2. Restrictions on new road construction in tortoise habitat.

3. Restrictions and some closures to oil and gas leasing and exploration work in tortoise habitat.

4. Seasonal restrictions on livestock grazing in tortoise habitat.

5. Change of livestock class from domestic sheep to cattle in some areas.

SYNOPSIS

The Las Vegas District is not involved in additional, more intensive studies for desert tortoise other than the above-mentioned food habitat study this fiscal year. This is primarily due to other work commitments such as the completion of planning for the Clark County Environmental Statement, ORV designations for Lincoln County, and implementation of the Caliente Management Plan. Because of their workload and funding cuts, it has been impossible to program for additional studies. All available data, however, is being incorporated into these planning processes to form the basis for the recommendations mentioned above. It should be mentioned that Coordinated Resource Management Planning is an essential part of BLM's planning process. Your participation in this process and your reviews of our planning efforts will be extremely important to the desert tortoise. You may expect contact from us for your review and comment on our planning in May. In late summer the public input plan for the ORV designations for Clark County will be initiated. Your involvement and cooperation in this will also be greatly appreciated.

STATE REPORT - NEVADA

BOB TURNER
Nevada Department of Wildlife
P. O. Box 10678
Reno, Nevada 89520

Ground surveys and transect lines were run to determine distribution, densities, and key habitats in Nevada. Two 1-mi^2 (2.6-km^2) plots were established in Eldorado Valley and Valley of Fire State Park. These plots were to investigate a possible survey method to be used by Department of Wildlife personnel for determining density estimates. A program of releasing turned-in, captive tortoise on various Las Vegas golf courses has been initiated and is being investigated as a partial solution to Nevada's captive tortoise problem. Further investigation and survey work will be conducted to determine the status of the desert tortoise in Nevada.

Determination of the general distribution of desert tortoise in Nevada is basically all that was accomplished due to both a limited budget and a limited nongame program prior to 1980.

Northern distribution extends into the upper portions of Pahranagat Valley and near Beatty, with the southern distribution extending south to the Arizona and California borders.

With a nongame biologist now assigned to the Las Vegas area, the Nevada Department of Wildlife has initiated several new projects and studies in order to determine more accurately the status of the desert tortoise and to develop a management program for the desert tortoise in Nevada.

Two 1-mi^2 (2.67-km^2)survey plots were established in Eldorado Valley and Valley of Fire State Park. Transect lines were established 0.1 mile (0.2 km) apart in a parallel and perpendicular pattern, resulting in 20, 1-mile (1.6 km) transect lines, 20 ft (6 m) wide for each plot. These transect lines were run during the first 2 weeks of May 1980. Transect lines were run throughout the entire day and data recorded, including all tortoise, scat, shell fragments, dens, and pellets observed. Estimated densities for these two areas were determined to be 21 tortoises/mi^2 (54/km^2) in Valley of Fire State Park and 50 tortoises/mi^2 (130/km^2) in Eldorado Valley. This method was utilized in an attempt to see if it would provide valuable and useful data and prove feasible for the amount of funding and manpower available for desert tortoise work. It has since been decided to abandon this method and to follow the same transect methodology utilized by the Desert Tortoise Council throughout California.

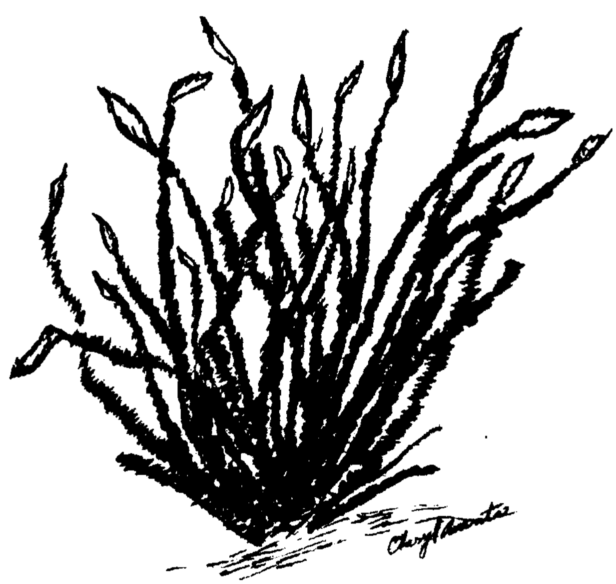
All observations of tortoises and tortoise sign to date have been in the creosote and creosote blackbrush types, on bajadas or hills and below the 5,000 ft (1525 m) elevation. Future surveys and work will further document tortoise distribution and densities, additional denning and burrow situations, and vegetative types utlized by the desert tortoise.

Classified as rare in Nevada, possession of the desert tortoise is illegal. A program for handling turned-in captive desert tortoise was initiated by the Department and is being monitored to determine its success. Captive desert tortoise are being marked, measured, and then released on various Las Vegas golf courses until a permanent program such as a permit system can be initiated. These tortoises are provided back yard type conditions (food, shelter and protection from harassment by children, pets, vehicles, and the general public). To date, a total of 80 tortoises has been released on two Las Vegas golf courses. Monitoring of the released tortoises will be resumed following their emergence from hibernation. This program is being well received and no problems have been encountered since its initiation in April 1980.

A proposal has been submitted to the U.S. Fish and Wildlife Service, Office of Endangered Species, by the State requesting funds for additional inventory work on desert tortoise. These funds, if approved, will be used to inventory state and federal lands not previously inventoried and previously identified high density areas, to aid in more accurately determining tortoise distribution and density in Nevada.

Input has been requested by several agencies on the impact of various land use practices on desert tortoise populations and habitat in southern Nevada. The most recent and major input being supplied has been on the impacts of the deployment of the MX Missile system and operating base in Nevada. This system will adversely impact the entire Coyote Springs desert tortoise population and their habitat, as well as adjacent populations and habitat due to the increased human activity and construction required for this project.

Public support and interest concerning the desert tortoise is rapidly increasing in southern Nevada, along with the increased cooperation between concerned state and federal agencies.



THE DISTRIBUTION AND RELATIVE DENSITIES OF THE DESERT TORTOISE, *GOPHERUS AGASSIZI*, IN LINCOLN AND NYE COUNTIES, NEVADA

ALICE KARL
21126 Chatsworth Street
Chatsworth, California 91311

INTRODUCTION

The Bureau of Land Management (BLM) is legally required to manage all resources located on land under federal jurisdiction such that no species will be threatened with decreased viability (U.S.D.I. 1980). Species which are already in a state of potentially fatal decline are to be given increased consideration in the formulation of land usage policies.

The desert tortoise, *Gopherus agassizi*, is presently listed as "sensitive" by the Nevada State Director. Thus, to aid in the preparation of Grazing Environmental Statements for Clark, Lincoln, and Nye counties in Neavda, data were collected on *G. agassizi* in these counties. Two permanent study plots in Clark County (Karl 1979*a*, *b*) and one in Nye County (Karl 1981*a*) were established to determine both absolute densities at these sites and ecological relationships. Additionally, potential desert tortoise habitat was surveyed in Clark (Karl 1980*a*), Lincoln, and Nye counties (Karl 1981*b*) to determine the relative densities and the distribution of *G. agassizi* in Nevada. This paper reports some of the results of the habitat survey in Lincoln and Nye counties.

Similar data were collected on *G. agassizi* in California (Berry and Nicholson 1979), to assist in the development of the California Desert Plan (U.S.D.I. 1980), and in Arizona (Burge 1979).

DESCRIPTION OF STUDY AREA

Lincoln County

The townships surveyed were suggested by BLM, with adjustments by the principal investigator. The surveyed area comprised 29 townships south of T7S and between R62E and 20W (Figure 1), a total of approximately 920 mi^2 (2400 km^2).

Larrea tridentata and *Ambrosia dumosa* are present throughout the area and dominate the shrub layer from approximately T10S to the south (found on 62% of all transects); the northernmost sighting of *L. tridentata* was T8S in R76E. The shrub layer in the *L. tridentata* community is moderately diverse, including *Sphaeralcea ambiqua*, *Atriplex confertifolia*, *Eurotia lanata*, *Krameria parvifolia*, *Thamnosma montana*, *Dalea fremontii*, *Yucca schidigera* (west of R67E), *Y. brevifolia* (east of R67E), *Hilaria rigida*, *Stipa* sp., *Aristida* sp., and *Muhlenbergia porteri*. *Coleogyne ramosissima* is co-dominant with *L. triodentata* in northeastern Kane Springs Valley and north-northeast of the Mormon Mountains (23% of all transects). Associated species in this ecotone are *Lycium andersonii*, *Grayia spinosa* and *Menodora spinescens*. At approximately the 4000 ft (1220 m) contour, *C. ramosissima* becomes the predominant shrub, although *L. tridentata* remains (15% of all transects). *Yucca baccata* is associated with the *C. ramosissima* community.

Shrub layer density is primarily medium (shrubs spaced approximately 15 ft or 5 m apart) to moderately dense (shrubs spaced approximately 5 to 10 ft or 4 to 9 m apart). Only the communities where *C. ramosissima* is a major component, and especially where it is predominant, are dense (shrubs spaced 0 to 5 ft or 0 to 4 m apart).

Bromus rubens is the dominant understory species for most of the area surveyed, with the exception of the southern boundary and the southeastern and southwestern corners of the surveyed area, where *B. rubens* is common, but *Festuca octoflora* is generally dominant.

Seldom-used dirt roads are present throughout the area and cattle are grazed throughout the area. According to grazing allotment data provided by the Las Vegas District BLM, the number of head grazed per square mile ranges from 0.5 to 6 (1.3 to 15.5/km^2). Use ranges from only in the spring to year round. Sheep and domestic horses are also grazed, but to much lesser extent than cattle.

Land between 2000 ft (610 m) and 4000 ft (1220 m) was surveyed; the average elevation was 3015 ft (919 m).

Nye County

The surveyed area comprised 28 townships south of T10S and between R45E and 54E, a total of approximately 900 mi^2 or 2331 km^2 (Figure 2).

The shrub layer for most of the area surveyed is dominated by medium to moderately dense *L. tridentata*, along with co-dominant *A. dumosa* and/or *Atriplex confertifolia* (84% of all transects). Diversity is generally poor, but includes *Ephedra* sp., *Lycium* spp., *M. spinescens*, *T. montana*, *Y. schidigera* or *Y. brevifolia*, *K. parvifolia*, *Oryzopsis hymenoides*, *Eriogonum fasciculatum*, *S. ambiqua*, and *D. fremontii*. *Atriplex hymenelytra* is co-dominant with *L. tridentata* in southeastern Ash Meadows, northern Pahrump Valley (where it is replaced by *A. polycarpa* in northernmost Pahrump Valley), on the alkali flatss in and northeast of Ash Meadows (Beatley 1976) and in the southern tip of Nye County. *L. tridentata* becomes subdominant to *Haplopappus cooperi* or to *C. ramosissima* north and northeast of Beatty and *C. ramosissima* is co-dominant with *L. tridentata* in T16S R53E at approximately 4000 ft (1220 m) contour.

The understory vegetation appeared to be primarily sparse (< 10% cover) in the surveyed area north of Ash Meadows and increased in density toward the east and west. *Chorizanthe rigada* is the predominant species north of Ash Meadows, but it is gradually replaced by grasses (e.g. *Gouteloua* sp., *Festuca octoflora*, *Erioneuron pulchellum*, and *Schismus arabicus*) and then by mustards, borages, and *Chaenactis* spp., progressing eastward. To the west, *Chaenactis* spp., and gradually members of the Graminae, Polemoniaceae, Oenograceae, and and Boraginaceae families become dominant; *Plantago insularis* is dense and predominates on hillsides. The area from Crater Flat north is predominantly *B. rubens* with some *P. insularis*, *E. pulchellum*, and *Erodium cicutarium*.

Old, rarely-travelled, dirt trails are the prevailing disturbances (in 59% of the transects), followed closely by burro and/or wild horse grazing. Cattle grazing was located in southeastern Nye County, as well as in northwestern Nye County, although grazing allotments are only recorded for the latter.

Land between 2440 ft (744 m) and 4320 ft (1317 m) in elevation was surveyed, with the mean elevation at 3004 ft (916 m).

METHODS AND MATERIALS

In Lincoln County, 52 transects were walked between 11 and 20 April 1980. In Nye County, 57 transects were walked between 7 and 15 March 1980 (48 transects) and between 22 and 29 May 1980 (9 transects).

The methodology employed to collect data was identical to that used for surveying Clark County (Karl 1980*a*, *b*) and was developed by Berry and Nicholson (1979). The amount of tortoise sign (e.g. burrows, scat, tortoises, skeletal remains, tracks) found during a transect was used to estimate the relative tortoise density at each transect site. To correlate sign to relative tortoise density, sign levels from multiple transects on five study plots, four in Nevada (Burge and Bradley 1976; Karl 1979*a*, *b*, 1981*a*) and one 17 miles (27 km) west of the Nevada border (Karl 1978) were compared to the previously-determined, absolute tortoise densities at each study plot using a linear regression analysis (Figure 3). From this correlation, an index was established against which sign could be used to estimate tortoise density at each transect site (Table 1). Two categories of sign were used to estimate tortoise density because of the seasonal and daily variation in tortoise activity which coincided with the surveys: burrows and adjusted total sign (Berry and Nicholson 1979). The latter refers to the total sign minus that sign which occurred with other sign (e.g. a tortoise in a burrow is equivalent to one sign, not two).

To formulate associations between habitat characteristics (other than elevation) and estimated tortoise density, a chi-square contingency table (probability = 0.05) was used. To determine associations between elevation and estimated tortoise density, a "Student's" t test was used (probability = 0.05).

TABLE 1. Estimated Equivalence of Tortoise Sign Observed on Transect to Relative Tortoise Density

Burrows		Adjusted total sign	
Number of burrows	Number of tortoises/mi^2	Number of sign	Number of tortoises/mi^2
0	0-5	0	0-10
1-3	5-50	1-3	10-45
4-6	50-110	4-7	45-90
7-9	110-150	8-11	90-140
≥-10	≥-150	≥-12	≥-140

Lincoln County Results

Range

Tortoise sign was found to the Nevada-Utah border and the eastern border of the Desert Game Range (Figure 4). The northern limit of sign was the boundary of T7S and 8S. Although Coyote Springs Valley north of T11S was unsampled, tortoise sightings in T9S, R62E have been reported by Las Vegas District BLM personnel.

Estimated Relative Tortoise Densities

Tortoise densities reach 100 tortoises/mi^2 (38.6/km^2) in only 1 to 3% of the total area (Figure 4). The remaining area had less than 50 tortoises/mi^2 (19.3tortoises/km^2), with 72% of the total area estimated to have no tortoises (Table 2).

TABLE 2. Estimated Relative Tortoise Densities in Lincoln County

		Estimated square miles occupied by each estimated tortoise density level			
		Within surveyed area		To projected northern limit of range	
Estimated tortoises/mi^2	Percent of all transects (n=52)	mi^2	% of total	mi^2	% of total
0	25	300	33	800	50
0-10	25	360	39	390	24
1-10	17	100	11	100	6
10-50*	31	150	16	150	9
50-100	2	10	1	10	1
Undetermined	0	0	0	150	10
	100	920	100	1600	100

*Ca 20 mi^2 (=2 transects) may have tortoise densities up to 100 tortoises/mi^2

Habitat - Comparisons to Estimated Relative Tortoise Densities

Vegetation. Tortoise sign was found primarily in the *L. tridentata-A. dumosa* communities (81% of the 26 transects where tortoise sign was located on or near the transect); however, it was also found in the *L. tridentata-C. ramosissima* ecotone (11%) and in *C. ramosissima* communities (8%).

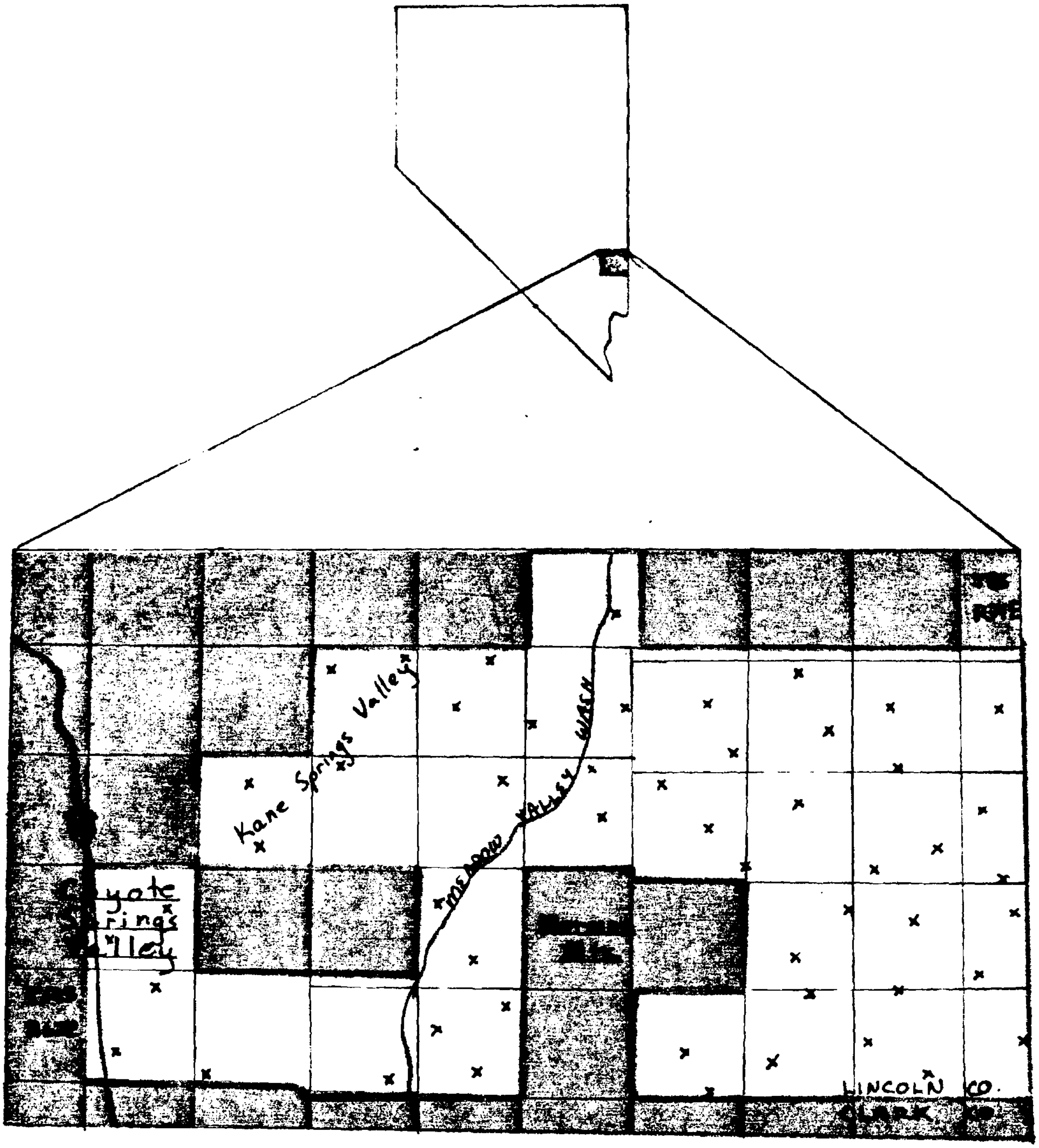


FIGURE 1. The surveyed area in Lincoln Co. (unshaded portion); x's (x) represent transect sites

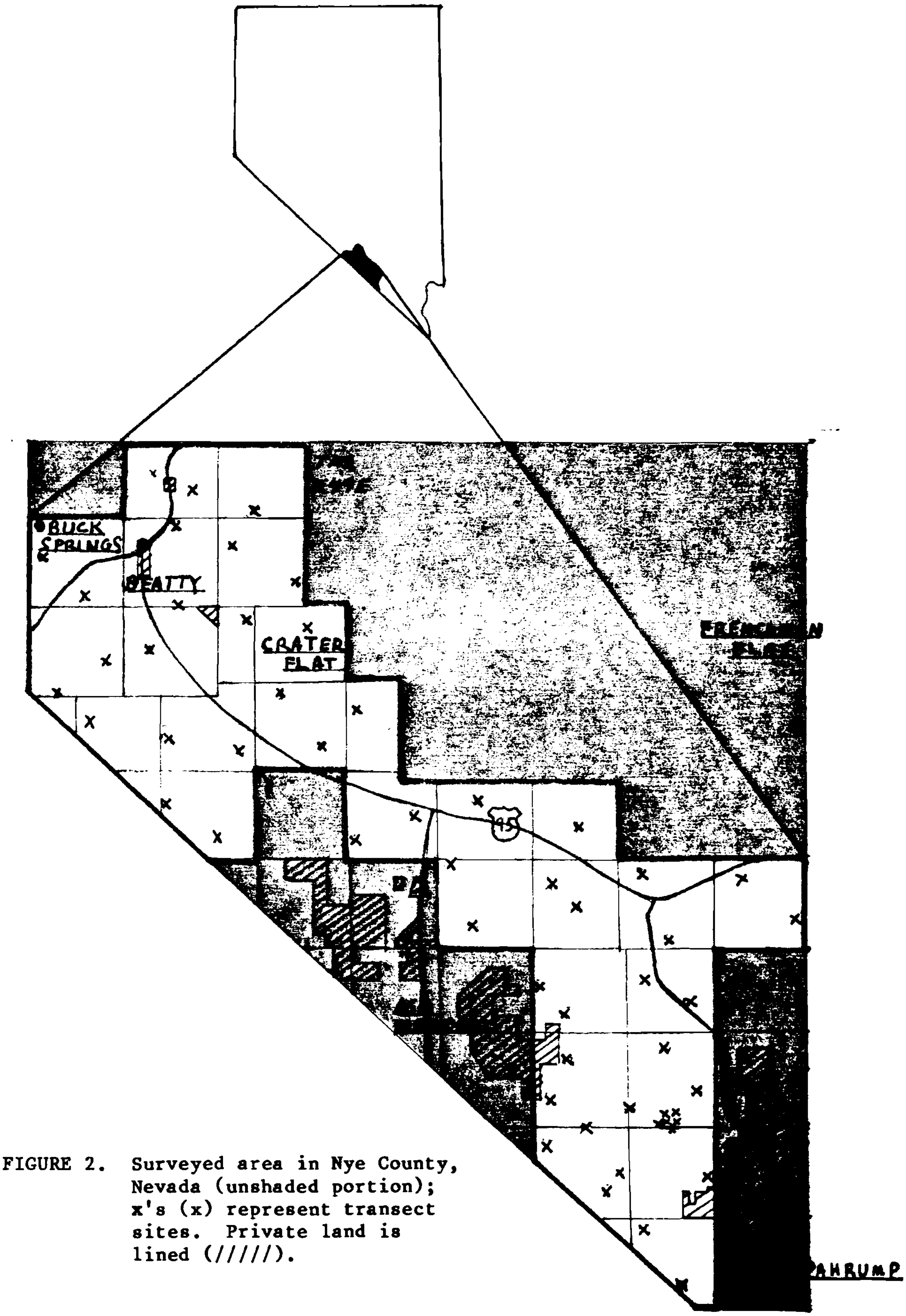


FIGURE 2. Surveyed area in Nye County, Nevada (unshaded portion); x's (x) represent transect sites. Private land is lined (/////).

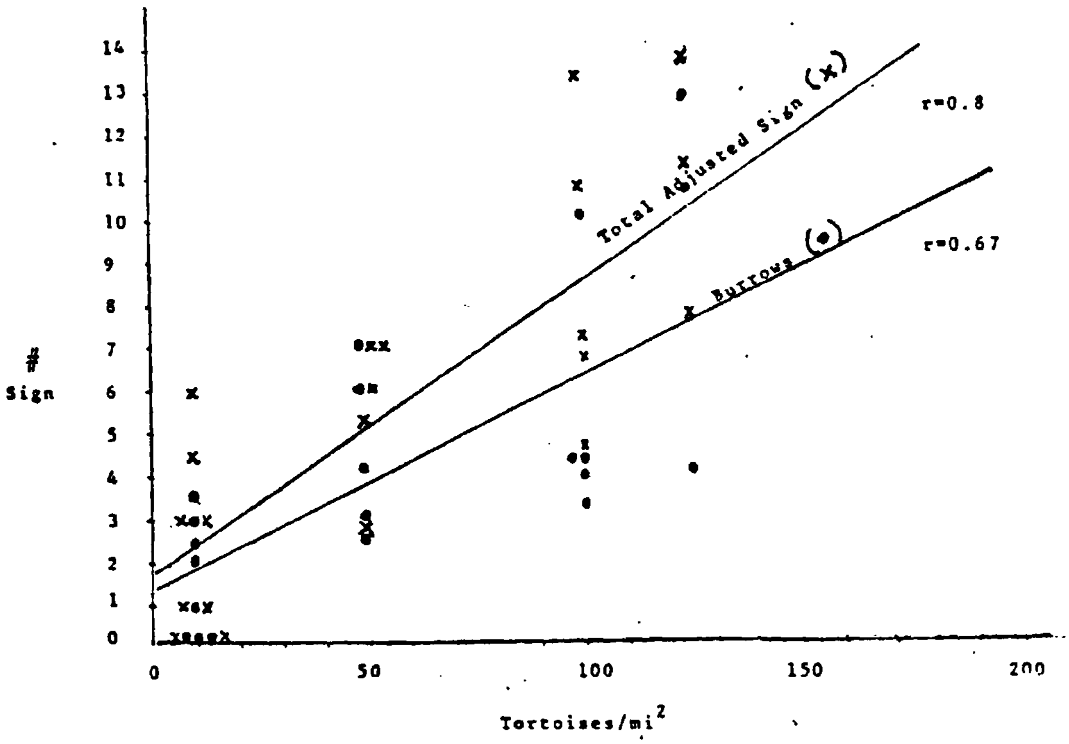


FIGURE 3. Transect sign, from multiple transects on five study plots, correlated to absolute tortoise densities on these study plots.

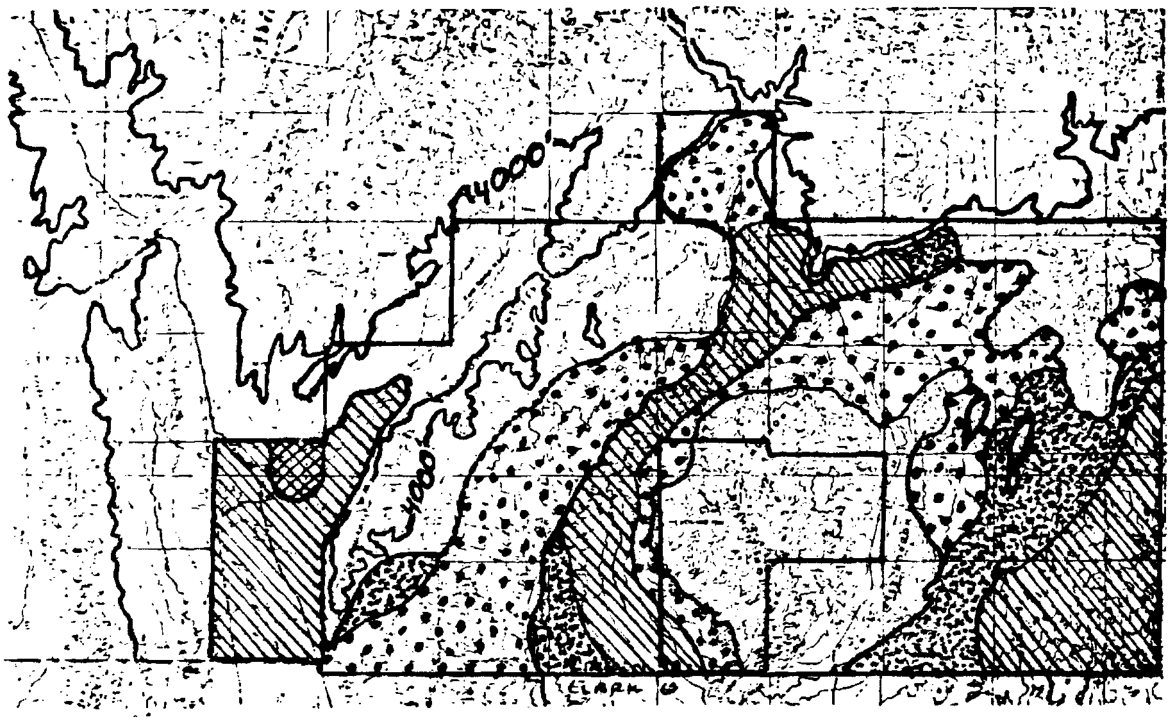


FIGURE 4. Estimated relative tortoise densities in Lincoln Co., Nevada.

The calculated chi-squared value (=12.11; tabular chi-squared value = 9.49) indicated that a significant difference exists between estimated tortoise density categories, relative to shrub-layer vegetation type, with estimated tortoise density being negatively correlated to the predominance of *C. ramosissima* (Figure 5). No *C. ramosissima* predominated and only one *C. ramosissima-L. tridentata* ecotone occurred where tortoise densities were estimated to exceed 10 tortoises/mi^2 (3.9 tortoises/km^2).

Difficulty was encountered in correlating estimated tortoise densities to understory vegetation; an accurate analysis of the density and composition of the understory cannot be made in a single year because of variability in the germination and survival success of winter annuals due to annual variation in rainfall (Beatley 1966). However, the exotic grass, *Bromus rubens*, successfully germinates each year (Beatley 1976) and, where it is dominant in a given year, probably retains its position of dominance even in years with high annual biomass and diversity, due to its: (a) increased survivorship; (b) decreased moisture and temperature requirements; and (c) increased fertility over native winter annuals. There was a significant difference (calculated chi-squared value = 11.05, tabular chi-squared value = 7.82) between the estimated tortoise density categories relative to the proportion of transects with predominant *B. rubens*. Where *B. rubens* was predominant (coincident with high cover), estimated tortoise densities were less (Figure 6). Of the transects where *B. rubens* was subdominant (n=9), seven occurred where tortoise densities were estimated to exceed 10 tortoises/mi^2 (3.9 tortoises/km^2). In these transects and in those transects where *B. rubens* was a co-dominant species the tortoise densities were estimated to exceed 10 tortoises/mi^2, the most common annuals were *F. octoflora*, *P. insularis*, *Cryptantha* spp., *Pectocarya* spp., and *E. pulchellum*. In transects where *B. rubens* was predominant (except in two of the three *B. rubens*-predominated transects in the 10 to 50 tortoise/mi^2 or 3.9 to 19.3 tortoise/km^2 category), the most common subdominant or co-dominant annuals were *Erodium cicutarium*, *Astragalus* sp., and *Lotus* sp. (In two of the three transects in the estimated 10 to 50 tortoises/mi^2 category where *B. rubens* was predominant, the understory species of apparently secondary importance included *E. pulchellum*, *Pectocarya* spp., *Cryptantha* spp., *Nama* sp., *Gila* spp., and *Phacelia* spp.).

Disturbance. Disturbances were similar throughout the surveyed area. Although the greatest number of cattle grazed per square mile occurred where tortoise densities were estimated to equal 0 tortoise/mi^2 (Kane Springs Valley), the number of cattle per square mile in this tortoise density category ranged from 0.5 to 6 cattle/mi^2 (.2 to 2.3/km^2). Up to 5 cattle/mi^2 (1.9 cattle/km^2) were grazed where tortoise densities were estimated to exceed 10 tortoises/mi^2 (3.9 tortoises/km^2). The heaviest grazing, with respect to the number of head and the season of use, was along the eastern border of Lincoln County, where grazing reached 3-4 cattle/mi^2 (1.2 to 1.5 cattle/km^2cattle/km^2) for 7.5 months in the winter and spring or 5 cattle/mi^2 (1.9 cattle/km^2) for 2 months in the spring. Tortoise densities here were estimated at 10-50 tortoises/mi^2 (3.9 to 19.3 tortoises/km^2).

Elevation. Evidence of tortoises was found between 2000 ft (610 m) and 3800 ft (1158 m). A significant difference exists between the mean elevation of those transects with tortoise sign and those without; the latter were higher (Table 3).

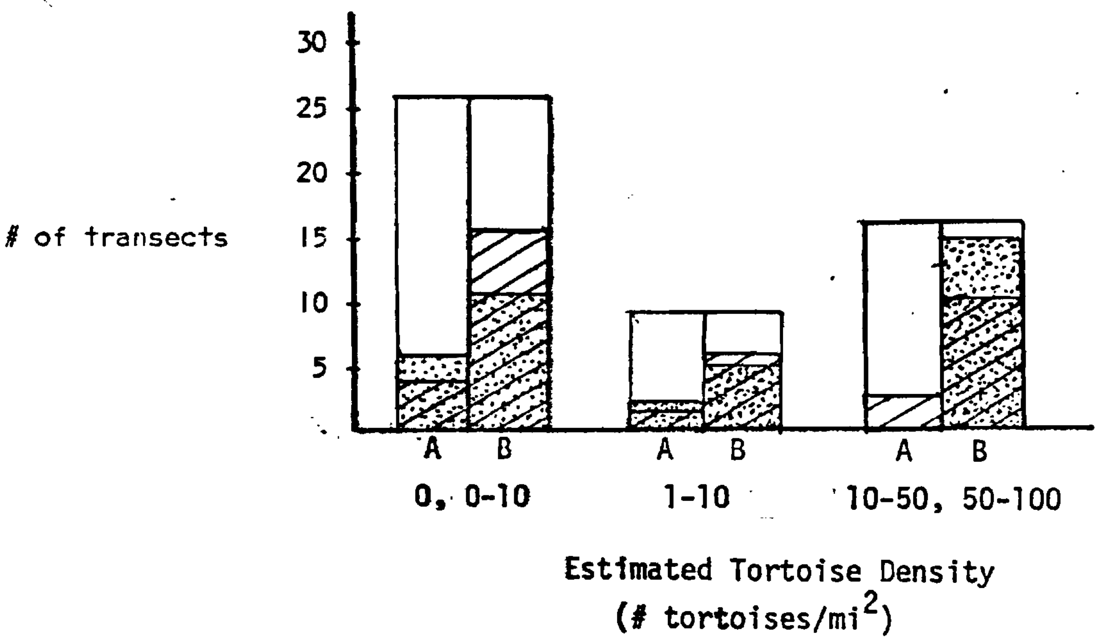


FIGURE 5. Shrub layer communities compared to estimated tortoise density. Column A represents *Coleogyne ramosissima*-predominated communities; column B represents *Larrea tridentata*-predominated communities. Expected values (///) were derived from chi-squared contingency table. (∴) = observed values; clear area = total number of transects for tortoise density category.

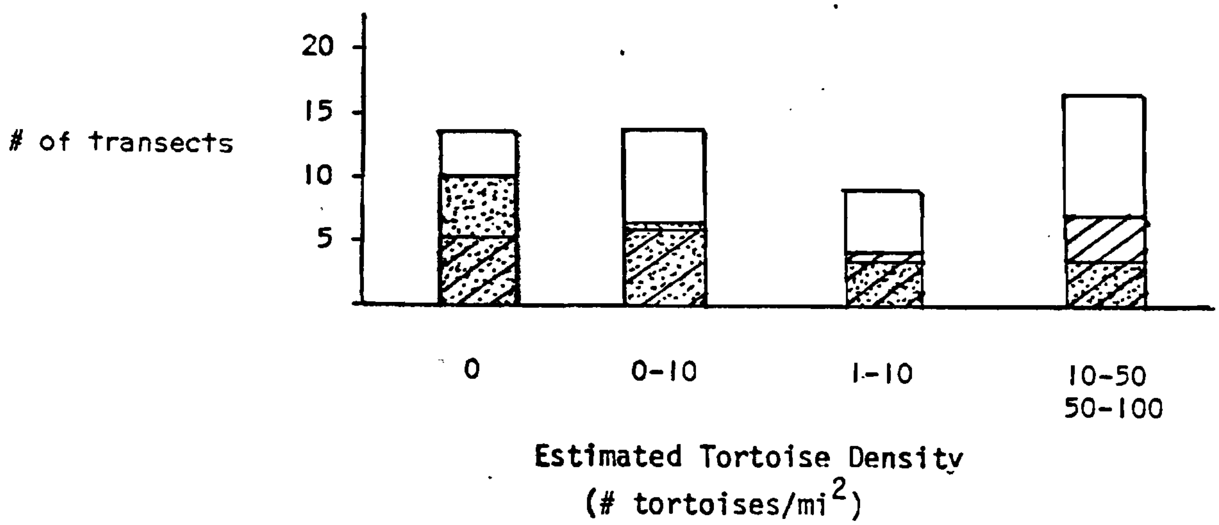


FIGURE 6. *Bromus rubens*-predominated transects compared to estimated tortoise density. Expected values (///) were derived from a chi-squared contingency table. (∴) = observed values.

TABLE 3. A comparison of the Mean Elevation of Transects in the Estimated Tortoise Density Categories by Use of the "Student's" t Test

	Estimated tortoise density (#tortoise/mi^2	Elevation (miles)	Calculated t	Tabular t	Significance
A.	0, 0-10 (n=26)	$\bar{x}$ = 3298 Range:2000-4000	Between A and B: t=2.51	t=2.04	Significant
B.	1-10 (n=9)	$\bar{x}$ = 2883 Range:2470-3800	Between B and C: t=1.45	t=2.07	Not significant
C.	10-50, 50-100 (n=17)	$\bar{x}$ = 2664 Range:2000-3800	Between A and C: t=4.95	t=2.02	Significant

RESULTS

Nye County

Range

Tortoise sign was found from R46 E east to the R52E/53E boundary, south to the T19S/20S boundary and north to the T12S/13S boundary (Figure 7). However, one long-time Beatty resident reported that tortoises reside in the area of Buck Springs (T12S, R46E). Although Buck Springs was unsurveyed, I question the presence of tortoises there due to the high elevation, 4600 ft (= 1402 m), the mountainous terrain, and the vegetation (above the *L. tridentata* zone; see "Discussion-Lincoln County").

Estimated Relative Tortoise Densities

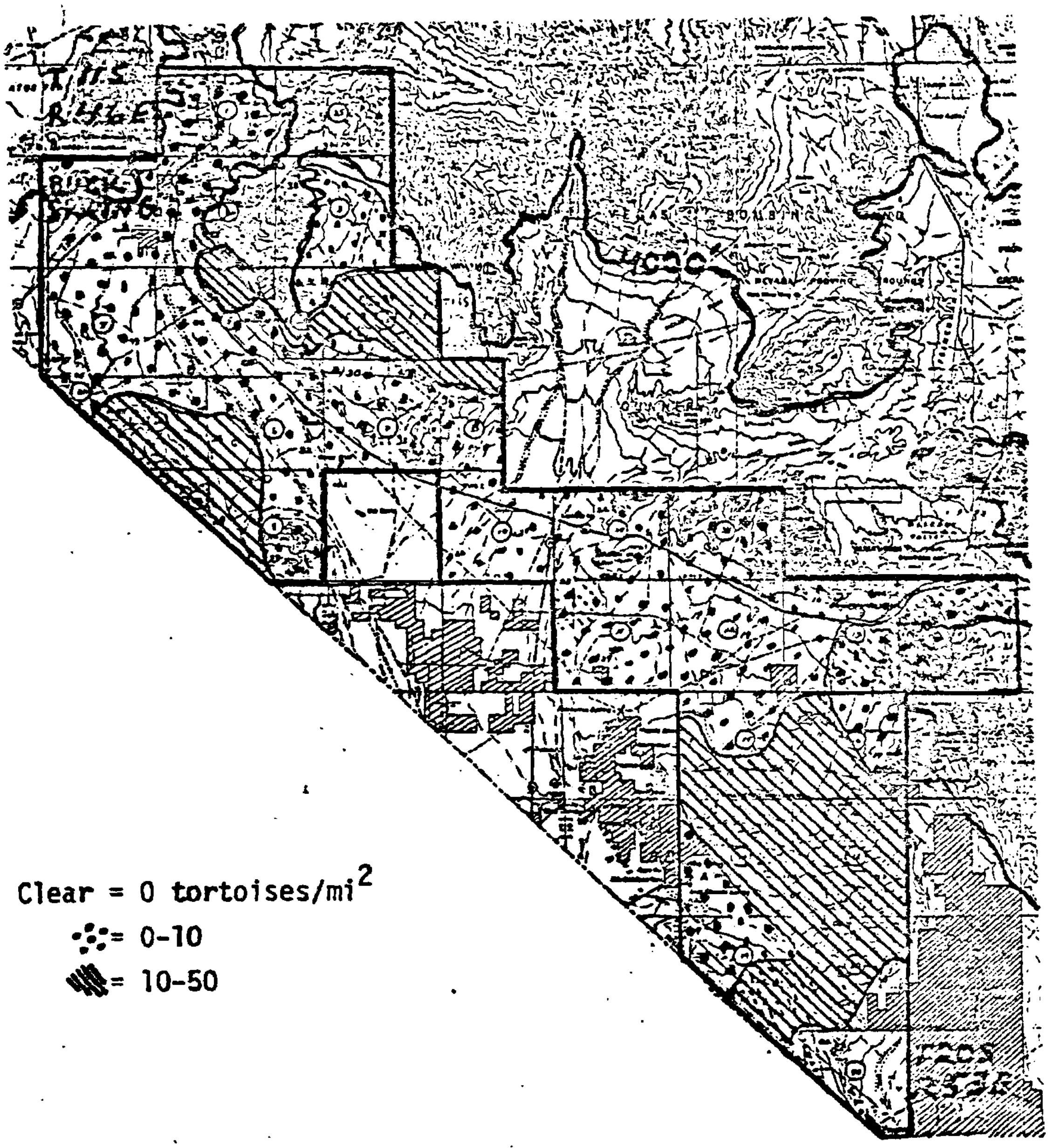
No tortoise densities greater than 50 tortoise/mi^2 (19.3 tortoises/km^2) were estimated to exist (Table 4). The majority of the area (74%) potentially has none, but possibly up to 50 tortoises/mi^2 (19.3 tortoises/km^2). The remaining area (26%) is estimated to have from 10 to 50 tortoises/mi^2 (3.9 to 19.3 tortoises/km^2).

Habitat - Comparisons to Estimated Relative Tortoise Densities

Vegetation. Tortoise sign was found entirely within the *L. tridentata-A. dumosa* and/or *A. confertifolia* community. No tortoise sign was found where *C. ramosissima* or *A. hymenelytra* were present (two and four transects, respectively) and/or where *L. tridentata* was subdominant (eight transects).

Only 4 of the 13 transects where the *L. tridentata* community was moderately diverse had evidence of tortoises. However, this was not significantly different than the expected value of 3.6.

FIGURE 7. Estimated relative tortoise densities in Nye County, Nevada.



Of the transects where tortoise sign was positively identified (n=14) *B. rubens* was predominant in only one transect; it was present, but in a co-dominant or sub-dominant capacity, in four other transects with evidence of tortoises. These values values were not significantly different from expected values. The remaining transects appeared to have moderately diverse understories, including grasses, mustards, borages, *Chaenactis* sp., and *C. rigada.*

TABLE 4. Estimated Relative Tortoise Densities in Nye County

Estimated tortoises/mi^2	Percent of all transects (n=51)	Estimated square miles occupied by each estimated tortoise density level: mi^2	% of total
0	8	80	8
0-10*	65	590	66
10-50**	27	230	26
	100	900	100

*Ca 60 mi^2 may have tortoise densities up to 50 tortoises/mi^2

**CA 10 mi^2 may have densities up to 90 tortoises/mi^2

Disturbance. Old roads are present throughout the surveyed area and show no correlation to tortoise density. However, 45% of all transects with horse or burro grazing occurred where tortoise densities are estimated to equal 10-50 tortoises/mi^2 (3.9 to 19.3 tortoises/km^2), a significant difference from the expected 27%. Additionally, grazing seemed heavy (i.e. several well-beaten paths, herds of 8 to 20 animals, and at least 12 piles of droppings) in 50% of the transects with tortoise sign.

Elevation. Tortoise sign was found between 2400 ft (732 m) and 4000 ft (1220 m).

DISCUSSION

Lincoln County

Berry and Nicholson (1979) doubt that tortoise populations with densities less than 50 tortoises/mi^2 (19.3 tortoises/km^2) and possibly even up to 100 tortoises/mi^2 (46.1 tortoises/km^2) can survive without adjacent high density populations. Thus, Coyote Springs Valley, estimated to contain the highest relative tortoise densities in Lincoln County, 50-100 tortoises/mi^2 (19.3 to 46.1 tortoises/km^2), is potentially the only viable population in

Lincoln County and, therefore, very important. It is likely that tortoise densities up to 100 tortoises/mi^2 (46.1 tortoiseskm^2) may extend south across the Lincoln-Clark counties line and into Hidden Valley, because Clark County transects in Hidden Valley indicated tortoise densities of 50-100 tortoises/mi^2 or 19.3 to 46.1/km^2 (Karl 1980*a*) and there are no apparent differences in the vegetation, disturbance, elevation, or geomorphology in the area between Coyote Spring and Hidden valleys. This would represent a large, moderately undisturbed, and potentially viable population, one of five in Nevada (Karl, 1980*a*, 1981*b*). This is of major importance in light of the impact which would be rendered by the construction and operation of the proposed MX Missle base in Coyote Springs Valley. Closer scrutiny of this area is necessary to more precisely delineate tortoise densities and probable impacts of an MX Missle site, in order to develop mitigation measures.

The finding that estimated tortoise density decreases with the addition of *C. ramosissima* as a major component to the shrub layer is consistent with the findings of Karl (1980*a*) for Clark County. Beatley (1976) stated that the climatic difference between the *L. tridentata* and *C. ramosissima* communities is the amount of precipitation. *C. ramosissima* enters the *L. tridentata* community where the mean annual rainfall reaches 6.4 inches (163 mm) and *L. tridentata* is absent at annual precipitation levels greater than 7.2 inches (183 mm). Munz (1959) states that the climatic difference between *L. tridentata* and *C. ramosissima* is that of lower temperatures in the latter (a minimum of -5.5°C and 130 frost-free days as opposed to a minimum of -1.1°C and 190 frost-free days in *L. tridentata*) as well as increased rainfall (up to 15 inches or 381 mm as opposed to a maximum of 8-10 inches or 203-254 mm in *L. tridentata*). As tortoises seem to primarily inhabit the *L. tridentata* community, one can theorize that this is because: (a) the composition and/or amount of cover of the vegetation associated with the *L. tridentata* community is favorable; or (b) the increased precipitation and/or lowered temperatures in the *C. ramosissima* community has a direct, negative effect on *G. agassizi*.

A strict elevational limit of tortoise habitation cannot be determined. However, because estimated tortoise densities decrease with a decrease in the dominance of *L. tridentata* and the upper elevational limit of *L. tridentata* in Lincoln County coincides approximately with the 4000 ft (1220 m) contour (at which point *C. ramosissima* becomes predominant), then the upper elevational limit of *G. agassizi* in Lincoln County is approximately 4000 ft. Therefore, it is likely that tortoises are present as far north as the T6S/7S boundary because of habitable vegetation (*L. tridentata* and *A. dumosa*) and elevtion (less than 4000 ft), although no tortoise sign was found here. The estimated habitat of *G. agassizi* in Lincoln County thus includes about 1600 mi^2 (4200 km^2).

Although there was no apparent negative correlation between present grazing levels and estimated tortoise densities, there are no data available against which to compare current tortoise densities. I propose that the long-term effects of grazing, as opposed to the current impacts, such as trampling of tortoises and burrows and direct competition for forage (which was documented by Berry 1978), would effect the greatest decrease in tortoise densities. The long-term result of grazing is a change of habitat through the reduction of native annuals and perennials and the introduction of successful exotics. This hypothesis is consistent with the observation that estimated tortoise densities decrease with the dominance of *B. rubens*, a grazing-introduced annual (Robbins, Bellue, and Ball 1951). As further support, *E. cicutarium*, another grazing-introduced annual (Robbins *et al.* 1951), occurred commonly only where tortoise densities were low or absent. The common occurrence of *Astragalus* sp. and *Lotus* sp. in areas of high *B. rubens* importance and low estimated tortoise density suggests that they may also be indicators of extensive (either spatially or temporarily) grazing. Many legumes require scarification of the seed coat for germination, which would be accomplished in the bovid digestive system.

Beatley (1966) found that the amount of *B. rubens* was inversely related to the success of the rodent, *Dipodomys microps*, in Nevada; however, no similar correlation was evident for *D. mirriami*. So, *B. rubens* may be differentially significant to various animals, including *G. agassizi*.

Although introduced annuals are often eaten by tortoises, their palatability or nutritive content may be less than that of native annuals. This may be especially important if an exotic annual is successful to the exclusion of most other annuals. Although Beatley (1966) concluded that there "is no evidence that numbers of the...native winter annuals...are reduced because of sharing a site with *B. rubens*", I found that where *B. rubens* was dominant, it was often dense and the diversity of other annuals was slight. It is impossible to determine from the current data if this low diversity is present annually or was a result of 1979/1980 climatic conditions.

DISCUSSION

Nye County

The estimate of 50 tortoises/mi^2 (19.3 tortoises/km^2) may be high. The estimated equivalence of transect sign to tortoise density is only an approximation and false impressions of tortoise density may result if:

1. the transect line travels through a single tortoise's home range, coinciding with several of its burrows;

2. the number of skeletal remains found are representative of mortality rate, rather than population size;

3. it cannot be determined without question whether a burrow, especially one which is caved in, is that of a tortoise; or

4. transects are not walked during tortoise activity periods, either seasonally or daily, which would result in decreased sightings of live tortoises. Seasonally, fewer scats and tracks are present during non-activity seasons.

An initial overestimation of the tortoise population size at the Nye County site according to the results of March transects, indicating densities of 10-50 tortoises/mi^2 (3.9 to 19.3 tortoises/km^2) was probably the result of 1) and 2), above. A concentrated search of the site in May revealed only 5-10 tortoises/mi^2 or 1.9 to 3.9 tortoises/km^2 (Karl 1981*a*).

The consequence of potentially very low densities in Nye County is that tortoises in this county haven't nearly the chance for survival as those in Lincoln and Clark counties, if one adheres to minimum levels for viable populations (Berry and Nicholson 1979).

If the 4000 ft (1220 m) contour (coinciding with the upper elevational limit of *L. tridentata*) is used as the upper elevational limit for *G. agassizi* in Nye County, then it is possible that tortoises are found as far north as the T11S/12S boundary, north of Frenchman Flat, and east to the Nye/Clark counties boundary. To these limits, the elevation remains below 4000 ft and the shrub layer vegetation is *L. tridentata*. Tortoise habitat in Nye County would then total about 1475 mi^2 (3820 km^2).

Due to the small sample size for transects with tortoise sign, the lack of previous data on tortoise densities and the inexact and subjective analysis of the extent of grazing, no interpretation of the data is possible relative to the effect of grazing on tortoise densities. Similarly, the first two conditions preclude valid interpretation of the data relative to the effect of shrub layer diversity or *B. rubens* dominance on tortoise densities.

ACKNOWLEDGMENTS

This project was funded by contract no. YA-512-CT9-90 of the Las Vegas District Office of the BLM. I am grateful to P. and W. Melograno for their excellent company, M. Maley for his patience and B. Civiche for his understanding and goodwill. I also thank A. Gaudin for reviewing a previous draft of this manuscript.

REFERENCES

Beatley, J. 1966. Ecological status of introduced brome grasses (*Bromus* spp.) in native vegetation of southern Nevada. Ecology, 47(4):548-554.

_______. 1976. Vascular plants of Nevada Test Site and Central-Southern Nevada: ecological and geographic distribution. Energy Research and Development Administration, U.S. Dept. of Commerce, Springfield, VA. 301 pp.

Berry, K. 1978. Livestock grazing and the desert tortoise. Pages 136-155 *in* C. G. Jackson and M. Trotter, eds. Tortoise Council Proceedings, Tucson, Arizona.

California. U.S.D.I., Bureau of Land Management, Desert Plan Staff, Riverside, CA.

Burge, B. 1979. A survey of the present distribution of the desert tortoise (*Gopherus agassizi*) in Arizona. Bureau of Land Management, Denver, CO. Contract No. YA-512-CT8-108.

Burge, B., and W. Bradley. 1976. Population density, structure and feeding habits of the desert tortoise, *Gopherus agassizi*, in a low desert study area of southern Nevada. Pages 51-74 *in* N. Engberg, S. Allan, and R. Young, eds. Desert Tortoise Council Symposium Proceedings, Las Vegas, Nevada.

Karl, A. 1978. An ecological study of a population of desert tortoises, *Gopherus agassizi*, at Shadow Valley, San Bernardino County, California. Calif. Desert Plan Program, Bureau of Land Management, Riverside, CA. Contract No. CA-060-CT8-000042.

_______. 1979*a*. An ecological study of a population of desert tortoises, *Gopherus agassizi*, in southern Nevada. U.S.D.I., Bureau of Land Management, Denver, CO. Contract No. YA-512-CT9-90.

________. 1979*b*. An ecological study of a population of desert tortoises, *Gopherus agassizi*, in Clark County, NV. U.S.D.I., Bureau of Land Management, Contract No. YA-512-CT9-90.

________. 1980*a*. Density and distribution of the desert tortoise, , in Clark County, Nevada. U.S.D.I., Bureau of Land Management, Denver, CO. Contract No. YA-512-CT9-90.

________. 1980*b*. Distribution and relative densities of the desert tortoise in Nevada. Pages 75-87 *in* K. Hashagen, ed. Desert Tortoise Council Symposium Proceedings. 1-179. Available from Desert Tortoise Council, 5319 Cerritos Avenue, Long Beach, California 90802.

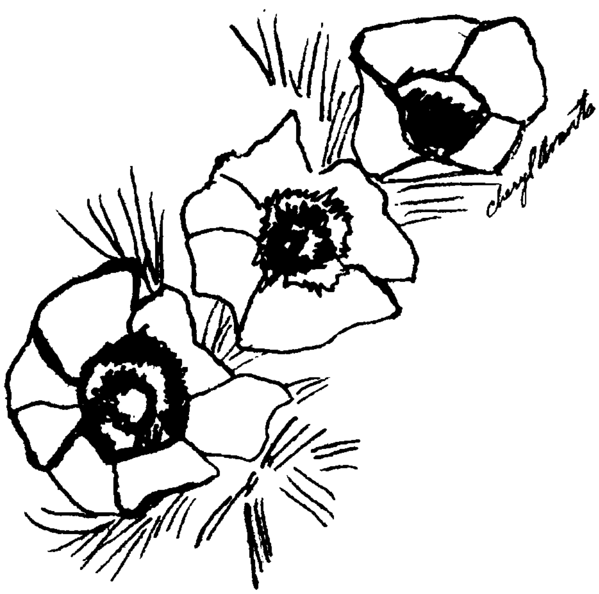
________. 1981*a*. The ecology of a population of desert tortoise, , near Pahrump, Nevada. U.S. Dept. of Int., Bureau of Land Management, Denver, CO. Contract No. YA-512-CT9-90.

________. 1981*b* . The distribution and relative densities of the desert tortoise, *Gopherus agassizi*, in Loncoln and Nye counties, Nevada. U.S.D.I., Bureau of Land Management, Denver, CO. Contract No. YA-512-CT-9-90.

Munz, P. 1959. A California flora and supplement. Univ. of California Press, Berkeley, CA.

Robbins, W., M. Bellue, and W. Ball. 1951. Weeds of California. Documents and Publications, Sacramento, CA. 547 pp.

U.S. Department of the Interior, Bureawu of Land Management. 1980. The California Desert Conservation Area. Final environmental impact statement and proposed plan.

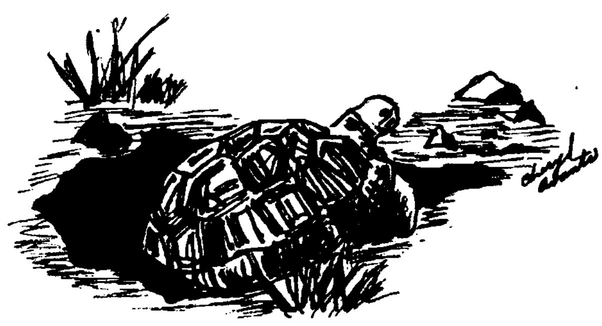


A REPORT ON DESERT TORTOISE DISTRIBUTION AND RELATIVE ABUNDANCE IN SIX SELECTED AREAS IN SOUTHERN NEVADA

PAUL B. SCHNEIDER
P.O. Box 570
Prescott, Arizona 86302

ABSTRACT

Six areas in southern Nevada were surveyed to determine distribution and relative abundance of desert tortoise, *Gopherus agassizi*. These areas are: Desert National Wildlife Range, Valley of Fire State Park, Blue Diamond Recreation Area, Lake Mead Recreation Area, Piute Valley, and Goodsprings-Jean area. The first four of these areas are state or federal lands that had not been previously surveyed. The latter two are federal lands where previous surveys indicated high density tortoise populations but additional data were needed to help manage the populations. A total of 150 1.5-mile transects were done in these six areas and tortoise counts were recorded. Transect techniques were similar to those developed by K. Berry and L. Nicholson for determining distribution and relative abundance in California. Sign counts were converted to relative density ranges using the sign classes established by Karl in other Nevada tortoise surveys. Tortoise sign was found in all areas, but only two areas (Cottonwood Valley, Lake Mead Recreation Area, and Piute Valley) indicated high density tortoise populations. The Cottonwood Valley population represents a significant find in terms of the total distribution within Nevada and deserves protection. Most areas surveyed had very low or low density tortoise populations with pockets of moderate density. Transects in the Goodsprings-Jean area indicated moderate density. This area was previously reported to have a high density population.



STATE REPORT - UTAH

FRANK ROWLEY
Bureau of Land Management
Cedar City District Office
P.O. Box 724
Cedar City, Utah 84720

GENERAL DESCRIPTION

In Utah, the desert tortoise, *Gopherus agassizi*, is located in the southwest corner of the state in the area known as the Beaver Dam Slope. This area is approximately 70 mi^2 (180 km^2) in size. The vegetative aspect for the area is Joshua tree-creosote bush type with a variety of annual and perennial forbs and grasses.

PRESENT PROTECTION AND MANAGEMENT OF THE DESERT TORTOISE

The listing of the Beaver Dam Slope population of desert tortoises as a threatened species was finalized in the 20 August 1980 Federal Register (CFR Part 17). This listing included the designation of 35 mi^2 (90 km^2) of critical habitat. Multiple use management will continue in the designated critical habitat area.

In the Federal Register notice the Fish and Wildlife Service reported that livestock grazing as recommended by the BLM in the Hot Desert Grazing Environmental Impact Statement would not adversely affect the desert tortoise. Implementation of the Allotment Management Plans analyzed in the final environmental impact statement is still pending final determination of a class action suit filed against the BLM in Federal Court.

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

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

1. Drilling would not be permitted in areas containing sensitive flora and fauna. Prior to issuing permits to drill, Bureau of Land Management will determine if sensitive flora and fauna are present.

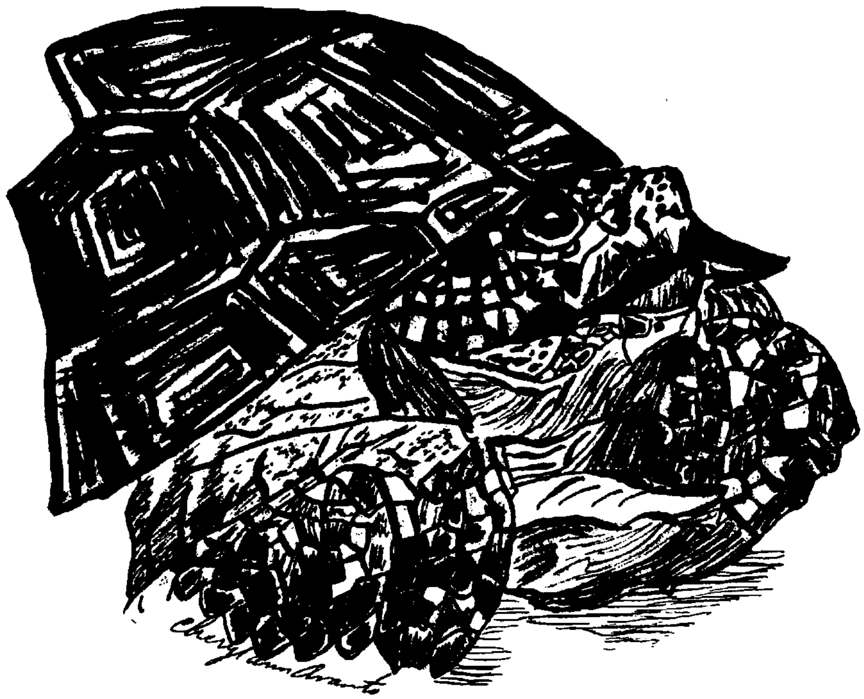
2. No surface-disturbing activity would be permitted during the months of April through September while the tortoises are active.

3. No surface-disturbing activities would be permitted within 500 ft (150 m) of any desert tortoise winter dens.

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

DESERT TORTOISE MONITORING PLAN

The Desert Tortoise Monitoring Plan will continue this spring with the Bureau of Land Management funding a population dynamics study coordinated through the Utah Division of Wildlife Resources. The Bureau of Land Management will also continue its vegetative studies as in previous years.



A REVIEW OF THE STATUS OF THE DESERT TORTOISE

C. KENNETH DODD, JR.
Division of Reptiles and Amphibians
National Museum of Natural History
Washington, D. C. 20560

During the past several years, there has been increasing concern about the viability of desert tortoise populations within the United States. This concern has centered on the threats to the habitat of the species, coupled with awareness of biological attributes (Hohman, Ohmart, and Schwartzmann 1980; Douglass, 1975, 1977), which make the species vulnerable to perturbations in its environment and population structure. Until recently, the status of individual populations has been poorly known and speculative; this continues to be the situation in Mexico with few exceptions (Bury, Luckenback, and Munoz 1978). One population of the tortoise, the Beaver Dam Slope in Utah, is Federally protected and all populations are on a Notice of Review of status published by the U.S. Fish and Wildlife Service (Dodd 1978). Each U.S. state where the species is found affords it some degree of protection.

Beaver Dam Slope, Utah

On 14 August 1980, the Director of the U.S. Fish and Wildlife Service signed the appropriate documents to list this population as Threatened and designate 35 mi^2 (90 km^2) of southwestern Washington County, Utah, as Critical Habitat (Dodd 1980). To put it mildly, the original proposal and reproposal of Critical Habitat (Dodd in press) sparked considerable controversy in this section of Utah, as part of a general dislike of the Federal government and its policies concerning land use. While sometimes based on legitimate misunderstandings, considerable blame for the local people's misconceptions of the proposed and final rules must be shouldered by the Fish and Wildlife Service for not adequately explaining the proposal at the public meeting and hearing, and in the press and by the local office of the Bureau of Land Management (BLM) and several prominent State and local individuals for misrepresenting both the status of the tortoise and the ramifications of the listing.

The deliberate misrepresentation of the Endangered Species Program to the people of southwestern Utah continues to this day by both the BLM and State and local interests. Meetings have been held in Utah for devising schemes to generate political pressure to remove the population from Federal protection and an aide from Senator Orrin Hatch's office has even threatened repercussions to the Federal Endangered Species Program. At a meeting of the BLM Advisory Council held in St. George, Utah, on 15 January 1980, during which discussions centered on how to remove the tortoise from the Endangered Species list, one prominent local citizen stated the best way to get rid of the tortoise problem on the Beaver Dam Slope was "one at a time". There also have been suggestions that BLM's St. George District Office may try to use the Endangered Species Act to totally eliminate sheep trailing across the Slope in spring to further inflame local resentment. With the political climate in Washington definitely opposed to the protection of non-resources (Ehrenfeld 1976) and the Endangered Species Act coming up for reauthorization in 1982, it is likely that we will see more attempts to undermine tortoise protection on the slope. At present, there are no biological data justifying removing the population from Federal protection (Office of Endangered Species 1981). Instead, the unproductive tests of political philosophy which I have warned against in the past (Dodd in press) are continuing, thus wasting valuable time that could be better used in the protection and management of the tortoise and resolving legitimate conflicts.

California and Nevada

Sections of California and Nevada provide areas with the highest densities of desert tortoises in the United States. However, little of the range in Nevada has been documented with the thorough field work needed to present an adequate picture of densities, distribution, and potential threats; preliminary work has begun (A. Karl, pers. commun; P. Lucas, Nevada Dept. of Fish and Game, pers. commun.) and it is encouraging to see both the State's Department of Wildlife and local BLM offices taking an active interest in pursuing tortoise studies.

California presents both the best hope for the continued survival of viable tortoise populations as well as some of the thorniest problems in tortoise conservation. Here, tortoises are threatened by habitat destruction through residential development, land development for agriculture, inadequate or unregulated control of off-road vehicles, surface mining and geothermal development, oil exploration, overgrazing by cattle and sheep, competition from livestock, and by removal as pets and from predation (Berry and Nicholson 1979). While much of the range is Federally owned, ownership patterns are fragmented between different agencies leading to different management strategies based on different priorities, or are interspersed with privately owned land making coordinated management difficult. A comprehensive ecosystem management plan, the California Desert Plan, was approved by then Secretary of the Interior Cecil Andrus in late 1980. Although theoretically providing protection for the desert tortoise and other sensitive species, there are many flaws in the plan and the ability of BLM to implement it has been severely questioned during the public comment period on the proposal even before the present hostility of the Reagan administration toward environmental protection. Indeed violations of BLM regulations and county ordinances have occurred with impunity with regard to off-road vehicles, as in the "unscheduled" Johnson Valley to Parker motorcycle race, and Environmental Impact Statements containing erroneous information with regard to the tortoise have been approved (BLM 1980). There are serious questions concerning BLM's ability and motivation to protect the tortoise in California. The State Fish and Game Department has done an admirable job of protecting tortoises within its means through prohibitions on take, licensing of captives, and the development of a reintroduction program based on scientific principles. However, the ultimate fate of the desert tortoise within the State rests with land stewardship, thus the State's role will continue to be peripheral to that of Federal agencies. In addition, projected cuts in State grant-in-aid programs for wildlife may adversely affect future conservation activities by State agencies.

Arizona

Within Arizona, the biology of the desert tortoise is still rather poorly known. A few populations have been studied in northern and central Arizona

(Schwartzmann and Ohmart 1976; Hohman and Ohmart 1980) and some preliminary distribution studies have been completed elsewhere (Burge 1979; Schneider 1980). These data present a rather precarious picture of a terrestrial "island" species subject to low population densities and discontinuous distribution. As such, their conservation may prove difficult in trying to avoid the problems posed by island distribution (Diamond 1975; Franklin 1980; Wilcox 1980). The strategies for protection of tortoise populations may be quite different depending on local population characteristics and trends.

Is the Tortoise Federally Threatened?

The Endangered Species Act of 1973, as amended, defines a Threatened species as "one likely to become Endangered in the foreseeable future". Five criteria are specified for listing:

1. the present or threatened destruction, modification, or curtailment of its habitat or range;

2. overutilization for commercial, sporting, scientific, or educational purposes;

3. disease or predation;

4. the inadequacy of existing regulatory mechanisms; or

5. other natural or man-made factors affecting its continued existence.

With regard to the desert tortoise, I believe that a case can be made for Threatened status for the following general reasons:

1. The present or threatened destruction, modification, or curtailment of its habitat or range.

   While the desert tortoise presently exists over a wide range from southwestern Utah and southern Nevada to northern Sinaloa, Mexico, the distribution is not continuous in most cases. Instead, populations of various sizes, age class structure, and sex ratios are scattered, surrounded by either unfavorable habitat or areas previously inhabited by tortoises but devoid of them at present. For this reason, small populations are subject to random fluctuations in numbers as well as the potential for inbreeding and decline in heterozygosity. These isolated populations are also vulnerable to extirpation from a variety of causes.

   Cattle and sheep grazing may prove detrimental to tortoises, since overlapping forage preferences occur to a greater or lesser degree depending on time of year, range condition, and grazing regimes. In times of poor range production, this can be an especially important factor since adequate forage is required not only for growth, especially for young tortoises, but also for proper reproduction. Cattle and sheep also may destroy cover sites and burrows through trampling, especially if such sites are located near stock tanks and other areas of stock congregation.

The use of off-road vehicles is particularly destructive to tortoise habitat since forage, burrows, and cover sites may be destroyed. Tortoises are run over and killed by these vehicles, especially during races; individuals may also be trapped within their burrows. Young tortoises are particularly affected by trampling and from destruction of forage by these vehicles.

Tortoise habitat is subject to alteration through surface mining, oil and mineral exploration, and geothermal development. In addition to the direct destruction of both habitat and tortoises, the roads constructed to supply exploration efforts are followed by vehicular traffic which can kill tortoises as well as confine population segments into smaller units. Oil exploration and geothermal development in prime tortoise habitat, such as is planned for Ivanpah Valley, could seriously affect the remaining populations.

Land development, like that occurring near California City, and land clearing for agriculture, such as that planned for the production of jojoba, will eliminate tortoise populations. Indeed, unless core areas are protected by significant buffer zones, nearby development will prove seriously detrimental to "protected" populations. There is also a good deal of miscellaneous development (highways, power transmission lines, etc.) which, taken together, could have negative impacts on tortoise populations. The proposed MX missile system will reportedly result in the destruction of over 2000 tortoises in one valley alone.

2. <u>Overutilization for commercial, sporting, scientific, or educational purposes.</u>

In the past, there has been considerable trade in desert tortoises, especially in southern California. While this trade is now prohibited by State laws, occasional tortoises are still taken. Additionally, some animals still turn up in pet stores, as occurred in the Chicago area this past summer. Scientific and educational collecting, if done in compliance with State laws, probably does not significantly affect the species.

3. <u>Disease or predation.</u>

Disease may be a minor factor affecting local tortoise populations, for example, if captive individuals are released into the wild without proper quarantine. Predation by coyotes and other small predators could have a significant impact in certain areas, especially on juveniles or on already depleted populations. The actual extent of these factors is still largely unknown.

4. <u>The inadequacy of existing regulatory mechanisms.</u>

All states within the range of the desert tortoise protect the species to some degree. Usually, collecting is prohibited and money, theoretically, is provided for research. In Mexico, the species is protected by Federal game laws but the laws aren't enforced (Flores-Villela 1980). While trade may be prohibited by State law, once the animal crosses a state line, the state must resort to the Federal

Lacey Act to prosecute. Federal protection under the Endangered Species Act would provide an additional deterrant to the violation of state laws.

While state laws may regulate take, they are not in general adequate to protect the habitat of the species, especially on Federal lands. Since so much tortoise habitat is federally owned, this is especially critical. For instance, I have been told by a representative of the U.S. Air Force they would not have to comply with Nevada state laws protecting the desert tortoise in the development of the MX missile system. Other Federal agencies would have to comply with Federal laws, such as the Endangered Species Act, however. If the tortoise were listed as a Threatened species, it would be subject to consultation under Section 7 of the Act, which prohibits Federal agencies from authorizing, funding, or carrying out activities which are likely to jeopardize a species or result in an adverse modification of its critical habitat. Such a consultation would be particularly important when reviewing BLM and other Federal agencies' permit systems for off-road vehicle races and energy development. BLM and county regulations have been either ignored or inadequately enforced in the past.

5. Other natural or man-made factors affecting continued existence.

Competition for food items between tortoises and cattle may be contributing to a decline in the species, although as many ecologists have noted, competition is extremely difficult to prove. Competition may be direct (for food items) or indirect (in terms of adequate diet needed for successful reproduction).

If the tortoise were a Federally Threatened species, special rules could be written which would allow the states to manage the species (in terms of "take", for instance), while allowing Federal protection governing interstate trade and habitat protection. Thus, research and the retention of captive tortoises would remain under state control and Section 7 of the Act would still apply to Federal agencies. This approach has worked successfully in a number of states, especially with regard to Threatened fish.

The Federal Future

Will the desert tortoise be listed under provisions of the Endangered Species Act of 1973? At this point it is too early to tell. There is mounting biological evidence that the species is being subjected to stress from a variety of sources, and that the full effects of this stress may now be apparent in some populations but not in others. The question becomes, how much information is necessary before a determination is made? How long do we wait before applying the additional habitat protection measures of the Act to those areas critical to the tortoise's survival?

There is a widespread belief that the new Administration has been given a mandate to overturn environmental legislation; the Federal Endangered Species Program is under increasing attack and pressure both from within and outside of the Interior Department to slow down or stop listing and the protection of species. Indeed, by the time a decision is made on the tortoise's status, there may be no Endangered Species Program. It is clear from statements made by Interior Secretary James Watt that he neither understands the role of his office in the conservation of resources, nor is inclined to learn. Mr. Watt will soon be forced to reevaluate his positions, however, either in the unlikely event it is thrust upon him by lesser officials in the Interior Department, or through repeated appearances in court. In the meantime, I suggest that all data on the tortoise--its range, status, biology--be pooled and analyzed. If the biological data warrant, a petition to the U.S. Fish and Wildlife Service should be submitted. Then at least, an official decision on the adequacy of the data must be rendered.

In the long run, the important thing to do is what is in the best interests of the species. Conservation will require both the preservation of existing populations and the preservation of the genetic reservoir of the species to allow for continuel evolutionary change (Franklin 1980); these are not necessarily the same. Private individuals and organizations must be encouraged and supported to protect both the tortoise and its habitat. And, finally, members of Congress and other politicians must be reminded of their legal and ethical responsibilities as stated in the purposes section of the Endangered Species Act of 1973:

> "The purposes of this Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions..."

and its stated policy of Federal agencies:

> "It is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act."

The desert tortoise is one such species and it deserves to be protected by Federal law.

REFERENCES

Berry, K. H., and L. Nicholson. 1979. The status of the desert tortoise in California. BLM California Desert Program, Riverside, California.

Bureau of Land Management. 1980. Final Environmental Impact Statement. Johnson Valley to Parker Motorcycle Race. Riverside District Office, Riverside, California.

Burge, B. L. 1979. A survey of the present distribution of the desert tortoise (*Gopherus agassizii*) in Arizona. Rept. to BLM on contract YA-512-CT8-108, Denver, Colorado.

Bury, R. B., R. A. Luckenbach, and L. R. Munoz. 1978. Observations on *Gopherus agassizii* from Isla Tiburon, Sonora, Mexico. pp. 69-79 *in* M. Trotter and C. J. Jackson, Jr., eds. Desert Tortoise Council Symposium Proc. 1978.

Diamond, J. M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. Biol. Conserv. 7:129-146.

Dodd, C. K., Jr. 1978. Review of the status of the desert tortoise, *Gopherus agassizii*. Fed. Reg. 43(164):37662.

_______. 1980. Listing as Threatened with critical habitat for the Beaver Dam Slope population of the desert tortoise in Utah. Fed. Reg. 45(163):55654-55666.

_______. 1981. Federal protection for North American tortoises--an update. Pages 19-24 *in* K. A. Hashagen, ed. Desert Tortoise Council: proceedings of the 1980 symposium: March 22-24, Riverside California. Douglass, J. F. 1975.

Bibliography of the North American land tortoises (genus). U.S. Fish and Wildlife Serv. Spec. Sci. Rept. Wildl. No. 190, 60 pp.

_______. 1977. Supplement to the bibliography of the North American land tortoises (genus *gopherus*). Smithsonian Herp. Inform. Serv. No. 39, 18 pp.

Ehrenfeld, D. W. 1976. The conservation of non-resources. Amer. Sci. 64:648-656.

Flores-Villela, O. A. 1980. Reptiles de importancia economica en Mexico. Tesis Profesional, Universidad Nacional Autonomica de Mexico, Ciudad de Mexico, D.F., 278 pp.

Franklin, L. R. 1980. Evolutionary change in small populations. Pages 135-149 *in* M. E. Soule and B. A. Wilcox, eds. Conservation biology, Sinauer Associates, Sunderland, Massachusetts.

Hohman, J., and R. D. Ohmart. 1980. Ecology of the desert tortoise (*Gopherus agassizii*) on the Beaver Dam Slope, Arizona. Rept. to BLM on contract YA-510-PH7-54.

Hohman, J. P., R. D. Ohmart, and J. Schwartzmann. 1980. An annotated bibliography of the desert tortoise, *Gopherus agassizii*. Desert Tortoise Council Spec. Publ. No. 1, 121 pp.

Office of Endangered Species. 1981. Memorandum entitled "Utah Beaver Dam Slope Desert Tortoise Study" dated March 13, 1981, from Chief, OES, to Director, U.S. Fish and Wildlife Service, Washington, D.C.

Schneider, P. B. 1980. A population analysis of the desert tortoise in Arizona during 1980. Rept. fo BLM on contract AZ-950-CT9-0014, Phoenix, Arizona.

Schwartzmann, J. L., and R. D. Ohmart. 1976. Preliminary investigation of a desert tortoise, *Gopherus agassizii*, population in Pinal County, Arizona. Pages 75-76 N. J. Engberg, ed. Desert Tortoise Council: proceedings of the 1976 symposium: March, Las Vegas, Nevada.

Wilcox, B. 1980. Insular ecology and conservation. Pages 95-118 M. E. Soule and B. A. Wilcox, eds. Conservation biology. Sinauer Associates, Sunderland, Massachusetts.

THERMAL ECOLOGY OF THE BOLSON TORTOISE REVISITED

GARY A. ADEST
University of California - San Diego
La Jolla, California 92093

A total of 3,704 deep-gut, telemetered body temperatures were collected from two adult bolson tortoises between 10 July and 19 August, 1980. The mean T_2 between the hours of 0630 and 2000 for the entire summer was 30.2 $\pm$ 0.95°C for a male tortoise (#95) weighing 7075g and 30.3 $\pm$ 1.16°C for a female tortoise (#91) weighing 8399g. Body temperature was significantly elevated during the latter half of the study period (rainy season) compared with the first half (p. <.001). The average amount of daily time spent in epigean activity was also different in the dry and rainy seasons for both subjects. Tortoise #91 spent an average of 18 minutes in aboveground activity daily in the dry season and 62 minutes daily in the rainy season ($t = 4.4$, $p < .05$). Thus, post-rain aboveground activity times were usually double those of the pre-rain period.

The mean daily change in body temperature, $\Delta T_B 1$, followed the same pattern as epigean activity with respect to dry and rainy seasons in tortoise #91 ($\Delta T_B = 3.7$ pre-rain; 7.4 post-rain), while the trend was reversed for tortoise #95 ($\Delta T_B = 6.4$ pre-rain; 4.1 post-rain). These differences and their basis are discussed.

The relationship between epigean activity time and ΔT_B was positive, linear and statistically significant ($r = .69$, $p < .01$). Estimates of maximum daily aboveground activity during this season were made using the equation for the least squares regression line of T_B on activity time, the literature on critical thermal maxima (C Tmax) for other species of Gopherus and calculations of the early morning mean T_B. Maximum tolerable activity time was estimated at 123 minutes and a total of 37 observed activity bouts yielded only one in excess of the predicted value. Longer activity periods and higher T_B in the rainy season was reflected in maximum daily T_B. Tortoise #91 had a mean maximum daily T_B of 32.5 $\pm$ 1.1°C in the dry season and averaged 36.5 $\pm$ 3.3°C in the rainy season. These differences are statistically significant ($p < .001$).

The physiological limitations on behavior and the relationship between tortoise temperature, climatic temperature and evaporative water loss are discussed.

Bolson tortoises, unlike other large Gopherus sp., apparently do not behaviorally thermoregulate during epigean activity. Tortoises heated rapidly (0.11° C/min) while active aboveground and cooled slowly (0.04° C/min) following subterranean reheat. The cooling/heating ration was .36.

HISTORY OF CALTRANS INTEREST IN THE DESERT TORTOISE

JACK EDELL
3060 Indian Creek Drive
Bishop, California 93514

I've been working on a cross between a tortoise and my neighbor's cat. Whether it's furry turtles or hard-shelled cats, there should be a good market for the offspring. I'll keep you posted. Today I'm supposed to talk about the California Department of Transportation (Caltrans) and desert tortoise research.

The California Division of Highways wrote the book on how to build highway systems and solve highway transportation problems. A few of their efforts made the papers, like the relocation of Pismo clams from a freeway corridor north of Ventura and the construction of replacement habitat for the long-toed salamander near Santa Cruz. Dozens of other examples went practically unnoticed before the Division of Highways sponsored a tortoise relocation project in 1971.

When the Division of Highways became the Department of Transportation, the organization remained the same as far as response to environmental problems was concerned. Only the name had been changed to protect the guilty.

It seemed to me both reasonable and timely for Caltrans to send a representative to speak to this group this year, but management would have no part of it. They wouldn't send anyone and I am not authorized to speak for Caltrans here, today.

Speaking strictly for myself, I'd like to give you a brief history of the two tortoise research projects with which I've been involved and, hopefully indicate an important problem with environmental law and its implementation by agencies. Please forgive the autobiography. I have to establish a self for whom to speak strictly.

When I went to work for the Division of Highways in 1953, I had completed 5 years of work at the University of California at Berkely in forestry, wildlife management and zoology. I was broke and still six units short of a degree in zoology. Mine was an unlikely background for an engineering position, but even graduates in the life sciences were having a hard time finding a job back then, and I took what I could get.

My study of the desert tortoise began in August 1959, when I brought one home from Shoshone and my 7 year-old son asked two impossible questions: "Is it a boy or a girl?" and "How old is it?" The local library had no answers so we had to find out for ourselves.

Later, I worked with the local Boy Scout troops as a merit badge counselor and then advancement chairman for the area.

Early in 1973, the Division of Highways had a sudden need for someone willing and able to make environmental studies and write impact statements in response to the National Environmental Policy Act and the California Environmental Quality Act, NEPA and CEQA. I was quick to volunteer. I had been a highway engineer for almost 20 years but my prime interest had always been in the natural sciences.

In 1974, at age 49, I went back for two semesters and a degree in Biological Sciences. The degree earned me the official title of Environmental Planner and a retroactive 5% cut in pay. They call this career development. Engineers are now 7-1/2% superior to environmental planners. I've been working with NEPA and CEQA now for about 8 years.

More than 10 years ago, in 1970, the Division of Highways decided to build a freeway between Mojave and Boron. The project would take a large slice out of a tortoise population I had visited so often I knew most of the residents by name. Environmental law was still a vague threat to the Division and I was still a highway engineer, but it bothered me to think of all those tortoises being smashed or buried. I talked to friends in the local office of the California Department of Fish and Game. One of these friends was Phil Pister, the man who went to Washington to save the pupfish. Phil contacted Jim St. Amant, Glenn Stewart and the Division of Highways.

In April 1971, I went to Mojave with Vern Koontz and Ron Powell from the Bishop office of the Department of Fish and Game. We met Dr. Stewart there and inspected the area to be impacted. A relocation of the tortoises seemed to be the best solution to the problem. Remove all tortoises from within 1,000 ft. (300 m) of both sides of about 8 miles (13 km) of freeway, first being sure that they could be relocated and then, move them to an area that they would not overpopulate.

The Division of Highways assigned me the task. I knew of a field population of tortoises that had been almost completely eliminated by collectors. This would be an ideal relocation site. Boy Scout headquarters offered me all the boy power I would need whenever I wanted it. Vern Koontz had done a lot of work with transmitting collars on Tule elk. Our Highways Electrician, Walt Lockhart, was a good friend of his. They developed telemetry equipment that could be mounted on a tortoise. I planned a preliminary relocation for the summer of 1971, to see if it would work, and the major effort for the following spring.

A short time later I suddenly found myself working for a highway right-of-way agent named Allan Hendrix and plans changed. We made the preliminary relocation in July of 1971 with the help of the Boy Scouts but not to my relocation site. Our telemetry equipment was discarded and duplicated in headquarters. Allen contacted Tillie Barling on the Navy Base at Ridgecrest and arranged some field trips into restricted areas. He negotiated a three-way agreement between the Navy, the Department of Fish and Game and the Division of Highways. He hired Kristin Berry as our project research scientist and he delayed construction to give us more time. He also brought in a professional photographer and lined up a lot of publicity. Allan is now one of about four Supervising Environmental Planners in the State.

A couple of Boy Scouts and I helped Kristin the first couple of days of her study but that was the end of my involvement. Kristin determined the feasibility of tortoise relocation, moved all of the tortoises out of the freeway corridor and continued studying tortoise behavior and the results of relocation until the end of 1975. Somewhere along the line, Dr. Berry took over and her report grew to about three volumes. Her report is in such demand now that Caltrans has had to start charging for copies of it.

Early in 1977, Glenn Stewart, Kristin and Jim contacted me. Kristin had done good work but it was sitting on the shelf and there was an even greater problem that was receiving no attention. Kristin had learned that a highway created a strip of no-mans-land through tortoise habitat for about a mile on each side. As tortoises approach maturity they forage a mile away from their hibernation burrow. If their path crosses highway traffic, they will probably be picked up or smashed before they are old enough to do anything for the population. Jim and Glenn and I met in Mojave in September to discuss the problem. We saw that the new freeway had fences that did nothing to restrict tortoise movement and under the pavement were concrete rectangular culverts that would easily accommodate the largest tortoise. If the bottom 18 inches of freeway fence was made tortoise proof and was extended in to meet each culvert we would have a cheap, efficient tortoise underpass. We didn't know if tortoises would use such a system or how difficult it would be to maintain.

Dr. Stewart and I each submitted a research proposal to Caltrans and Dr. Berry sent a letter to the District Director in Bishop explaining the problem and documenting tortoise road kills. The proposals were accepted, re-written in headquarters, and administered from there but Kristin, Glenn, and I were left in control of the project. Kristin found a scientist to do the work. The contract was handled through Cal Poly under Glenn's guidance and I was lucky enough to get full cooperation from the maintenance departments of Caltrans Districts 8 and 9 and from the Bureau of Land Management in Barstow.

The project began in the spring of 1979 and another report in The Proceedings will tell you what was learned.

The two research projects make a strong case for habitat reclamation. Every mile of road that now crosses tortoise habitat has a 2 mi^2 (5.2 km^2) mile zone of impact. We now have the know-how to reduce this 2-mile strip of no-mans-land to the width of the roadbed and reclaim more prime tortoise habitat than we once thought we had lost. The threat of highway traffic would almost disappear. We have the know-how but we don't have a way to get it done. Caltrans sponsored the research, but will Caltrans use the results? This agency might not use these results for at least two good reasons.

Now--know this-- I cannot say that Caltrans will or will not use Maggie's underpass system. They wouldn't tell me. I don't know. I will try to show you how law and circumstance make it difficult for an agency to even consider doing so.

The first good reason: The very nature of environmental legislation is negative. I don't know of any laws that require positive environmental action. NEPA and CEQA control the behavior of agencies only when these agencies propose to do something. The laws are effective only if the proposed action will damage the environment. These laws force agencies to mitigate that damage. The mitigation reduces the magnitude of the impact but rarely, if ever, eliminates it. Even when the mitigation takes the form of compensating positive environmental action there is usually a net loss to the environment with NEPA and CEQA we fight a losing battle. Whenever these laws are involved we can expect to suffer an environmental loss. They simply reduce the amount of the loss.

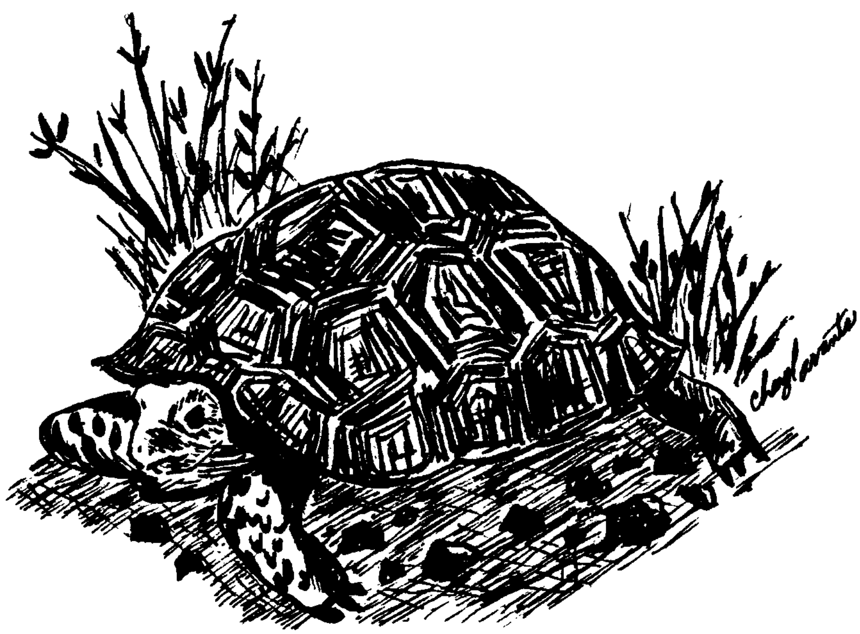
For example: With her relocation project, Kristin saved tortoises, but an 8-mile (13 km) strip of their habitat is now freeway roadbed and she has learned that the zone of highway impact extends a mile on either side of the pavement. We have lost 16 mi^2 (41 km^2) of habitat.

The second part of the problem is more political in nature. Highway building activity in California has almost stopped. Caltrans might not ever build any new highways through tortoise habitat. Without a proposed project, NEPA and CEQA do not apply. There is no law requiring an agency to recognize damage done in the past and to compensate for that damage. Laws guide agencies. Caltrans can't spend transportation tax money to reclaim tortoise habitat without an associated transportation project.

Thanks to Kristin, it will be easy in the future to show that highways impact tortoise populations a mile away. Because of this some good work, however, it will be almost impossible to claim that any highway construction activiity would have a significant impact on an adjacent tortoise population that has already been decimated. New pavement or roadbed reconstruction without a change in alignment simply won't result in a significant impact.

Where does this leave us? Maybe the reclamation of habitat by agencies would be a brave new step in environmental consideration. It might be the first step forward. The people would have to say yes - use tax money for this purpose. We might want to use Kristin's work to promote such a move.

Judging by their history, I would guess that Caltrans would work with us to the extent that it could.



MORTALITY STUDIES ON *GOPHERUS AGASSIZI* AND *GOPHERUS BERLANDIERI* TORTOISES

WALTER J. ROSSKOPF, JR.
Animal Medical Centre of Lawndale
4473 W. Rosecrans Avenue
Hawthorne, California 90250

and

EDWIN HOWARD, A. P. GENDRON,
EMILY WALDER, JAMES O. BRITT, JR.
County of Los Angeles
Department of Health Services
Comparative Medical and Veterinary Services
12824 Erickson Avenue
Downey, California 90242

Due to the lack of published information on causes of mortality in Gopherus tortoises, recent pathology reports were reviewed and analyzed. Clients and tortoise society members were asked to allow necropsies on any dead tortoises. Many of the cases were terminally ill animals seen in private veterinary practice. With the cooperation of the Los Angeles County Veterinary Pathology Laboratory, the study was completed after 3 years of careful analysis.

Necropsy procedures were standard. The plastron was removed after carefully sawing the junctions of the carapace and plastron. The muscular attachments were gently cut away, exposing the internal organs of the tortoises.

Five "type" tissues were usually selected, with additional tissues added if necessary. The five "type" tissues were the liver, kidneys, lungs, heart, and intestine. All tissues were sectioned and submitted to the laboratory in 10% formalin. A gross description of the organs seen was included and a complete history of the case added when possible. Many of the cases were sudden deaths, with unknown histories; most were "pet" animals, in captivity for years. Cultures of selected tissues for bacteriologic work were also submitted but will not be discussed in this paper.

All tissue sections were interpreted by trained pathologists at the Los Angeles County Pathology Laboratory. Reports were then obtained for statistical analysis.

During the 3-year period, 114 turtle and tortoise necropsies were performed. For the purpose of this study, only the *Gopherus sp.* reports will be discussed. Eighty-four *G. agassizi* and two *G. berlandieri* cases were received. No *G. polyphemus* and no *G. flavomarginatus* cases were presented. Ages of animals studied varied from young hatchlings to extremely aged individuals. Most individuals were mature adults. However, age groupings were not considered for this paper.

The first consideration for the study was to determine percentage of organ involvement by system (Table 1). The tissues were examined for any abnormalities even if these abnormalities were not necessarily the cause of death. This gives the veterinary clinician some idea of propensity for disease of the various tortoise organs.

TABLE 1. Involvement of Organs by System
84 *G. agassizi* and 2 *G. berlandieri*

	Lesions present	No. of tissues examined	Disease percentages
Liver	61	84	72.6%
Lung	35	65	53.8%
Intestine	35	69	50.7%
Kidney	28	69	40.6%
Heart	23	67	34.3%

Many other tissues were examined but for purposes of this paper were not tabulated. It can be seen that multiple system involvement is common in diseased tortoises.

The next consideration for study was to determine principal histopathological lesions as causes of mortality in tortoises. Lesions obviously contributing to mortality and listed under diagnoses on the pathology reports were tabulated. Minor lesions in the all-inclusive tabulation of Table 1 are not included. Some of the cases would have one lesion as the cause of death, others would have multiple lesions (Table 2).

The next consideration in the study was to tabulate the most common conditions seen as an aid to those actively involved in treating and preventing disease in tortoises (Table 3). These conditions were considered as the principal cause of death in the cases examined.

TABLE 3. Common Conditions in Gopherus Tortoise Mortality Study

Disease conditions	No.
Bacterial hepatitis	22
Enteritis (usually parasite induced)	18
Kidney disease (most frequent diagnoses were Interstitial nephritis = 9; Nephrosis = 7)	18
Bacterial septicemia	15
Pneumonia	15
Fatty hepatosis	11
Iron storage disease	8
Myocarditis	7

TABLE 2. Gopherus Tortoise Mortality Study: Principal Histopathologic Lesions Directly Considered as Causes of Death

Liver disease	No.	Kidney disease*	No.
Bacterial hepatitis	22	Interstitial nephritis	9
Fatty hepatosis	11	Nephrosis	7
Iron storage disease	8	Glomerulo-sclerosis	3
Hepatopathy	3	Membranous glomerulitis	3
Caseogranulomatous hepatitis	3	Gout	3
Toxic hepatitis	1	Tubular nephritis	1
Protozoan hepatitis	1	Glomerulopathy	1
		Acute suppurative nephritis	1
		Amyloidosis	1
Gastro-intestinal disease		Pulmonary disease	
Enteritis	18	Pneumonia	15
Gastritis	2	Pulmonary hemorrhage	5
Foreign body perforation	2	Pulmonary thrombosis	1
Colitis	1		
Total body involvement		Heart disease	
Bacterial septicemia	15	Myocarditis	7
Peritonitis	2		
Vascular collapse	1	Pericarditis	2
Granulocytic (myeloblastic) leukemia	1	Epicarditis	2
		Endocarditis	1
Hemolytic disorder	1		
Urinary bladder disease		Unknown (Idiopathic) demise	11
Cystitis	1	Miscellaneous	
Cystic calculi (ruptured bladder)	1		
		Sand impaction	1
		Necrotizing andrenalitis	1

*In the kidney cases, often more than one type of lesion was present

The final consideration for purposes of this study was to list some of the more unusual conditions uncovered (Table 4). This serves to stimulate interest in further research and will hopefully guide other investigators in studying the diseases of Gopherus tortoises.

TABLE 4. Unusual Conditions Encountered in Gopherus Tortoise Mortality Study

G. agassizi

Mycotic myocarditis

Iron storage disease (from overload on dietary iron--what areas in Southern California have iron laden water?--needs further study)

Caseation necrosis of adrenal gland (the only endocrine problem seen in study)

Peritonitis from ruptured egg yolk* (this is a common condition in avians)

Foreign body perforation (glass) of intestine

Sand impaction (common in hatchlings)

Hepatitis from unknown protozoan (the only protozoan disease encountered--needs to be studied)

G. berlandieri

Granulocytic (Myeloblastic) leukemia (the only cancer case in the study)

CONCLUSIONS

This study has only scratched the surface. Investigators must find the answers to many of the puzzling problems that are present when dealing with sick tortoises.

Several generalities can be made, based on this study. They are listed as follows:

1. Multiple organ system involvement is common in tortoises. The seriously ill animals often have liver disease, kidney disease, etc. at the same time. They must be treated accordingly. They are septicemic in nature, as are avians.

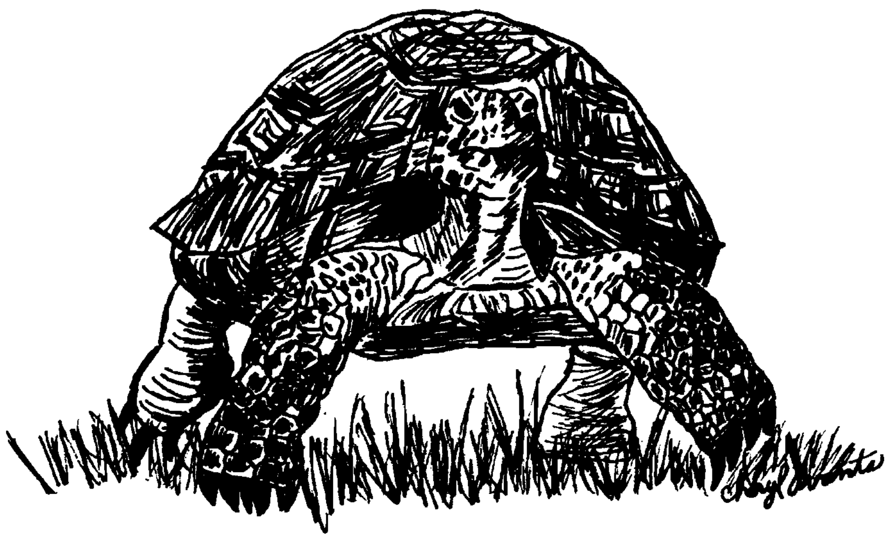
* Since the data for this study was compiled, many cases of this condition have been encountered.

2. It is well known that liver disease is common in tortoises. Heart and kidney disease are extremely common also.

3. Systematic cancer is extremely rare. The only malignancy seen in the study was the granulocytic leukemia case.

4. The intestinal parasites often seen in *Gopherus* tortoises may be much more important as pathogenic organisms than previously thought. This is especially true in captivity, where crowding leads to proliferation of parasites in surrounding soil.

5. Dietary factors are very important to tortoise health. More work is necessary on the causes of fatty hepatosis and iron storage disease.



THE DESERT TORTOISE IN SERI INDIAN CULTURE

RICHARD S. FELGER
Arizona-Sonora Desert Museum
Route 9, Box 900
Tucson, Arizona 85743
and
Office of Arid Lands Studies
University of Arizona

MARY BECK MOSER
Summer Institute of Linguistics
Huntington Beach, California

and

EDWARD W. MOSER*
Summer Institute of Linguistics
Huntington Beach, California

The Seri Indians of Sonora, Mexico hunted the desert tortoise for food throughout the year, employing different strategies for warm and cool seasons. It was also used for medicine, music, and play. Tortoises were particularly abundant on Tiburon Island, which is now the most significant sanctuary for the species.

The Seri Indians of Sonora, Mexico, have traditionally been a hunting and gathering and seafaring people. They have not practiced agriculture within the confines of their territory; the climate is too arid. The original area of occupation closely coincides with Shreve's (1951) Gulf Coast of Sonora vegetational subdivision of the Sonoran Desert. Their territory once extended from the vicinity of Guaymas northward along the coast to the vicinity of Puerto Libertad, with occasional camps as far north as the Colorado River, and included Tiburon and San Esteban Islands (Figure 1; Moser 1963). Yaqui Indian lands adjoined Seri territory to the south and the Papago were their neighbors to the north. The various Seri groups subsisted on a rich array of land and sea animals and plants (Felger and Moser 1976*a*). For descriptions of Seri culture see McGee (1898), Kroeber (1931), Griffen (1959), and Bowen (1976).

NOMENCLATURE

The Seri have considerable knowledge of the seven species of turtles which occur in their region (Felger et al. 1976; Clifton *et al.* in press; E. Moser and Felger unpubl. data). Sea turtles featured prominently in their culture, and for most Seri groups the green turtle was their single most important food resource, as well as playing a prominent role in many other aspects of traditional life. Compared with biological nomenclature, the Seri overclassified the green turtle and the loggerhead. They recognized at least seven ethnotaxa

*Deceased 1976

or kinds of green turtle *Chelonia*, two ethnotaxa of loggerhead, *Caretta*, and one each for the olive ridley, *Lepidochelys*, hawksbill, *Eretmochelys*, leatherback, *Dermochelys*, Sonoran mud turtle, *Kinosternon sonoriense*, and desert tortoise, *Gopherus agassizi*.

The Seri have three names for the desert tortoise (Table 1). *Xtamóosni* is probably the oldest term for this animal [for descriptions of Seri phonemes see Moser and Moser (1965) and Marlett (1981)]. *Kta-* seems to be a prefix and occurs in other words, including the term for mud turtle, but we are unable to find a meaning for it. *Móosni* is used in a distributive or broad sense for all sea turtles, or as the folk generic term for green turtle, and more specifically it is the name for the most common kind of green turtle. This term also shows relationship with Cahitan (Yaqui and Mayo) language terms for sea turtle (Table 1; Johnson 1962). Although the Seri and Yaqui have long had cultural contacts, their languages are totally unrelated.

In contrast, the Papago names for turtles (Table 1) do not show linguistic similarity to the Seri terms. The Papago traditionally occupied the territory to the north of the Seri and the two groups had cultural contacts. Their language is also totally unrelated to Seri. The Papago use the term *Komkich'd* for the Sonoran mud turtle, and also as a distributive term for all turtles [G. P. Nabhan, pers. commun.; also see Mathiot (1973) and Saxton and Saxton (1969)].

The usual, present-day Seri name for desert tortoise is *zíix héhet cöquíij*, 'thing bushes what-sits-in' or "what sits in bushes." Another descriptive term for it is *zíix cátotim*, 'thing that-scoots'. For some reason the term *xtamoosni* probably became taboo. When the name of a plant or animal became taboo, it was often replaced by a longer, descriptive one (Felger and Moser 1976*b*).

The term *xtamóosni* occurs in the name used for several desert plants, indicating they are eaten by the tortoise: *xtamoosn-óohit*, 'desert-tortoise what-it-eats' or "what the desert tortoise eats" (Felger and Moser, in prep.). This is the name usually given to *Chaenactis carphoclinia* (Compositae) and *Fagonia californica* and *F. pachyacantha* (Zygophyllaceae). Similarly, the name for *Nemocladus glanduliferus* (Campanulaceae) indicates it is eaten by the mud turtle: *xtamáaija óohit*, "mud-turtle what-it-eats."

ETHNO-ECOLOGY

The Seri point out that desert tortoises were and still are particularly large and abundant on Tiburon Island, but have no explanations for this observation. They say tortoises on the mainland are common in the mountains near El Desemboque and Pozo Coyote (about 3.7 miles or 6 km NE of El Desemboque), and in the summer "north of *Hapis-ihoom* near Los Mochos" (about 12.4 miles or 20 km NE of El Desemboque). They know that tortoises prefer rocky habitats (Malkin 1962). The Seri say that these animals do not walk into the direction of the sun. According to them the only enemy of the desert tortoise is the mountain lion (Malkin 1962).

The Seri told us that tortoise eggs are laid in loose gravel at the mouths of small caves. Newly hatched tortoises are somewhat curled up (the plastron and carapace), and as they grow the plastron flattens or straightens out. They say tortoises stay rather small for 3 to 4 years, and then seem to grow up rapidly.

TABLE 1. Native Names for Turtles in Sonora and Southern Arizona

Species/culture	Indian name	Translation
Gopherus agassizi		
Seri	zíix héhet cöquíij	'thing bushes what-sits-in' or "thing that site in bushes"
	zíix cátotim	'thing that-scoots'
	xtamóosni	'xta-sea turtle'
Papago	cheho komkich'ed	'cave turtle' (1)
	do'ag komkich'ed	'mountain turtle' (1)
Mayo	mótchic	(unanalyzable)
Yaqui	mótchic	(unanalyzable)
Kinosternon sonoriense		
Seri	xtamáaija	(unanalyzable)
Papago	komkich'ed	"what lives inside" (2) kom = small of back, or shell or carapace of hard-shelled animal. ch = linking or connecting morpheme ed = in
Chelonia mydas		
Seri	móosni	(unanalyzable)
Mayo	moósen (2)	(unanalyzable)
Yaqui	móosen (3)	(unanalyzable)

(1) G. Nabhan, pers. commun., 1981.
(2) D. Saxton, pers. commun., 1981.
(3) H. Collard, pers. commun., 1975.
(4) J. Dedrick, pers. commun., 1975.

SUBSISTENCE

Seri men and women picked up tortoises whenever they were encountered and brought them back to camp. During the times of year when they were active, such as when out in the open feeding on grasses, women hunted them with dogs trained to locate tortoises by smell. Two or three older women often went hunting with dogs trained to hunt nothing else except tortoises. When the dogs located one they began barking and continued to bark until the women came and picked up the tortoise. The Seri apparently acquired dogs from Mexican ranchers in the 19th century (E. Moser, unpubl. data). The women carried the tortoises in baskets on their heads, which was the usual method for women to carry cargo (Moser 1973). Tortoises on Tiburon Island were known to sometimes be quite large, and an older woman could carry only about four of them in a basket on her head.

When the women had collected enough tortoises, they often built a fire, sat down and killed the tortoise in the usual manner, by breaking open the plastron with a pointed rock. The viscera and other soft organs were removed. The liver, which was often relatively large, and stomach were cleaned, roasted on a fire, and eaten. The rest of the turtle was taken back to camp to be shared with their families.

During the cooler months, usually between November and April, the Seri say tortoises crawl into small caves or burrows extending beneath large rocks, and remain there for some time. During this time of the year the usual method of hunting was to search in canyons for likely caves or burrows with tortoise dung around the entrance, even if the dung was old. The women then fashioned a pole, about 3 yd or 3 m in length, often made from a stout branch of desert lavender, *Hyptis emoryi*. *Hyptis* was used because it was frequently common where tortoises were found, and it has tall branches or stems. With a wire hook fastened to one end of the pole, they pushed it into the cave to feel for tortoises. When they felt one they poked at it until it was hooked in the "undercurl" of the posterior part of the carapace and then pulled the animal out. Sometimes they were able to secure a number of tortoises from a single small cave.

When a cave was found with tortoise droppings, and the hunters were unable to extract the animals, they put water by the entrance and the tortoises came out. The Seri said the tortoises smell the water and think it is raining.

Men usually carried tortoises back to camp alive, suspended from a carrying yoke by a piece of mesquite-root twine tied to one of the hind legs. Another way to carry a tortoise home was to bind it lengthwise with two strips of *Jatropha cuneata* branches with the bark removed. Loops fastened between the strips were slung on a carrying pole.

Along with chuckwallas, *Sauromalus obesus* and *S. varius*, tortoises were often kept alive in camp for a number of days or even weeks. The meat was cooked by placing a heated stone in the cavity with the remaining blood, and building a small fire on the ground next to the turtle. When cooked, the legs were twisted off and eaten, as well as the rest of the meat.

Although the desert tortoise was highly esteemed as a food item, it was generally not nearly so important in the Seri diet as was the green turtle and other major food animals. Tortoises are still eaten in the same manner as in the past.

NON-FOOD USES

Desert tortoises were also used for purposes other than food. A heated stone was placed in the body cavity the same as if cooking the meat. A person put his face over the rising steam to help him retain good eyesight.

The Coolidges (1939:210) cite the use of a tortoise rattle. The older Seri recall that these instruments, used as toys, were often made from dry tortoise shells found on the desert. Russell (1908:169) mentions such an instrument among the Pima, but did not see one (Bowen and Moser 1970:188). Little girls played with clay figurine dolls and made clothing for them from tortoise bladders which had been dried with ashes and then worked until soft (Moser and White 1968:148). In the past tortoises were probably not regarded as pets (Malkin 1962). However, today several families keep tortoises as pets.

Any fruit which looked ripe but turned out not to be so was called *xtamóosni yacóaal* 'desert-tortoise what-it-ordered'; or "called by the desert tortoise". The Seri say the star Aldebaran made the fruit look ripe to fool the tortoise.

If a woman has given birth to only female offspring, she is said to have eaten the reproductive organs of a female desert tortoise. If her offspring are all male, it is said that as a child she had been hit in the small of her back with the reproductive organ of a male desert tortoise playfully thrown at her by a girlfriend.

CONSERVATION

In recent decades the Seri have lived mostly entirely on the mainland, and Tiburon Island has been unoccupied except by soldiers and wildlife biologists stationed at the east and north ends of the island. Thus, hunting pressure on tortoises on Tiburon Island has become substantially reduced. Mexican fishermen, however, occasionally hunt them, particularly at the south end of the island (K. Cliffton pers. commun.).

Absence of certain larger predators from Tiburon Island may have contributed to the large tortoise population on the island. Coyotes are probably the only major predator found there. (Cats, including the mountain lion, and badger, skunks, and ringtail do not occur on the island.) Seri hunting pressure, even in earlier times, does not seem to have been a major factor affecting tortoise populations since there was at least as great Seri population density on the island as on the mainland.

The Sonoran mud turtle, which in the past probably had a wider distribution in the Seri region, now occurs only near the periphery of the Seri territory, such as the the Rio Sonora dam near Hermosillo. The leatherback turtle continues to be an infrequent visitor to the northern part of the Gulf of California. All other sea turtle populations in the Gulf of California have eclined drastically. The green turtle or *caguma prieta* is now rare in the Gulf. Thus, of the seven species of turtles in the Seri region, only the desert tortoise still occurs in large numbers, especially on Tiburon Island and the adjacent Turners Island (Isla Datil) (Reyes and Bury 1981). Tiburon Island is now the most significant sanctuary anywhere for the desert tortoise.

ACKNOWLEDGMENTS

We are grateful to the Seri who have shared their knowledge with us. We thank M. A. Dimmitt, H. Lawler, S. Marlett, P. Schneider, and C. Schwabe for critical review of the manuscript. Partial support for the field work was provided by the National Science Foundation (BNS 77-08-582 and SOC 75-13-682), World Wildlife Fund, and the Roy Chapman Andrews Research Fund of the Arizona-Sonora Desert Museum.

REFERENCES

Bowen, T. 1976. Seri Prehistory. Anthropological Papers of the University of Arizona, no. 27.

Bowen, T., and E. Moser. 1970. Material and functional aspects of Seri instrumental music. Kiva 35(4):178-200.

Cliffton, K., D. O. Cornejo, and R. S. Felger. In press. Sea turtles of the Pacific Coast of Mexico. : K. Bjorndal and W. King, eds., Proceedings of the world conference on sea turtle conservation, Smithsonian Press, Wash., D. C.

Coolidge, D. and M. R. Coolidge. 1939. The last of the Seris. E. P. Dutton, New York. 264 pp.

Felger, R. S., K. Cliffton, and P. J. Regal. 1976. Winter dormancy in sea turtles: independent discovery and exploitation in the Gulf of California by two local cultures. Science 191:283-285.

Felger, R. S., and M. B. Moser. 1976a. Seri Indian food plants: desert subsistence without agriculture. Ecology of Food and Nutrition 5:13-27.

_____. 1976b. Seri Indian pharmacopeia. Econonic Botany 28(4):414-436.

Griffen, W. B. 1959. Notes on Seri Indian culture, Sonora, Mexico. Latin American Monograph Series 10, School of Inter-American Studies. Johnson, J. B. 1962. Idioma Yaqui. Instituto National de Anthropologia e Historia, Mexico City. 303 pp.

Kroeber, A. L. 1931. The Seri. Southwest Museum Papers 6.

Malkin, B. 1962. Seri ethnozoology. Occasional Papers of the Idaho State College Museum, No. 7. Pocatello, Id. 68 pp.

Mathiot, M. 1973. A dictionary of Papago usage. Vol. I. Indiana University Press, Bloomington, In. 504 pp.

Marlett, S. A. 1981. The structure of Seri. Dissertation. University of California, San Diego, Ca.

McGee, W. J. 1898. The Seri Indians. Seventeenth Annual Report of the Bureau of American Ethnology, Part I. Smithsonian Institution.

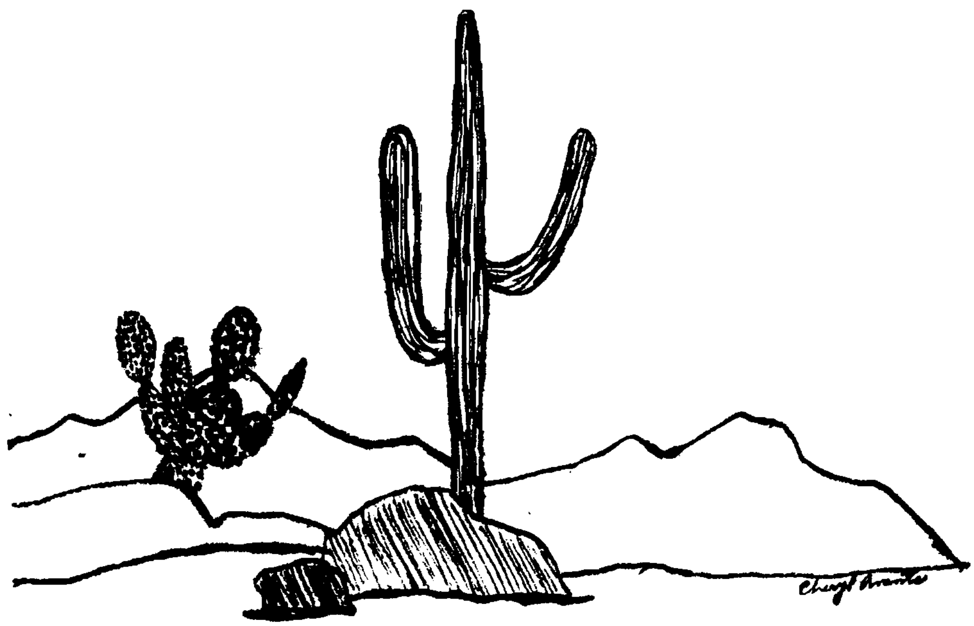
Moser, E. 1963. Seri bands. The Kiva 28:14-27.

_______. 1973. Seri basketry. The Kiva 38:105-140.

Moser, E., and M. B. Moser. 1965. Consonant vowel balance in Seri (Hokan) syllables. Linguistics 16:40-67.

Moser, E., and R. S. White. 1968. Seri clay figurines. The Kiva 33(3):133-154.

Reyes, S., and R. B. Bury. 1981. Biological aspects of the desert tortoise (*Gopherus agassizii*) on Tiburon Island, Sonora. (This volume).
Russell, F. 1908. The Pima Indians. Twenty-sixth Annual Report of the Bureau of American Ethnology. Smithsonian Institution.
Saxton, D., and L. Saxton. 1969. Dictionary: Papago and Pima to English; English to Papago and Pima. University of Arizona Press, Tucson, Az. 191 pp.
Shreve, F. 1951. Vegetation of the Sonoran Desert. Carnegie Institution of Washington, Pub. No. 591.



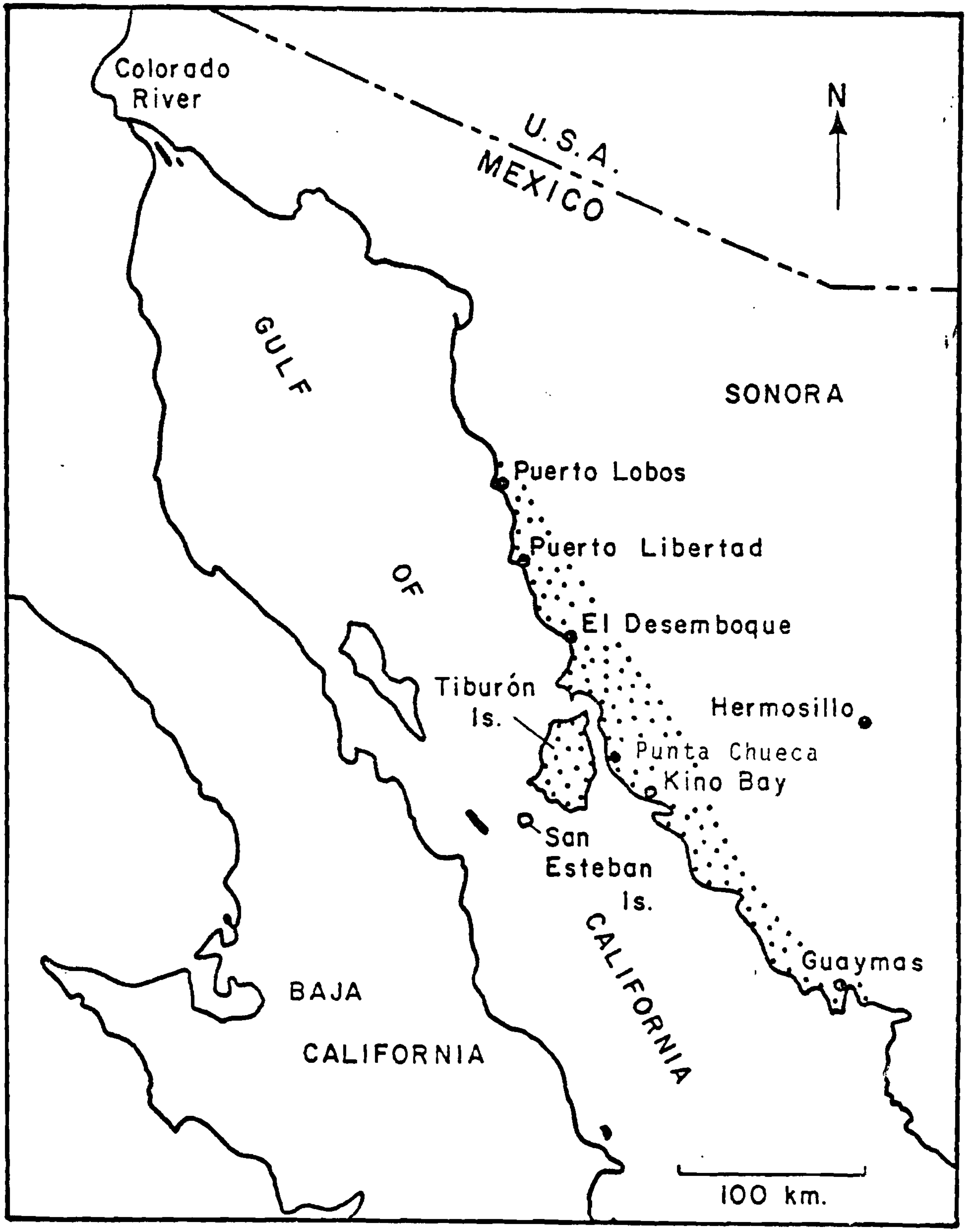


FIGURE 1. Northern Gulf of California Region showing distribution of Shreve's Gulf Coast of Sonora phytogeographic subdivision of the Sonoral Desert and pre-contact Seri occupation. Today most Seri live in the villages of El Desemboque and Punta Chueca.

SOME EFFECTS OF RECREATIONAL ACTIVITIES AT THE DESERT TORTOISE NATURAL AREA

TOM CAMPBELL
1928 E. Cornell
Fresno, California 93713

BACKGROUND INFORMATION

The Desert Tortoise Natural Area (DTNA) was established in 1973 by the Bureau of Land Management (BLM) to protect 30 mi^2 (7770 km^2) of unique desert habitat and the associated wildlife. The Natural Area was enlarged to its present size of 38 mi^2 (9840 km^2) in 1975. During this same year $135,000 was received by the BLM for fencing, signs, interpretive materials, and for preparation of a management plan. The new interpretive facility and nature trails were dedicated in April 1980. The DTNA is the largest nongame wildlife refuge in the United States. The DTNA contains a portion of the most diverse creosote-bush scrub plant community known to exist and supports the highest densities of desert tortoises found throughout their range.

Current threats to the integrity of the tortoise population at the Natural Area include livestock grazing, urban and agricultural development, off-road vehicle activities, indiscriminant firearms use, and other uncontrolled human activities.

Cattle and sheep grazing have occurred in the western Mohave desert since the late 1800's. Livestock grazing has resulted in what appears to be significant habitat loss or deterioration. Grazing is not now permitted in the Natural Area, although intensive sheep grazing is allowed around the perimeter of the Natural Area. Trespass by sheep grazers still occurs on the Natural Area.

The California City land speculation trend initiated in 1958 is still being propagated. Most of the land within the cities 186 mi^2 (48,000 km^2) area is subdivided. Graded roads are spaced at 0.5 to 0.25 mi (or.8 to 0.4 km) intervals, or less. In addition to direct loss of habitat, housing developments introduce the potential for increasing the rates of tortoise mortality due to collection, road kills, and predation by domestic animals. The State Lands Commission has just recently released the surface mineral rights to the California City second city development. This land, which is adjacent to the eastern border of the Natural Area, can now be developed for housing tracts.

Agricultural development is currently destroying up to 1000 acres (400 ha) per year in the areas to the north and west of the Natural Area. Ground water has been lowered to such an extent that a stand of mesquites, in a sand dune area adjacent to the Natural Area, have now died.

Off-road vehicle (ORV) use is the most popular activity in the areas immediately adjacent to the DTNA; trespass onto the Natural Area has been a persistent problem.

Hunting occurs in the areas adjacent to the Natural Area. Most hunting activities are concentrated in the areas south and west of the DTNA. Casual shooting, or plinking, is a much more popular activity. Shooting is most often observed immediately adjacent to the southern and western borders of the DTNA and is not confined to areas outside the Natural Area. Shooting activities are often acts of vandalism. Shooting may be a significant source of tortoise mortality on the DTNA.

Tortoise populations are known to be declining throughout their range. Tortoises exhibit a low reproductive potential, low rate of recruitment of young, and high hatchling mortality. Even limited, continual losses due to the sources discussed will cause mortality rates to increase, in excess of natural levels.

Numerous individuals and organizations, including the Desert Tortoise Preserve Committee and the Desert Tortoise Council, have been in favor of closing the Natural Area to hunting and shooting. The DTNA Special Wildlife Habitat Management Plan, prepared by the U.S. Bureau of Land Management (BLM), states that "all populations of native flora and fauna in the Natural Area will be allowed to naturally fluctuate".

The closure of the Natural Area to hunting has been opposed by the California Department of Fish and Game. Hunting areas and hunting opportunities have continually declined throughout the State. The Department of Fish and Game would like to keep as many areas open to hunting as possible. The original Fish and Game support of the Habitat Management Plan was with the stipulation that the area remain open to hunting.

In November 1979, at a joint meeting of the Department of Fish and Game and the BLM, the Desert Tortoise Preserve Committee recommended that the Natural Area be closed to hunting and that the closure be enforced by both agencies.

No long-term studies had been initiated to document the effects, intensities, types, and locations of hunting and shooting activities. In a letter, dated 5 May 1980, to David Stevens (Co-chairman, Desert Tortoise Council), E. C. Fullerton (Director, Department of Fish and Game) stated that upland game hunting would be allowed on 9+ Sections of the DTNA, and a study would be initiated to investigate possible adverse effects of sport hunting. The naturalist position at the DTNA was established by Fish and Game in November 1980 to investigate these possible adverse effects.

For the past 4 months I have been recording hunting, shooting, ORV, camping, and other activities on and near the DTNA. The fence surrounding the Natural Area is surveyed each month for breaks or other damage. This project will be continued until 1 July 1981. Reports are submitted at the end of each month to the appropriate persons and agencies.

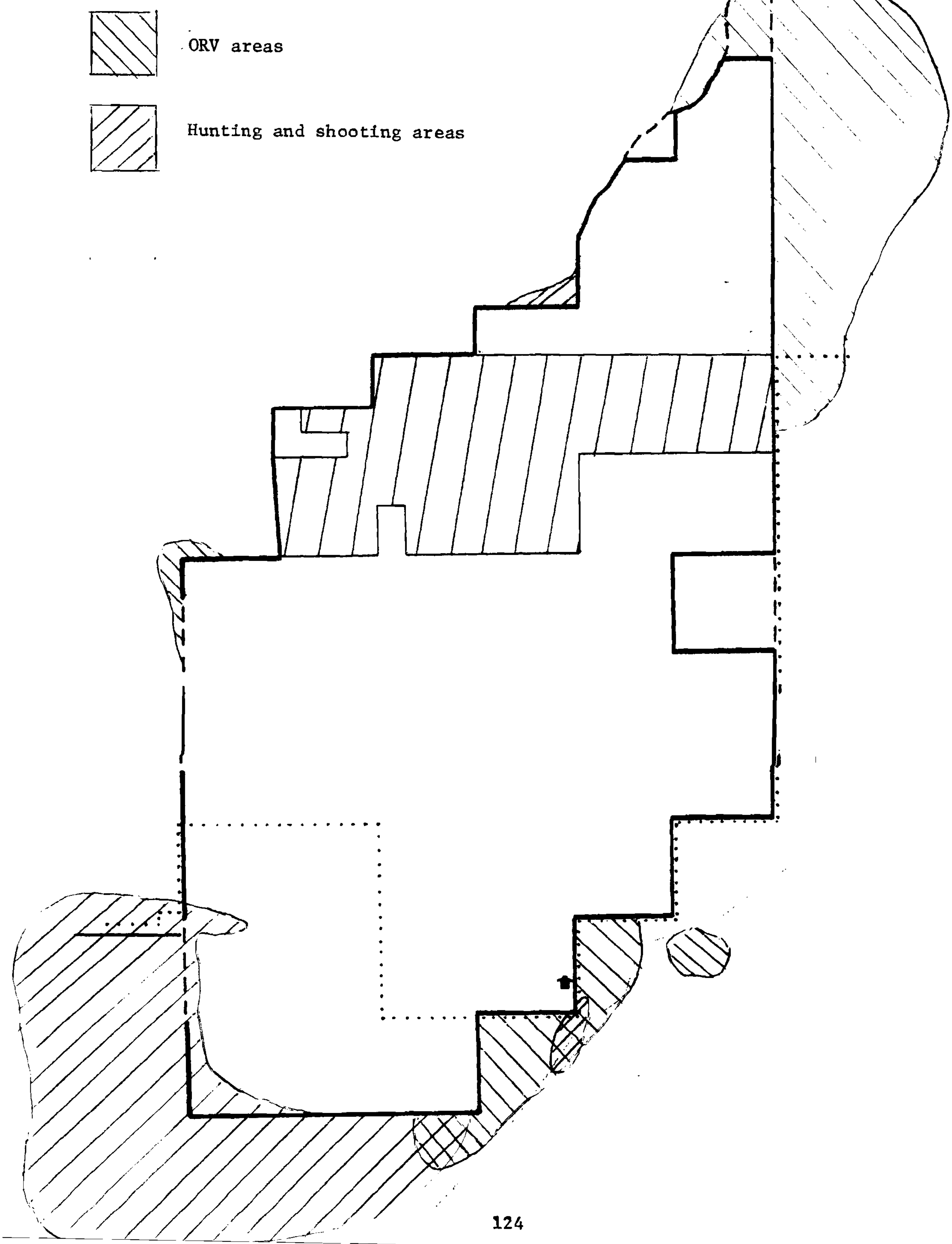
RESULTS

The results of my work to date support and document the position of those individuals who believe that the Natural Area should be closed to hunting (Table 1, Figure 1). I have discovered that most of my findings were already the common knowledge of those people who are familiar with the Natural Area.

TABLE 1. Number of Hunters, Shooters, and ORV Users Observed on and Near the DTNA, November 1980 through February 1981.

Month	November				December				January				February				
	weekday	weekend	Holiday	total	weekday	weekend	holiday	total	weekday	weekend	holiday	total	weekday	weekend	holiday	total	TOTAL
No. days surveyed	3	3	2	8	4	4	1	9	6	4	0	10	5	3	4	12	39
<u>Hunters</u>																	
On DTNA	0	0	0	0	0	0	2	2	0	0	-	0	0	0	2	2	4
Near DTNA	0	1	6	7	0	6	0	6	2	3	-	5	0	0	2	2	20
<u>Shooters</u>																	
On DTNA	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0
Near DTNA	7	0	0	7	0	7	3	10	3	0	-	3	0	6	13	19	39
<u>ORV's</u>																	
Total all types	0	0	80+	80+	5	10	0	15	11	37	-	48	2	29	121	152	295+
No. dirt bikes	0	0	80+	80+	5	10	0	15	11	33	-	44	2	25	112	139	278+
No. on DTNA	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0

FIGURE 1. Location of ORV, hunting, and shooting activities on and near the DTNA November 1980-February 1981



Hunting and Shooting

Hunting has been observed infrequently within the borders of the Natural Area. The most frequented areas outside the Natural Area are along the western and southern borders. All hunters encountered have been hunting blacktailed jackrabbits. The more successful of these hunters collect, clean, and package their kills in a most efficient manner. After numerous discussions with local law enforcement personnel, including local police, Department of Fish and Game wardens, and BLM rangers, it has become known that many of these hunters are collecting the hares for commercial resale purposes. The current price is about $2.00-2.85 per hare. Piles of jackrabbit hides and entrails are a common site in the areas frequented by hunters. No serious hunting activity has been observed in the Natural Area. With only one exception, all hunting activity observed to date has been within the city limits of California City. Discharge of firearms within the city limits is technically illegal, but little effort is made to enforce the firearms limitations.

The extensive agricultural developments to the north and west of the Natural Area are currently being posted as closed to hunting. This may result in increased numbers of hunters frequenting the areas directly adjacent to the Natural Area.

Almost all of the casual, or non-hunting, firearms use is indiscriminant or destructive. The most frequented areas are within the city limits of California City along the western and southern borders of the Natural Area, and near the Interpretive Center. Activity is most intense directly adjacent to the fence posts, as evidenced by spent shotgun shells, broken bottles, and other trash.

ORV Activity

The most popular ORV area is the Rand "Pit Open Area." The area near the Interpretive Center and along the southern border of the Natural Area receives less, but still a significant amount of use. Some areas are beginning to take on the abused appearance of the Rand Pit. Motorcycles are by far the most popular off-road vehicle. The area adjacent to the fence at the Interpretive Center access road has been noted as receiving a continuous increase in use by ORV groups.

Camper Use

Almost all camping near the Natural Area observed to date has been by groups of people utilizing mobile homes and trailers and was always in association with ORV activity.

As expected, almost all activities are concentrated during weekend and holiday periods; very few people are observed in the vicinity of the Natural Area during mid-week periods or during periods of poor weather.

FENCE SURVEY

The entire fenced perimeter of the Natural Area has been surveyed four times since December. Twenty-eight sections of fencing have been observed to be in need of major and minor repair. Twenty-two of these fence sections have been purposefully damaged. Eleven of the sections have been used by ORV's, usually dirt bikes, to gain access into the Natural Area. Three of the access points are at sites previously repaired. Two of these sections are popular, repeatedly used access points.

Access is gained into the Natural Area through the fence by undoing sections previously repaired, by cutting the fence, or by lifting the poles out of the ground and then driving over or under the slackened fence.

RECOMMENDATIONS

The Natural Area should be closed to hunting and shooting by the Department of Fish and Game. Signs indicating this closure should be posted around the perimeter of the Natural Area and the closure should be actively enforced by Fish and Game wardens, BLM rangers, and the local police. Some of the justifications for this closure include:

-The only successful hunters I observed were collecting black-tailed jackrabbits, apparently for illegal commercial resale purposes.

-With only one exception, all hunting I observed has been within the city limits of California City.

-Adjacent areas, such as the El Paso Mountains, reportedly provide superior hunting opportunities.

-Only one cottontail rabbit has been observed by me in over 50 days on the Natural Area. According to the BLM Habitat Management Plan, jackrabbits are not to be hunted on the Natural Area.

-Jackrabbits are a principal food of the kit fox. Excessive harvesting of jackrabbits may inhibit maintainence of a viable kit fox population.

-Opening some areas to hunting, and closing others, invites confusion and makes enforcement difficult or impossible.

-Firearms use may be a significant cause of tortoise, and other wildlife, mortality on the Natural Area. Ground squirrels and numerous raptors, victims of indiscriminate firearms use, have been found on and near the Natural Area.

-The Natural Area was designed "to protect the unique desert habitat and wildlife". Shooting is an incompatable use for an area designed to protect wildlife and for providing non-consumptive recreational opportunities. Firearms on the Natural Area may create an unsafe condition for those individuals visiting the area for such recreational activities.

-The various federal, state, and private organizations responsible for protecting the integrity of the Natural Area have not been able to stimulate the local police to adequately enforce the firearms use restrictions already in effect.

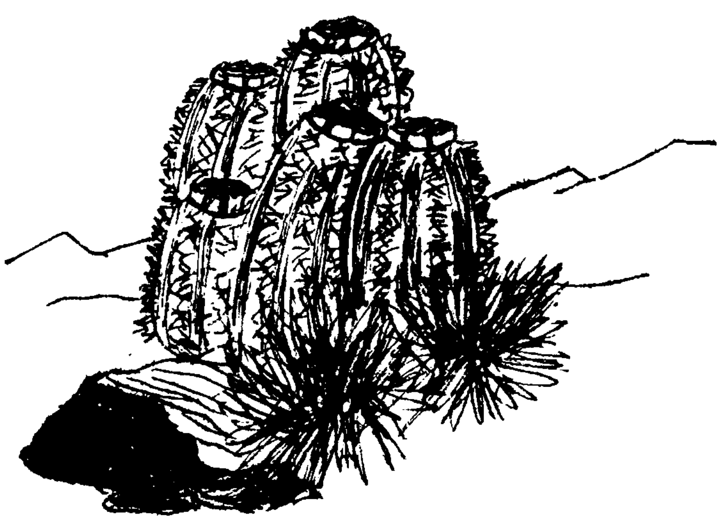
Other Recommendations

-Off-road vehicle activity should be eliminated in all areas adjacent to the Natural Area except the Rand Pit Open Area. This is most important on those sections of land adjacent to the southern and eastern borders of the Natural Area. Fence breaks should be promptly repaired to discourage additional trespass.

-Mining scapes, pits, and dirt piles should be left as they are. Pits that pose a potential for entrapment of tortoises and other wildlife should be filled in only to the extent that trapped animals can easily escape. All of the mining scrapes and dirt piles provide homes for rodents and many contain tortoise burrows.

ACKNOWLEDGMENT

I would like to acknowledge and thank D. Christensen, D. Chesmore, and K. Berry for their assistance with this project.



FIELD STUDIES OF NATALITY IN THE DESERT TORTOISE, *GOPHERUS AGASSIZI*

ANNE M. HAMPTON
Biological Research Associates
Box 11627
Tahoe Paradise, California 95708

Reproduction in the desert tortoise is discussed along with the results of a 20-day field study of natality conducted in October 1979. The purpose of the field study was to assess natality as expressed by the number of recently emerged hatchlings. Data were also gathered on population density, age structure, sex ratios, burrows, and behavior. After the study commenced, it was decided to actively search for recently hatched nests to aid in determining natality.

The study area was a 1-mi^2 permanent Bureau of Land Management study plot located in the Fremont Valley, Kern County, California. It was a creosote bush scrub community with a primarily fine sandy loam, except where traversed by washes.

A total of 48 tortoises were located in the age classification of adults, subadults, and immatures. No juveniles or hatchlings were seen even though several were found in a spring study.

Sex ratios of adults and subadults were 22 females to 20 males, which is a 52 to 48% sex ratio. These findings were consistent with the spring study, which indicated a population higher in females.

A total of 15 tortoise nests were found and these were determined to have been constructed by 14 different females. In two instances adult female tortoises were found using burrows associated with nests. Nests tended to be located at the entrance to large burrows; 12 of the 15 were located in the shade of a creosote bush, while 3 were in the open. Average burrow length was 43 inches (1080 mm); width, 11 inches (278 mm); height, 5 inches (139 mm) and soil cover, 3 inches (85 mm). Most faced in a westerly or northerly direction; 10 were constructed in fine sandy loam and 5 in coarser soil.

Natality and natality rate were calculated by several means, with the nest method the preferred method.

Natality was calculated by multiplying the number of nests by the average clutch size (15 x 3 = 45). Natality rate was determined by dividing natality by the estimated number of tortoises in the square mile (45/300 = 15). The percent adult females which bred on the area was determined by taking the number of adult females found in the spring and dividing that number into the number of females which had constructed nests (14/53 = 26).

INTRODUCTION

Little is known about natality in wild, free ranging populations of the desert tortoise, *Gopherus agassizi*. Natality is defined as the production of new individuals by a population per unit of time. Most evidence regarding natality in this species is documented from observations of captive individuals. While data from captive tortoises provide valuable information on nesting behavior, egg morphology, development time, clutch size, and number of clutches, they help little in assessing the reproductive potential of wild populations.

In the field, natality can be ascertained by clutch number and size, a common method in studies of island nesting tortoises. Other methods include determining sex ratios and numbers of sexually mature individuals or counting hatchlings. Most field studies of the desert tortoise have assessed natality by the latter method.

Berry (1978) summarized natality data for 10 wild tortoise poulations from California, Utah, and Nevada. She expressed natality as the percent of hatchlings produced per year compared to the total population and determined that 0 to 6% of the animals in these populations were in the hatchling class (<2.4 inches or 60 mm in carapace length). She pointed out that these figures were low because hatchlings are more difficult to locate than larger individuals.

There are several reasons that hatchling counts tend to be low. First, the animals are tiny and have cryptic coloring. It is very difficult to see them unless the observer is within a few metres and the hatchling is in the open. Behavioral traits such as stopping when they detect an observer or running away and coming to rest in and amongst vegetation are often effective means of avoiding detection. Finally, the younger age classes of tortoises tend to be less active than the older in that they move shorter distances from their burrows and are found less often above ground in the autumn.

In this paper natality is assessed by observing nests during the spring and fall on permanent study plots. This method provides additional data on habitat preferences of wild tortoises for nesting sites, as well as information dealing with numbers of adult females nesting per year and clutch size. These new data will help both students of *Gopherus* and land managers to more accurately assess natality and the condition of populations.

Reproductive Season

Tortoises are considered to be adult and presumably sexually active at a mean carapace length of 207 mm. Courtship occurs throughout the time they are above ground, particularly in spring and fall (Berry 1975). Nest construction and egg deposition have been most often observed in early summer, with hatching occurring in autumn (Berry 1978). However, some clutches hatch in the spring (Grant 1936; Berry 1972). Incubation time varies primarily due to temperature differences. Harless and Morlock (1979) gave a mean incubation time of 109.3 days at 26.7°C.

Captive adult females do not necessarily produce a clutch each year and single clutches are more common than multiple ones. Some adult captive female tortoises have never been observed to nest, a few have nested annually, but most nested some years and not others (Miles 1953; Stuart 1954; Miller 1955; Nichols 1957; Burge, pers. commun.; Roy Tate, Curator, Victor Valley Museum, pers.commun.). This erratic nesting behavior is also exhibited in a number of snakes, crocodiles and some lizards (Berry 1974; Gans and Tinkle 1977).

Nest Construction

Several days prior to nest construction, the behavior of captive tortoises has been observed to change. Animals become restless, decrease their feeding, and scratch and dig at the ground either with their front or hind limbs (Stuart 1954; Miller 1955; Booth 1958; Lee 1963).

The actual nests of tortoises are usually constructed just prior to egg laying and this phase of nesting tends to be stereotyped in turtles and tortoises (Ehrenfield 1979). The flask-shaped nest cavity is dug with the hind feet and they are used alternately. Then the female stands over the opening and deposits her eggs. Following egg laying she fills in the cavity by depositing soil with the hind legs. The soil on the mound is patted and pressed and sometimes the females void and pat the mud.

The above described process has been observed to take place in both captive and free tortoises. It took place in under 4 h and occurred in the morning or evening (Miller 1955; Lee 1963; Burge 1977).

Nests are small, being limited by the distance the female can extend her hind limbs in the stereotyped nest building process. Dimensions for 6 nests of captive tortoises varied from 4 to 8 inches (102 to 203 mm) in diameter and 4 to 10 inches (102 to 254 mm) in depth (Miller 1955; Booth 1958; Lee 1963; Tate, pers. commun.). Burge's (1977) data for a nest in the wild indicate a maximum diameter and depth of 4.1 inches (104 mm).

Egg Size and Number

Eggs are white, slightly asymmetrical from spherical and are approximately 1.6 inches (40 mm) in diameter (Harless and Morlock 1979). Range in egg number is 2 to 14, with the average clutch size being 5 to 7 (Berry 1978).

Egg Viability

Viability of eggs produced by captive tortoises tends to be low. For example, Nichols' (1957) nesting data for three captive adult female tortoises over a period of 10 years indicate 95 eggs were produced but only 10 hatched. Similar data were given by Stuart (1954), who had a female tortoise which laid clutches of 5 to 13 eggs each year for 10 years but the only ones that hatched were those incubated in his home. Lee (1963) reported a clutch of five which did not hatch. On the other hand, others have experienced more success. In the spring of 1980 each of Roy Tate's three adult females nested in the yard and produced 30 eggs, 21 of which hatched.

These conflicting reports point out the vexing problem of ascertaining tortoise egg viability in captive individuals. In addition there is a paucity of information on egg viability in wild tortoises with the exception of

Burge's (1977) work in Nevada and California. The Nevada nest had four eggs, two of which hatched and the California nest had five eggs, all of which presumably hatched.

A major contributing factor to prenatal mortality apparently is the failure of the eggs to hatch. This is not an uncommon phenomenon in amniote eggs and is due primarily to temperature and moisture extremes in the tortoise nest as well as to the genetic constitution of the zygote (Ewert 1979). Another cause of prenatal mortality is predation. The shallow tortoise nests are excavated by predators and the eggs destroyed (Burge, unpubl. data). She located two nests in which the egg contents had been consumed by predators, which in one case was clearly a kit fox. It has been proposed by Patterson (1971) that the practice of voiding on the completed nest by the female tortoise might be a deterrent to nest predators.

STUDY PLOT

The study was conducted on a Bureau of Land Management permanent desert tortoise study plot, located in the Fremont Valley, Kern County, California. It is a 1-mi^2 (2.59-km^2) area located 4 miles (6.44 km) west of Randsburg on the Randsburg-Redrock Road.

The terrain is relatively flat, sloping gently from east to west at elevations of 2677 to 2398 ft (816 to 731 m). Soil is a fine sandy loam which becomes infused with gravel and rubble, particularly at its southern end, which is traversed by several washes. Vegetation is a creosote bush scrub community, with the predominant ground cover being the grass, *Schismus barbatus*.

The habitat is disturbed from several sources. The entire area is crossed by numerous trails which receive regular weekend use by motorbikes and occasional campers. Hunters and shooters use the area and grazing by sheep, although not recent, is evident.

METHODS

Field studies were conducted for 20 days in October 1979 to obtain quantitative data on the density, age structure, sex ratios, and behavior of the desert tortoise. Particular emphasis was on natality and hatchling tortoises were actively sought.

In the previous spring, 60 days had been spent on the study area and the locations of several hatchlings and juveniles had been determined as well as the location of a nest which hatched out sometime during the last week of May 1979 (Stewart, unpubl. data). These areas were searched intensively in October but, after 6 days, yielded no hatchlings. After locating a recently hatched nest on day 6, it was decided to actively search for nests as an aid to assessing natality.

As most nests described in the wild have been associated with burrows (Woodbury and Hardy 1948), nests were mainly sought at burrow sites. Each burrow over 6 inches (150 mm) in width was examined for shell fragments and evidence of recent disturbance. If fragments were located, the burrow was designated a nesting area. Each nest was described in detail, photographed, and recorded on a map. Included in the description were burrow length, width, height, soil cover, soil type, direction of burrow opening, and nearest shrub. All shell remnants were observed, collected, and placed into labeled containers. Notes were made on the probable number of eggs and their location in the nest. Hatchling tortoises and their burrows were sought in and around the nesting area. Adult tortoises found using burrows with nests were numbered, sexed, and weighed and measured according to procedures described in the spring study.

RESULTS AND DISCUSSION

A total of 48 live tortoises was located. Of these, 75% were adults, 12.5% subadults, and 12.5 immature. No hatchlings or juveniles were found.

Females outnumbered males, 28 females to 20 males. The sex ratio of all age groups was 58.3% females to 41.7% males. However, immatures are often difficult to sex accurately. If this group is not considered and only adults and subadults are included, there were 22 females to 20 males, or 52.4% to 47.6%. These ratios are similar to those of the spring study and indicate that the sex ratio in this population approaches one to one, slightly in favor of females.

Nest Location

A total of 15 nests was found (Figure 1 and Table 1). Distribution of nests was skewed with 13 of the 15 located in the two northern, wash-ridden quarter sections. The two southern quarter sections that are parallel to the Randsburg-Redrock Road yielded only 1 nest each.

In addition to the nests, a single egg was found on the surface of the ground, apparently unassociated with a nest. It was located on 23 October and was in the open on the southwestern quarter section 30.

Nest distribution paralleled the findings of the spring study in that most tortoises found were in the two northern quarter sections, particularly the northwestern quarter. Also, hatchlings and juveniles were concentrated in the northern quarter sections.

Nest Area Description

Nests tended to be constructed at the entrance to large burrows. Average burrow length was 43 inches (1082 mm); width, 11 inches (278 mm); height, 5 inches (139 mm) and soil cover, 3 inches (85 mm) (Table 1). Twelve of the 15 burrows were located under a creosote bush, while three were in the open. One of the latter was on the bank of a wash.

Twelve of the burrow openings faced in a northerly or westerly direction with the remainder facing south. Ten were constructed in a fine sandy loam and the other five constructed on much coarser soil consisting of gravel and in some cases, rubble also.

TABLE 1. Estimated Clutch Size Along with Dimensions and Locations of Burrows Associated with Nests.

Nest No.	Burrow Dimensions (mm) Length	Width	Height	Soil cover	Aspect burrow mouth	Shrub cover	Soil‡	Estimated clutch size
1	1500	310	159	139	West	L**	SL	6
2	910	300	130	89	West	L	SL	1
3	1600	260	120	50	West	L	SL	1
4	800	190	155	90	N West	L	SL	9
5*	1100	310	130	125	N West	L	SL	1
6	930	220	130	70	North	L	SL	2
7*	1600	320	150	65	West	L	G,R	2
8	720	305	130	140	West	L	G,R	5
9	1700	280	120	70	N East	L	SL	2
10	700	300	120	70	South	Open Wash	SL, G,R	2
11	1600	300	150	120	South	Open	SL, G	2
12	670	260	110	62	North	L	SL	2
13	500	255	170	60	N West	L	SL	2
14	1000	300	125	60	South	L	SL, G	2
15	900	260	200	75	West	Open	SL	6
Total	16,230	4170	2099	1285	6W,3NW 2N,1NE 3S	12 L 3 Open	10 SL 5 G or R	45
Ave.	1082	278	139	85				3

*Adult female using burrow.
**L, *Larrea divaricata*
‡ SL, Sandy loan; G, Gravel; R, Rubble

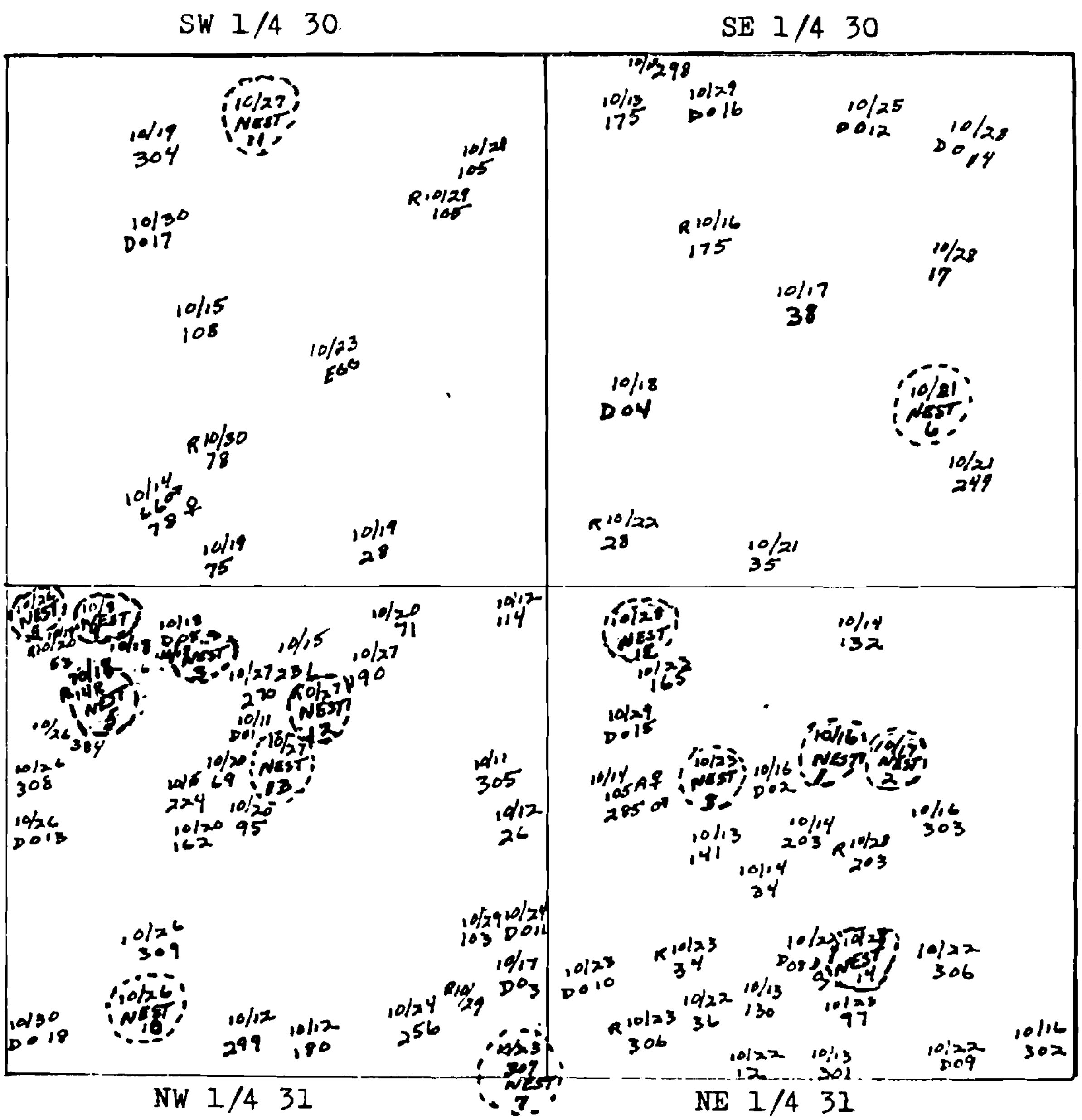


FIGURE 1. Distribution of tortoises and nests October 1979, Fremont Valley, Kern County, California. (Township 29 South; Range 40 East; Sections S30;N31.)

Adult Female Tortoises Associated with Nests

Two of the 15 burrows associated with nests had tortoises using them at the time of the study. In both cases, the tortoises were adult females. On 18 October, female number 148 (mean carapace length, MCL, 227) was found at noon-time (Pacific Standard Time) resting just inside her burrow. Nest 5 was located at the burrow entrance. Then on 23 October at 9:45 a.m. female number 307 (MCL 255) was basking a few metres from nest 7. Both females were observed using these burrows subsequent to the initial findings.

Clutch Size

At each nest an estimate was made of the number of eggs hatched there. This was based on the amount, condition, and location of shells. Four of the nests (1, 4, 8, 15) had considerable and widely dispersed remains; eight (6, 7, 9, 10, 11-14) had fewer, but obviously multiple eggs and three (2, 3, 5) had only a few scattered fragments. In all cases the egg shell fragments were smooth and thin. Some fragments still had dried albumin attached.

The range in egg number was estimated from 1 to 9, with the average number per nest estimated to be 3. A total of 45 eggs was estimated to be associated with nests.

Burrow Width and Clutch Size

The nests with the most shell fragments (1, 4, 8, 15) were analyzed for possible correlation of animal size and clutch size. Assuming that the tortoise that constructed the nest also constructed the burrow and that the width of the burrow is usually sufficiently large for the parent animal to turn around, the wider the burrow, the longer the animal.

Mean width of all 15 nests was 11 inches (278 mm) with a range of 7.5 to 12.6 inches (190 to 320 mm) (Table 1). Nests 4 and 15 were below the mean width (190 and 260 mm) while nests 1 and 8 were above (310 and 305 mm). Furthermore, the narrowest burrow (nest 4 with a width of 190 mm) had the most shell fragments (i.e., eggs).

The length of adult females associated with nests was compared with burrow width. Tortoise 148 had an MCL of 8.9 inches (227 mm) and a burrow width of 12.2 inches (310 mm); tortoise 307 was 10 inches (255 mm) in length and her burrow width was 12.6 inches (320 mm). The nests associated with these females (5 and 7) appeared to contain small clutches.

From these data, there was no convincing evidence that larger animals produce larger clutches. However, the mean burrow width of 10.9 inches (278 mm) indicates that animals constructing them were at or above the 8.1 inches (207 mm) designated as the adult length.

Number of Clutches

Probably nests 1 and 2 were constructed by the same female. This assumption is based on two major pieces of evidence. One, the proximity of the two nests 30 ft (10 m) and two, the nests were essentially the same width, 12.2 and 11.8 inches (210 and 300 mm). Nest 1 appeared to be the major nest because of the numerous shell fragments, while nest 2 had few fragments. This was the only case in which the possibility of multiple clutches could be hypothesized.

Evidence of Predation

Nests 1 and 2 were also the only ones which exhibited obvious signs of predation. The predator was a large bird which had left numerous large droppings in the burrow entrance and in a circle of approximately 3 ft (1 m) outside the burrow. The bird droppings are what attracted me to the nests. The predation was presumably on developed eggs or hatchlings as the remaining shell fragments were thin, smooth on the inside and several had albumin attached to them.

Proportion of Adult Females Reproducing

In the spring of 1979 a total of 219 living tortoises was located on this study plot (Stewart, unpubl. data). Of these, 53 were adult females. Assuming the 15 nests found in October were constructed by 14 different tortoises, 26% of the adult females in this population nested in 1979.

Natality Estimates

Based on observations made in the field during 1979, there are several means by which natality could be estimated. These are number of nests, clutch size, number of hatchlings, number of juveniles, number and condition of adult females, and proportion of adult males and females.

The desert tortoise population in this 1-mi^2 (2.59-km^2) area is calculated to be 300 (Stewart, unpubl. data). Parent stock is available and in apparent good health, with sufficient food and water (Stewart, unpubl. data). In the spring of 1979, 53 adult females and 39 adult males were observed on this plot. These sex ratios favor successful reproduction for this polygamous species.

There were 15 nests with an average of 3 eggs per nest, giving a natality figure of 45 young produced this year. Three live and one dead hatchlings located in the spring indicate 4 young were produced in the previous year. However, it is common knowledge that the number of hatchlings found tends to be very low. If the number of live (15) and dead (16) juveniles located in the spring are considered and their average age is 5, then their total number over 5 (31/5) is 6 young per year. Again, this estimate must be low due to the relative difficulty of locating juveniles.

Based on finds of both hatchlings and juveniles, there are approximately 4 to 6 new animals added to the population each year. However, based on nest finds, there are 45 hatchlings produced (at least this year). Furthermore, only 26% of the adult females present produced these offspring.

Natality Rate

Natality rate is expressed here as the number of new individuals in the population per year divided by the total population. It was stated previously that the population in this 1-mi^2 (2.59-km^2) area is about 300 individuals. Natality rate based on the 1979 hatchling finds is 1.3% (4/300); based on juvenile finds and manipulating the figures to give hatchling counts for five seasons, it is 2% and, based on the nest method, it is 15% (45/300). The high tortoise density here, the apparent good health of the population, the favorable sex ratio, and the large number of adult females, indicate that the nest method of assessing natality is superior to counts of young tortoises. Furthermore, the low numbers of hatchlings and juveniles located indicate that only 1 or 2 of the 53 adult females in this population nest each year. This simply cannot be true.

The disparity in estimates based on nest finds compared to hatchling and juvenile finds is mainly based on the fact that a stationary nest is easier to locate than a mobile young tortoise, which is small and cryptic in both coloration and behavior.

A major shortcoming of the nest count method of assessing natality is that an old nest might be mistaken for one of the current year. This is possible and to date no observations have been done in the wild to determine nest longevity. This problem can be minimized by having the observer well familiar with the study area as was the case in the present investigation. The area to be analyzed should be small and the investigator should spend several days in the field, both in spring and fall. Investigations conducted in the spring should include population data along with the marking, measuring and mapping of burrows. Nest surveys in the fall would concentrate on the marked burrows.

Permanent study plots and intensive population surveys like those being conducted by the Bureau of Land Management are vital to the understanding and management of the desert tortoise and its habitat. It is hoped that the method of assessing natality presented here will contribute to the understanding of natality in the wild, free ranging desert tortoises.

ACKNOWLEDGMENTS

The author is grateful to K. Berry, B. Burge, and R. Tate for their thoughts and perceptions about the desert tortoise, which they freely shared.

REFERENCES

Berry, K. H. 1972. Report on tortoise relocation project, July 1971 to November 1971. Division of Highways, State of California, in partial fulfillment of Contract F-9353.

_______. 1974. The ecology and social behavior of the chuckwalla (*Sauromalus obesus obesus* Baird). Univ. Calif. Publ. Zool. 101:1-60.

_______. 1975. Desert tortoise relocation project: status report for 1974. Department of Transportation, State of California, Contract F-9353, III. 5. 26 pp.

_______. 1978. Livestock grazing and the desert tortoise. Trans. 43rd North Amer. Wildlife and Nat. Res. Conference, Wildlife Management Inst. Washington, D.C., pp. 505-519.

Booth, K. 1958. Development of eggs and young of desert tortoise. Herpetologica, 13:261-263.

Burge, B. L. 1977. Movements and behavior of the desert tortoise, *Gopherus agassizi*. M.S. Thesis. Univ. Nevada, Las Vegas.

Ehrenfeld, D. W. 1979. Behavior associated with natality, pages 417-434 in M. Harless and H. Morlock, eds. Turtles, Perspectives and Research. John Wiley and Sons, New York, N.Y.

Ewert, M. A. 1979. The embryo and its egg: development and natural history. Pages 33-413 *in* M. Harless and H. Morlock, eds. Turtles, perspectives and research. John Wiley and Sons, New York, N.Y. 695 p.

Gans, C. and D. W. Tinkle. 1977. Biology of the reptilia. Academic Press, New York. VII:720 p.

Grant, C. 1936. The southwestern desert tortoise, *Gopherus agassizii*. Zoologica, 21:225-229.

Harless, M. and H. Morlock, eds. 1979. Turtles, perspectives and research. John Wiley and Sons, New York, N.Y. 695 p.

Lee, H. H. 1963. Egg-laying in captivity by *Gopherus agassizii* Cooper. Herpetologica, 19:62-65.

Miles, L. E. 1953. The desert tortoise. Audubon, 55(4):172-175.

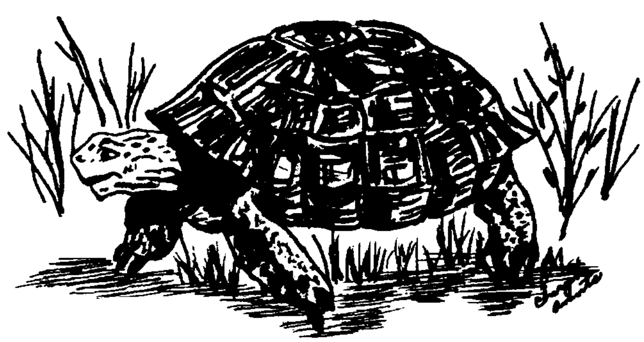
Miller, L. 1955. Further observations on the desert tortoise, *Gopherus agassizi* of California. Copeia, 1955(2):113-118.

Nichols, U. G. 1957. The desert tortoise in captivity. Herpetologica, 13:141-144.

Patterson, R. 1971. The role of urination in egg predator defense in the desert tortoise (*Gopherus agassizi*). Herpetologica, 27(2):197-199.

Stuart, G. R. 1954. Observations on reproduction in the tortoise, *Gopherus agassizi*, in captivity. Copeia, 1954:61-62.

Woodbury, A. M. and R. Hardy. 1948. Studies of the desert tortoise, *Gopherus agassizii*. Ecol. Monogr., 18:145-200.



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

FREDERICK B. TURNER
Laboratory of Biomedical and Environmental Sciences
University of California, Los Angeles
Los Angeles, California 90024

PHILIP A. MEDICA
5049 S. Mesaview Drive
Las Vegas, Nevada 89120

and

CRAIG L. LYONS
Reynolds Electrical and Engineering Company
P.O. Box 14400
Las Vegas, Nevada 89114

A field experiment designed to evaluate possible effects of cattle grazing on the well-being of the desert tortoise, *Gopherus agassizi*, was begun in the spring of 1980. This work was carried out in Ivanpah Valley, California (lat 35° 23' N, long 115° 18' W), about midway between Baker, California, and Las Vegas, Nevada. A fenced exclosure of 2.6 mi^2 (672 ha) was built by the Bureau of Land Management (BLM) (Plot 1), and cattle were removed from this area on 10 April. An unfenced area of the same size (Plot 2) was established just southwest of the exclosure. Perennial vegetation in both plots was composed principally of creosotebush, *Larrea tridentata*, and bursage, *Ambrosia dumosa*. The annual floras of the two areas were similar in terms of species composition and estimated dry weight standing crops during the spring of 1980. Because all cattle were removed from the vicinity of both plots shortly after the exclosure was completed, grazing experience in the two areas in 1980 differed only slightly.

All work on tortoises was carried out in "core" areas of ~ 1 mi^2 (260 ha) centered in each plot. These areas were staked in 109-yd (100-m) grids. Between 25 March and 13 June, 75 tortoises were captured and fitted with radio transmitters. Thirty-five tortoises (12 males, 23 females) were in Plot 1, 40 tortoises (12 males, 28 females) in Plot 2. All tortoises were ≥7.3 inches (186 mm) in plastron length and sexually mature. Neither mean lengths of males (9.2 inches or ~ 233 mm) and females (8.1 inches or ~ 205 mm) nor body weights (6.8 to 7.1 lb or 3100 to 3240 g in males, 5.0 to 5.1 lb or 2275 to 2315 g in females) differed significantly in the two areas. Mobility of tortoises in the two plots, as inferred from home range polygons, did not differ significantly. Body weight changes of tortoises during the 1980 season were qualitatively similar in the two areas between 24 April and 25 June. Both sexes gained weight until early May. Between 15-28 May,

females in Plot 1 exhibited an average weight loss of 8.0%; those in Plot 2 averaged a decline of 5.0%. Mean body weights of males in the two areas remained essentially unchanged during this interval. Between 29 May-11 June, females gained from 3.3 to 5.2%; males lost from 0.5 to 2.7%. Between 12-25 June, females in Plot 1 averaged a loss of 8.5% in body weight; females in Plot 2 a loss of 5.4%. Changes in males during this interval were only -0.2 to -0.4%. Between 26 June and 2 July, both males and females in Plot 1 gained weight conspicuously (from 8-12%) following an early July rain. Tortoises in Plot 2 did not gain weight at this time. Between April and October 1980 mean body weights of tortoises were remarkably stable. Changes in females and of males in Plot 1 were <1.0%. These differences are too small to be considered significant. Mean weights of three male tortoises in Plot 2 declined 2.8%. Female weight losses in May and June were interpreted as evidence of laying two clutches of eggs. Comparisons of absolute weight losses with estimated mean egg weight (1.4 oz or ~40 g) and weight of fluid lost with egg laying (0.35 oz or 10 g per egg) suggested mean May clutch sizes of 4.5 in Plot 1 and 3.0 in Plot 2. Mean June clutch sizes were, respectively, 4.6 and 4.1. Tests of means showed that the May means differed significantly while the June means did not. Proportions of females laying clutches in May were 88% in Plot 1, 75% in Plot 2. Proportions in June were, respectively, 94% and 65%. Chi-square tests failed to show that observed proportions in the two areas differed significantly.

INTRODUCTION

BLM is responsible for managing livestock grazing on several hundred million acres of public land in the Southwest. The BLM must also manage wildlife habitats so that species will not become threatened or endangered with extinction. During the last few years, biologists have recognized the desert tortoise populations have declined in numbers. The decline appears to be related to some human activities and disruption of tortoise habitat. Desert tortoises and their habitat are threatened by a number of man's activite and/or uses of public land (off-road vehicle uses, collecting, road construction and/or use, oil and gas exploration, agricultural development, home construction, livestock grazing, etc.).

Livestock grazing has been postulated as one of the major sources of past and continuing damage to natural populations of tortoises. Following an exhaustive appraisal of the status of desert tortoises at many sites in California, it was concluded that of all land uses, grazing by domestic livestock and/or feral ungulates was the most prevalent. Livestock grazing occurs on 93% of existing tortoise habitat in California and 90% in Arizona. There is good reason to examine the issue of grazing immediately, especially since the desert tortoise has been Federally listed as threatened in Utah. The desert tortoise is also under status review by the Office of Endangered Species, and may soon be proposed for threatened listing in California, Arizona, and Nevada by the U.S. Fish and Wildlife Service.

The results of the California study and further analysis of the livestock grazing problem by Berry (1978), give circumstantial evidence that past and present grazing practices are deleterious to tortoise habitat and tortoise populations. One of the principal points made was that numbers of tortoises in southwestern deserts have declined markedly over the past 30 to 40 years, and that existing populations often exhibit demographic qualities suggesting impaired recruitment and/or disruption of normal sex ratios. At the same time, areas occupied by tortoises have often experienced continued grazing, or overgrazing, and suffered either a demonstrated or assumed decline in habitat quality. However, the coincidence of these changes does not establish a cause and effect relationship. There is no experimental evidence unequivocally linking declines in numbers of tortoises with grazing, nor any evidence (other than occasional observations of trampled tortoises) that tortoises have suffered because habitats have been grazed. It is, nonetheless, reasonable to hypothesize a cause and effect relationship between range use by domestic and/or feral ungulates and declines in numbers of tortoises. There is no easy way to test this idea, but the problem can be attacked more directly by field experiments in which tortoises occupying the same specific environments are protected from grazing in one area and exposed to it in another.

Because some attributes of tortoise populations respond slowly to severe stresses, a field study of tortoises occupying grazed and ungrazed areas should initially emphasize comparisons of the general status of individual animals. Much can be demonstrated or inferred from seasonal changes in body weights of tortoises. Overall loss or gain of weight in the course of a season is an important integrative measure of individual well-being. An inspection of weight change records of females may permit the determination of whether and when egg-laying occurred. Whether the number of eggs laid can be estimated from the loss of weight relative to total body weight is not clear, but it may be possible to contrast reproductive effort among tortoises occupying grazed and ungrazed environments

The following report describes the beginning of a field experiment in Ivanpah Valley in San Bernardino County, California, including the establishment of a fenced exclusion area and an adjoining area subject to normal grazing practices, as well as data pertaining to desert tortoises occupying these plots during the spring and summer of 1980.

METHODS

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

Cattle are normally grazed in the valley during the spring and fall. Allotments vary from year to year, but BLM-authorized usage has generally been in the range of 1.5 to 2.0 head/section/year. Cattle may be grazed at lower elevations during the early spring, but must be moved to higher range around mid-May to early June. Usage during 1980 followed typical patterns.

Our study area included portions of BLM's Ivanpah Valley Permanent Tortoise Study Plot, which lies in Section 27 (T15N, R15E). Our area included that portion of Section 27 lying northwest of the power lines crossing the valley from southwest to northeast (Figure 1). Investigations of tortoises in the BLM plot were carried out in the spring of 1977, for 6 days in April 1978, and for 60 days in the spring of 1979 (Berry, Bureau of Land Management, Riverside, CA, unpubl. data).

We began work in the exclusion plot (Plot 1) on 11 March 1980. This plot is about 3 miles (4.8 km) northwest of the community of Ivanpah. The easternmost corner of the plot is at the intersection of Ivanpah Road and the power line running northeast-southwest across the valley (Figure 1). Fencing of the exclosure was begun 1 April and completed 7 April. The fence runs for 2 miles (3.2 km) parallel to the power line and for about 1.3 miles (2.1 km) along Ivanpah Road (Figure 1) and encloses a rectangle of 1664 acre (672 ha). All cattle were removed from the exclosure on 10 April. A smaller study was centered within the exclosure. This area was 1422 x 2188 yd (1300 x 2000 m) and was staked in a 109-yd (100-m) grid.

The area to be grazed (Plot 2) was established southwest of Plot 1 (Figure 1). Plot 2 was similar to Plot 1 in terms of slope and general terrain, and the same size as the exclosure. Again, a smaller central area 1422 x 2188 yd was marked off and staked in a 109-yd grid. All plot establishment work was completed by 1 May 1980. The southwestern edge of Plot 2 is around 3200 ft above sea level (976 m), and from this point the valley floor falls about 20 m/km to the northeastern border of Plot 1 at 2800 ft (854 m) above sea level.

Rainfall

Rainfall in Ivanpah Valley has been recorded since 1961 at the San Bernardino County Maintenance Yard about 1.2 miles (1.9 km) northwest of Plot 1. Clear-view rain gauges were installed near the center of Plot 1 on 24 March, in Plot 2 on 16 May. Rainfall was recorded within a day after each rainfall event.

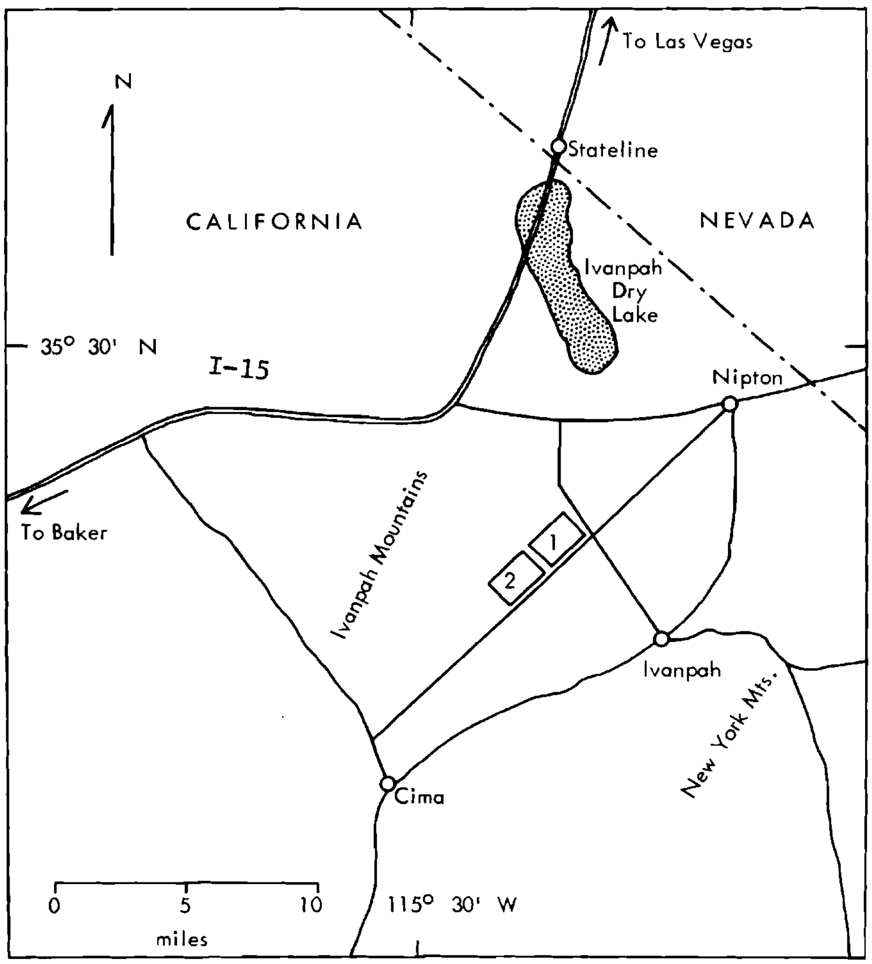
Aerial Photography

Aerial photographs of Plot 1 and 2 were taken by Genge Photo Company (Sacramento) on 8 April 1980. Overflights were at 1000 ft (305 m) and photographs were made with Kodak® S0397 film. Four strips 219-yd (0.2-km) wide and 0.5 mile (0.8 km) long were photographed in each plot. Each strip was about 40 acres (16.2 hectares) in extent so a total area of about 160 acres (65 hectares) was photographed in each plot. The core area of our plots was about 1 mi^2 (260 hectares) in extent, so the photographs registered around 30% of these areas. Arrangements are being made to have these photographs interpreted at the California Desert Plan Office of the Bureau of Land Management in Riverside, California.

Annuals

Annual plants in the two plots were inspected during March-April 1980. Estimates were made of relative abundance of various species. Densities of annual plants in Plot 1 were estimated from samples taken between 7-11 April 1980.

FIGURE 1. Location of fenced exclosure (1) and unfenced plot subject to grazing (2) in Ivanpah Valley, California. Each area was 2.6 mi^2.



Sixteen north-south lines and six points along each line were randomly selected. At each of these 96 points, four sampling points were established: two in the open, one beneath *Larrea tridentata* and one beneath *Ambrosia dumosa*. Species of *Cryptantha* and *Pectocarya* were abundantly represented, and these kinds of plants were counted in 1.1-ft^2 (0.1-m^2) quadrats at each sampling point. Other species were counted in 2.7-ft^2 (0.25-m^2) quadrats. Densities were computed for each species in three situations: in the open, beneath *L. tridentata*, and beneath *A. dumosa*. To estimate overall denities we used cover estimates developed by Woodman in 1979 (Berry, unpubl. data). Woodman estimated that total perennial cover was about 23%, of which 96% was conferred by either *Larea* or *Ambrosia*. Coverage by *Larrea* was about 2.5 times that of *Ambrosia*. Overall densities ($\underline{D}_o$) of annual plants were estimated as:

$$\underline{D}_o = 0.77\underline{d}_{open} + 0.165\underline{d}_{Larrea} + 0.065\underline{d}_{Ambrosia} \qquad (1)$$

Woodman's cover estimates were based on the point quarter technique, a procedure now deemed to overestimate actual coverage. According to Berry (pers. commun.) total perennial cover in Ivanpah Valley is probably around 10% or less. New cover estimates for Ivanpah Valley are being derived from our aerial photographs, and when these data are available, we will recompute overall annual densities using a revised form of Equation (1).

Dry weight biomass of annual plants in Plots 1 and 2 was estimated from harvest samples taken at 30 points in Plot 1 and 33 points in Plot 2. At each sampling point one quadrat was in the open and one under a shrub. High density species (*Cryptantha* spp., *Pectocarya* spp.) were combined in one group collected from 1.1-ft^2 (0.1-m^2) quadrats. All other species were harvested collectively from 2.7-ft^2 (0.25 m^2) quadrats, but separated into grasses and non-grasses. All samples were oven-dried and weighed. Overall standing crops ($\underline{S}_o$) were estimated as:

$$\underline{S}_o = 0.77S_{open} + 0.23S_{shrub} \qquad (2)$$

These estimates are also subject to revision depending on new perennial cover values.

Samples of eight species of annual plants were collected from Plot 1 on 12 May and Plot 2 on 14 May. This material was dried and ground using a Spex Mixer/Mill, in which a lucite pellet pulverized material in a polystyrene vial. Samples were never in contact with metal during grinding. Ground material was separated into three replicates and analyzed for K, Na, Ca, P, and Mg with an Applied Research Laboratories 1.5 m direct reading spectrometer. Statistical comparisons were based on replicated samples of each species from the two areas. Single samples of annual plants were analyzed for percent organic nitrogen by standard Kjeldahl procedures.

Tortoises were fitted with battery-powered transmitters so that they could be relocated using a receiver. All necessary items were acquired from AVM Instrument Co., Champaign, Illinois. The basic roster of equipment included a Model LA-12-channel receiver, 105 SB-2 transmitters, a test box (for batteries and transmitters), antenna wire, a hand-held 3-element Yagi directional antenna, and lithium sulfate batteries. We experimented with both C and D batteries. The C batteries are lighter, 1.6 vs. 3.0 oz (46 vs. 84 g), but D batteries longer-lived (36 vs. 12 months). We opted for D batteries, and all but eight tortoises were so fitted in the spring. During October we replaced seven of the C batteries with D batteries. An important feature of our program was the use of transmitters with signals of different quality. Emitted signals varied both in frequencies (from 164.436 MHz to 164.719 MHz) and pulse rates (from 55 to 140/min). Signal quality was built into each transmitter by the manufacturer. We attempted to keep transmitters with similar frequencies and pulse rates well separated in space (e.g., we used them in different plots, or at opposite ends of plots).

General Schedule of Work

Plot 1 was ready for work first, and we worked in this area between 25 March and 23 April before beginning in Plot 2. We then worked in Plot 2 between 24 April and 8 May. From then on we sampled both plots each week except during the weeks of 14-18 April, 19-23 May, 2-6 June and 7-11 July, when no work was done in either plot. Plots were also sampled on 8, 10, 14, and 16 October.

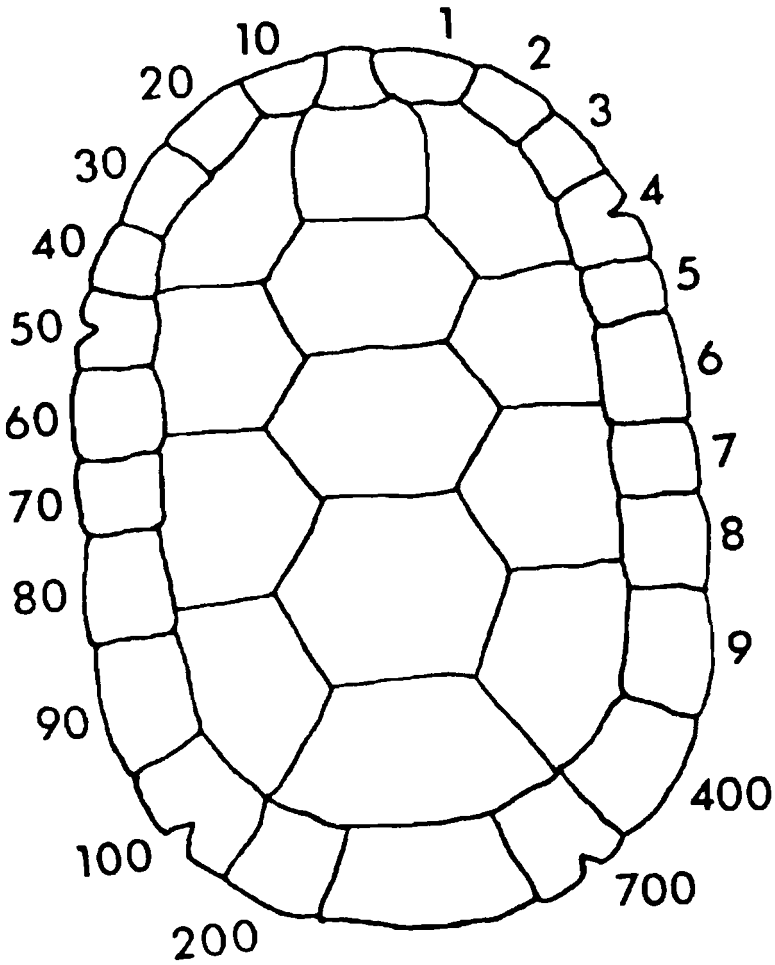
Initial Processing of Tortoises

Each tortoise was weighed and measured before installation of the transmitter and battery pack. Plastron measurements were recorded from the notch in the gular scute to the notch in the abdominal scute (Medica, Bury, and Turner 1975). Animals were measured only at the time of first capture and again at the end of the season, so as to avoid unnecessary losses of fluids (animals turned over for measurement often voided urine). We used a spring-type scale (John Chattillon & Sons, New York) to weigh tortoises. It weighed between 0-13 lb (0-6 kg) and was accurate to within 0.9 oz (25 g). For tortoises weighing between 4.4 and 8.8 lb (2 and 4 kg), our measurements were accurate within ± 1.2% to ± 0.6%.

Tortoises were permanently marked by filing notches in marginal scutes (Figure 2). We used the same numbering system used by Burge (1977*a*). We also painted orange numerals on the rear of each tortoise--usually on the last vertebral scute.

Attachment of transmitter and battery pack was carried out as suggested by Kenneth Moore and Neil Middlebrook (U.S. Bureau of Land Management, St. George, Utah, pers. commun.). Our procedures were similar to those used by Schwartzmann and Ohmart (1977). Antenna wires were cut to about 14 inches (35 cm) for easy accommodation to the carapaces of tortoises. Our transmitters weighed about 0.5 oz (15 g), and these were affixed to the rear of the carapace of males and the front of the carapace of females with Devcon® epoxy cement.

FIGURE 2. Method used to mark tortoises in Ivanpah Valley study plots (see also Burge, 1977).



Batteries were attached with the same adhesive. The mean overall weight of transmitters and associated batteries was 0.3 lb (150 g).

Recapturing Tortoises

Our objective was to recapture marked tortoises at least every two weeks so as to maintain accurate records of changes in body weights. In seeking out marked tortoises we made use of rosters showing points at which tortoises had been previously captured and the directional antenna.

Transmitters have a range of about 766 yd (700 m), and worked equally well whether tortoises were above ground or in burrows. When within 109 yd (100 m) of a tortoise, the receiver gain control could be fine tuned so as to ascertain the exact direction of the signal. In general, all electronic equipment functioned well, and only one of 75 transmitters attached is known to have failed in the field.

Conventional records were maintained for all tortoises, including estimates of x-y coordinates of capture loci. All data were transcribed to IBM cards for ease in manipulation and reduction.

Home Ranges

Home ranges of tortoises captured four or more times were computed as minimum polygons--A_2 of Jennrich and Turner (1969). Capture points were ordered counterclockwise around the geometric center and the area of the polygon computed by the following formula:

$$A_2 = 1/2 \; \Sigma \; (x_i y_{i+1} - x_{i+1} y_i) \qquad (3)$$

Home range areas were then adjusted for sample size bias using values in Table 2 of Jennrich and Turner (1969).

RESULTS

Rainfall

The general pattern of precipitation in Ivanpah Valley is similar to that described for the Great Basin, except that the Continental component peaking in spring and fall is weakly represented. The valley essentially experiences a winter component and a Gulf component peaking during summer. The predominating rains occur during winter.

Rainfall records maintained by the San Bernardino County Flood Control District since 1961 indicate that annual rainfall varies from around 1.5 to 7.5 inches (37 to 190 mm), with an annual mean of 3.9 inches (98 mm). Monthly rainfall has been recorded during the latter part of 1979 and for the first 7 months of 1980 (San Bernardino County records), and our plots since April 1980 (Table 1).

TABLE 1. Rainfall (mm) in Ivanpah Valley

Dates	Plot 1	Plot 2	Ivanpah Valley
September 1979	-	-	0
October	-	-	2.8
November	-	-	0
December	-	-	3.0
January 1980	-	-	24.1
February	-	-	29.2
March	-	-	13.2
April 1	4.3	-	
April 28	10.2	-	
April Total	14.5	-	23.6
May 2	5.3	-	
May 16	7.9	-	
May Total	13.2	-	25.7
June	0	0	0
July 1	4.6	3.8	
July 14	1.8	1.8	
July Total	6.4	6.4	6.9

[1]Rain gauges were put out on March 24 (Plot 1) and May 16 (Plot 2)

TABLE 2. Estimated Densities of Those Annual Plants in Plot 1 Exceeding 5/m^2 in Ivanpah Valley in 1980

Species	Number counted	Estimated density (number/m^2)
Bromus rubens	554	5.8
Chaenactis carphoclinia	796	8.3
Cryptantha angustifolia	2,491	64.9
C. circumscissa	1,315	34.2
C. micrantha	3,084	80.3
Descurainia pinnata	844	8.8
Linanthus aureus	766	8.0
Mentzelia albicaulis	517	5.4
Pectocarya heterocarpa	3,809	99.2
P. platycarpa	785	20.4
Stylocline micropoides	875	9.1

Annuals

Fifty-eight species of annuals were recorded in quadrats examined in Plot 1 in 1980. Estimated overall density was estimated to be 310/yd^2 (371/m^2). Densities in the open, beneath creosote bushes, and beneath bursage, were 288, 372, and 402/yd^2 (345, 445, and 481/m^2), respectively. Density estimates for those species in Plot 1 with densities exceeding 5/m^2 ranged from 4.5 to 83/yd^2 or 5.4 to 99.2/m^2.

(Table 3). Wilcoxon tests of biomass data showed no plot differences in standing crops of subgroups of annuals or of annuals in aggregate. Standing crops of annuals beneath shrubs were significantly greater than in the open in both areas, in spite of the fact that densities of annuals were greater in open spaces. This followed from the much greater size of annual plants growing beneath shrubs.

TABLE 3. Estimated Biomass (g dry weight/m^2) of Annual Plants in Ivanpah Valley in 1980

Plot	Kinds of annual plants			Totals
1	*Cryptantha* spp. *Pectocarya* spp.	12.0 ± 13.1	5.9 ± 5.9	7.3
	Other forbs	5.4 ± 7.0	1.6 ± 2.8	2.5
	Grasses	0.7 ± 1.8	0.1 ± 0.2	0.2
	Total	18.1	7.6	10.0
2	*Cryptantha* spp. *Pectocarya* spp.	9.0 ± 8.0	4.1 ± 4.7	5.2
	Other forbs	5.5 ± 7.2	0.8 ± 1.1	1.9
	Grasses	0.8 ± 1.2	0.04± 0.1	0.2
	Total	15.3	4.9	7.3

Mean concentrations of six major nutritive elements were based on measurements made of various species in the two plots (Table 4). Data for P, Na, K, Ca, and Mg were analyzed in two ways. First concentrations in samples of each species from the two areas were compared by t-tests. Of the 40 comparisons made (8 species and 5 elements), 12 showed statistically significant differences between plots. Every species except *Erodium cicutarium* showed plot differences for two to three of the five elements considered. Most of the differences indicated somewhat higher concentrations in samples from Plot 2. We also performed an analysis of variance of concentrations of these five elements in all species of annual plants from the two plots. A factorial analysis of variance involving eight species and two plots showed (as expected) highly significant differences between species. The analysis also indicated that, among the eight species of plants analyzed, concentrations of P, K, and Mg differed between plots. Interaction terms for P and Mg were statistically significant, implying no consistent pattern of difference among species in the two areas.

Perennial Plants

Aerial photographs of our plots have not been analyzed. However, the general nature of the perennial vegetation of the area can be inferred from previous sampling data. Woodman estimated the density of perennials on the BLM plot as around 2,925/acre (7,224/ha). The most abundant shrub was *A. dumosa* (2,134/acre or 5,272/ha), with *L. tridentata* a common co-dominant (506/acre or 1,249/ha). The grass, *Hilaria rigida*, had an estimated density of 199/acre (492/ha), while *Hymenoclea salsola*, *Lycium andersonii*, *Opuntia echinocarpa*, and *O. ramosissma* all had densities of around 16/acre (40/ha).

TABLE 4. Mean Concentrations (%) of Six Elements in Annual Plants in Ivanpah Valley in May 1980

Element	Plot 1	Plot 2
Phosphorus	0.46	0.30
Sodium	0.44	0.43
Potassium	2.15	2.33
Calcium	1.93	2.04
Magnesium	0.43	0.49
Organic nitrogen	1.58	1.55

Tortoises

General Background

The most recent work in Ivanpah Valley (by Woodman in 1979) indicated a probable tortoise population of some 200/mi^2 (0.77/ha) (Berry, unpubl. data). This estimate included adjustments for small tortoises, which are never seen in relation to their actual numbers. Of the 168 tortoises registered in Ivanpah Valley in 1979, 109 could be sexed and 62 of these were males. These figures do not represent a statistically significant departure from an expected sex ratio of 1:1 (X^2 = 2.06, p = >0.10).

Capturing and Recapturing Tortoises

Between 25 March and 13 June 1980, 75 tortoises were fitted with radio transmitters. Thirty-five tortoises (12 males, 23 females) were in Plot 1; 40 (12 males, 28 females) in Plot 2. From earlier work with tortoises near Arden, Nevada (Burge 1977*a*, *b*) we judged that all animals 7.9 inches (200 mm) in plastron length (8.4 inches or 214 mm in carapace length) were sexually mature. Only one of 51 females fitted was less than 7.5 inches (190 mm) in plastron length (7.3 inches or 186 mm).

Sizes of tortoises marked in the two areas were similar (Table 5). Males and females in the two plots were compared separately, and t-tests showed that neither mean weights nor lengths differed significantly.

Sex Ratios and Size Distributions of Tortoises

Size distributions of 221 tortoises in Plots 1 and 2 during 1980 were calculated (Table 6). Table 6 includes the 75 tortoises fitted with transmitters, as well as other tortoises observed in the two areas. Only plastron lengths (P) of tortoises without transmitters were recorded. Carapace lengths (C) for these tortoises were estimated using an equation based on tortoises measured over a wide range of body lengths in Rock Valley, Nevada (Medica, *et al.* 1975):

$$C \text{ (mm)} = 1.06P \text{ (mm)} + 2.25 \qquad (4)$$

Because our experiment focused on animals presumed to be sexually mature, we do not represent these data as reflections of the true dize distributions of two populations. It is, however, appropriate to infer a 1:1 sex ratio in both areas.

TABLE 5. Mean Plastron Lengths (mm) and Body Weights (g), ± Standard Errors of Means, of 75 Desert Tortoises in Ivanpah Valley, 1980. Ranges of measurements are given in parentheses.

Measurement	Plot 1		Plot 2	
	Males	Females	Males	Females
Length	233.8 ± 5.1 (205-261)	204.9 ± 2.0 (191-226)	233.2 ± 4.6 (205-255)	205.5 ± 1.9 (186-225)
Weight	3104 ± 161.4 (2100-3970)	2316 ± 66.9 (1860-3270)	3240 ± 185.1 (2430-4340)	2275 ± 62.6 (1690-3040)

TABLE 6. Sex and Size Structure of Desert Tortoise Populations in Ivanpah Valley in 1980

Age group	Carapace length(mm)	Plot 1 males	Plot 1 females	Plot 1 unknown	Plot 2 males	Plot 2 females	Plot 2 unknown
Hatchlings	<56			3			1
Young juveniles	56 - 99			11			11
Juveniles	100 - 180	2	3	20	4	6	15
Subadults	181 - 207	3	6		8	8	1
Adults	208 - 299	32	26		29	32	
Totals		37	35	34	41	46	28

Home Ranges of Tortoises

Fifty-five tortoises (38 females, 17 males) were captured four or more times in Plots 1 and 2 during the 1980 season. Numbers of captures ranged as high as 11, with a mean of about 7. The overall mean home range size (after bias correction) was about 54 acres (22 ha), with individual ranges from as small as 7.2 acres (2.9 ha) to as large as 219 acres (88.6 ha). The reader is reminded that the bias corrections used are based on an assumed bivariate normal utilization distribution (Jennrich and Turner 1969), but we do not know how tortoises really distribute their above-ground activities. In our view, the bias corrections give unrealistically large home range estimates, but they remove sample size bias and permit better comparisons of groups. Estimated home range areas corrected for sample size bias were uncorrelated with capture frequencies of tortoises.

With few exceptions, tortoises were always recaptured within the plot where they were first marked. However, between 14 and 30 May, a male 9.0 inches (229 mm) in carapace length moved about 1.9 miles (3.1 km) from Plot 2 to Plot 1. Our principal concern with mobility of tortoises lay in the relative behavior of animals in the two plots. We considered home ranges in terms of plots, sex, and two size groups of each sex. Smaller females ranged from 7.9 to 8.7 inches (202 to 221 mm) in carapace length (3.7 to 5.7 lb or 1.7 to 2.6 kg); larger females from 8.8 to 9.9 inches (223 to 252 mm) (4.6 to 7.3 lb or 2.1 to 3.3 kg). Smaller males ranged from 8.8 to 10.1 inches (225 to 257 mm) in carapace length (4.6 to 8.4 lb or 2.1 to 3.8 kg); larger males from 9.8 to 11.4 inches (248 to 289 mm) (7.3 to 9.5 lb or 3.3 to 4.3 kg). Table 7 gives means of estimated ranges for four classes of tortoises. Home range estimates (HR) were obviously non-normally distributed, so for analytical purposes we used the square roots of ranges. Table 8 gives mean values of $(HR)^{1/2}$ for these same groups. Factorial analysis of variance of the values contributing to Table 8 indicated no significant effects owing to sex, plots, or body weights. We are assured, then, that movements by tortoises in the two areas were similar at the outset of our experiment.

TABLE 7. Mean Home Ranges ± one Standard Error of Desert Tortoises in Ivanpah Valley in 1980

Sex	Range in carapace length (mm)	Plot	*n*	Mean home ranges (ha)
f	209-220	1	8	13.9
	202-221	2	10	15.7
	223-252	1	8	22.3
	224-244	2	12	24.1
m	232-244	1	6	41.7
	225-257	2	4	22.4
	248-275	1	4	22.3
	267-289	2	3	20.1

TABLE 8. Means of Square Roots of Home Ranges (Hectares) of Desert Tortoises in Ivanpah Valley in 1980.

Category	Plot 1	Plot 2
Smaller females	3.54	3.70
Larger females	4.35	4.49
Smaller males	6.24	4.58
Larger males	4.46	4.43

Weight Changes Among Tortoises

We computed weight change profiles for males and female tortoises in the two areas by converting weight gains and losses by individuals to percent changes in body weights for selected time intervals. This was done for 24 tortoises weighed at the beginning (April) and end (October) of the 1980 season. Body weights, on average, were essentially unchanged (Table 9). Except for males in Plot 2, mean percent changes were less than expected errors in measuring tortoise weights.

It is also instructive to examine weight changes over shorter time intervals during the season (Table 10). Here percent changes were computed for the intervals shown, and were not based on initial spring weights. These data show similar trends in males and females in the two plots up until the first week of July, when weights increased conspicuously in Plot 1 but not in Plot 2. This difference will be discussed later in connection with effects of rainfall on body weights. All groups gained weight until around 1 May. After this, weights of males either declined gradually (Plot 2) or remained stable until the increase in early July (Plot 1). Among females, however, a sharp drop in body weight occurred during May (8.0% in Plot 1, 5.0% in Plot 2). This decline occurred during a time when some rain fell (Table 1), and when body weights of males remained generally stable. The same thing occurred in June when weights of females declined (8.5% in Plot 1, 5.4% in Plot 2) while weights of males were steady. In contrast with these observations, no female tortoises reweighed by Woodman in May 1979 showed conspicuous losses of weight (Berry, unpubl. data).

Influence of Rainfall on Body Weights

As expected, most tortoises gained weight after rains. We analyzed such changes after rainfall on 28 April and 1 July 1980. Weights of tortoises in Plot 1 were available for 22 and 23 April and again on 1 and 5 May; tortoises were weighed in Plot 2 on 24-26 April and again on 2 May. Measurements were made in Plot 1 on 25-27 June and again on 3 July; on 23 and 24 June and again on 2 July in Plot 2. Table 11 summarizes these observations.

We analyzed weight changes among females in the two plots by paired *t*-tests (Table 12). Here the null hypothesis is that there is no weight change after a rain. This hypothesis is clearly rejected for Plot 1 in July and Plot 2 in April, but cannot be rejected in the other two instances. There is no obvious explanation for the differences in behavior of tortoises in the two plots. Rainfall gauges registered 0.18 inches (4.6 mm) in Plot 1 and 0.15 inches (3.8 mm) in Plot 2 after the 1 July rainfall, so total precipitation barely differed

TABLE 9. Weight Changes Among Desert Tortoises in Ivanpah Valley Between April and October 1980

Plot	Sex	n	Range of initial body weights (g)	Mean initial body weight (g)	Range of final body weights (g)	Mean final body weight (g)	Range of % changes in body weights	Mean % change in body weight
1	f	8	1960-3270	2379	1925-3030	2349	-7.3 to 6.6	-0.6
	m	6	2300-3570	3143	2445-3550	3154	-5.5 to 6.3	0.8
2	f	7	1840-2640	2257	1770-2630	2241	-4.0 to 2.4	-0.8
	m	3	3040-3820	3537	2930-3730	3438	-3.6 to-2.4	-2.8

TABLE 10. **Mean Percent Change (± One Standard Error) in Live Body Weights of Tortoises in Ivanpah Valley during 1980**

	Plot 1				Plot 2			
Dates	n	Males	n	Females	n	Males	n	Females
9-23 April		-	3	1.0 ± 1.9		-		-
24-30 April	3	3.9 ± 1.2	4	2.1 ± 1.4	2	8.3 ± 1.9	9	5.2 ± 0.8
7-14 May	2	2.6 ± 0.5	4	0.8 ± 2.4	3	-1.0 ± 1.3	3	1.1 ± 0.7
15-28 May	5	0.7 ± 0.6	7	-8.1 ± 0.8	4	-0.1 ± 0.8	8	-3.6 ± 1.4
29 May-11 June	6	-0.5 ± 0.6	8	5.2 ± 1.1	3	-2.7 ± 1.1	8	3.3 ± 0.9
12-25 June	6	-0.4 ± 0.5	17	-8.5 ± 1.3	3	-0.2 ± 0.5	21	-5.4 ± 1.1
26 June-2 July	3	8.0 ± 1.3	9	11.9 ± 2.2	1	-3.1	10	0.2 ± 1.3
3-16 July	5	-4.4 ± 1.4	10	-3.6 ± 0.5	3	-1.6 ± 1.1	8	-0.7 ± 0.9
17 July-12 October	6	-7.9 ± 0.9	14	-0.3 ± 0.8	6	-4.3 ± 1.4	14	1.1 ± 1.6

TABLE 11. Changes in Live Body Weights of Desert Tortoises in Ivanpah Valley After Rains on 28 April and 1 July, 1980

Date	Plot	Sex	n	Mean weight before rain (g)	Mean weight after rain (g)	Mean change in weight (g)	% change in weight	Range of individual weight changes (g)
April	1	f	6	2283	2328	45	+2.0	-70 to 120
	2	f	9	2218	2338	120	+5.4	0 to 200
	1	m	3	3447	3580	133	+3.9	40 to 210
	2	m	2	3395	3685	290	+8.5	170 to 410
July	1	f	9	2182	2431	249	+11.4	75 to 425
	2	f	10	2290	2302	12	+0.5	-125 to 225
	1	m	3	3410	3693	283	+8.3	150 to 425
	2	m	1	4005	3880	-125	-3.1	-125

at the sites of gauges. Rainfall intensity may have varied, with formation of puddles in Plot 1 but not in Plot 2. The principal point to be derived from these measurements is that, although plot centers are only 1.5 mi (2.4 km) apart, we cannot always count on identical behaviors of tortoises involved in the experiment.

Reproduction in 1980

One instance of courtship (22 April) and another of mounting (27 May) were observed in Ivanpah Valley in 1980. In the latter instance, the animals remained coupled for at least 5 min. Four other observations of males and females were recorded--13 May in a pallet, 9 June and 2 July in washes, 15 July in a burrow. During the fall 7 pairs of tortoises were observed; one on 4 September and six between 8-18 October. In all of these instances the female was in a burrow or pallet and the male was basking at the entrance. October breeding of the desert tortoises has been reported in Mohave County, Arizona (Tomko 1972). Deposition of eggs was never observed, but four nests excavated by predators were observed (three in Plot 1, one in Plot 2). These nests were seen between 18 June and 18 July and, judging from shell fragments around the excavations, probably contained from 2-4 eggs.

TABLE 12. Analyses of Weight Changes Among Female Desert Tortoises in Ivanpah Valley Following Rains of 28 April and 1 July 1980

Date	Plot	n	t	Probability of a larger t-value
April	1	6	1.59	0.1 - 0.2
	2	9	5.62	<0.001
July	1	9	5.67	<0.001
	2	10	0.42	>0.5

We believe that our measurements of body weights give a more informative picture of what happened in Ivanpah Valley in 1980. In our view, the conspicuous declines in weights of females during May and June had little to do with changes in nutritional status or degree of hydration of tortoises. Some rain fell (2 and 16 May) during one of these declines, and no such declines were observed among male tortoises occupying the same environment. Our interpretation of the observed weight losses in females is that two clutches of eggs were laid--one in May and one in June. Table 13 gives summarizing statistics for weight changes among female tortoises in May and June 1980. Further details were given by Turner, Medica and Lyons (1980). Most of the tortoises under observation experienced substantial weight losses during May and June. A few, on the other hand, either gained weight or showed no change in body weight.

We can draw further inferences from Table 13 if we make some assumptions about losses of fluid associated with egg laying and weights of individual eggs. Grant (1936) reported the weights of three eggs as 1-1.1 oz (27-30 g), but these were laid in early June and not weighed unti 4 months later. Berry (1975) reported the mean weight of six freshly laid eggs to be 1.5 oz (41.7 g).

TABLE 13. **Mean Weight Changes Amont Female Desert Tortoises in Ivanpah Valley During May and June 1980**

Plot	Interval	n	Mean carapace length (mm), ± one s.e.	Mean first body weight (g), ± one s.e.	Mean second body weight (g) ± one s.e.	Mean change in body weight (g)	Range of changes in (g)
1	12-16 May to 26-30 May	8	230 ± 5	2596 ± 148	2387 ± 132	-209	-320 to -95
2		8	224 ± 5	2379 ± 165	2258 ± 150	-121	-200 to -25
1	9-13 June to 23-27 June	17	226 ± 3	2395 ± 76	2191 ± 75	-204	-425 to +175
2		23	223 ± 2	2340 ± 84	2214 ± 66	-126	-350 to +75

Weights of 50 eggs laid by captive female tortoises in Las Vegas, Nevada, ranged from 1 to 1.4 oz (26 to 39 g), with a mean of 1.1 oz or 31.3 g (Burge, pers. commun.). Iverson (1980) reported a mean weight of 1.4 oz (41 g) for eggs of *Gopherus polyphemus* in Florida. We estimate that an egg weighs about 1.4 oz (40 g), and that about 0.4 oz (10 g) of urine per egg is lost at the time of egg deposition (Nichols 1953, Lee 1963). Hence, each 1.8 oz (50 g) loss of body weight may be equated to the laying of one egg. We will further assume that weight losses less than 3.5 oz (100 g) did not result from egg laying. Table 14 summarizes what may be inferred from these assumptions. May and June means in the two areas were compared by *t*-tests. The *t*-value for May was 2.69 (11 d.f.), indicating a statistically significant difference between the means ($t_{0.05}$=2.20). The *t*-value for June was 0.75 (29 d.f.), implying no significant differences in area means ($t_{0.05}$=2.04). Chi-square tests (1 d.f.) of proportions of reproducing females in the two areas showed no significant differences in either May (X^2 = <1.0) or June (X^2 = 3.1, $X^2_{0.05}$ = 3.8).

TABLE 14. Postulated Egg Production by Female Desert Tortoises in Ivanpah Valley in 1980

Month	Plot	Number of females observed	Number of females laying eggs	Range of estimated clutch sizes	Mean clutch size
May	1	8	7	3.0 - 6.4	4.5
	2	8	6	2.0 - 4.0	3.0
June	1	17	16	2.0 - 8.5	4.6
	2	23	15	2.0 - 7.0	4.1

DISCUSSION

In an experiment of this nature one relies heavily on divergences in the states and/or performances of populations in treated (grazed) and untreated areas. If such divergences occur, one is on much firmer ground in interpreting them if the two populations were shown to be similar before the experiment began. Circumstances during the 1980 season were such that much of what we accomplished contributed to this objective. Shortly after the exclosure was completed and cattle removed (10 April) most of the cattle in the area were moved elsewhere. Some cattle may have continued to graze in Plot 2.

Body sizes (lengths and weights) of tortoises composing the two groups under study did not differ significantly, and the size distributions of tortoises in the two areas were the same. We were not primarily concerned in this experiment with home ranges of tortoises, but alterations of an animal's environment may influence a species' mobility and its utilization of space. As pointed out previously, we are less interested in actual sizes of home ranges than with our ability to make valid comparisons between tortoises occupying grazed and ungrazed study areas. Hence, our emphasis on sample size bias corrections which give comparable estimates of home ranges. The most important result of our analysis of home ranges was the absence of an area effect.

Measurements and analyses of seasonal changes in live body weights of tortoises in the two areas will be a critical feature of the experiment. We are hoping to be able to use these changes as indirect measures of reproductive success. During 1980 we demonstrated two periods of distinct weight loss among females--one between 5-26 May, the other between 13-27 June. Individual body weight losses were as great as 11.3 oz (320 g) for the first clutch and 15.0 oz (425 g) for the second clutch. Mean weight losses among females during May and June were 5.8 and 5.6 oz (165 and 160 g), respectively. Such losses were rarely, if ever, sustained by males, and during times of maximal weight loss among females, males either gained weight or showed mean losses of <0.7 oz (20 g).

For the purposes of our experiment, estimates of reproductivity by females will be one of the most important measures of the continuing status of the two populations. If we have interpreted female weight losses correctly, our data showed that some females laid two clutches in both areas. Higher proportions of female tortoises laid eggs in Plot 1 than in Plot 2 in both May and June, but tests showed that these differences were not statistically significant. Estimates of mean June clutch size based on 31 tortoises (4.6 in Plot 1 and 4.1 in Plot 2) did not differ significantly. Only the estimated mean clutch sizes in May, based on 13 tortoises, differed significantly. Gibbons and Greene (1979) have shown that clutch sizes of freshwater turtles may be determined by X-ray photography. This could prove to be a valuable means of validating conclusions drawn from weight changes, or might even be adopted as a method of measuring clutch sizes in Ivanpah Valley directly.

ACKNOWLEDGMENTS

We thank S. Beasley, B. De Santis, H. Hiatt, H. Hill, N. Mays, B. Maza, D. Nuby, M. Speers, B. Steinberg, and A. Vollmer for assistance with field work. We are grateful to personnel of the U.S. Bureau of Land Management for advice during the planning of the project: W. Radtkey, K Berry, H. Johnson, L. Foreman, J. Bicket, R. Crowe, and E. Sorenson. We thank Gary Overson for his cooperation in planning and siting the exclosure. K. Berry, P. Schneider, and P. Woodman suggested important improvements in this article. We thank K. Feary and D. Weston, San Bernardino County Flood Control District, for rainfall records from Ivanpah Valley, and B. Burge for records of tortoise egg weights. J. Kinnear, G. Kiser, L. Valainis, and F. Gen-Kuong assisted with data reduction. D. Garrison gave secretarial assistance. The California Fish and Game Commission issued permits for this project. We acknowledge support by the Civil Effects Test Operations Office and A. Morrow. This work was supported by an inter-agency transfer of funds from the U.S. Department of Interior to the U.S. Department of Energy and by Contract DE-AM03-76-SF00012 between the University of California and the U.S. Department of Energy.

REFERENCES

Berry, K. H. 1975. Desert tortoise relocation project: status report for 1973. Dept. of Transportation, State of California, Contract F-9353, Section III.

_______. 1978. Livestock grazing and the desert tortoise. Trans. 43rd N. Amer. Wildl. and Nat. Res. Conference: 505-519. Wildlife Management

Burge, B. L. 1977*a*. Movements and behavior of the desert tortoise, *Gopherus agassizi*. Thesis. Univ. Nevada, Las Vegas.

_______. 1977*b*. Daily and seasonal behavior, and areas utilized by the desert tortoise, *Gopherus agassizi*, in southern Nevada. Pages 59-94 *in* M. Trotter and C. G. Jackson, Jr., eds. Desert Tortoise Council Symposium Proc. 1977, Las Vegas, Nevada.

Gibbons, J. W., and J. L. Greene. 1979. X-ray photography: a technique to determine reproductive patterns of freshwater turtles. Herpetologica, 35:86-89.

Grant, C. 1936. The southwestern desert tortoise, *Gopherus agassizii*. Zoologica, 21:225-229.

Iverson, J. B. 1980. The reproductive biology of *Gopherus polyphemus* (Chelonia: Testudinidae). Am. Midl. Nat., 103:353-359.

Jennrich. R. I., and F. B. Turner. 1969. Measurement of non-circular home range. J. Theoret. Biol., 227-237.

Lee, H. H. 1963. Egg-laying in captivity by *Gopherus agassizi* Cooper. Herpetologica, 19:62-65.

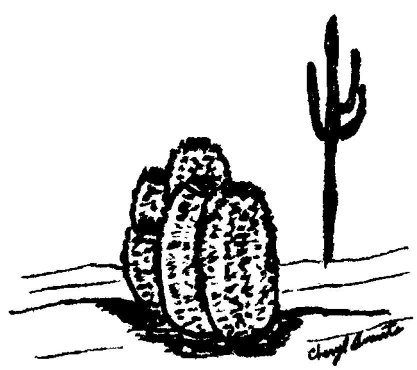
Medica, P. A., R. B. Bury and F. B. Turner. 1975. Growth of the desert tortoise (*Gopherus agassizi*) in Nevada. Copeia, 1975:639-643.

Nichols, U. G. 1953. Habits of the desert tortoise *Gopherus agassizii*. Herpetologica, 9:65-69.

Schwartzmann, J. L., and R. D. Ohmart. 1977. Radiolocating free-ranging desert tortoises (*Gopherus agassizii*): maximizing transmitter range and longevity. Pages 57-58 *in* M. Trotter and C. G. Jackson, Jr., eds. Desert Tortoise Council Symposium Proc. 1977, Las Vegas, Nevada.

Tomko, D. S. 1972. Autumn breeding of the desert tortoise. Copeia, 1972: 895.

Turner, F. B., P. A. Medica and C. L. Lyons. 1980. A comparison of populations of the desert tortoise (*Gopherus agassizii*) in grazed and ungrazed areas in Ivanpah Valley, California. Report to the U.S. Bureau of Land Management. 66 pp.



SHEEP GRAZING AT THE KRAMER STUDY PLOT, SAN BERNARDINO COUNTY, CALIFORNIA

LORI NICHOLSON
and
KEN HUMPHREYS
6590 De Anza Avenue
Riverside, California 92506

During a desert tortoise, *Gopherus agassizi*, study in the spring of 1980, about 1000 sheep grazed the 1-mi^2 (259-ha) study area intermittently for 12 days, 10 through 21 May. The study site was located in western San Bernardino County, California, 23 mi (38 km) southwest of Barstow. This desert area has been grazed for over two decades, and is currently leased to the I & M Sheep Company for ephemeral use. The sheep used 73% of the section; 4% of this use area was bedding sites, with soil disturbance averaging 80%. Thirty-three percent of the plot was heavily used, with soil disturbance averaging about 75%. The mean annual plant cover was greatest in no-use areas. Between late April and late May, the percent cover of annuals decreased 41% on a no-use area, as opposed to a 69% decrease on a heavy-use area. Annual plant frequency decreased 45% from late April to late June in the heavy-use area, while decreasing only 5% in the no-use area. Between paired June transects within similar habitat, the transects with less soil disturbance usually had more native annual cover. Perennial plant transects in bedding sites had less cover than transects in light- to no-use areas, but this difference could be due to sheep preference for bedding areas with lower cover or to sampling bias, rather than the reduction of cover by sheep. Flowering annuals and burrobushes were preferred sheep forage. Some dietary overlap of annuals between sheep and tortoises was observed. One hundred sixty-four burrows used by tortoises during the study were checked after the sheep left in order to assess damage. Burrows were rated according to their vulnerability to trampling. Few burrows were poorly protected, as most were dug under shrub cover. Ten percent had been damaged by sheep and 4% were destroyed. Burrow damage was considered insigificant because tortoises were often observed digging new burrows in late spring regardless of established available burrows.

INTRODUCTION

While performing a desert tortoise, *G. agassizi*, study for the Bureau of Land Management (BLM) (contract #CA-060-CTO-6) on the 1-mi^2 (259-ha) Kramer Hills Tortoise Study Area during the spring of 1980, about 1000 sheep grazed for 12 days over the majority of the study area. Since data on tortoise burrows and general habitat conditions had been collected prior to sheep use, an opportunity to examine the effects of sheep was presented. Sheep impacts upon soils, vegetation, and tortoise burrows were assessed, and sheep use observations and tortoise-sheep encounters were also recorded.

A summary of the tortoise study results on the Kramer Hills study area follows. From March to May, 147 tortoises were marked during a 68 man-day study, and the density was estimated at 200/mi^2 (75 tortoises/km^2). The age and sex ratios of live tortoises were near normal, and 102 shells were found on the plot (Berry, in prep.).

DESCRIPTION OF STUDY AREA

The Kramer Hills tortoise study area is in western San Bernardino County, California (section 28 T8N R5W) (Figure 1). The 1-mi^2 (259-ha) site is about 23 mi (38 km) southwest of Barstow, and more than 2 mi (3 km) from any paved road. The site has low hills on the west and east, which are vegetated with a creosote bush-shadscale scrub community mix (Munz 1975). Between the hills is a creosote bush community. Most of the northwest quarter is dominated by a Mojave saltbush, *Atriplex spinifera*, community, where 50% fewer tortoises were found. Elevation on the plot ranged from 2700 to 2780 ft (823 to 847m). The soil is generally a sandy loam, however, hill ridges are gravelly and/or hardened by lime deposits. Soils around the playa in the northwest quarter have a high clay content.

The plot is easily accessible by graded dirt roads and most of the plot shows signs of off-road-vehicle activity. Motorcycle trails and shotgun shells are ubiquitous. On or bordering the plot are 3.5 mi (5.6 km) of dirt roads.

METHODS

Data on the effects of sheep grazing were gathered by walking soil and vegetation transects, relocating marked tortoise burrows, mapping the section's sheep use, and observing sheep and tortoise behavior. Bureau of Land Management (BLM) grazing records were reviewed, and Nicholson spoke with BLM and sheep company personnel.

Vegetation

Three permanent vegetation transects were established in the plot, one in each of the three plant assemblages representative of the majority of the section. Annual plants were sampled three times on each transect: 24 April, 22 May, and about 23 June. One transect was in a heavy-use area, one was in a no-to-light use area, and one was in a no-use area. Within each of 50 annual quadrats per transect the percent cover of each annual species was estimated. The percent cover per metre, frequency, and relative cover and frequency were calculated for each species in each transect.

Fifty 329-ft (100-m) transects, walked from 22-25 June, were inventoried for soil disturbance and live annual plant conditions. On 6 of the 50 transects perennial plant information was collected as well. It was predetermined that 5 transects would be in sheep watering areas, 10 in sheep bedding areas, 10 in no-use areas, and 25 in grazed areas. The 35 transects in grazing and no-use areas were systematically located. The watering and bedding transects were located to assure that they would be on land of designated use.

Annual plant data were gathered along the 50 transects by placing a 8 x 20-inch (20 x 50-cm) quadrat every 16 ft (5 m) along the 329-ft (100-m) transect lines. Within each annual quadrat the percent cover of each annual species was estimated.

Perennial plant data were collected from six belt transects each 10 x 29 ft (3 x 100 m). Three of these transects were located in sheep bedding areas. The other three were in no use or light use areas in habitat that approximated as closely as possible a corresponding transect in a bedding area. Each perennial plant within the belt was classified according to its average diametere and sheep use received, as follows:

class	average diameter (cm)
A	0-20
B	20-40
C	40-70
D	70-120
E	120-200

class	sheep use description
0	plant not used
1	tips of branches lightly grazed (tips refer to this year's growth)
2	tips of branches moderately grazed
3	tips of branches heavily grazed, grazing may extend beyond tips
4	entire plant heavily grazed, well beyond tips
5	one side of plant broken down, as if a sheep bedded on one side
6	not all , but nearly all of the plant's sides broken back
7	all sides of the shrub are broken back by bedding sheep
8	shrub is moderately trampled
9	shrub is heavily trampled

A plant could fit into one to three of the use classes. Calculated for each transect were percent cover per hectare, relative cover, density, and relative density. The results of transects within the bedding areas were compared to the results on transects with no sheep use or only light use, respective to habitat.

Soils

Soil data were gathered by use of a point frame device. This was located along the 50 transect lines every 33 ft (10 m), so that 10 samples were taken per transect. The number of points which hit disturbed soil when dropped from the frame were recorded. Soil was considered disturbed if the crust had been broken or if no crust existed (structureless).

If the point hit soil disturbed by a source other than sheep, an attempt was made to identify the source and it was noted on the data sheets. During analysis, all disturbed points, regardless of origin, were lumped. Analysis of the soil data consisted of computing the percent of disturbed points hit and the mean disturbed points hit per sample for each transect.

Burrows

From 16 to 18 June, 164 burrows found during the tortoise study were rechecked for sheep damage and to assess their vulnerability to trampling. Intensity of sheep use about each burrow was recorded. Burrows were assigned a condition class:

class	description
A	active, tortoise is present or has been recently
B	no recent use, but the burrow is in good condition
C	filled with dirt, as if a rodent had been digging in the burrow
D	damaged by sheep
E	destroyed by sheep, unusable by tortoises

A burrow could fit into more than one of these classes. Next, all burrows were assigned a vulnerability rating, that is their exposure to sheep trampling. This was a rather complex process that considered the following criteria: burrow width, soil cover over both the entrance and tunnel, and perennial plant protection at the entrance and over the tunnel. The burrow was said to have no tunnel if its length was less than twice its width. Soil cover classes were defined as:

class	cm cover
1	less than 6 cm (poor)
2	fair; 6-12 for large burrows (greater than 10 cm width); 6-10 for small burrows
3	good; 12-15 for large burrows; 10-13 for small burrows
4	excellent; g.t. 15 cm for large burrows; g.t. 13 cm for

Shrub protection was based on our own judgement from extremes of no cover to sturdy branch and root cover of a large shrub. Perennial plant protection classes were defined as:

class	description
1	none
2	poor; branches or roots of a shrub (dead or alive) thinly cover the entrance/tunnel
3	fair; branches covering entrance/tunnel are a little thicker, or a very small shrub is over it
4	good; thicker scrub cover over entrance/tunnel, there may be some root protection
5	excellent; protection of sturdy thick shrub cover, or under a shrub which is 40 cm or more in width and height

These protection classifications were based on observations of grazing sheep. During this study the sheep did not break down shrubs to graze inside them, so excellent shrub protection was defined as cover we felt sheep would not penetrate. We observed that sheep could break through soil cover that was 13 cm or less over an adult burrow, unprotected by a shrub. We thought a small burrow could have slightly less soil cover and not be affected by trampling. Soil structure and composition also affects how easily a burrow could be damaged by sheep, but this was not considered in the rating system.

Plant protection and soil cover ratings were applied to both the entrance (E) of the burrow and the tunnel (T) beyond the entrance. (Example: E23 T34) For both, the number of the soil cover class was added to the number of the plant protection class. (Example: E5 T7) If the resulting sum of the entrance was less than that of the tunnel (as was usually the case), the tunnel rating was reduced by one and became the overall burrow protection rating. (Example: rating = 6) If the entrance sum was equal to or larger than the tunnel sum, the tunnel sum became the burrow rating. If the burrow was too short to have a tunnel, the entrance sum minus one became the burrow rating. The following protection class system is based on the burrow's protection from sheep trampling afforded by shrubs and soil cover.

class	description
1	no protection
2	poorly protected
3	fair protection
4	good protection
5	very good protection
6	excellent protection

Direct Observations

Direct observations of sheep were made infrequently because we had to fulfill other contract obligations while the sheep were on the plot. It was difficult to track the sheep's daily movements on and off the plot due to the hilly terrain. A few sheep did wear bells which could be heard when they were actively moving, and in this way we could determine approximate sheep locations. Dust clouds were also used to determine locations.

On 14 May, Nicholson arrived at the plot in time to see the sheep being watered. She attempted to follow the sheep around at this time and afterwards, but the sheep were skittish and spooked if she made any movements, or if she was closer than about 66 ft (20 m). To find what the sheep were eating, especially annuals, we examined various plant species for signs of grazing.

Observations of direct sheep and tortoise interactions were even less common. One was seen, and a few other incidences were easily deduced. We looked for all the juvenile tortoises previously marked, but found only three.

On 21 May Nicholson talked about one-half hour with a man from Bakersfield who said he was a manager with the sheep operation. They discussed some grazing practices and whether or not sheep had an effect on the tortoises. On 23 June we spoke with Paco, who works for the I & M Sheep Company. He was visiting the plot with Ken Moore of the BLM Barstow Area Office, and they were looking at the range condition to determine if the sheep could stay out longer. We also discussed grazing practices with them.

Mapping

From 27 May to 9 June Nicholson mapped sheep use throughout the plot by walking the quadrat borders (a 329-ft (100-m) grid had been flagged on the plot for study purposes) east to west and assigning a H (heavy), M (medium), L (low), or 0 (no) to each quadrat side. The percent soil disturbance assigned to the letter rating was: H=50-100% disturbance, M=20-50%, L=1-20%, and 0=no disturbance. The rating was subjective. The no-use areas of the plot were mapped in detail by walking the perimeter of the use areas and marking the boundaries on an aerial photo. Old heavy use areas were identified by soil and perennial plant disturbance and numerous old sheep scats, and were also marked on an aerial photo.

The bedding and watering areas were marked on an aerial photo, and were easily identified by characteristic signs. Bedding pallets, shallow bowls about 24 inches (60 cm) in diameter and up to 2 inches (5 cm) deep, were dug in the ground by the sheep to lie in. These were usually dug next to shrubs, sometimes under creosotes. They could be on all sides of the shrub, but often not on the east side. There were frequent urine stains on the ground, many scats, and between shrubs the ground was nearly 100% disturbed in these bedding areas. Some bedding sites were small, and it is possible that additional small sites were not found.

Watering sites were identified by vehicle tracks left by the water-hauling truck, and by the evidence of trough water spilled on the soil. Soil disturbance could be heavy only on the side of the truck the troughs were extended from. Nicholson observed one watering near the plot's center. The watering truck parked on the road with the troughs to one side. Later the sheep passed over this site a second time, obliterating all signs of sheep watering. This could have happened elsewhere on the plot, so there could be more watering sites than the three we found.

Historical and current grazing information were obtained from BLM personnel. Hyrum Johnson of the Desert Plan Staff gave us information on grazing leases, and Jerry Townsend of the BLM Barstow Area Office gave us information on grazing practices and leases.

RESULTS

Grazing History and Current Use

Bureau of Land Management personnel we contacted agreed that grazing has occurred in the area for at least 40 years, perhaps longer. The earliest BLM record is a lease to the Silver River Ranch in Oro Grande before 1960.

Currently the I & M Sheep Company of Bakersfield has a 10-yr lease (#6206) on the Buckhorn Canyon Allotment (#7103), which will be up for renewal in 1982. The size of the allotment is 16,791 acres (U.S.D.I. 1980). In the spring of 1980, 31 March to 31 May, the BLM allowed 289 Animal Unit Months (AUM's) and a herd of 900 sheep. The lease was extended from 1 June to 30 June, to allow 237 AUM's more on the allotment, a herd of 1500 sheep. (Five sheep equals one AUM.) In 1979, the BLM allowed 555 AUM's, a herd of 1700 sheep, from 30 March to 31 May.

Sheep grazing by trespass undoubtedly occurs, but was not observed on the plot this year. Sheep company personnel complained that the BLM does not do enough to prevent trespassing. While we were on the plot, we once spoke with a BLM Ranger who was looking for trespassers. A trespassing herd had been found elsewhere on the allotment.

Sheep are grazed on the Buckhorn Allotment usually between 1 March and 31 May. Before the herds are turned out, BLM personnel perform an occular reconnaissance of area and its vegetation to determine when the sheep can be turned out, when they must be taken off, and how many sheep can be grazed. The BLM instructed the company to not bed the sheep in a place more than once, and that they should be kept moving.

A chronology of sheep use on the Kramer Tortoise Study Area and nearby follows.

Late April: Sheep were being unloaded on Shadow Mountain Road 1.6 mi (2.5 km) southwest of the study area.

1 May: More sheep were seen being unloaded on Shadow Mountain Road. A turquoise sheep herder trailer was seen about one mile north of this road, 1.6 km west of the plot.

5, 6 May: Sheep were heard less than 1 mi (1.6 km) northwest of the Plot's north border, beyond some hills.

8 May: A camp trailer used by sheep herders was hauled onto the northwest quarter of the plot, and a camp was set up about 230 ft (75 m) south of the graded road. We briefly spoke with two Peruvian herders. They did not speak much English, but did indicate that the sheep were to the northwest.

9 May: The sheep camp was still in the northeast quarter, but no sheep were seen on the plot all day. We left the plot at sunset.

10-13 May: Sheep arrived on the plot and grazed portions of the north half. The two most northern watering sites were used during this time.

14 May: Nicholson arrived at the plot at 11:30 a.m. and observed the sheep resting near the plot's center. The herd was watered one-half hour later. She was told later by a sheep company employee that there were about 1000 ewes and yearlings in the herd. In the evening the herder camp moved to a new site south of the plot, about 1500 ft (500 m) southeast of the southwest corner. The sheep moved with the camp.

15-20 May: The sheep grazed portions of the southern half of the section and south of the plot, moving up to 0.5 mi (800 m) off the plot before circling back onto the plot.

21 May: At 5:00 a.m. the sheep were herded from the southeast quarter to about 0.6 mi (1 km) south of the plot on the graded road, where they were watered. In the afternoon the sheep herder camp moved 1 mi (1.6 km) south of the plot, and 0.25 mi (400 M) north of Shadow Road. The sheep moved with the camp.

22-26 May: Sheep were still at the above location.

27 May: The sheep camp moved from its location by Shadow Mountain Road to an unknown location. Sheep were seen being loaded (or unloaded) onto trucks in Fremont Wash, about 1 mi (1.6 km) southeast of where the sheep herder camp was last seen.

The following description of grazing practices by the sheep operation on the plot was put together from observations and by Nicholson's observations with sheep company employees. Their remarks which are not supported by our observations are indicated with an asterisk. For those remarks contrary to our observations, an explanatory note is included.

The sheep herder's trailer is hauled by a large truck to the vicinity to be grazed by sheep. The campsites are preferably located on hilltops, so the herder may watch the herd from the traler. The trailer was about 9 ft (3 m) wide by 18 ft (6 m) long and equipped with a propane gas tank and probably water tanks. Two trash cans were outside, and a garbage pit dug nearby. The pit was not buried when the camp was abandoned and the trash was scattered by ravens and the wind. Five dogs were at the camp when we first saw it; later there were only two dogs but some dogs did travel with the herder and water truck. The herders relieved themselves behind bushes, leaving quite a bit of toilet paper blowing about and stuck in the bushes. A man from Bakersfield brought supplies to the camp, and the water truck will often spend the afternoon at the camp. A new 600-ft (200-m) road to the campsite had been created by repeated use. Few shrubs were crushed when this road was made because it followed a less vegetated ridge.

The sheep grazed within a 0.8-mi (1.2-km) radius of the herder's camp,and were usually left unattended. The herder headed the sheep in a direction in the morning and the sheep walked and grazed from there.* The herder turned the herd in a different direction when they began to get too far from camp.* Sheep will bed at night and in the afternoon. The herders were instructed not to let the sheep bed in any location more than once, and this appeared to be done not due to the herder's work, but because the sheep just ended up at a different bedding site when they stopped moving. Most grazing and walking occurred in the morning and evening when it was cool. Sometimes the herder actively herded them at these times.

A second herder drove the water truck, and watered all herds in the area. The sheep are watered once every day, usually early in the morning.* Nicholson observed two waterings, one in the early morning and one in the afternoon. Interestingly, the sheep usually are not thirsty and will not drink.* Later in the spring when it was hotter, the sheep will be watered twice daily.* The truck is sometimes driven to the herd, and sometimes the herd is driven to the water truck. Twice the truck, a heavy vehicle with four tires on the rear axles, had been driven off the established dirt roads for about 0.25 mi (400 m), to the sheep. Once the truck began to follow an old motorcycle trail, which quickly became much too narrow for the truck to stay on. The truck crushed numerous shrubs on its way to the herd. The other occasion the truck drove along a less vegetated ridge to the sheep, so that few shrubs were crushed. When the truck reached the sheep, two 15-ft (3-m) long troughs are extended from the truck in a "V" shape, and filled. The sheep approach to drink on only one side of the truck, and stay in a tight herd. After about one-half hour, the herders dump the water out of the troughs and drive away.

A company manager supposedly came and checked forage conditions to see if the sheep should be moved to a new location.* (We thought that the camp and sheep were moved periodically, about once a week.) The sheep were removed from the allotment sooner than expected because small black gnats were bothering the sheep, causing them to rub their heads in the shrubs to remove the biting bugs.* (We also found the gnats to be very annoying, but during our observations the sheep did not appear to be bothered.)

Use Areas

Sheep used 72.5% of the section (Figure 2). The largest unused portion of the plot was in the east hills. Small, isolated no-use areas were also in the northwest and southwest quarters. Fifteen bedding sites were mapped, and totaled 4.4% of the use area. Heavy use areas were not mapped, though the effects of sheep were probably comparable to the effects in bedding areas. The proportion of heavy use areas, estimated by mapping trampling disturbance along quadrat lines, was about 33% of the section (Figure 3). By this method, approximately 77% of the plot was used. Also plotted are the percent soil disturbance results from the line transects, which correspond fairly well with what was estimated when walking the quadrat lines.

Sheep Directly Affecting Tortoises

Three tortoises which had been directly encountered by sheep were observed. Male 34 was where the sheep were being watered on 14 May. The sheep moved in a tight herd all about him while they watered. When I checked him after the sheep left, he was basking less than 1 yd from where he was sighted basking before the sheep surrounded him. He seemed unconcerned, had not sought brush protection, and had not urinated. All the ground around him for 10 yd (10 m) or more had been 100% disturbed by sheep.

Also on 14 May the sheep had partially collapsed the burrow of female 16 while she was inside. Most of the first 24 inches (60 cm) of a nearly 6-ft (2-m) deep burrow had been collapsed. The soil cover had been 4 inches (10 cm) thick or less. At 3:35 p.m. she was sitting just inside what was left of the burrow entrance. This was her first time exiting the burrow since the sheep had damaged it.

In the evening of 15 May, juvenile 20 (carapace length 2.8 inches or 72 mm) was found trapped in burrow 40, the same burrow he had been using since 10 April. This burrow was the only one on the plot which had a rating of no protection. The burrow had been totally destroyed by sheep, probably the afternoon before. When juvenile 20 was unburied, he was under about 3 inches (7 cm) of structureless soil. Whether or not he would have been able to dig out of the sand is unknown. We think that he would not have been able to dig out because the sand was packed around him. He appeared unable to get his legs out of the shell to begin digging or to turn around. Juvenile 20 apparently had not urinated while trapped; he had gained 1 gm in weight and 1 mm in length since his last capture on 9 May.

Male 34 was again observed on 15 May at 4:30 p.m., about 0.25 mile (400 m) west of the watering site, walking 15 ft (5 m) south of burrow 78. At the entrance of the burrow was a fresh plastron imprint, presumed to be male 34's. The burrow could not be entered without excavation, because sheep had caved in the entrance. Male 34 may have been leaving the burrow for this reason. There was no tortoise in the burrow on the 15th, and probably no tortoise inside when damaged.

Soil Disturbance

Bedding and watering sites had heavy soil disturbance, about 75%, while grazing sites had less than half that impact (Table 1). In the bedding areas, the soils were typically 100% disturbed between the shrubs. No-use areas had about 5% soil disturbance, representing normal background disturbance unrelated to sheep. Rodents were the major cause of this disturbance although ants, motorcycles, and washes also contributed.

Annual Plants

Annual plant transects show the dominance of non-natives, both split grass, *Schimus arabicus*, and filaree, *Erodium cictarium*, throughout the plot where they combine for about 75% in both relative frequency and cover. It appeared that sheep reduced annual cover in heavy use areas; however, correlations of annual cover and frequency with soil disturbance, of 50 transects done 22 to 25 June and without regard for transect site locations, are insigificant. We believe that this lack of correlation was due to the lack of transect homogeneity. No-use areas did have almost twice the mean annual cover and almost 50% greater mean frequency than the sheep bedding areas (Table 2).

Sheep may reduce cover of late maturing native annuals through trampling. As evidence of this, 19 transects were paired; compared were two transects that were close to each other and of similar habitat yet with differing soil disturbance. Fourteen of these pairs had more native annual cover in the transect with less soil disturbance (Table 2). These transect pairs support our hypothesis that spring sheep grazing probably does reduce abundance of annual plants in early summer -- annuals which may provide tortoises green forage in early summer if there were no sheep grazing.

TABLE 1. Data Summary of Soil Disturbance and Plant Transects in Sheep Use and No-use Areas of the Kramer Tortoise Plot, June 1980. (10 samples/transect, 20 points/sample)

Size use	Number of transects	% disturbed points	% mean annual cover	Mean annual frequency	Mean number of annual species
Bedding	10	80.0	0.61	0.44	3.3
Watering	5	66.5	0.79	0.52	3.2
Grazing	25	37.1	1.12	0.60	5.6
No-use	10	5.1	1.43	0.73	6.7

TABLE 2. A Comparison Between Cover of Late Maturing Native Annuals (cm^2/m^2) and Percent Soil Disturbance (Caused by Sheep Trampling and Grazing) of Paired Homogeneous Transects on the Kramer Tortoise Plot, June 1980.

Transect number	% soil disturbance	Annual cover	Transect number	% soil disturbance	Annual cover
3/49	2/11	20/15	9/8	0.5/54.5	25/45
47/50	2.5/27	10/45*	6/10	10/40	100/26
37/38	46.5/99.5	80/5	41/39	43/53	5/65*
36/35	8.5/17	245/65	42/40	17/51.5	0/5*
24/23	26/85.5	60/15	50/33	27/66	45/15
19/23	8/56.5	45/15	29/27	8/59	95/10
25/26	62/88.5	15/0	35/43	17/84	65/15
16/15	3.5/22.5	35/51*	39/84	53/15	65/10
29/30	8/72.5	95/20	13/12	67.5/79.5	0/0*
10/45	40/78	25/10			

* a pair with more or equal annual cover on the transect with more disturbance

TABLE 3. Changes in Annual Cover and Frequency in Three Transects on the Kramer Tortoise Plot, 1980. April Transects Were Done Prior to Sheep Use, May and June Transects Were Done After Sheep Use.

TRANSECT #1, heavily grazed, in creosote scrub

	24 April	22 May	23 June	Total % change April - June
total % live cover	51.9	16.0	1.1	
% change		- 69.2	- 93.1	- 97.9
frequency	100.0	100.0	55.0	
% change		0.0	- 45.0	- 45.0

TRANSECT #2, no sheep use, northeast hills shadscale scrub

	24 April	22 May	22 June	Total % change April - June
total % live cover	46.4	27.4	1.9	
% change		- 40.8	- 93.1	- 95.9
frequency	92.0	100.0	95.0	
% change		+ 8.7	- 5.0	+ 3.3

TRANSECT #3, lightly grazed, Mojave saltbush scrub

	24 April	22 May	25 June	Total % change April - June
total % live cover	59.9	30.2	0.5	
% change		- 49.6	- 98.3	- 99.2
frequency	94.0	100.0	45.0	
% change		+ 6.4	- 55.0	- 52.1

TABLE 4A. Data Summary of the Creosote Scrub Perennial Transects, Including Only the Dominant Species and Comparing a Bedding Area Transect (B) and a Light-Use Area (L).

Shrub	Density (#/ha)		Cover (m^2/ha)		Mean cover per shrub (m^2)	
	L	B	L	B	L	B
Burrobush	5700	3200	475	155	.08	.05
Shadscale	1233	433	309	65	.25	.15
Goldenhead	267	233	5	8	.02	.03
Anderson's thornbush	67	200	22	48	.33	.24
Creosote	67	167	134	202	2.00	1.21
Other	100	67	7	3	.07	.04
Total	7434	4300 42.2 less	952	481 49.5% less	$\bar{x}$ .13	$\bar{x}$ .11

TABLE 4B Data Summary of the Shadscale Scrub Perennial Transects, Including Only the Dominant Species and Comparing a Bedding Area Transect (B) and a No-Use Area (O).

Shrub	Density (#/ha)		Cover (m^2/ha)		Mean cover per shrub (m^2)	
	O	B	O	B	O	B
Burrobush	5500	5033	562	296	.10	.06
Shadscale	1033	767	213	122	.21	.16
Creosote	167	167	290	290	1.74	1.74
Other	133	133	21	29	.16	.22
Total	6833	6100 10.7% less	1086	737 32.1% less	$\bar{x}$ .16	$\bar{x}$ .12

Three annual transects were done during the early tortoise study, one in each habitat type, to determine annual cover and frequency during the peak bloom. Although the transects had been selected before the sheep arrived, by fortunate coincidence one transect was in a heavily grazed area, one in a light to no-use area, and one was in a no-use area. Each transect was sampled three times: 2 weeks before the sheep arrived, 1 week after the sheep left, and 5 weeks after the sheep left. By comparing how the transect results changed over time and betweeen transects in different use areas, we hoped to quantify the effects of sheep use on annuals. Unfortunately, differences between transects may reflect not only effects of sheep use, but the differences between the habitats and soils as well. Between April and May, annual plant cover decreased 70% in the heavy-use area, compared to 40% in the no-use area and 50% in the light-use area (Table 3). Frequency stayed about even through this time period. The cover was almost entirely dry by June in all habitats, but there was more than twice the live cover remaining in the no-use habitat in the east hills. On the grazed transect, frequency decreased about 50% by June, while on the no-use area the frequency of annuals actually increased. This difference may be due to soil disturbance causing the soils and late maturing spring annuals to dry out faster in the heavily disturbed area.

Perennial Plants

Perennial shrubs are used by tortoises for cover: as shade in the afternoons, protecton from predators, and to dig their burrows under. Reduction in density and cover of perennials caused by sheep grazing, bedding, and trampling could negatively affect tortoises and their habitat.

Perennial transects, done after the sheep had left, were paired: for each of three transects done in a bedding area, one in a corresponding no- or light-use area of a similar habitat was selected. The intent was to reveal "before" and "after" sheep effects on perennials in a given habitat. The transect sites chosen appeared similar in the aerial photos. The transects in the bedding areas averaged 27% fewer shrubs and 26% less cover than the no- and light-use areas (Tables 4a, b, c). However, many of the 15 sheep bedding sites on the plot appeared to have low shrub cover before quantitative data were collected. Sheep may have a preference for bedding sites with lower shrub cover, as opposed to sheep actually causing the cover reduction with just one bedding use.

TABLE 4C. Data Summary of the Mojave Saltbush Scrub Perennial Transects, Including Only the Dominant Species. Comparing a Bedding Area Transect (B) and a No-use Transect (0)

Shrub	Density (#/ha) 0	Density (#/ha) B	Cover (m^2/ha) 0	Cover (m^2/ha) B	Mean cover per shrub (m^2) 0	Mean cover per shrub (m^2) B
Mojave saltburh	2100	1200	1074	939	.51	.78
Burrobush	533	600	15	43	.03	.07
Other	0	100	0	135	0	1.35
Total	2633	1900 27.8% less	1089	1117 2.6% more	$\bar{x}$ .41	$\bar{x}$ .59

None of the perennial shrubs within the transects receiving no-sheep use showed any effects. The one transect within a lightly-grazed area had 82% of its perennials unaffected by sheep. The proportion of apparently unaffected shrubs within bedding area transects ranged from 2% to 9%. Shrubs could have received root damage by trampling, but we were unable to ascertain this type of damage (Tables 5 a, b, c).

Sheep can potentially damage shrubs because of their bedding habits: they try to use shrubs for cover when they lie down. Ten total shrubs (3%) within three bedding areas transects were damaged by these habits. Only one large creosote was judged to be severely damaged. Eighty percent of the shrubs with bedding damage were greater than 28 inches (70 cm) in diameter, larger than the average plant within the transects. Size of shrub seemed to be a more important factor, rather than shrub species, to a sheep selecting a bedding site. Only one shrub (0.4%) was damaged by a bedding sheep in the lightly-grazed transect.

Eighteen percent of the shrubs in the lightly grazed transect actually had been grazed. Burrobush, *Ambrosia dumosa*, was the preferred forage species. Within the bedding areas burrobush was also favored, but most shrubs received some grazing use (92%). Creosote, *Larrea tridentata*, was the only species not grazed by sheep. Plant size was not a factor in forage preference. From 0.5% to 6% of the shrubs within the bedding area transects received heavy to extreme forage use, while 88% to 91% were grazed lightly to moderately (Tables 5 a, b, c).

No shrubs were trampled within the transect receiving light grazing use. Seventeen percent of the shrubs in the bedding areas were trampled to some extent. Smaller shrubs were more likely to be trampled.

Plants Eaten by Sheep

While observing grazing sheep on 16 May, it was apparent that they preferred to eat flowering annuals between the shrubs, and burrobush. Little attention was paid to rice grass, *Oryzopsis hymenoides*, Anderson's thorn bush, *Lycium andersonii*, or shadscale, *Atriplex confertifolia*.

When we walked about the plot in grazed areas, it was evident what the sheep ate, and what they preferred most by the relative proportion of the plant removed. Practically every Mojave aster, *Machaeranthera tortifolia*, flower was removed. Trumpet buckwheats, *Erigonum inflatum*, and Fremont daleas, *Dalea fremontii*, were heavily grazed; the daleas often had 2-cm thick branches broken off them. Branch tips of shadscale, especially the seedheads, were more than moderately grazed. Few grazing signs were noticed on Mojave saltbushes. Sometimes goldenhead, *Acamptopappus sphaerocephauls*, flowers were eaten, and sometimes the plants were not touched. Almost every burrobush had seed heads and new growth removed. Most locoweeds, *Astragalus* spp., were grazed. Spiny hopsage, *Gravia spinosa*, and uncommon shrub, was heavily grazed. Winter fat, *Ceratoides lanata*; mirabilis,*Mirabilis bigelovii* ; and thornbushes, *Lycium* spp, were usually not grazed. Annuals commonly eaten were checker fiddleneck, *Amsinckia tessellata*; filaree; desert dandelion, *Malacothrix glabrata*; and Fremont pincusion, *Chaenactis fremontii*. We only observed split grass, the most abundant annual on the plot, to be eaten when it was around a preferred species and difficult to avoid.

TABLE 5A. Sheep Use of Perennial Plants, By Species and Size, in the Creosote Scrub Community: Bedding Area Transect (B) Compared to a Light Sheep Use Transect (L). (A shrub could fit into more than one shrub use class.)

			Shrub Use Designation (% N)											
	N		0		1		2	3	4	5	6	7	8	9
Shrub	L	B	L	B	L	B	B	B	B	B	B	B	B	B
Burrobush	171	92	80	0	20	16	78	3	1	0	0	0	25	3
Shadscale	37	13	95	0	5	31	69	0	0	15	0	0	23	0
Goldenhead	8	7	62	0	37	43	29	29	0	0	0	0	57	14
Anderson's thornbush	2	6	100	0	0	100	0	0	0	0	0	0	33	0
Creosote	2	5	50	40	0	0	0	0	0	L/50	40	20	0	0
Other	3	2	100	0	0	0	0	100	0	0	0	0	0	50
Size (cm diam.)														
A 1-20	71	66	70	3	30	18	70	6	2	0	0	0	24	6
B 20-40	91	30	84	0	16	13	77	10	0	0	0	0	37	3
C 40-70	52	25	94	0	6	40	56	0	0	8	0	0	20	0
D 70-120	3	1	86	0	14	100	0	0	0	L/50	0	0	0	0
E 120-220+	2	3	50	0	0	0	0	0	0	0	6	33	0	0

TABLE 5B. Sheep Use of Perennial Plants, By Species and Size, in the Shadscale Scrub Community: Bedding Area Transect (B) Compared to a No-Use Transect (0). (A shrub could fit into more than one shrub use class.)

	N		Shrub Use Designation (% N)											
			0		1		2	3	4	5	6	7	8	9
Shrub	0	B	0	B	0	B	B	B	B	B	B	B	B	B
Burrobush	165	151	100	4	0	50	45	0	0	0	0	0	11	2
Shadscale	31	23	100	9	0	74	17	0	0	0	0	0	13	0
Creosote	5	5	100	40	0	0	0	0	0	60	0	0	0	0
Other	4	4	100	25	0	25	25	25	0	0	0	0	0	0
Size (cm diam.)														
A 1-20	42	76	100	11	0	64	24	0	0	0	0	0	14	5
B 20-40	93	77	100	1	0	41	48	1	0	0	0	0	8	1
C 40-70	62	22	100	0	0	27	73	0	0	0	0	0	9	0
D 70-120	4	4	100	25	0	25	50	0	0	0	0	0	0	0
E 120-220+	4	4	100	25	0	0	0	0	0	75	0	0	0	0

Shrub use designations:

0 no use
1 lightly grazed }
2 moderately grazed } grazed
3 heavily grazed }
4 extremely grazed }

5 lightly broken by a bedding sheep }
6 moderately broken by a bedding sheep } bedding use
7 severely broken on all sides by a bedding sheep }
8 moderately trampled
9 heavily trampled

TABLE 5C. **Sheep Use of Perennial Plants, By Species and Size, in the Mojave Saltbush Community: Bedding Area Transect (B) Compared to a No-Sheep-Use Transect (O). (A shrub could fit into more than one shrub use category.)**

	Shrub Use Designation (% N)													
	N		0		1		2	3	4	5	6	7	8	9
Shrub	O	B	O	B	O	B	B	B	B	B	B	B	B	B
Mojave saltbush	63	36	100	17	0	92	0	0	0	5	0	0	5	0
Burrobush	16	18	100	0	0	33	56	11	0	0	0	0	0	0
Other	0	3	0	67	0	33	0	0	0	0	0	0	0	0
Size (cm diam.)														
A 1-20	17	9	100	11	0	78	11	0	0	0	0	0	11	0
B 20-40	21	16	100	13	0	31	44	13	0	0	0	0	0	0
C 40-70	16	12	100	0	0	83	17	0	0	0	0	0	0	0
D 70-120	18	9	100	0	0	100	0	0	0	11	0	0	11	0
E 120-220+	7	11	100	18	0	82	0	0	0	9	0	0	0	0

Dietary Overlap

Many annuals observed eaten by tortoises were also eaten by sheep (Table 6). The primary dietary species overlapping between sheep and tortoises were checker fiddleneck, filaree, and desert dandelion. Undoubtedly nearly all annual species overlapped, but perhaps to a lesser extent. Split grass was most often eaten by tortoises, but we believe it was infrequently eaten by sheep.

Burrows

The number of tortoise burrows found within sheep use areas (75%) was proportional to the percent of the study area used by sheep (73%).

Of the 164 burrows found, 64% were rated good, very good, or excellent (classes 4, 5, and 6) in respect to the protection afforded them by shrub and soil cover (Table 7). The burrows in these three classes were more likely to be active when re-checked (73%) than those burrows with less protection (27% of those burrows in classes 1, 2, and 3) (Table 9). Only 13% of the burrows were in the no- and poor-protection classes. Burrow size did not correlate significantly with the protection classes, although there was a higher percent of juvenile burrows in classes 1 and 2. This was likely due to sampling bias because juvenile burrows are especially difficult to find resulting in a small sample size, and also the burrows with the least amount of protection, especially by shrubs, are most likely to be found.

Four percent of the burrows re-examined were totally destroyed and 10% were damaged (Table 9). Of these burrows, 86% were in the moderate to heavy sheep use areas. The one burrow with no protection and in a heavy-use area, was destroyed. The moderate- and heavy-use areas also had the lowest percent of active burrows.

In summary, the better protected burrows on the study area were least likely to be damaged or destroyed by sheep. As a majority of tortoise burrows on the study area had good protection of shrub and soil cover, few were damaged by sheep under normal grazing use. Tortoises fortunately seem to prefer burrows having more shrub and soil cover.

DISCUSSION

Soils were heavily impacted by sheep on the study area. It can be debated whether or not soil disturbance is beneficial to tortoise habitat. Postitive effects include the more rapid breakdown of dead shrubs and annuals adding organic matter to the soil, annual seeds are worked into the soil instead of lying on top, and rain is better able to penetrate the disturbed soil.

On the other hand, trampled soil is more exposed to erosion. A very heavy rain or wind would wash or blow loose soil particles way. Also, water evaporates out of disturbed soils faster than if the soil had a crust, especially under windy conditions. Because the rainy season is in the months of January and February, and the sheep are on the desert from March to June, the possibility of sheep use affecting water erosion or increased water absorption into the soil is unlikely. However, the four windiest months, in order, are April,

TABLE 6. Plants Observed Eaten by Tortoises at the Kramer Tortoise Plot, and Dietary Overlap With Sheep.

Species and common name	Occurrence*	Number of tortoise eating observations	Estimated sheep preference
Schismus arabicus split grass	A	9	low
Amsinckia tessellata checker fiddleneck	C	7	high
Malacothrix glabrata desert dandelion	C	5	high
Erodium cicutarium filaree	A	4	high
Chaenactis fremontii Fremont pincushion	C	2	high
Stephanomeria parryi Parry rock pink	U	2	moderate
Rafinesquia neomexicana chickory	U	1	moderate
Malacothrix coulteri snake's head	U	1	moderate
Bromus rubens red brome	C	1	moderate
Psorales castoria Beaver-dam breadroot	U	1	unknown

*occurrence: A abundant, C common, U uncommon

TABLE 7. Tortoise Burrow Size Compared to the Protection Afforded the Burrow by Shrub and Soil Cover, on the Kramer Tortoise Plot, June 1980.

		Burrow protection (%N)					
Width of burrow	N	none 1	2	3	good 4	5	6
4 - 9 cm	27	4	19	15	22	15	26
10 - 19 cm	34	0	6	12	35	24	24
20 - 40 cm	103	0	12	30	27	9	22
Total	164	1	12	24	28	13	23

TABLE 8. Burrow Protection Compared to Burrow Condition, in No-Use and Sheep-Use Areas on the Kramer Tortoise Plot, 1980.

Burrow protection		N	No Use *burrow condition (%N) A	B	C
None	1	0	0	0	0
	2	4	25	25	50
	3	8	63	13	25
Good	4	8	25	50	25
	5	6	17	33	50
	6	13	31	62	8
Total		39	33	41	26

protection		N	Sheep Use *burrow condition (%N) A	B	C	D	E
None	1	1	0	0	0	0	100
	2	15	13	40	33	33	33
	3	31	16	48	23	13	10
Good	4	38	39	37	18	13	0
	5	15	33	40	33	7	0
	6	25	32	36	40	4	0
Total		125	28	50	40	13	5

*burrow condition:

A = active
B = usable, inactive
C = filled with soil
D = sheep damage
E = destroyed by sheep

TABLE 9. Sheep Use Around Tortoise Burrows Compared to Burrow Condition Upon June Re-examination on the Kramer Tortoise Plot, 1980. (A burrow could belong to more than one condition category.)

		*Condition category (%N)				
Sheep use	N	A	B	C	D	E
none	39	33	41	26	0	0
light	39	36	44	21	8	0
moderate	56	25	43	30	11	5
heavy	30	23	30	30	23	10
Total	164	29	40	27	10	4

*condition categories:

A = active
B = usable, inactive
C = filled with soil
D = sheep damage
E = destroyed by sheep

March, May, and June. The negative soil drying and wind erosion factors affecting the topsoil seem more important and relevant.

Earlier we discussed the apparent decrease of late maturing annual native plants due to the effects of sheep disturbances. This reduction of native annuals may significantly change species composition and reduce early summer biomass and available green forage. Native annual plants on the desert did not evolve under the conditions presented by sheep grazing: enhanced soil drying, increased wind erosion, and the working of seeds into the soil.

On the other hand, the abundance and dominance of non-native annual plants (split grass and filaree) may reflect the ability of non-natives to flourish under grazing conditions. A study of the abundance and composition of native and non-native annual species in grazed and ungrazed areas in the desert could be undertaken to determine the effects of sheep grazing.

The transect methods we employed had several problems associated with them. Within all transects only live cover was recorded. Some of the reduction of cover within the transects was due to drying, and the dry annual plants were not recorded. The percent dry cover should have been recorded so that the ratio of original cover to remaining cover could have been calculated for each transect, and compared between sheep use and no-use areas. Also, the transects should have been done both immediately before the sheep arrived and sooner after they left. For future studies, perhaps this could be coordinated with the sheep company.

Although the mean number of annual species, cover, frequency, and percent undisturbed soil were higher in no-use areas, the correlations between percent soil disturbance and the annual variables were insignificant. We feel that our study design incorrectly addressed the problem of differences between transect sites. Our samples were taken plot-wide from non-homogeneous sites; there were wide variations in soil type and initial species composition. Additionally, our sample sizes for some use classes may have been too small. Future studies should be done in a more homogeneous study area to minimize these problems.

Reduction of perennial cover through sheep grazing and trampling would negatively affect tortoises. Tortoises use perennial cover for protection from the elements and predators, as well as sites to dig burrows. Sheep reduce perennial cover most within heavy use areas, such as bedding and watering sites, especially if these areas are used repeatedly as apparently was done in the past on the plot. With proper management of sheep grazing by the BLM, we do not see reduction of perennial plants as a significant problem to tortoises.

One possible way sheep can directly affect a tortoise population is by stepping on and killing small tortoises and disturbing nests with eggs, thereby increasing the mortality rate of the young. Sheep are actively moving and grazing during the times juvenile tortoises are active. Only a 25% soil disturbance by trampling sheep can be threatening to a juvenile tortoise (Figure 4). A sheep manager Nicholson spoke with thought that sheep would not step on a small tortoise because the sheep watch where they step, and would avoid stepping on something rough (a tortoise) as opposed to flat sandy soil. Nicholson has had some experience with livestock, and agrees that sheep usually are very careful where they put their feet. The sheep were carefully watching the ground when foraging. However, when trailing or moving in a tight herd, dust may be kicked onto a small tortoise by the first members of the herd. Following sheep may not recognize the tortoise as something to avoid stepping on. Furthermore, if the sheep spook, as these often did, the sheep may step before looking. If the sheep are on rocky soil and must step on rocks, they may not differentiate a small tortoise from a rock. At one watering site Nicholson observed a horned lizard which had been killed by sheep trampling, and in an area where sheep had grazed heavily she found a crushed zebra-tailed lizard. If these lizards, fast as they are, cannot escape sheep hooves, a small tortoise has no chance of escaping a tight herd of sheep.

Juvenile tortoises exhibit certain behavior towards humans which have implications with respect to their encounters with sheep. Almost any tortoise will freeze when it sights a human. A stationary object is more difficult to see and this behavior would protect them from predators, but would be anything but an effective defense against sheep trampling. Tortoises will sometimes dash for cover after the freeze. When juveniles are captured and handled, they will often try to escape by hiding under any available cover. If a tortoise is able to find cover which the sheep will not walk into, it can avoid being trampled. Another problem is a tortoise's tendency to void its bladder when threatened. Sheep walking near a tortoise may trigger this defense reaction and cause the tortoise to lose its water reservoir. This was not observed in our study.

The importance of burrows to tortoises for protection from heat, cold, and predators is obvious. Although no detailed behavior studies were done on the plot, we found that tortoises will return to old burrows, and may enlarge and rebuild them. One tortoise could use many burrows in a season. If a tortoise returned to a burrow destroyed by sheep, the tortoise could be in trouble if it could not dig or find another burrow quickly. In this study, a low percentage of burrows were destroyed by sheep, so this scenario seems unlikely. Also, temperatures were not extremely hot or cold during the study, which made it unnecessary for tortoises to be inside a burrow day or night.

While we were doing transects and rechecking burrows on the plot after the sheep left, many unmarked and freshly dug burrows were found. These burrows were often more than a yard (metre) long. Perhaps tortoises had been stimulated by the hot weather to dig new burrows regardless of the presence of old, usable burrows. Only a few of the old burrows were enlarged, and very few freshly dug burrows had been found earlier in spring. Tortoises were digging new burrows regardless of burrow damage caused by sheep. This study suggests that burrow damage has little effect on tortoises. Exceptions include tortoises trapped inside a damaged burrow, as juvenile 20 had been. If the tortoises used fewer, more permanent burrows and if burrows were difficult to construct, then damage to burrows might be more serious.

Evaluation of Grazing Methods

There are two types of ephemeral grazing methods commonly employed. The one used on the study area involved a shifting of the bedding and watering areas, or high intensity use areas, spreading damage and effects "thinly" over the desert. The other method is to have a "sacrifice area", and repeatedly bed and water the sheep in one place several days, and grazing the sheep outside this area. These intensive-use areas would be used year after year. Evidence of this method can be seen on the study area; there are two intensive-use areas each about 7.5 acres (3 ha) in size, which we believe to have been used last year. There are three other areas on the plot which are suspected to have been used in past years for repeated bedding and watering. Intensive-use areas were identified by a decrese in perennials, remnants of shrubs, and sometimes by vehicle distubance made by the heavy water truck when it drives over the soil it has wetted. If these intensive-use areas were to be used year after year, they would become larger, and the effects would be long lasting. In comparison, the average bedding and watering sites of 1980 are about 1.3 acres (0.5 ha) large. These sites which are used only once do not have the long-term effects on perennial plants and soils as the repeatedly used sites. The smaller sites were difficult to identify in 1981. We feel that it is better for the habitat if the severe effects of grazing, bedding, and watering are spread out over a large area rather than concentrating the effects on a small area.

We disapproved of the method used to water the sheep because it adds to the proliferation of desert roads. The herders should not be allowed to continue their practice of driving their water trucks off well established dirt roads. The sheep should be herded to the water truck. By restricting vehicles used by herders to roads, the grazing use on lands not easily accessible by roads may also be reduced.

We calculated the number of days (D) the herd of 900 sheep (180 AU's) should have spent per section on the allotment if the allowed 289 AUM's had been equally distributed. $\frac{D x 180\ AU}{1\ section} = \frac{61 \times 289\ AU}{26.2\ sections}$; 3.7 per section. In actuality, the plot received about twice that, 7 to 8 full days of sheep use. This means that the grazing method used was a method which concentrated damage on a small area, while leaving the majority of the allotment ungrazed. We feel that 4 days per section would have been "moderate" use and much less damaging to the habitat.

The particular herd on the study area was, to the best of our knowledge, unloaded onto the allotment 1 May, and taken away 27 May. It was herded north from Shadow Mountain Road 3 to 4 miles (5 to 6 km), east about 1.2 miles (2 km), then back south to Fremont Wash; affecting a swath of land 0.6 to 1.6 miles (1 to 2.5 km) wide. If so, there were 200 to 180 AU's on the allotment for less than 1 month, resulting in a use far less than the allowed 289 AUM's. Company personnel did say that the herd was taken off the area sooner than expected. From 1 May to 27 May, we estimated that the herders set up five camps and grazed the sheep on 8 to 10 sections, using about 30-38% of the allotment. (Due to good forage conditions the lease was extended through June.)

We believe that the best sheep grazing method should mitigate the effects on juveniles, since they are more vulnerable to adverse effects of sheep grazing. One mitigation would be to include "tortoise nurseries", sections or half sections of good tortoise habitat within the allotments left ungrazed year after year. This would allow juveniles to grow larger than a crushable size before they disperse to their adult ranges, which may be in grazed areas. Our suggestion for a grazing system would be to keep significant areas, roadless to the greatest extent possible, continually ungrazed in order to minimize the impact on juveniles, while spreading the grazing out as evenly as possible on the remaining portions of the allotment so as to reduce the impact on the habitat and the presure on tortoises. Trespass grazing must also be eliminated.

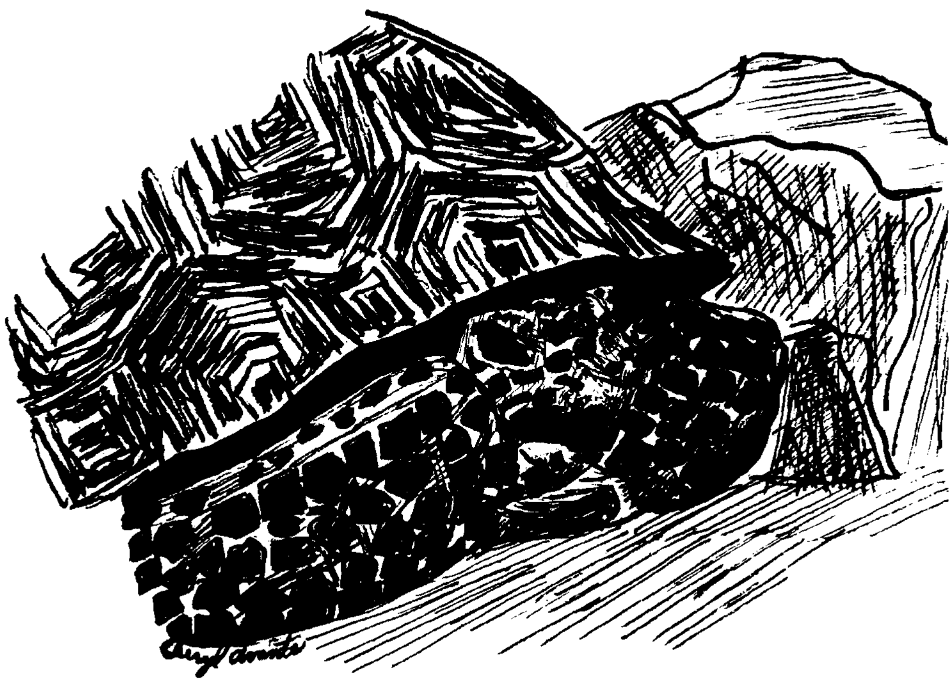
ACKNOWLEDGEMENTS

We would like to acknowledge K. Berry and L. Foreman for their help in designing the study and preparing the report, F. Turner for his comments.

REFERENCES

Munz, P. A. 1974. A flora of Southern California. University of California Press. Berkeley, Calif. 1086 pp.

U.S.D.I. 1980. California desert conservation area plan 1980. Page 77, Table 6, Part C.



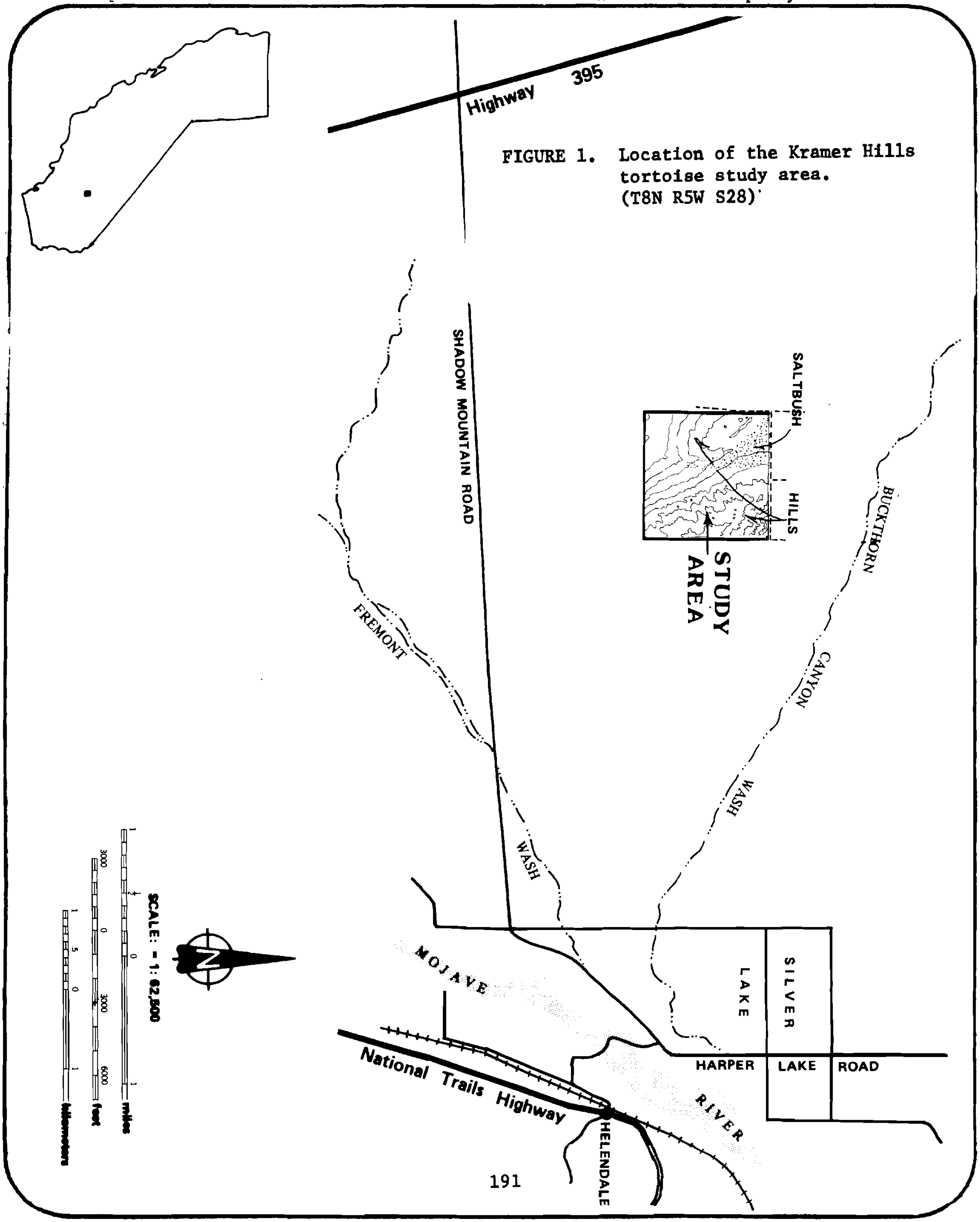


FIGURE 1. Location of the Kramer Hills tortoise study area. (T8N R5W S28)

FIGURE 2. Sheep use at the Kramer Hills tortoise study area.

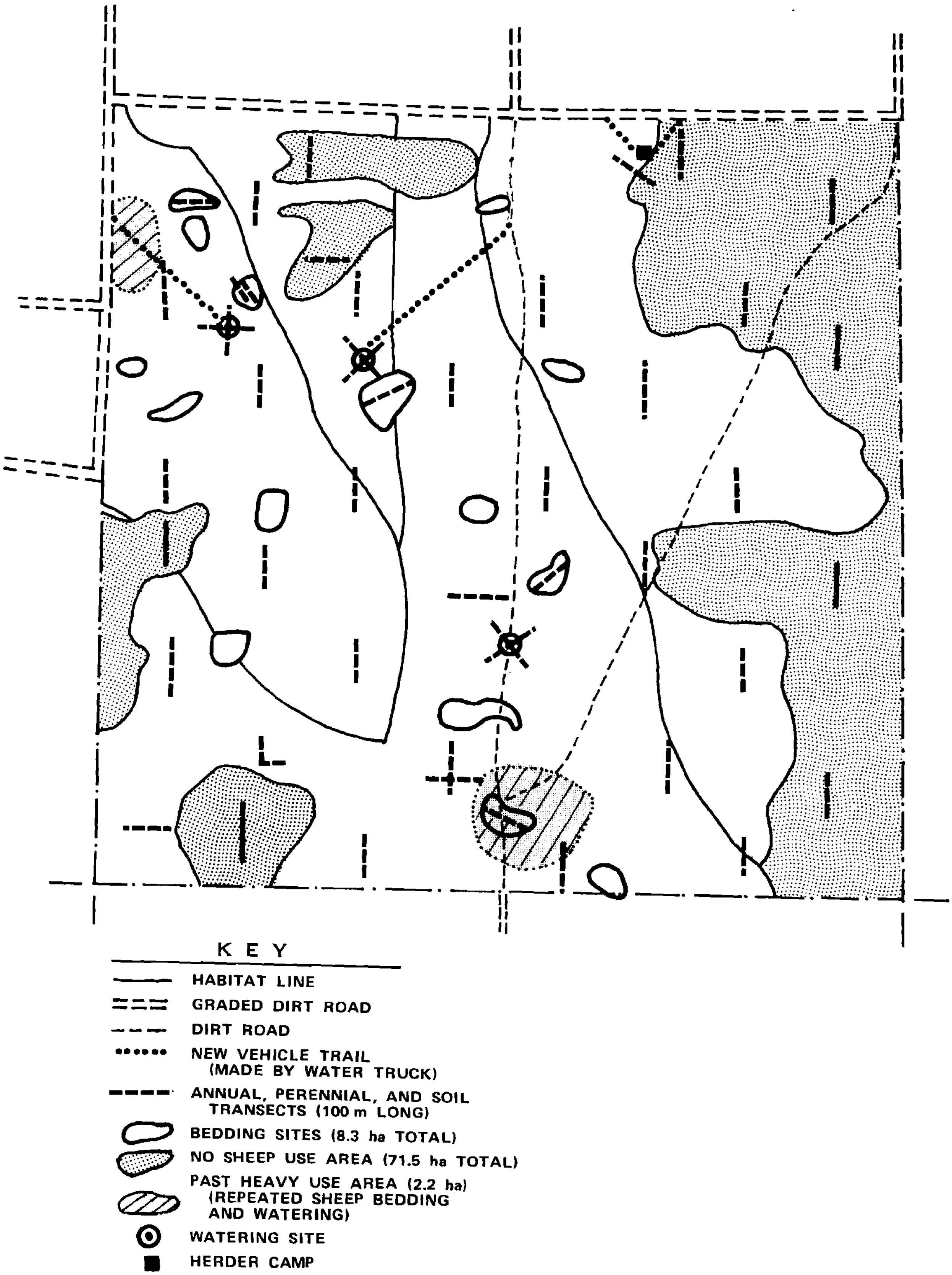
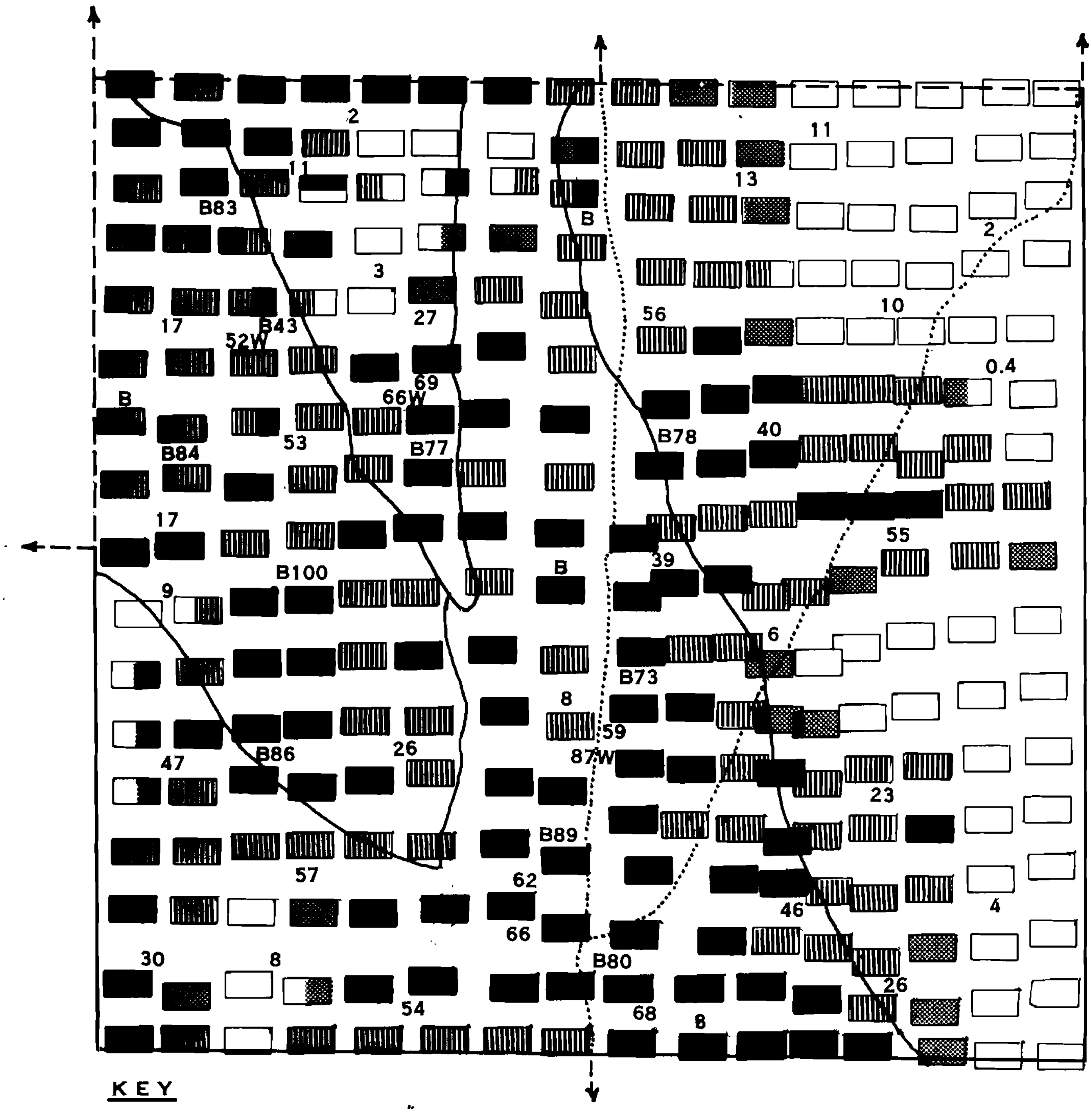


FIGURE 3. Occular estimation of sheep trampling between shrubs along quadrat lines, mapped 26 May to 9 June, on the Kramer Hills Tortoise Study Plot, 1980.

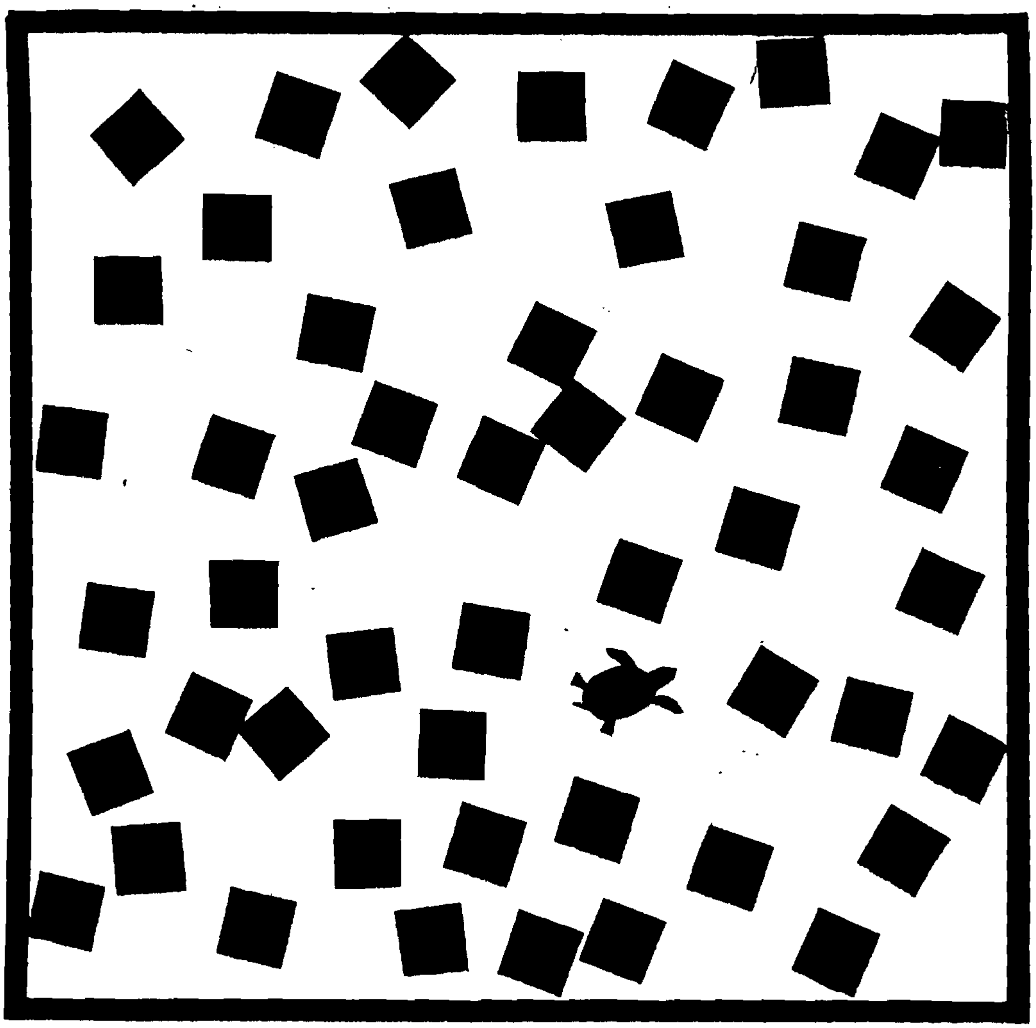


KEY

% DISTURBANCE		#	%
NONE	0	63.5	22.8
1 - 20	L	24.5	8.8
20 - 50	M	97.0	34.9
50 - 100	H	93.0	33.5

W = WATERING SITE
B = BEDDING SITE
68 = NUMBERS REPRESENT PERCENT SOIL DISTURBANCE FOUND IN THE TRANSECT WHERE THE NUMBER IS LOCATED

FIGURE 4. A representation of 25% soil disturbance (squares) in 1 mi^2, near an 8-cm juvenile tortoise.



THE DESERT PLAN - 1980 AND 1981 UPDATE

JAMES A. ST. AMANT
5319 Cerritos Avenue
Long Beach, California

I come here not to bury the California Desert Conservation Area Plan (Plan), and certainly not to praise it, but to attempt to bring you up to date on the Plan and how it appears to affect the desert tortoise.

I say how it appears because the final Plan will not be available until 6 April, when it is scheduled to be out of the printer's shop. Therefore, my comments today are based on what the Bureau of Land Management (BLM) tells me is in the final Plan, but, before I comment on what I am told is in the final Plan, let's put it in historical perspective.

In 1967 the BLM began studies in the desert, recognizing at that time that some type of management plan would be needed. In 1972 this program was expanded by hiring specialists, including biologists in various natural resources fields, to conduct an extensive inventory to provide a baseline for development of a comprehensive Desert Plan. This inventory is no doubt the most intensive study ever conducted over such an extensive area and the BLM--particularly the Desert Planning Staff--deserves praise for this program.

The data collected should provide baseline data for further studies and management programs not only for BLM but also for other resource agencies.

In 1976 the Federal Land Policy and Management Act (FLPMA) established the 25-million acre (10-million hectare) California Desert Conservation Area (CDCA). This Act required the Secretary of the Interior to prepare a comprehensive 20-year plan for the management, use, development, and protection of over 12 million acres (4.9 million hectares) of public lands in the California Desert Conservation Area.

Part of the program in developing the Plan included obtaining public opinion and the use of a 15-member Citizen's Advisory Committee.

In February the Draft Plan was completed. Unfortunately the Desert Planning Staff, whom it would seem would have the most insignt into the needs of the fragile desert ecosystem, had little to do with the actual plans. This preparation of the Draft Plan was turned over to the BLM managers, who interpreted the scientific data along with a so-called "whole picture" view of multiple-use and sustained yield. Scientific data were used in the Environmental Impact Statement but with a disclaimer from the managers to discount the impact to wildlife habitats and populations. This included the desert tortoise. At this point it was beginning to become obvious that what was being developed was a managers' plan -- not a management plan, for the California Desert.

Inadequate time was allowed to digest and make a comprehensive analysis of this confusing, complex, cumbersome draft. The appendices were provided in a haphazard way and the appendix on wildlife was not available until only a few days prior to the deadline for comment.

Three multiple-use alternatives were presented in the Draft Plan; these were labled Protection, Balanced, and Use plans. A No-action Alternative was also described. Over 8,000 citizens and numerous organizations, including the Desert Tortoise Council, commented on this Draft Plan. Of the alternative plans presented, the Protection Alternative received the most public support.

In September 1980, the Final EIS and proposed Plan was completed. Again, thousands of citizens and numerous agencies, including the Desert Tortoise council, commented.

I agree with James Ruch when he remarks in an introductory letter that the final Environmental Impact Statement and Proposed Plan are short and concise. Compared to the Draft Plan, much of the detail is left out, particularly in the final wildlife appendix which was obviously done by people unfamiliar with the way and again the wildlife appendix was not available until only a few days prior to the deadline.

The Plan, at first glance, gives the impression that everything has been taken care of and therefore everybody should be happy. The wildlife section includes such reassuring statements as, "The Proposed Plan will increase protection for wildlife species and habitats over the Balanced Alternative. endangered, threatened, and rare Federal and State-listed species are protected better than under any other alternative".

Under the Wildlife Protection portion of the Plan, the BLM states:

> "Desert tortoise numbers are generally in a state of decline throughout much of the CDCA. Under the Proposed Plan, large areas of Class L (limited use) should manage vehicle and public access, reducing habitat effects. Four major and three minor crucial habitat areas have been identified within the CDCA, parts of which are considered necessary to maintain the continued existence of the species. Under the implementation commitments of the Proposed Plan, tortoise numbers will be monitored. Under the monitoring systems, special emphasis will be placed on both vehicle access and livestock managment. The Proposed plan should enchance habitat condition in several of the key areas such as Chuckwalla Bench and Ivanpah Valley. In some areas the Plan may, at best, be neutral. Adverse effects on habitat in some areas over the years may have reduced populations below threshhold levels".

The Desert Tortoise Council and others who have expertise on the desert tortoise, including BLM's own wildlife staff, have disagreements with this impact analysis that was rewritten by the BLM managers at the last minute, apparently without reference to available scientific data.

For example, three of four crucial habitat areas will sustain substantial detrimental impacts as a result of implementation of the Plan. Ninety-five percent of Fremont-Stoddard crucial habitat will be negatively impacted as a result of severe fragmentation. Ninety-seven percent of Ivanpah Valley will suffer from the negative impacts of grazing. Forty-five percent of the Fenner-

Chemehuevi crucial habitat north of Interstate 50 will be discriminately affected, as well as 36% of the habitat south of Interstate 50.

We can therefore conclude that implementation of this Plan will not only NOT improve the status of the desert tortoise, but will result in the loss of certain viable populations.

The continuing decline of the desert tortoise in California has been pointed out to BLM, not only by its own people, but by the Desert Tortoise Council and other conservation organizations and by the California Department of Fish and Game, the agency responsible for the wildlife resources of the State. This concern was expressed in a letter on the Proposed Plan to James Ruch from James Burns, Assistant Secretary for the Resources Agency. Here is an excerpt from that letter:

> "Although desert tortoises are widespread throughout most of the CDCA, recent studies have found that most populations are either not viable because of very low densities or are in a serious state of decline. Four large and four small areas with high tortoise densities have been identified. Each major population center is in a different type of desert and is representative of a major lowland desert ecosystem. Studies indicate that these populations are highly fragmented due to urban development, agriculture, livestock grazing, off-road vehicle use, utility corridors and pipelines, roads and other types of human-related uses, and, as a result, are generally in a declining condition".

Four large and four small areas with high tortoise densities are recognized by those familiar with the status of the desert tortoise in California. Unfortunately, these areas have NOT been recognized by the BLM. At lest there are no indications that recommendations to prevent adverse impacts on these areas--impacts that will surely result in the continued decline of the tortoise--have even bee considered for inclusion in the Plan.

Although the desert tortoise is listed as a Sensitive Species by BLM and is under review for Federal listing as Threatened, the BLM provides no comprehensive program in the Plan for recovery of California's State reptile.

On 17 December 1980, Guy Marten, Assistant Secretary for Land and Water Resources, signed approval for the final Plan.

Since that time, five lawsuits have been filed against the Plan:

1. American Motorcycle Association

2. California Mining Associates

3. Inyo County

4. National Outdoor Coalition

5. Sierra Club (This lawsuit is not directly against the Plan but in regard to off-road vehicle (ORV) use.)

Since the signing of the final Plan, two documents regarding the Plan have been made available; The California Desert Plan Implementation Strategy Working Draft, and the Record of Decision.

Only two programs directly related to the tortoise under the Plan Implementation Strategy are mentioned. One concerning the Desert Tortoise Natural Area states:

> "Tortoise population study, fencing, land acquisition and maintenance of interpretive facilities".

This program has supposedly been in effect for some time but, partially because of off-road vehicle use and the ownership pattern, a situation has developed that makes it completely incompatible with maintaining a viable population. Therefore, in the long-term, the Desert Tortoise Natural Area will be nothing more than a refugium or a zoo.

The other progrm is mentioned under Studies on Sensitive Wildlife Species - an "analysis of desert tortoise trend studies". These studies have been underway since 1973 and have been analyzed to the point where seirous problems are obvious.....I wonder why these data haven't been used?

Recommendations in the Record of Decision directly affecting tortoises were:

1. Allocate 350 lb/acre (390 kg/ha) of forage in highly crucial habitat and allow emergency of tortoises before grazing.

   Data from tortoise plots within the last six months indicate that 350 lb/acre may not be adequate, particularly to promote breeding.

2. Allow only one grazing pass by sheep.

   This is actually only in a small portion of the western Mojave Desert.

3. Designate livestock bedding and water areas.

4. Allocate 200 lb/acre (225 kg/ha) forage before grazing on ephemeral feed on crucial tortoise habitat.

   This is totally inadeaquate--200 lb/acre is the result of a dry year and tortoises spend most of the year underground. It is insufficient feed for sheep.

These recommendations were approved by Guy Marten with the condition "that a specific effort should be made to mitigate the effect of these decisions on any livestock operator whose operation would suffer major detriment".

There was no mention of mitigation for the 11th hour addition to the Plan of three competitive vehicle events: 1) Stoddard Valley to Johnson Valley, 2) Johnson Valley to Parker, 3) Parker 400. Although these events are very profitable for the sponsors, they are highly detrimental to wildlife, with major impacts on the California Desert, they were not included in either the draft or proposed Plans. Therefore, we did not have an opportunity to comment.

To take this sad scenario of the Plan through to the final step -- implementation -- we already have an example of how that works.

There are certain sensitive areas that were to be treated in a protection-oriented way. If there was to be a major land use section that could cause severe or deleterious impacts, a full EIS was to be prepared with extensive public comments. However, in reality, this does not occur. We have recently been made aware that the Bureau has decided to lease crucial tortoise habitat in Ivanpah Valley without doing the promised EIS. Therefore, I question whether the whole Plan isn't a sham, particularly in regard to the protection of the desert tortoise.

I was recently asked at the Bureau of Land Management/Fish and Game coordination meeting if California was going to list the tortoise. My answer was, "It depends on the final California Desert Plan".

From what I know of the Plan at this time, I will recommend that the desert tortoise be listed.

CONTROLLED EXPERIMENTS ON SOIL COMPACTION PRODUCED BY OFF-ROAD VEHICLES IN THE MOJAVE DESERT, CALIFORNIA

JOHN A. ADAMS
ALBERT S. ENDO
Bureau of Land Management
Riverside, California 92521

LEWIS H. STOLZY
Department of Soil and Environmental Sciences
University of California
Riverside, California 92521

and

PETER G. ROWLANDS
HYRUM B. JOHNSON
Bureau of Land Management
Riverside, California 92521

ABSTRACT

(1) Soil compaction is being caused by intensive off-road recreational vehicles in the California deserts. Vehicle tracks produced by different members of motorcycle and four-wheel drive passes were made on the Mojave Desert of California on both a Typic Haplargid and a Typic Torripsamment soil in an attempt to estimate minimum amounts of soil compaction which may produce significant reductions in growth of desert annual plants.

(2) A motorcycle produced much smaller increases in soil strength than did a four-wheel drive vehicle.

(3) Soil strength of drying compacted soil (even slightly compacted soil) increased at a much greater rate than soil strength of drying uncompacted soil. This may be an explanation for observed reductions in annual desert plant growth even on areas with a relatively small amount of compaction.

INTRODUCTION

Off-road motorcycle riding has increased greatly since the early 1960s. At the beginning of the decade there were less than 400,000 registered motorcycles in the United States (Sheridan 1979). By 1976, 8.3 million motorcycles were reported to be in use, with 5.4 million, or 66% in use off-road at some time (Motorcycle Industry Council, Inc. 1977). Numbers of other types of off-road vehicles were less certain but Sheridan (1979) estimated that over 3 million four-wheel drive vehicles were in operation in the United States with perhaps half used regularly for off-road driving. Because much of this activity occurs on public land, there have been concerns about damage to these areas. Presidential Executive Orders 11644 and 11989 require agencies responsible for management of public lands, in the U.S.A., to adopt policies which protect public resources, including soil.

Damage to the soil caused by ORVs was due in part to soil compaction. Off-road vehicle activity has been shown to gently increase soil compaction in areas of intense traffic (e.g. Wilshire & Nakata 1976; Wilshire, Nakata, Shipley & Prestegard 1978; and Webb, Ragland, Godwin & Jenkins 1978). J. Adams and A. Endo (unpublished BLM data) used aerial photographs to estimate total areas, in the California deserts, which have had the largest amounts of intense soil compaction due to off-road vehicles, such as motorcycles and four-wheel drive vehicles. Out of a total of around 10,100,000 ha of desert land, approximately 495 ha (0.0049%) were estimated to be highly compacted campsites, or pit areas, which were virtually devoid of vegetation; 2406 ha (0.024%) were estimated to contain compacted trials on hill climbs; and 16,391 ha (0.16%) were estimated to have a relatively high frequency of highly compacted motorcycle and four-wheel drive trails on more level terrain. Surface area of highly compacted trails, in the last category, generally ranged from 5 to 10%. Even though a very low percentage of the desert has received substantial amounts of soil compaction, localized effects in some areas are considerable. These result in scars on the landscape (especially on hill climbs) which are highly visible, and for the most part denuded of vegetation. Regrowth and revegetation are particularly slow on the compacted soil.

The purpose of our research was to investigate the minimum amounts of off-road motorcycle or four-wheel driving which would cause significant reduction in the establishment and growth of desert annuals, in subsequent years. Soil strengths under tracks created by single or increasing numbers of vehicle passages were measured and related to later responses of desert annuals. Annual plant responses will be discussed in detail in another paper. Increases in soil strength with drying were also characterized in tracked and untracked soil. The relationships between soil water and soil strength need further study to better understand the implications of increased resistance to root growth of desert annuals during periods of soil drying.

MATERIALS AND METHODS

The Study Sites

Field studies were initiated in 1977 in the Mojave Desert of Southern California and continued up to 1979. Soil compaction was produced by driving over both wet and dry desert soil with different types of off-road vehicles at five sites. Illustrative data from the two sites with the most homogeneous values of soil strength in untracked soil are presented in this paper. Site one in Stoddard Valley has coarse loamy, mixed, thermic Typic Haplargid soil with surface textures of loamy coarse sand. The top of the argillic horizon is at a depth of about 60 cm. In the top 60 cm, the soil averages 5% clay, 19% silt, and 76% sand. Site two in Johnson Valley has mixed, thermic, Typic Torripsamment soil with surface textures of coarse sand. Little profile development is apparent and the top 60 cm of soil has average values of 1% clay, 8% silt, and 91% sand.

Methods of Compacting the Soil

A four-wheel drive 1975 Ford "Bronco" and a 1973 Yamaha 175 cc^3 DT2 "Enduro"motorcycle were used to produce soil compaction. The Bronco had tires which were 19.7 cm wide and inflated to 2.7 kg cm^{-2}. The vehicle and driver together weighed 2190 kg. The motorcycle had a front tire and a knobby back tire which were 8.3 and 10.2 cm wide, respectively. The motorcycle and driver together weighed 188 kg.

The Bronco and motorcycle were driven across the study plots at a steady speed of about 15 km h^{-1} to produce sets of tracks which consisted of one, three, five, ten, twenty and 100 (the last set for the motorcycle only) vehicle passes. The multiple passes along the same track were made with as little lateral spread as possible. Typical track widths are shown in Table 1. A large part of this spread resulted from greater divergence of a small proportion of the passes used to make a track. Most vehicle passes and all subsequent penetrometer measurements (see below) were made close to the center of the tracks.

Measurements of Soil Strength

Soil strength was measured in the field with a hand-held recording penetrometer (Carter 1976) using a 1.27 cm^2, 30° cone tip. According to Taylor (1971, 1974) the mechanical resistance of soil to expanding roots is

TABLE 1. Track Widths Created by Different Numbers of Four-Wheel Drive Ford "Bronco" and Motorcycle Passes

	Width of track (cm)	
No. of passes	Bronco	Motorcycle
1	23	13
3	30	15
5	30	15
10	40	20
20	45	30
100	-	50

best characterized by penetrometer soil strength measurements. Measurements were made when the soil was near field capacity (in order to produce the most comparable measurements) and later when the soil had become drier. Soil moisture was measured by mass wetness by drying samples for 24 hours at 105° C. Values of soil mass wetness are given in Tables 2-5. Soils under shrub canopies were avoided when making penetrometer measurements, whether in tracked or untracked soils. The sandier soils under shrubs at sites one and two occupy much less total area than intershrub soils and have much lower values of soil strength when tracked or untracked than the corresponding controls or treatments between shrubs.

Soil strengths at depths of 5, 10, 15, 20, 25, and 30 cm below the surface were analyzed statistically with the Student-Newman-Keuls Test (Sokal & Rohlf 1969).

TABLE 2. Mean Soil Strength (kg cm^{-2}) Produced on 19 August 1977 by Different Numbers of Ford "Bronco" Passes on Wet Soil at Site 1 and Measured on Three Successive Dates When Mass Wetness Values (MW) for the Top 30 cm of Soil in the Control Were 6.0%, 5.1% and 1.8%, Respectively

(a) 19 August 1977; MW = 6.0%

No. of passes	Depth (cm) 5	10	15	20	25	30
0	4.4 Z*	9.2 Z	7.9 Z	5.5 Z	6.8 Z	8.0 Z
1	9.7 Y	10.3 Z	11.6 Z	9.7 Z	8.5 ZY	8.3 Z
3	13.6 X	18.5 Y	17.9 Y	16.2 Y	11.3 YX	13.1 Z
5	12.9 X	20.2 Y	21.9 Y	16.8 Y	13.3 X	15.7 Z
10	16. 2 X	26.1 X	22. 4 Y	18.0 Y	12.9 X	12.5 Z
20	19.8 W	31.3 W	30.4 X	23.4 X	18.9 W	14.8 Z

(b) 26 August 1977; MW = 5.1%

No. of passes	Depth (cm) 5	10	15	20	25	30
0	2.2 Z	11.3 Z	13.4 Z	13.4 Z	9.2 Z	10.5 Z
1	6.3 Z	16.6 ZY	16.7 Z	15.6 ZY	13.5 Z	10.6 Z
3	4.9 Z	21.9 YX	27.1 Y	23.4 YX	18.2 ZY	12.5 Z
5	8.0 Z	26.3 X	26.4 Y	24.1 YX	15.5 ZY	14.0 Z
10	5.3 Z	39.2 W	37.7 X	27.7 X	19.3 ZY	14.0 Z
20	8.2 Z	53.1 V	46.8 W	29.8 X	25.6 Y	14.9 Z

(c) 6 September 1977; MW = 1.8%

No. of passes	Depth (cm) 5	10	15	20	25	30
0	12.3 Z	21.1 Z	20.4 Z	18.8 Z	19.2 Z	19.3 Z
1	30.6 Y	49.5 Y	45.4 Y	29.9 Z	22.5 Z	17.2 Z
3	39.3 Y	55.1 Y	45.0 Y	27.1 Z	18.3 Z	12.8 Z
5	44.1 Y	54.9 Y	50.0 Y	32.6 Z	19.2 Z	15.6 Z
10**	-	-	-	-	-	-
20**	-	-	-	-	-	-

* Column means followed by the same letter are not significantly different at $P<0.01$ according to the Student-Newman-Keuls procedure.

**The soil could not be penetrated due to its extreme strength upon drying (>67 kg cm^{-2}).

TABLE 3. Mean Soil Strength (kg cm^{-2}) Produced on 24 January 1978 by Different Numbers of Motorcycle Passes on Wet Soil at Site 1 and Measured on Three Successive Dates When Mass Wetness Values (MW) for the Top 30 cm of Soil in the Control were 6.3%, 3.7% and 3.2%, Respectively.

(a) 24 January 1978; MW = 6.3%

No. of passes	Depth (cm) 5	10	15	20	25	30
0	1.2 Z*	5.9 Z	8.7 ZY	6.9 ZY	6.5 ZY	7.4 Z
1	0.7 Z	a5.3 Z	6.1 Z	5.8 Z	6.7 ZY	7.9 Z
3	1.0 Z	8.6 Y	8.2 ZY	7.8 ZY	6.7 ZY	7.9 Z
5	3.2 Z	10.3 YX	9.1 ZY	6.6 Z	5.3 Z	7.4 Z
10	2.3 Z	13.9 W	9.3 ZY	10.3 YX	6.7 ZY	6.7 Z
20	3.3 Z	11.7 XW	10.6 Y	8.0 ZY	6.9 ZY	6.8 Z
100	12.5 Y	21.7 V	17.4 X	11.5 X	8.9 Y	9.5 Z

(b) 20 April 1978; MW = 3.7%

No. of passes	Depth (cm) 5	10	15	20	25	30
0	1.5 Z	10.3 Z	10.0 Z	9.4 Z	8.5 Z	11.3 Z
1	1.2 Z	10.4 Z	9.2 Z	7.4 Z	7.2 Z	10.3 Z
3	-	-	-	-	-	-
5	3.6 Z	12.2 Z	12.1 ZY	15.5 Z	11.2 Z	8.2 Z
10	6.4 Z	25.9 Y	17.5 ZY	11.4 Z	10.1 Z	10.5 Z
20	9.5 Z	27.9 Y	19.5 Y	14.4 Z	11.5 Z	12.5 Z
100	39.2 Y	40.6 X	21.1 Y	14.2 Z	13.9 Z	9.5 Z

(c) 23 August 1978; MW = 3.2%

No. of passes	Depth (cm) 5	10	15	20	25	30
0	2.7 Z	14.7 Z	13.9 Z	12.9 Z	10.1 Z	16.7 Z
1	2.9 Z	19.2 XY	17.1 Z	14.5 Z	11.8 Z	13.4 Z
3	4.9 ZY	30.9 ZY	21.5 Z	12.4 Z	12.5 Z	17.6 Z
5	3.8 ZY	35.2 Y	30.9 Z	21.3 Z	15.3 Z	16.0 Z
10	7.1 ZY	28.2 ZY	22.1 Z	13.4 Z	7.5 Z	7.3 Z
20	10.6 Y	35.0 Y	21.0 Z	20.7 Z	20.3 Z	14.8 Z
100**	-	-	-	-	-	-

* Column means followed by the same letter are not significantly different at $P<0.01$ according to the Student-Newman-Keuls procedure.

**The soil could not be penetrated due to its extreme strength upon drying (>67 kg cm^{-2}).

TABLE 4. Mean Soil Strength (kg cm^{-2}) Produced by Different Numbers of Ford "Bronco" Passes on Dry Soil (Mass Wetness in the Top 30 cm of Soil Was 0.8%) at Site 1 and Measured on Three Successive Dates When Average Soil Mass Wetness Values (MW) for the Top 30 cm of Soil in the Control Were 6.3%, 3.7% and 3.2%, Respectively.

(a) 30 December 1977; MW = 6.3%

No. of	Depth (cm)					
passes	5	10	15	20	25	30
0	2.6 ZY*	5.3 Z	4.7 Z	5.7 Z	5.6 Z	6.7 Z
1	0.9 Z	3.9 Z	3.9 Z	3.0 Z	4.5 Z	5.6 Z
3	1.4 Z	4.7 Z	4.8 Z	4.3 Z	4.4 Z	5.3 Z
5	4.5 Y	6.1 Z	5.8 Z	5.5 Z	6.9 Z	5.7 Z
10	7.3 X	6.8 Z	4.7 Z	4.8 Z	4.0 Z	6.6 Z
20	10.7 W	12.1 Y	8.7 Y	5.8 Z	5.4 Z	5.3 Z

(b) 20 April 1978; MWQ = 3.7%

No. of	Depth (cm)					
passes	5	10	15	20	25	30
0	1.5 ZZ	13.1 Z	13.1 Z	9.8 Z	9.1 Z	9.0 Z
1	2.6 Z	10.4 Z	9.4 Z	7.7 Z	7.4 Z	7.4 Z
3	5.0 Z	14.2 Z	11.9 Z	9.0 Z	8.3 Z	9.7 Z
5	16.8 Y	21.3 Y	12.2 Z	10.4 Z	8.8 Z	9.8 Z
10	10.8 ZY	22.1 Y	12.0 Z	7.9 Z	8.1 Z	9.5 Z
20	17.5 Y	26.3 Y	14.3 Z	8.3 Z	6.7 Z	7.5 Z

(c) 23 August 1978; MW = 3.2%

No. of	Depth (cm)					
passes	5	10	15	20	25	30
0	4.0 ZY	14.5 Z	14.0 Z	12.1 ZY	9.9 ZY	14.9 Z
1	1.1 Z	14.7 Z	16.1 Z	11.0 Z	9.3 Z	13.8 Z
3	4.8 ZY	24.2 Y	20.1 Z	16.4 ZY	14.1 ZYX	14.7 Z
5	10.1 YX	29.7 Y	22.3 Z	18.2 ZY	17.1 YX	20.3 Z
10	10.1 YX	52.2 XX	35.8 Y	18.2 ZY	18.3 X	17.5 Z
20	14.5 X	48.1 X	36.5 Y	20.5 Y	14.8 ZY	12.4 Z

*Column means followed by the same letter are not significantly different at P>0.01 according to the Student-Newman-Keuls procedure.

TABLE 5. Mean Soil Strength (kg cm^{-2}) Produced by Different Numbers of Ford "Bronco" Passes on Wet Soil at Site 2 Measured on two Successive Dates When Average Soil Mass Wetness Values (MW) for the Top 30 cm of Soil in the Control were 6.0% and 1.3%, Respectively. Average MW at the time of Compaction (December 30, 1977) was 3.3%.

(a) 1 January 1978; MW = 6.0%

No. of passes	Depth (cm) 5	10	15	20	25	30
0	1.3 Z*	5.1 Z	6.5 Z	7.2 Z	8.7 Z	12.1 Z
1	1.8 Z	5.7 Z	7.5 Z	8.8 Z	9.7 Z	10.5 Z
3	2.7 Z	8.9 Y	12.4 Y	12.4 Y	11.1 ZY	8.5 Z
5	4.5 Z	12.1 X	15.5 X	15.9 YX	11.6 ZY	11.1 Z
10	3.9 Z	12.6 X	17.3 X	18.4 X	14.8 Y	13.9 Z
20	8.9 Y	17.6 W	20.5 W	16.2 YX	12.6 ZY	14.4 Z

(b) 20 April 1978; MW = 1.30%

No. of passes	Depth (cm) 5	10	15	20	25	30
0	4.1 Z	17.6 ZY	19.9 Z	15.7 Z	14.6 Z	15.6 Z
1	8.7 ZY	14.3 Z	17.4 Z	16.5 Z	14.1 Z	11.9 Z
3	12.3 Y	24.5 Y	27.1 Z	20.6 Z	14.2 Z	11.6 Z
5	25.1 X	48.8 X	49.6 Y	33.3 Y	19.3 Z	16.2 Z
10**	-	-	-	-	-	-
20**	-	-	-	-	-	-

*Column means followed by the same letter are not significantly different at $P<0.01$ according to the Student-Newman-Keuls procedure.
**The soil could not be penetrated due to its extreme strength upon drying (>67 kg cm^{-2}).

RESULTS

Comparisons of Soil Strengths Produced by Passes of the Motorcycle and Bronco

The Bronco produced greater increases in soil strength than the motorcycle when both were driven over wet soil at site one or site two an equivalent number of times (Tables 2 and 3 show data for one site). The increases in soil strength produced by driving the Bronco on wet soil at site two (Table 5) were not as great as those produced by driving the Bronco on wet soil at site one, possibly because the wet sand at site two may have compacted less readily than the wet loamy sand at site one. Bodman & Constantin (1965) reported that loamy sands were the soils most susceptible to density increases under loading.

Increases in Soil Strength Produced at Different Soil Depths

All statistically significant increases in soil strength compared to the controls occurred within the top 25 cm. Driving the Bronco on wet soil compacted the soil to a greater depth than driving either the Bronco on dry soil or the motorcycle on wet soil.

Tracks produced by driving the Bronco on wet soil at site one (Table 2(s)) showed significant differences in soil strength with as little as three passes at a depth of 25 cm. However, driving the Bronco on dry soil at site one produced no significant differences below 15 cm (Table 4(a)) and significant differences in soil strength at a depth of 15 cm were produced only after twenty passes. Driving the motorcycle on wet soil at site one produced significant differences in soil strength between the control and 100 pass tracks (Table 3(a)) down to 20 cm but not below.

For twenty or less of motorcycle passes, significant differences in soil strength between the control and treatments only occurred at a depth of 10 cm (but not below this depth).

Tracks made with the Bronco on the wet sand at site two caused significant increases in soil strength as deep as 25 cm below the soil surface, when compared to the control (Table 5(a)). Larger significant increases in compaction occurred at a depth of 25 cm in the wet soil at site one (Table 2(a)) than at site two.

In addition to possible differences in compactability of the sand at site two compared to loamy sand at site one, the wetting front from previous rainfall had an average depth of about 25 cm when Bronco tracks were made at site two (Table 4(a)) compared to an average depth of around 45 cm when Bronco tracks were made at site one (Table 2(a)). The more shallow wetting depth at site two may have limited the depth of compaction.

Relationships Between Compaction and Soil Drying

As the soils of both the compacted and the control areas (tracked and untracked) became drier, with time, the rate of increase in soil strength was much greater in the compacted zones (Table 2-5).

Rates of increase in soil strength after 19 August 1977 (Table 2(b)) were much greater under tracks created by higher numbers of four-wheel drive passes, and therefore compacted to a greater degree initially, than under tracks created by smaller numbers of passes. By 6 September 1977 (Table 2(c)), 20 days after a 3.25 cm rainfall, even the area compacted by a single vehicle pass had a significantly higher soil strength than the control. Strengths under the ten and twenty pass treatment exceeded 67 kg cm^{-2} (the operational ceiling of the penetrometer) on 6 September 1977. The only exceptions to the increases in soil strength with time were measured at depths of 5 cm on 26 August 1977. This was probably due to a small amount of rainfall, 0.20 cm, measured on 23 August 1977, about 6 km north of the site.

The relationship between soil strength, soil depth, days after significant rainfall (3.25 cm of rainfall measured about 6 km north of the site), and number of transits on a vehicle track were analyzed for the Bronco tracks made on wet soil at site one (Table 2) by multiple linear regression as S = 5.83 - 0.11(D) + 0.88(R) = 3.23 (T); r = 0.68 where:

S = Soil strength (kg cm^{-2})
D =Depth (cm)
R -Number of days after a rain
T = Number of vehicle passes

r^2 = 0.46 so about 54% of the variation in soil strength remains unexplained

Some soil strength values under the one, three, and five pass tracks were over 67 kg cm^{-2} on 6 September 1977. The equation represents an underestimate of increased strength with compaction and drying.

Large increases in soil strength of drying compacted areas compared to drying control areas also occurred in the sandy soils at site two (Table 5). Single pass tracks remained close in value to the control after drying (Table 5(b)) but tracks created by five vehicle passes had very large increases in strength compared to controls between 12 January 1978, and 20 April 1978. All values of soil strength in the tracks created by ten and twenty passes exceeded 67 kg cm^{-2} on 20 April 1978.

Tracks made by the Bronco, on dry soil at site one (Table 4), showed large increases in soil strength when compared to untracked soil following subsequent wetting and drying. Soil strength values from single pass tracks of the motorcycle on wet soil and the Bronco on dry soil were similar to the controls even under the driest conditions (Table 3(c) and 4(c)). Mean values for multiple pass tracks of the Bronco on dry soil and the motorcycle on wet soil increased substantially in comparison to the controls as the soil became drier. The 100 pass motorcycle tracks reached soil strengths in excess of 67 kg cm^{-2} on 23 Auigust 1978.

DISCUSSION

Soil strengths exceeding 20 cm^{-2}, when measured at about field capacity, have been reported to cause very limited root extension of alfalfa (*Medicago sativa* L.), corn (*Zea mays* L.), and cotton (*Gossypium hirsutum* L.) (Grimes, Miller & Wiley 1975 and Grimes, Sheesley & Wiley 1978). Desert annuals would be subjected to substantial periods of drying more often than agricultural crops. Mirreh & Ketcheson (1972) reported that soil strength in laboratory tests increased at a greater rate with decreasing matric potential at higher bulk densities than at lower bulk densities. They stated that as soils dry beyond the tensionmeter range the decrease in cross-sectional area of interstitial water becomes so great that water bonds are lost and soil strength increases less rapidly with further decreases of matric potential. This may eventually result in no additional strength increases and could even result in a decrease in strength with further drying of the soil. In compacted soil the greater proportion of small pores causes larger amounts of interstitial water to be retained as matric potential decreases. The greater numbers of water bonds remaining in compacted soil during drying produce a larger increase in strength as matric potentials decrease. The much greater rate of increase in soil strength of compacted soil when drying than non-compacted soil shown in our experiments may be related to the same phenomena. There may be greater water content in drying compacted soil than drying non-compacted soil because of reduced plant growth and transpiration on the compacted soil. As an illustration, mass wetness of the top 15 cm of soil under the twenty pass track had an average value of 2.9% (5.3 cm^3 cm^{-3} volume wetness) on 6 September

1977; whereas the top 15 cm of adjacent untracked soil had an average mass wetness of 1.1% (1.8 cm^3 cm^{-3} volume wetness). The track had a large reduction in growth of annuals in the summer of 1977 which may have resulted in a larger water content. Higher values of water content in tracked soil as compared to untracked soil also occurred in some of the tracks created by smaller numbers of passes which also had significant reductions in density of annuals.

Merrill & Rawlins (1979) concluded that differences in soil strength associated with the different irrigation treatments appeared to be the predominant factor controlling root distribution of sorghum plants (*Sorghum bicolor* (L.) Moench.) grown in lysimeters with three different irrigation frequencies. Differences in frequencies of desert rains will also produce differences in soil strength which, similarly, should be expected to affect root growth of desert annuals, apart from plant stress effects produced by decreasing soil water potentials per se. Where the increases in soil strength with drying are intensified by compaction, the effects of drying can cause even greater reductions in plant growth.

Significant reductions in annual cover compared to controls occurred at site one during April 1979 in tracks created by as few as one Bronco pass on wet soils, twenty Bronco passes on dry soil, or five motorcycle passes on wet soil. All of these tracks had soil strength (measured near field capacity) which were substantially less than 20 kg cm^{-2}. The great sensitivity of desert annuals to the compaction probably resulted from greater periods of drying during the growing season which caused large increases in soil strength of tracked soil when compared to untracked soil.

Desert annual plant response to compaction varied with seasonal rainfall characteristics. The springs of 1978 and 1979 had very different rainfall patterns. Between 1 December 1978 and 25 May 1979, 9.70 cm of rainfall was measured in Stoddard Valley approximtely 6 km north of site one. During 1978, a wetter year with more frequent rains totaling 19.63 cm between 18 December 1977 and 1 May 1978, soil strength would have remained closer to the minimum values (e.g. Table 2(a)). Compacted soil had less reduction in plant growth during 1978 when compared to untracked soil than during the spring of 1979.

Desert annual response also varied with species. Relatively large, taprooted, annual dicotyledons such as *Chaenactis fremontii* Gray and *Erodium cicutarium* (L) L'Her had significant reductions in cover in all track treatments compared to controls in April, 1979 (Table 2). In contrast *Shismus barbatus* (L.) Thell, a grass with fibrous roots, significantly higher cover in comparison to controls for one, three, ten, and twenty past tracks (Table 2). The single cotyledon leaf and fibrous root system of the grass allows greater ease of germination and root growth, respectively, than is the case for the taprooted docotyledons. Greater amounts of water available to the grass in compacted soil (because other non-grass species were reduced in density and size) may be another reason for increased growth of grasses in the track.

Because soil water was characterized by mass wetness rather than soil water potential, it is difficult to relate the soil water values to plant availability. Annual plants showed no evidence of water stress at an average mass wetness value of 1.8% at site one.

Soils with intensive use by off-road vehicles (e.g. on campsites, pit area, or vehicle trails) generally had higher measured values of wet soil strength than the maximum values measured under the tracks of our studies. Soil stregnths measured in wet soils of campsites frequently ranged from about 35 to over 67 kg cm^{-2}. Trails intensely used by motorcycles had wet soil strengths which typically ranged from 20-60 kg cm^{-2}. The areas of low to moderate compaction such as we have studied may cover a larger total area than the more highly compacted soils.

REFERENCES

Bodman, G.B. & Constantin, G.K. (1965). Influence of particle size distribution in soil compaction. Hilgardia, 36, 567-591.

Carter, L.M. (1967). Portable recording penetrometers measures soil strength profiles. Agricultural Engineering, 48, 348-349.

Grimes, D.W., Miller, R.J. & Wiley, P.L. (1975). Cotton and corn root development in two field soils of different strength characteristics. Agronomy Journal, 67, 519-523.

Grimes, D.W., Sheesley, W.R. & Wiley, P.L. (1978). Alfalfa root development and shoot regrowth in compact soil of wheel traffic patterns. Agronomy Journal, 70, 955-958.

Merrill, S.D. & Rawlins, S.L. (1979). Distribution and growth of sorghum roots in response to irrigation frequency. Agronomy Journal, 71, 738-745.

Mirreh, H.F. & Ketcheson, J.F. (1972). Influence of soil bulk density and matric pressure on soil resistance to penetration. Canadian Journal of Soil Science, 52, 477-483.

Motorcycle Industry Council, Inc. (1977). Motorcycle Statistical Annual. Newport Beach, California.

Sokal, R.r. & Rohlf, F.J. (1969). Biometry. Freeman Press, San Francisco.

Taylor, H.M. (1971). Effects of soil strength on seedling emergence, root growth, and crop yield. Compaction of Agricultural Soils (Ed. by K.K. Barnes), pp. 293-305. American Society of Agricultural Engineering Monograph.

Taylor, H.M. (1974). Root behavior as affected by soil structure and strength. The Plant Root and its Environment (Ed. by E.W. Carson), pp. 271-279. University Press of Virginia, Charlottesville, Virginia.

Webb, R.H., Ragland, H.C., Godwin, W.H. & Jenkins, D. (1978). Environmental effects of soil property changes with off-road vehicle use. Environmental Management, 2, 219-233.

Wilshire, H.G. & Nakata, J.K. (1976). Off-road vehicle effects on California's Mojave Desert. California Geology, 29, 123-132.

Wilshire, H.G., Nakata, J.K., Shipley, J.K. & Prestegaard, K. (1978). Impact of vehicles on natural terrain at seven sites in the San Francisco Bay Area. Environmental Geology, 2, 295-319.

Reprinted (as published) from Journal of Applied Ecology by permission from Blackwell Scientific Publications Limited.

Paper presented at 1979 Symposium of The Desert Tortoise Council.

PUBLICATIONS AVAILABLE

Copies of the publications listed below are available until supplies are exhausted. They may be obtained by sending a check (payable to the Desert Tortoise Council) to:

Desert Tortoise Council
5319 Cerritos Avenue
Long Beach, California 90805

The Desert Tortoise Council Proceedings

1976 Symposium	$5.00
1977 Symposium	$5.00
1978 Symposium	$5.00
1979 Symposium	$5.00
1980 Symposium	$8.00
1981 Symposium	$8.00
An Annotated Bibliography of the Desert Tortoise,	$8.00

Foreign addresses please add $1.00 per copy to cover postage and handling for surface mail or $3.00 per copy for air mail. U.S. drafts only.

DESERT TORTOISE COUNCIL
APPLICATION FOR MEMBERSHIP

DATE ______________

NAME ____
Please print

ADDRESS ____
Number Street City

______________________________ PHONE ( ) ______________
State Zip Code

AFFILIATION ____

I hereby apply for the following membership:

( ) Regular ($8.00 per year)

( ) Student ($5.00 per year)

( ) Contributing ($20.00 per year)

( ) Organization ($25.00 per year)

( ) Lifetime ($150 or more) Lifetime memberships may be paid in installments of $25 per year for 6 consecutive years.

ALL MEMBERSHIPS, EXCEPT LIFETIME, ARE RENEWABLE IN MARCH OF EACH YEAR.

Please make check or money order payable to the DESERT TORTOISE COUNCIL and send with the application to:

DESERT TORTOISE COUNCIL
5319 Cerritos Avenue
Long Beach, California 90805