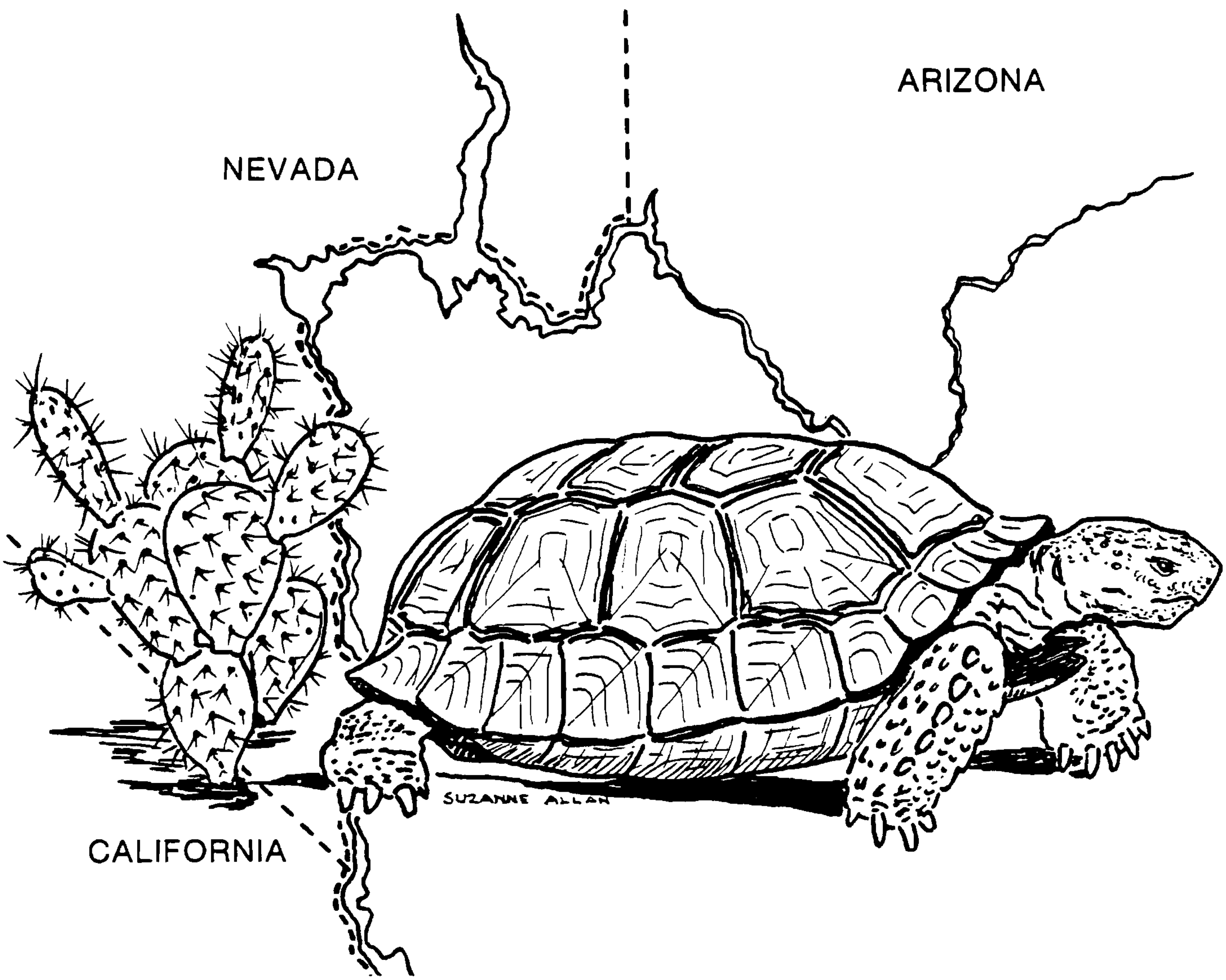
THE

DESERT TORTOISE COUNCIL



PROCEEDINGS OF 1979 SYMPOSIUM

THE
DESERT TORTOISE COUNCIL

5319 Cerritos Avenue
Long Beach, California 90805

July 13, 1983

To: Owners of 1979 Proceedings of Desert Tortoise Council

From: Evelyn St. Amant, Secretary

Subject: Errata sheet

Enclosed is a corrected version of pages 112-113 for your Tortoise Council Proceedings. The change is that the sex column was omitted in the original. You can either place this in your book or write symbols on page now there.

Evelyn

Evelyn St. Amant
Secretary

Table 2. Live tortoises - Joshua Tree National Monument - Pinto Basin.

Date	Sex	#	Wt/Kg	MCL	M3	M4	M5	H	PL N	PL T	Notes	Recapture
3-18-78	♀	1		248							Located before data sheets in use	
	♂	2	2.9	243	167	177	189	107	229	252		3-21-78
3-21-78	♂	3		253							Eating *Lotus tomentellus* (no data sheets)	
	♂	4	3.0	237	162	176	197	123	235	252	Ticks	5-14-78 5-19-74
	♂	5		266							No data sheets	
	♂	6		204							No data sheets	
	J	7		76							No data sheets	
4-21-78	♀	8	2.5	237	141	154	170	102	212	229		
4-22-78	♀	9	1.81	199	137	151	148	96	192	207		
	♂	10	.99	169	111	121	124	74	155	169		4-29-78
4-23-78	♀	11	2.24	216	139	164	166	103	205	227	Shell wear extreme	
	♂	12	3.95	272	171	188	201	119	267	280	Ticks, eating *Lotus tomentellus*	
4-29-78	♀	13	2.55	227	148	160	172	103	211	234	Almost no shell wear	
	♀	14	1.92	213	141	154	158		192	212	Teeth marks on shell, eating *Gilia* sp.	
	J	15	.05	55	46	47	47	30	56	57	Eating *Gilia* sp.	
	J	16	.045	60	45	48	48	30	55	58	Eating *Lotus tomentellus*	
	J	17	.70	145	87	105	111	73	131	146	Eating *Gilia* sp.	
4-30-78	♀	18	.87	161	106	114	119	80	147	163	Eating grass: tick	
	♂	19	3.01	240	161	172	180	113	221	240	Ticks	10-11-78
	J	20	.16	90	61	69	66	40	85	93		
	J	21	.05	46	38	45	46	14	44	45		
	♂	22	1.58	200	131	140	143	93	179	195	Eating *Lotus tomentellus*	
	♂	23	3.47	248	165	188	187	115	225	242	Teeth marks on shell; eating *Lotus tomentellus*	
	♂	24	1.61	205	129	146	151	86	185	201	Teeth marks; eating *Oenothera deltoides* (5-29)	5-29-78
	J	25	.19	92	63	70	72	45	84	92		
	♂	26	3.41	258	177	183	199	115	245	260	Ticks	5-14-78

Table 2. (continued)

Date	Sex	#	Wt/Kg	MCL	M3	M4	M8	H	PL N	PL T	Notes	Recapture
5-6-78	♀	27	2.0	210	126	150	154	93	196	212	Verm active; eating *Oenothera deltoides* (5-20) laid 3 eggs in burrow	5-20-78; 10-10
	♀	28	1.92	217	136	152	159	91	194	216		
	♀	29	.96	165	105	118	123		145	159		5-7-78
5-7-78	♂	30	4.99	279	189	207	225	130	266	284	Ticks; shell wear extreme	
	♀	31	2.67	242	153	176	192	103	221	247	M scutes curle	5-28-78
5-7-78	♂	32	3.15	246	161	177	183	132	233	256	Eating *Gilia* sp.	
	♂	33	3.99	269	171	194	209	115	255	268	Extreme shell wear; tooth marks	
5-14-78	J	34	.075	62	40	46	52	38	51	59		
	♀	35	1.44	185	134	144	149	86	188	209	Double precentral	
5-19-78	♂	36	4.01	259	170	188	198	112	242	254	Ticks; extreme shell wear	
	♂	37	1.36	191	127	132	135	87	171	185	Ticks; teeth marks	
	♀	38	2.2	225	144	163	172	97	209	228		
	♀	39	2.51	231	142	166	175	104	218	236		10-11-78
5-20-78	♂	40	2.97	239	162	184	193	106	224	241	10-11 eating *Gilia* sp. and *Allionia ditaxis*	10-9; 10-11-78
5-21-78	♂	41	1.43	200	132	142	152	95	179	198		
	J	42	.095	76	53	62	62	36	70	74		
5-29-78	♀	43	2.49	224	149	162	171	106	204	216	Teeth marks	
	♀	44	1.51	206	129	144	149	92	190	203	Digging pallet (10-10) in burrow (10-12)	10-10-78; 10-12-78
5-30-78	♀	45	3.05	243	158	167	179	110	224	241	Eating: *Allionia ditaxis*	7-1
10-9-78	J	46	0.02	60	45	48	50	26	55	60	Eating *Gilia* sp. and *Allionia ditaxis*	10-11-78
10-10-78	♂	47	2.55	235	175	184	186	115	221	235	Interest in female #48	
	♀	48	1.85	210	136	154	173	105	190	214	With male #47	
	♀	49	2.15	222	144	162	173	105	211	228	In burrow; ticks; extreme shell wear	10-11-78
10-11-78	♂	50	3.65	273	184	199	212	143	249	274	In burrow; ticks	
11-8-78	♂	51	4.30	271	186	198	217	125	255	279	Ticks	11-9-78

DESERT TORTOISE COUNCIL

PROCEEDINGS OF 1979 SYMPOSIUM

A compilation of reports and papers presented at the fourth annual symposium of the Desert Tortoise Council, 24-26 March 1979, in Tucson, Arizona

Copies of the 1976, 1977, 1978, or these 1979 proceedings may be obtained from the Desert Tortoise Council, 5319 Cerritos Avenue, Long Beach, California 90805. Make checks payable to Desert Tortoise Council, in the amount of $5.00 per copy for U.S. orders. (Foreign, please ADD $1.00 per copy postage and handling for surface mail, or $3.00 per copy for airmail. U.S. drafts only.)

Acknowledgement

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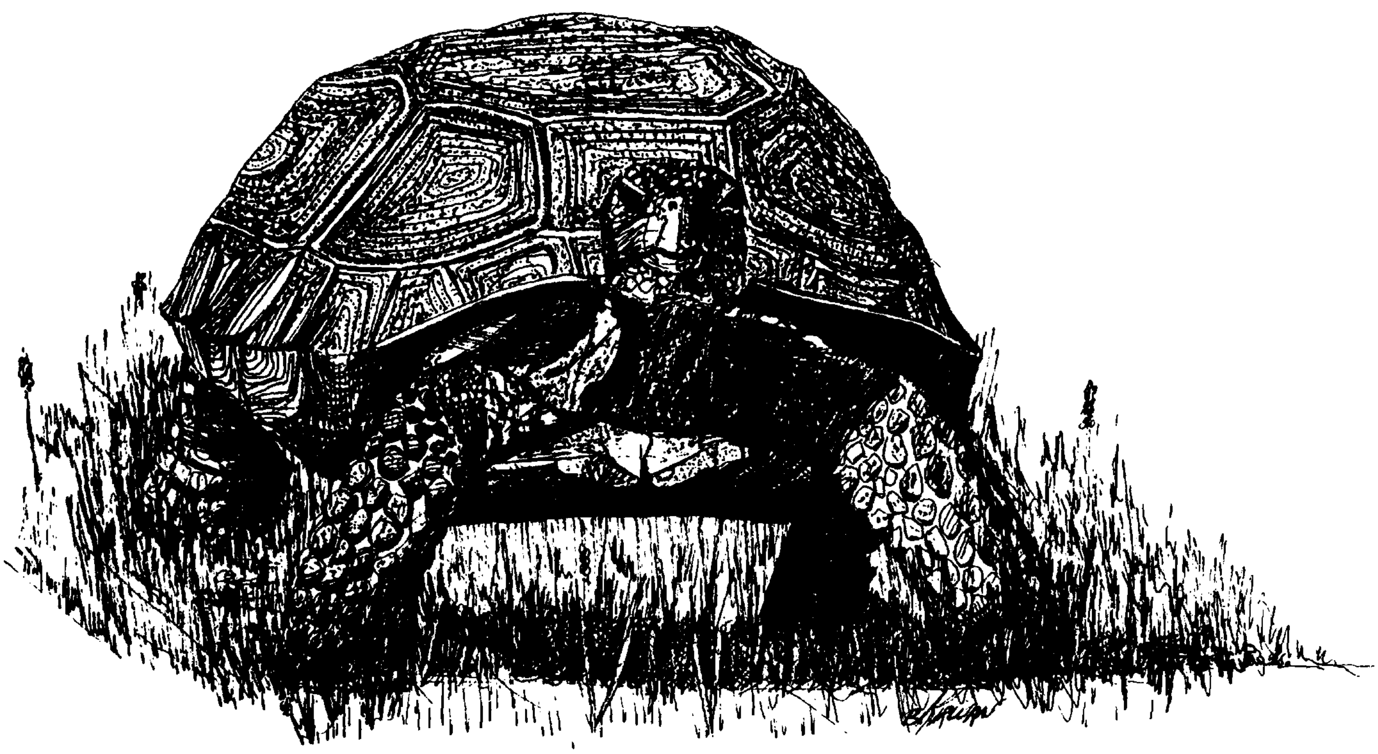


Dedication to Carl Leavitt Hubbs

Phil Pister

The Desert Tortoise Council dedicates the 1979 Symposium Proceedings to Dr. Carl L. Hubbs.

Professor Carl L. Hubbs passed away 30 June 1979 at the age of 84, a victim of the cancer which for several years had been draining his strength. Although I wept when I learned of his passing, I realized that my sadness was not really for Carl, but for all who have learned to love him. It helped enormously to know that Carl will never really leave us, but will live on forever both in memory and in the superb contributions that he made to fishery science. His career began at Stanford University under the immortal David Starr Jordan. Carl proved to be a worthy successor to his former mentor, and history will show him to be no less a man.

Yet as great as were his scientific works, of even greater long-term significance was his magnificence as a person, friend, father and selfless teacher. Carl was never too busy to greet colleague, student, or stranger with a smile and a genuine offer of assistance. There has never been a truly great man without humility, and Carl's greatness was matched and enhanced by his unfeigned awe at the magnificence of the creation about him.

A few years ago Carl and Laura sent a fine photograph of themselves taken at the time of the dedication of the Hubbs-Sea World Research Institute. I keep it pinned next to my desk to serve as often needed inspiration. When I look at it and consider the scope of Carl's accomplishments, my own problems seem to dissolve. Typically, Laura is at his side, ever his faithful wife, superb mother of his three children, colleague and helpmate, always a twinkle in her eye as she did so much to make him what he is. Their life together constitutes a love story seldom duplicated.

Perhaps the great philosopher and humanist Loren Eiseley said it best, "I see Christ in every man who dies to save a life beyond his life." He continues, "I have been accused of wooly-mindedness for entertaining even hope for man. I can only respond that in the dim morning shadows of humanity, the inarticulate creature who first hesitantly formed the words for pity and love must have received similar guffaws around a fire. Yet some men listened, for the words survive."

It was this same optimism that motivated Carl and made him so effective in inspiring others to work toward the goals that he knew were right. He, too, "received guffaws around a fire." Yet men did listen, and because of his great research, foresight, inspiration, and genius of communication, men are now beginning to understand and are working to preserve resources that otherwise would have passed unnoticed from the face of the earth. It is an absolute certainty that without Carl Hubbs, the Desert Fishes Council would never have been formed.

I find comfort in the knowledge that Carl is now with the Creator of all that he lived for and loved. And this same Creator will bless him for his good works here and the sensitivity and reverence for life that he exemplified, much as Carl would often express his appreciation to those who espoused and worked for the ideals that he held so dear.

Carl Hubbs is not really gone, he is just away. And even then, not very far.

Executive Secretary
Desert Fishes Council
407 W. Line Street
Bishop, California 93514

The Desert Tortoise Council

Executive Committee

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

The objectives of the Council are:

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

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

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

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

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

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

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

Brief History of Desert Tortoise Council

Executive Committee

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

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

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

FOURTH ANNUAL MEETING AND SYMPOSIUM

The fourth Annual Meeting and Symposium was held 24-26 March 1979 at The Hilton Inn, Tucson, Arizona. The field trip was to the Research Ranch, Elgin, Arizona.

MAJOR ACCOMPLISHMENTS OF THE PAST YEAR

1. The Council provided additional data relating to its recommendation for the listing of the desert tortoise population in Utah as Federally Endangered under the 1973 Endangered Species Act.

2. Worked with the Desert Tortoise Preserve Committee to expand the Desert Tortoise Natural Area and coordinated with the Bureau of Land Management in California to implement management of the Desert Tortoise Natural Area for the desert tortoise.

3. Recommended to the Office of Endangered Species that the bolson tortoise, *Gopherus flavomarginatus*, be listed as Endangered. The species was subsequently listed.

4. Reviewed several Environmental Impact Reports and provided necessary comments.

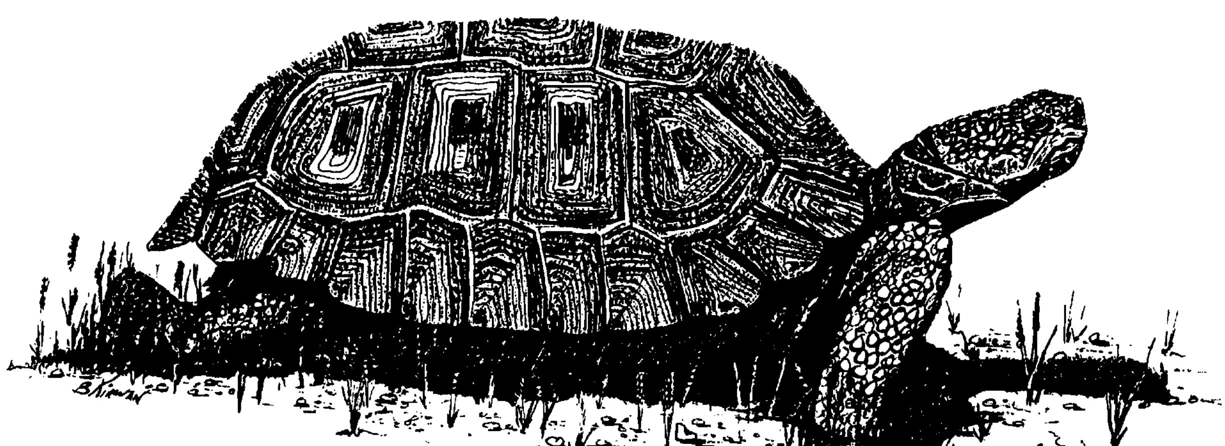
5. Recommended Threatened status for the desert tortoise, *G. agassizi*, in California, Arizona, and Nevada.

6. Assisted the Bureau of Land Management in preparing a management plan for the desert tortoise in California.

7. Supported the California Department of Fish and Game in banning commercial collecting and selling of native reptiles and amphibians for the pet trade.

8. Desert Tortoise Council members have given lectures to various groups, explaining environmental impacts on the desert and the desert tortoise.

9. Presented annual award to The Nature Conservancy for its help in purchasing land to preserve desert tortoise habitat.



Fourth Annual Meeting and Symposium

The fourth Annual Symposium was opened by the program chairman, Dr. Kristin H. Berry, followed by the keynote address by Mr. Richard Shunick, Bureau of Reclamation Project Manager for the Central Arizona Project.

An informative and entertaining after dinner program was provided by Dr. Paul Martin, Laboratory of Paleoenvironmental Studies, University of Arizona. The subject of Dr. Martin's presentation was, "The Mysteries of Ice Age Extinctions" with insights into the factors causing the extinction of the giant sloth.

Excerpts from the Minutes of the Fourth Annual Business Meeting

Ivanpah Environmental Analysis Record (EAR). Dr. Mark Dimmitt reported on the status of the Ivanpah Valley gas leases and he recommended that further action be taken by the Council. Some of the important points mentioned include:

1. The tortoise population in Ivanpah is one of the 4 healthiest and densest in California and the most manageable as it is nearly all on Bureau of Land Management (BLM).

2. The EAR contains numerous inconsistencies.

3. The EAR has inaccurate information.

4. Even though there is an important tortoise population on the proposed project location, BLM management has concluded that the oil and gas leasing will not create a significant impact. Several biologists who have read the EAR do not agree with the BLM's conclusions.

A letter for the Co-chairpersons' signatures will be drafted for submittal to BLM State Director, Ed Hastey. (Subsequently a letter was sent.)

Dr. Kenneth Dodd will also contact the Solicitor's office regarding this matter.

Annotated Bibliography. Judy Hohman, James Schwartzmann and Dr. Robert Ohmart have compiled an annotated bibliography for the desert tortoise. This document has been given to the Council for printing and sale.

Gopher Tortoise Council. Dr. Bruce Bury recommended that an Executive Committee-level member from the Gopher Tortoise Council, Desert Tortoise Council, and representatives of those performing research on the bolson tortoise in Mexico and on the Texas tortoise maintain contact. He also suggested that a combined Proceedings be considered. The Council agreed that, at a minimum, all mailings should be exchanged. Dr. Bury was asked to chair a committee to ensure that correspondence and other information is passed between all tortoise councils. The matter will be further reviewed by the Executive Committee.

Resolution on Off-Road-Vehicle (ORV) Use

WHEREAS, ORV use disrupts soil structure, leading to reduced water-holding capacity, accelerated erosion by wind and water, and substantial loss of topsoil, and

WHEREAS, ORV use directly destroys plants and animals, and further reduced their numbers by damaging their habitats and permitting access to remote areas where they may be molested, maimed, killed and carried off, unrestrained by law enforcement officers or public disapproval, and

WHEREAS, ORV use encourages the introduction of weeds, and in other ways distorts ecological relationships that have taken thousands of years to develop, and

WHEREAS, ORV use seriously damages or destroys archaeological and paleontological material, historical features, relect land forms, and other legacies of inestimable scientific, educational, cultural, and aesthetic value, therefore, be it

RESOLVED, that the Desert Tortoise Council urges all public agencies which are charged with administering and protecting the public lands to take immediate and effective action to:

1. Evaluate existing and proposed ORV use areas and restrict use to those areas where damage will affect the fewest resources and will not cause irreversible damage to sensitive resource values.

2. Enforce existing restrictions on vehicle use, including current executive orders and federal, state, and local regulations.

3. Take immediate and effective action to restore ORV-damaged lands where ORV use is not authorized.

4. Use the vehicle use fees and other funds as necessary to rehabilitate authorized ORV use areas so as to maintain them in a useable condition.

5. Rehabilitate authorized ORV use areas so as to maintain them in useable condition.

6. Promote education of the public as to the values and responsible use of the desert.

7. Encourage road, horseback, and foot travel, camping, and other forms of less destructive recreation, and immediately restore ORV-damaged lands where ORV use has been prohibited; and provide the means necessary to prevent further unauthorized use.

<u>Attendees</u> - Fourth Annual Meeting and Symposium

Dr. Gary Adest	California State University, Los Angeles
Nora Allen	California Turtle and Tortoise Club, Westchester Chapter
Walter Allen	California Turtle and Tortoise Club, Westchester Chapter
Ariel B. Appleton	The Research Ranch, Elgin, Arizona
Jeannie Banta	San Diego, California
John Barrow	Pomona Unified Schools, Pomona, California
Jeanne Bellemin	El Camino College, California
Dr. Kristin H. Berry	Bureau of Land Management, Desert Plan Staff, Riverside, California
Jan Ellen Bickett	Student-Sacramento State College, California
Jerry R. Boggs	Bureau of Land Management, Bakersfield District Office, California
Karen Bohuski	Student-California State University, Fresno
Allan H. Borden	Bureau of Land Management, Havasu Resource Area, Arizona
Betty L. Burge	Las Vegas, Nevada
Dr. R. Bruce Bury	National Fish and Wildlife Laboratory, Fort Collins, Colorado

Bruce H. Campbell	Bureau of Reclamation, Glendale, Arizona
Jean M. Christensen	Reference Librarian, Weaver County Library, Ogden, Utah
Michael P. Coffeen	Utah Division of Wildlife Resources, Cedar City, Utah
Roger Cogan	Arizona Zoological Society, Scottsdale
Shelley Cogan	Arizona Zoological Society, Scottsdale
Ted Cordery	Bureau of Land Management, Phoenix District Office, Arizona
Barb Davis	Student-University of Wisconsin, Milwaukee
Donald Dietlein	Co-director, Division of Conservation & Environmental Affairs, Captran Inc., Sanibel, Florida
Dr. Nora Dietlein	Gopher Tortoise Council and Co-director, Division of Conservation & Environmental Affairs, Captran Inc., Sanibel, Florida
Dr. Mark A. Dimmitt	Bureau of Land Management, Riverside District Office, California
Dr. C. Kenneth Dodd, Jr.	Office of Endangered Species, Fish and Wildlife Service, Washington, D.C.
A. Sidney England	Bureau of Land Management, Desert Plan Staff, Riverside, California
Patrick Finney	California Turtle and Tortoise Club, Orange County Chapter
Rochelle Fried	California Turtle and Tortoise Club, Orange County Chapter
Margaret Fusari	Prescott Center College, Prescott, Arizona
Ken Geiger	Student-University of Wisconsin Milwaukee
Dr. Richard M. Hansen	Colorado State University, Fort Collins
Mark Hoffman	Santa Monica College, California
Judy P. Hohman	Student-Arizona State University, Tempe
Dr. Barbara K. Hopper	The Nature Conservancy, Woodland Hills, California
James Hudnall	Student-University of Arizona, Tucson
Jackie Jacobsen	Claremont Educational Sanctuary for Discarded Animals, California
Kenneth Bruce Jones	Bureau of Land Management, Phoenix District Office, Arizona
Dr. Frank Judd	Pan American University, Edinburgh, Texas

Merritt S. Keasey III	Arizona-Sonora Desert Museum, Tucson
Bruce W. King	Student-Arizona State University, Tempe
Cindy Kish	Bureau of Land Management, Phoenix District Office, Arizona
Beverly Lackey	California Turtle and Tortoise Club, Westchester Chapter
Thomas Lackey	California Turtle and Tortoise Club, Westchester Chapter
Gustavo Aguirre Leon	Instituto De Ecologia, Mexico
Mark R. Maley	Bureau of Land Management, Las Vegas District Office, Nevada
Jeanine Mason	Student-University of Wisconsin, Milwaukee
Dr. Paul S. Martin	University of Arizona, Tucson
Bernardo Maza	UCLA-Laboratory of Nuclear Medicine, Mercury, Nevada
Philip A. Medica	UCLA-Laboratory of Nuclear Medicine, Mercury, Nevada
Neil Middlebrook	Bureau of Land Management, Arizona Strip District, St. George, Utah
Dr. John E. Minnich	University of Wisconsin, Milwaukee
Lori Nicholson	Riverside, California
Dr. Robert D. Ohmart	Arizona State University, Tempe
Lauren Porzer	Student-Arizona State University, Tempe
William Radtkey	Bureau of Land Management, California State Office, Sacramento
Dr. Tony Recht	California State University, Dominguez Hills
Dr. Francis Rose	Texas Tech University, Lubbock
Richard T. Rusch	Student-University of Wisconsin, Milwaukee
Lance Sachara	California Turtle and Tortoise Club, Gilroy
Evelyn St. Amant	California Department of Fish and Game, Long Beach
James A. St. Amant	California Department of Fish and Game, Long Beach
Peter J. Salamun	University of Wisconsin, Milwaukee
Donald J. Seibert	Bureau of Land Management, Arizona State Office, Phoenix
Michael Seidman	Phoenix Zoology Society, Arizona
Richard Shunick	Bureau of Reclamation, Central Arizona Project
Steve Sopkowicz	Student-University of Wisconsin, Milwaukee
Sandra Stein	Alexander Lindsay Junior Museum, Walnut Creek, California

David W. Stevens	Southern California Edison Company, Environmental Affairs, Rosemead
Duna Strachan	Student-Arizona State University, Tempe
Linda J. Swantz	California Turtle and Tortoise Club, Orange County Chapter
James L. Swartzmann	Student-Arizona State University, Tempe
Bob Tribatoski	Student-University of Wisconsin, Milwaukee
Vincent L. Tripi	Student-University of Wisconsin, Milwaukee
Mary Trotter	San Diego Natural History Museum, San Diego, California
Dr. Frederick B. Turner	UCLA-Laboratory of Nuclear Medicine, Mercury, Nevada
Dr. Thomas R. Van Devender	University of Arizona, Tucson
Ann E. Weber	Student-California State Polytechnic University, Pomona
Janet Wenger	Student-University of Wisconsin, Milwaukee
Frances W. Werner	Tucson, Arizona
Winton K. West, Jr.	Loma Linda University, California
David Willis	Student-University of Wisconsin, Milwaukee
Mike Winoske	Student-University of Wisconsin, Milwaukee
Peter Woodman	Bureau of Land Management, Desert Plan Staff, Riverside, California
Martha Young	California Turtle and Tortoise Club, Orange County Chapter

Field Trip
The Research Ranch, Elgin, Arizona

Ariel Appleton

At the conclusion of the Fourth Annual meeting and Symposium of the Desert Tortoise Council, members and guests visited The Research Ranch, Elgin, Arizona for a general tour conducted by Ariel Appleton.

They inspected 2 bolson tortoise sites established at the ranch. The first was a 2.8-ha [=7-acre] area surrounded by low fencing and located in tobosa grass bottomland to the west of O'Donnell Canyon stream and directly south of the Babocamari Ranch -- Research Ranch fence line. This site was selected and fenced by Dr. John Hendrickson of the University of Arizona with funding donated by SAFE, through the assistance of Dr. Thomas Lovejoy. Eleven tortoises from the 15 loaned to Dr. Hendrickson by the Instituto de Ecologia in Mexico were placed in the enclosure in July 1976. These tortoises did not establish adequate individual burrows so Dr. Hendrickson dug artificial tunnels (reinforced with wood) with soil-covered metal sheets for roofing. From 1976 to 1979 there has been an attrition of 6 tortoises in this area and now Dr. Hendrickson is placing the remaining 5 under the care of Ariel Appleton. They will be moved during the summer of 1979 to an area near her house.

The second site visited was a 32.4-ha [=4/5 acre] bottomland enclosure near Ariel's house, just north of Post Canyon, edged by live oaks and primarily covered with perennial plains love grass and gramas. The soil is relatively hard and rocky but not as dense and stickly as the first site in tobosa grassland. Her original female and 4 of the 15 on loan from Mexico have established well-drained and protected individual burrows with an average depth of 1.2 to 1.8 m [= 4-6 ft]. They have remained in constant good health despite the cold winters at this 1524-m [= 5000 ft] altitude.

In O'Donnell Canyon, a riparian area, the group observed the Sonoran mud turtle in a wide, shallow stream area above the dam.

The western box turtle is found at Post Canyon Dam and at Finley Tank, a spring-fed pond north of East Corrals.

Those attending were: Walter Allen, Kristin Berry, Jane Bickett, Karen Bohusk, Betty Burge, Norman Christensen, Phil Culley, Mark Dimmitt, Ken Dodd, Sid England, Richard Hansen, Andy Hayostek, Judy Hohman, Barbara Hopper, Beverly Lackey, Tom Lackey, William Radtkey, Lance Sachara, Sandra Stein, Dan Tortorell, Winston West, Jr., Peter Woodman, and Martha Young.

P.O. Box 44
Elgin, Arizona 86511

1979 Annual Award: Profile of Recipient, The Nature Conservancy

The California Field Office and Southern California Chapter Board of Directors of The Nature Conservancy are joint recipients of the 1979 Annual Award for their contributions to conservation of the desert tortoise.

The Nature Conservancy, founded in 1951, is a national, non-profit organization which is dedicated to the acquisition of ecologically important natural lands. The Conservancy is committed to preservation of biological diversity by protecting lands containing the best examples of natural ecosystems. To date The Conservancy is responsible for preservation of over 1.5 million acres [= 607,050 ha] that provide habitat for many rare, endangered, and sensitive species of wildlife and plants.

The California Field Office under the direction of Peter Seligmann and Steve McCormick and the Southern California Chapter Board of Directors work closely with the Desert Tortoise Preserve Committee, Incorporated. The Committee is a Project Committee within the Nature Conservancy, as well as being a separate entity unto itself. Both organizations strive toward the goal of making the Desert Tortoise Natural Area a viable unit that can withstand the rigors of human activities on adjacent lands.

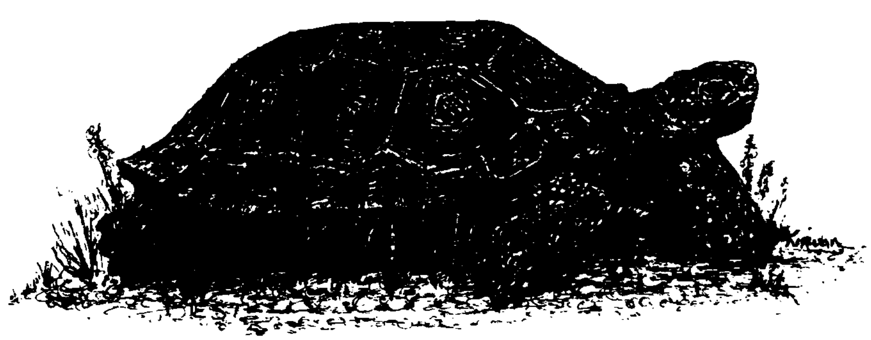
During the last few years, the California Field Office obtained an option to purchase 1280 acres [= 518 ha] of habitat belonging to a single owner in the northern part of the Natural Area. After more than a year of discussions with the land owner, The Conservancy consummated the purchase in October 1978 using funds raised primarily by the Desert Tortoise Preserve Committee. This acquisition, along with earlier purchases of parcels totalling 160 acres [= 64.8 ha], ensured the protection of approximately 3200 acres [= 1295 ha] of mixed public and private lands on the northern part of the Natural Area. In addition to this major acquisition, the California Field Office has been negotiating for an option to buy another 640 acres [= 259 ha] of prime habitat in the western part of the Natural Area. In early 1979 they assisted San Diego Gas and Electric Company in purchasing this property for transfer to the Bureau of Land Management.

The Nature Conservancy's interest in the desert tortoise is not limited to land acquisition. In this regard, special mention should be given to three people on the Southern California Chapter Board of Directors who have not been recognized previously: Barbara Horton, Dr. Barbara Hopper, and Judy Surfleet. During the past 2 years, Barbara Horton has spearheaded efforts to prod Bureau of Land Management administrators into fulfilling long-overdue promises to fence and sign the Preserve, to construct an interpretive center and nature trails, and to take a more active role in protecting the habitat. She also prepared special notes and informational articles to help with fund-raising, and organized an overnight trip to the Natural Area for special donors.

Dr. Barbara Hopper was instrumental in getting an invitation from the Sacramento Office of Education, State of California, to include a packet on the desert tortoise as part of the National Conservation Week mailing to 10,000 primary and secondary public schools in California. The educational packet with colored poster was prepared by the Desert Tortoise Preserve Committee. Thus the story of the desert tortoise was provided to school children throughout the State.

Judy Surfleet has travelled throughout the Los Angeles basin giving desert tortoise slide programs and selling tortoise T-shirts, wind chimes, and other merchandise. She has given numerous programs to school children and adults during the last few years.

The combination of the Desert Tortoise Preserve Committee and The Nature Conservancy is complimentary, effective, and powerful. The Conservancy brings its expertise in real estate, legal matters, and tax benefits to bear in land acquisition, while the Committee emphasizes fund-raising. The Conservancy raises the issues of preservation and management of desert tortoise habitat to a national level, reaching out to an ever-expanding audience, while the Committee focuses on the local and regional publics. The continued efforts of The Nature Conservancy on behalf of the desert tortoise will help to fulfill the goal of the Desert Tortoise Council -- to preserve representative portions of habitat throughout the geographic range.



Keynote Address

Richard Shunick

Bureau of Reclamation

Thank you for that kind introduction, and good morning, ladies and gentlemen, members of the Desert Tortoise Council. Being the keynote speaker for your 3-day meeting is a privilege, of course, but I also view it as a challenge. A challenge to see that my remarks set a positive tone for this meeting; that you realize the people of the Bureau of Reclamation who are building the Central Arizona Project (CAP) are supportive of one of the principal goals and objectives of your organization: to insure the continued survival of desert tortoises and the maintenance of their habitat in a natural state.

Before I make particular references to the desert tortoise and the Central Arizona Project, however, I want to review briefly the general plan for CAP and the progress that has been made to date. For this part of my talk, I believe the slides I have will be helpful.

Now for some specifics about the desert tortoise and the Central Arizona Project:

To date, the Arizona Projects Office of the Bureau of Reclamation has had minimal involvement with the desert tortoise. The final Granite Reef Aqueduct Environmental Statement (1974) which assesses the impacts of construction of an open aqueduct between Lake Havasu and the Salt River east of Phoenix, recognized that a small but undefined population of the desert tortoise existed along the aqueduct alignment. The U.S. Fish and Wildlife Service did not recommend specific mitigation and no special facilities or modifications are planned at this time. This is not to say, however, that the "door is closed,". During 1978, the Bureau of Reclamation and the Bureau of Land Management jointly funded a survey of tortoise distribution on Federal lands in Arizona. If the results of this investigation, which will be reported later this morning by Mrs. Burge, indicate populations along the Granite Reef Aqueduct, special mitigative measures will be considered.

During 1974 and 1975, field studies of the nongame mammals, birds, herpetofauna, and vegetation analysis along the proposed alignment of the Salt-Gila Aqueduct were made by students of Arizona State University supervised by Dr. Robert D. Ohmart as part of a contract with the Bureau of Reclamation. This report states:

> "The desert tortoise was found in very high concentrations on and adjacent to the proposed aqueduct

> route in the Picacho Mountains. Ten tortoises were found in an area of less than 0.25 miles and seven more were found within an 0.5 square mile area. This area may have one of the highest densities of desert tortoises in Arizona...."

In August 1977 the length of the Salt-Gila Aqueduct was redefined and that portion of the proposed CAP aqueduct route where Dr. Ohmart observed the tortoise has now become a part of the Tucson Aqueduct. The Tucson Aqueduct is not scheduled for construction until late 1982, and detailed planning of this feature is in the preliminary stage. At this time four alternate routes are being studied for the location of this aqueduct. As plans to determine the type of conveyance system, size, and location are developed, the findings of Dr. Ohmart and Mrs. Burge, as well as other environmental concerns, will be factors in the decisions to be made. As a part of this planning process, we have an ongoing program of public involvement in the Tucson and southern Pinal County area. I have brought copies of the material that we have used thus far in this program. We would welcome the participation of those of you here today in the program. If those of you who are interested will give me your names and addresses, I will see that you receive notices of future meetings and any reports and materials that are prepared.

It is possible that, due to tortoise distribution and concentrations, modifications in the design of the aqueduct will be recommended. Some of the possible compensatory modifications which have been mentioned during discussions with members of your organization and others include:

1. Construct low height tight mesh fencing in areas of tortoise concentrations.

2. Construct a low slipform concrete barrier wall.

3. Provide a tight mesh training fence to wildlife or tortoise bridge crossings.

4. Provide a training barrier to cross drainage overchutes or culverts which could be used by the animal.

5. Design a turtle turner so that the animal upon contact at collection points is turned away from the aqueduct.

6. If aqueduct design capacity allows, place the aqueduct underground in a pipe.

7. Locate the route through areas with low or no tortoise concentrations.

As you can see, the different approaches have differing apparent degrees of practicality and variations in materials may be used to accomplish the desired goal. Any selected approach should be proven practical and effective through a systematic research study and evaluation.

We are very interested in the investigations currently underway by Dr. Berry and the Bureau of Land Management and the applicability of their findings to our situation. The biologists in our organization feel that information valuable to mitigation planning will result from their work. We are also interested in any constructive criticism and suggestions that this Council might have.

I hope that I have made the point that the Bureau of Reclamation will be responsible and responsive to your interests as we design and build the Central Arizona Project.

Central Arizona Project
201 N. Central Avenue
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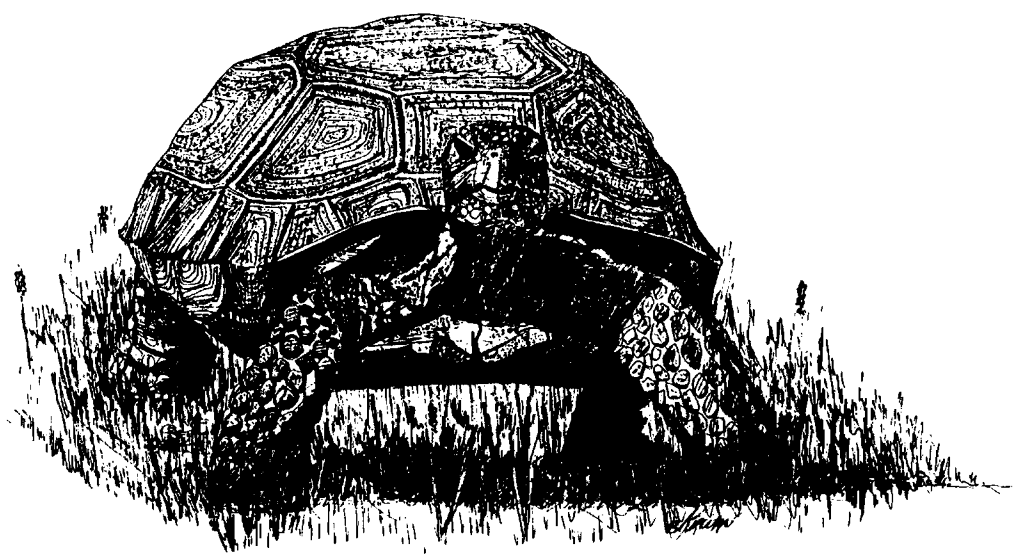
Phoenix, Arizona 85073



Albino Tortoises at the Arizona-Sonora Desert Museum

Merritt S. Keasey III

Sometime in the early 1970's, Mr. Fonell Fox, a resident of Tucson, Arizona found a male desert tortoise wandering down the alley behind his home. He picked it up and placed it in the backyard. A year or two later, another tortoise was found nearby. Since this one happened to be a female, it, too, was kept, as a mate for the previously acquired male.

On 11 October 1974, the Fox family was delighted to discover that 6 little tortoises had hatched and were ambling about the yard. Although a hatching of tortoises is not an uncommon occurrence here in this sprawling desert city where thousands of persons keep these common desert reptiles as backyard pets, the unusual thing about this particular hatching was that 2 of the babies were of pale yellow coloration, with pink eyes! Our institution was contacted and we gratefully accepted a donation of 1 of the albino babies. The other specimen was raised by the Fox family for several years, but has since died.

The following year, at almost the same time, another litter of tortoises hatched. Only 1 albino was found. This was also donated to the Museum.

For unknown reasons, no hatchlings were found during the following years of 1976 and 1977. Then, On 15 October 1978 9 babies hatched. Of them, only 1 was an albino. The entire litter was donated to the Museum and at this writing are on display in the Small Animal Room.

The first specimen, hatched on 11 October 1974 has grown quite rapidly and now weighs 910 gms [= 2 lb]. It has a carapace length of 16.5 cm [= 6.5 in].

The second specimen, hatched on 15 October 1975, has never been as fast growing, and, although quite healthy, only weighs 180 gms [= .39 lb] and has a length of 9 cm [= 3.5 in].

The third specimen, hatched on 15 October 1978, currently weighs 48 gms [= .1 lb] and is 6 cm [= 2.4 in] in length.

Whether or not there are other albino desert tortoises in captivity, we do not know, but if there are, we would be glad to hear from anyone familiar with their existence. They are a beautiful and rare form of a very interesting and important reptile, and we have certainly enjoyed our experience with these unusual offspring of a pair of backyard tortoises.

Arizona-Sonora Desert Museum
Route 9, Box 900
Tucson, Arizona

Federal Listing Activities and the Genus *Gopherus*

C. Kenneth Dodd, Jr.

Since the Desert Tortoise Council's 1978 meeting in Las Vegas, Nevada, two significant events have occurred which have affected U.S. Fish and Wildlife Service conservation activities on behalf of Endangered and Threatened species. These involve the adoption of new Interior Department regulations regarding the proposing of regulations and the passage of the 1978 amendments to the Endangered Species Act of 1973. Presidential Executive Order 12044 required that steps be taken to "improve government regulations." Accordingly, the Department of the Interior adopted an elaborate procedure for: (1) the determination of "significant" rules and preparation of regulatory analyses, (2) methods by which members of the public may petition for a rulemaking, and (3) procedures for periodic review of existing rules (*see* the Federal Register of December 13, 1978 [43 FR 58292-58301] for details of these regulations). It is anticipated that all future listings, especially those which include Critical Habitat, will be treated as significant rules. If so, this will severely hamper future attempts to list those species that are Endangered or Threatened and therefore provide needed federal protection and conservation programs to insure survival. This should be of particular concern to members of the Desert Tortoise Council because the desert tortoise, *Gopherus agassizii*, and gopher tortoise, *Gopherus polyphemus*, may require eventual listing, pending the results of surveys currently underway. With regard to Endangered and Threatened species, procedures for the implementation of these new regulations have yet to be adopted.

On 1 October 1978 the authorization of the Endangered Species Act of 1973 expired and funding and all programs involving Fish and Wildlife Service endangered species activities were terminated. President Carter, while expressing misgivings about additional amendments to the Act which had been linked with reauthorization and subsequently passed by Congress, signed the Endangered Species Act Amendments ot 1978 on 10 November 1978. Like the new Interior Department regulations, the amendments call in part for a significant input of economic data, especially with regard to Critical Habitat, prior to the proposal and listing of any species as well as an exemption process for federal agencies faced with the restrictions involving Section 7 (Critical Habitat) of the Act (*see* Dodd, 1978*a*, for a discussion of Critical Habitat). Details of the 1978 amendments are available elsewhere (Public Law 95-632, 16 USC 1531; Anon, 1978). At the present time (March 1979), there have as yet been no guidelines prepared as to how the amendments will be carried out, or the amount of detail required for an economic analysis, nor is it known who will actually prepare the analyses. Before a species that was proposed prior to 10 November may be added to the list (for example, the Beaver Dam Slope population of the desert tortoise), these questions must be answered and appropriate analyses prepared. With regard to the Beaver Dam Slope population, this is a critical point because all species proposed prior to the adoption of the new amendments must be finalized within 2 years of the date of their proposal to the list or be withdrawn from consideration. Given the complications arising from Critical Habitat proposals (see below), it is unlikely that most species of plants and animals previously proposed, numbering over 1800, will be listed under provisions of the Act.

With regard to Critical Habitat, the 1978 amendments specified a number of procedures which must be followed before a proposal can be considered valid. Included are:

1. A proposal to list a species as Endangered or Threatened be accompanied, to the maximum extent prudent, by a specification of Critical Habitat for the species to be listed, and that notice of any proposal which specifies Critical Habitat be published in a newspaper of general circulation in or adjacent to such habitat.

2. The substance of the Federal Register notice of any proposal to determine a species as Endangered or Threatened or specify its Critical Habitat be offered for publication in appropriate scientific journals.

3. All general local governments located within or adjacent to a proposed Critical Habitat be notified of the proposed regulation at least 60 days before its effective date.

4. A public meeting (and if requested, a public hearing) be held on any proposed regulation which specifies Critical Habitat within the area in which such habitat is located in each State, and, if requested in each such State.

5. A public meeting be held on a proposed regulation which does not specify Critical Habitat if such a meeting is requested by any person within 45 days of the date of publication of the notice of proposal.

6. Any proposed regulation which includes a specification of Critical Habitat be accompanied by a brief description and evaluation of those activities which may be impacted by such specification.

7. In determining the Critical Habitat of any Endangered or Threatened species, consideration be made of the economic impact, and any other relevant impacts, of specifying any particular area as Critical Habitat and that any such area may be excluded from a Critical

> Habitat if the benefits of such exclusion are found to outweigh the benefits of specifying the area as part of the Critical Habitat and if the exclusion would not result in the extinction of the species.

Clearly then, those proposals which had not been made prior to 10 November 1978 must be supplemented before the species can be added to the List of Endangered and Threatened Wildlife and Plants. In the Federal Register of 7 March 1979 the Fish and Wildlife Service published a notice of withdrawl of all proposals for Critical Habitat which had not been made final prior to the 1978 amendments. The Service noted that the withdrawls were made "voluntarily". Although the listing proposal itself will remain valid, the species cannot now be listed without Critical Habitat, according to the 1978 amendments, which in effect denies listing to species in need of protection. The reason the Critical Habitat proposals were not merely supplemented instead of being completely withdrawn remains unclear. In any case, all Critical Habitats must be reproposed, which makes them subject to the significant regulations provisions of the new Interior Department regulations. With regard to the Beaver Dam Slope population of *G. agassizii*, all requirements must be met by 23 August 1980, or the original proposal must be withdrawn. Once a species has been proposed, it cannot be reproposed unless significant new data become available. Details of the withdrawl of Critical Habitats can be obtained in the Federal Register of 6 March 1979 (44 FR 12382-12384).

Beaver Dam Slope Population of *Gopherus agassizii*. On 23 August 1978 the Fish and Wildlife Service proposed that the Beaver Dam Slope population of *G. agassizii* be listed as an Endangered species with approximately 90 km^2 [= 35 mi^2] area of southwestern Washington County, Utah, as Critical Habitat (see the Federal Register 43 FR 37662-37665 and Dodd, 1978*b*, for details). The five criteria for listing, as specified by the Act, were as follows for this unique population:

1. The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range. The Beaver Dam Slope has had a long history of overgrazing. Although both sheep and cattle have grazed in the past, presently only cattle are using the range. Overgrazing has modified the habitat, especially by reduction of the availability of perennial grasses and destruction of native vegetation, especially creosote bush, around which tortoises construct their burrows. Livestock also cave in burrows, perhaps step on young tortoises, and trample forage.

2. Overutilization for Commercial, Sporting, Scientific, or Educational Purposes. Collection of individuals for pets is thought to have had severe effects on the

population in the past, especially since females were collected more than males because they are sedentary and easier to find. Collection is probably not a major factor at present although any removal of individuals not in connection with conservation efforts would probably be detrimental.

3. Disease and Predation. Predation by natural or feral animals may be contributing to the decline of the population, especially as it affects eggs and young tortoises, both of which are very vulnerable.

4. The Inadequacy of Existing Regulatory Mechanisms. Not applicable.

5. Other Natural or Man-Made Factors Affecting its Continued Existence. Competition for food items between tortoises and cattle may be contributing to a decline in this population, both directly (for food items) and indirectly (in terms of adequate diet needed for successful reproduction). Dietary overlap is as high as 37.5% between cattle and tortoises based on fecal samples.

Critical Habitat areas of the Beaver Dam Slope population of the desert tortoise, exclusive of those existing man-made structures or settlements which are not necessary to the normal needs or survival of the species, were proposed as follows: Utah, Washington County, E½ Sections 13 and 24, T43S R20W; S½ Section 7, all of Sections 8 through 28, E½ Section 29, SE¼ Section 4, T43S R19W; all of Sections 7 through 10, 15 through 22, 28 through 30, and W½ Section 27, R43S R18W.

As stated previously, the Critical Habitat of this population must be reproposed before it can be listed and the entire proposal must be finalized by 23 August 1980 to remain valid. To date, no biological data have been received which would alter either the proposal or the boundaries of the Critical Habitat although the proposal was somewhat controversial in southwestern Utah.

Status Review for *Gopherus agassizii*. Also on 23 August 1978 the Service published a notice to review (43 FR 37662) of the status of the desert tortoise throughout its range. According to the review:

"The desert tortoise, *Gopherus agassizii*, is a long-lived inhabitant of the desert areas of the Southwestern United States (California, Nevada, Utah, and Arizona) and adjacent areas of Mexico as far south as southern Sonora. Few populations of this species have been extensively investigated although the data presently available indicate that the species may be declining throughout significant portions of its range. Preliminary work in 2 areas in Arizona indicates that the tortoise is not doing well, and recently the Desert Tortoise Council petitioned the Fish and Wildlife Service to list the Beaver Dam Slope population in Utah as Endangered and presented substantial data in support of the petition. Extensive surveys by the Bureau of Land Management and Department of Fish and Game in California have also documented declines in certain populations. The chief threats to the tortoise appear to be from habitat destruction because of overgrazing and the extensive use of the desert by off-road vehicles (ORVs). In addition, cattle may be competing with the tortoise for forage, trampling burrows and cover, and stepping on young tortoises. In the past, collection of individuals for pets has been a severe problem."

Since notices of review were not affected by the 1978 amendments, this review is still being conducted. To date, however, not enough biological data have been received to determine what future conservation measures may be warranted.

Bolson Tortoise, *Gopherus flavomarginatus*. On 15 June 1978 the Fish and Wildlife Service was petitioned by Dr. David Morafka of California State University-Dominguez Hills to list the bolson tortoise, *G. flavomarginatus*, as an Endangered species under provisions of the Endangered Species Act of 1973. Included with the petition was a report entitled, "The Ecology and Conservation of the Bolson Tortoise, *Gopherus flavomarginatus*," in which Dr. Morafka reviewed the biology and status of the species throughout its range. On 29 June 1978 the Director of the Service notified Dr. Morafka that he had supplied sufficient information to warrant serious consideration for listing under provisions of the Act.

The bolson tortoise was proposed as Endangered in the Federal Register on 26 September 1978 (43 FR 43692-43693). The 5 criteria for listing of the tortoise, as specified in the Act, were as follows:

1. The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range. Habitat destruction is accelerating throughout the range of the bolson tortoise. Plowing and irrigation of fields for cotton, beans, corn, and melons has apparently contributed to the extirpation of the species in certain areas, such as the region west of Mexican highway 49 and around Tlahualilo in Durango. As Mexico's resettlement program continues, more and more of the tortoise's habitat will likely be converted to agricultural and grazing uses. The continued existence of the tortoise in the vicinity of such practices is highly unlikely.

   Habitat destruction also occurs through overgrazing by cattle and goats. Goat herds have long moved across the foothills of the tortoise country. Water supplies have been increased by underground drilling and as a result cattle are rapidly increasing in density in these arid grasslands. Some areas are now beginning to show the marked effects of overgrazing, usually indicated in this type of habitat by the erosion of topsoil and invasion of mesquite and creosote shrub. Cattle and goats destroy browse needed by the tortoises as well as burrows and cover sites.

2. Overutilization for Commercial, Sporting, or Educational Purposes. In the past, bolson tortoises have been in demand for private collections, zoos, and museums in the United States and elsewhere; occasional shipments have reached dealers in El Paso. The extent of this collection is presently unknown in light of the tortoise's status as an Appendix II species on the Convention on International Trade in Endangered Species of Wild Fauna and Flora. However, Mexico is not a party to the Convention and it is likely that some trade is continuing. As recently as January 1978 Americans have been reported in Ceballos, Durango buying specimens.

3. Disease and Predation. Natural predation is probably only a minor factor contributing to the status of the bolson tortoise. However, human predation may be the main cause for the extirpation or reduction in numbers of this tortoise over large areas of its range. This species is used extensively for food by the local population and although much of the area inhabited by tortoises is only sparsely settled, the tortoise populations are often eliminated as far away as 10 km from the nearest habitation. As settlement increases, continued predation on the tortoises will accelerate.

4. The Inadequacy of Existing Regulatory Mechanisms. Although permits are required by Mexico for the scientific collection of this species, no active resident personnel are present to enforce whatever legal protection may exist. There is no legal protection for the tortoise from local consumption. According to Dr. Morafka's report, the enforcement of existing trade restrictions is also lacking.

5. Other Natural or Man-made Factors Affecting its Continued Existence. Not applicable.

Because this species is not domestic and there was no Critical Habitat involved in the proposal (Critical Habitat is not determined for a foreign species), only minor adjustments had to be made to prepare the final document for listing.

The package is presently being circulated for in-house review by the Fish and Wildlife Service and it is expected to be published shortly. All comments received were favorable to the listing as Endangered. Of additional note -- the U.S. delegation to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), presently meeting in San Jose Costa Rica, has recommended that this species be upgraded to Appendix I status which should provide additional protection against trade.

Gopher tortoise, *Gopherus polyphemus*. The Office of Endangered Species will be in contact with the newly formed Gopher Tortoise Council to monitor the status of this species. As data become available from various studies presently being conducted, the Service will request the recommendations of those most familiar with the tortoise before deciding what, if any, action to take to help insure the survival of this species.

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---. 1978*b*. Status of the petition to list the Beaver Dam Slope population of *Gopherus agassizi* as Endangered. pp 55-57 *In* Proceedings of the 1978 Symposium, Desert Tortoise Council.

Office of Endangered Species
U.S. Fish and Wildlife Service
Washington, D.C. 20240

State Report - Arizona

Donald J. Seibert
Bureau of Land Management

This past year the desert tortoise program in Arizona has taken a giant step forward. Judy Hohman has completed her 2-year study of the desert tortoise on the Beaver Dam Slope in Arizona; the first such study funded by the BLM in Arizona. A paper by Judy is included in these Proceedings.

The BLM and the Bureau of Reclamation (BR) initiated an inventory of the desert tortoise in Arizona. The inventory is being conducted by Betty Burge. Her first year's report is included in these Proceedings.

The California and Arizona offices of the BLM are starting a 2-year research study committee on, "The Effects of Livestock Grazing on Desert Tortoise Populations." The research is planned to be conducted by Dr. Fred Turner with the Laboratory of Nuclear Medicine and Radiation, Department of Energy.

Merritt Keasey, Curator of Small Mammals, Arizona-Sonora Desert Museum, Tucson, spoke at the Symposium about the desert tortoise program at the Arizona-Sonora Desert Museum. They have reared several tortoises at the museum and have an albino one. He invited the people to visit the Museum while in the Tucson area.

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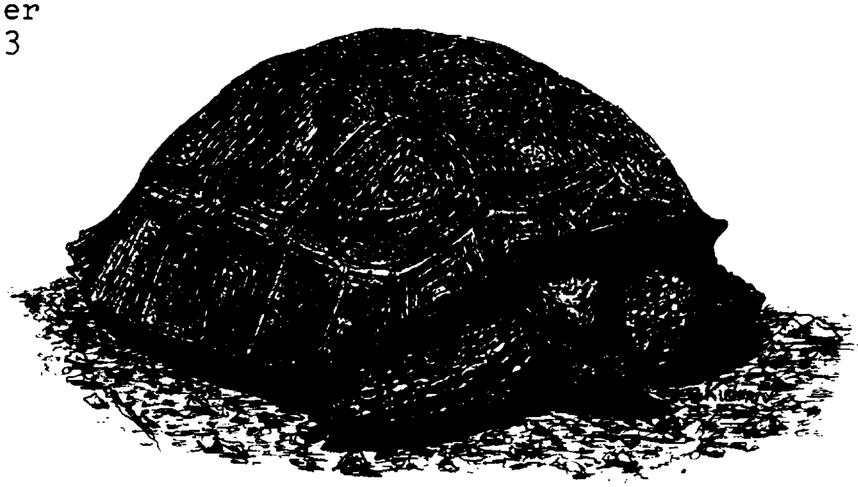

A Survey of the Present Distribution of the Desert Tortoise, *Gopherus agassizi*, in Arizona

Betty L. Burge

To sample for tortoises and their sign, 289 sites were transected for a total of 800 miles [= 1288 km]. Most sites were in west-central Arizona. Transect sites were spaced as regularly as possible and averaged 1.3 per township. Terrain ranged from bajada to mountaintops. With the exception of 14 sites on bajada north of the Grand Canyon in the northwest corner of the State, tortoises and sign were most often found on slopes with extensive outcrops and boulders, with gradients up to 70%. Ninety-five percent of the sign was found on slopes; those with spheroidally weathered granite yielded significantly more sign than volcanic hills. Burrows dug in exposed soil were rare -- 95% of all cover sites were among or under rock formations or in cavities in various consolidated materials. The frequency and density of sign was greatest in Arizona Upland communities (Palo Verde-cacti) of Sonoran Desertscrub. Population densities of more than half of the 94 sites with sign were estimated at $\leq$50 tortoises per square mile [= 2.6 km^2].

INTRODUCTION

Field work to determine the present distribution of the desert tortoise within designated areas in Arizona extended from May through October 1978. Public and private land other than State and National parks, forests, and monuments; Indian reservations and military installations were sampled by walking transects. Objectives were: (1) to determine the distribution of tortoises within the sampled area, (2) to show any relationships of the presence of tortoises and sign to areas with particular characteristics of topography and vegetation, and (3) to estimate relative densities.

DESCRIPTION OF DESIGNATED AREAS

The predetermined areas to be sampled (Fig. 1) were within the geographic distribution of the desert tortoise with the possible exception of part of the Safford District at the southeast edge of the State (Stebbins, 1966). After work was in progress and some transects completed, the Safford District and other portions were deleted. The deleted areas in which transects had been made were referred to collectively as Area B. The remaining areas designated for transects (Area A) comprised ≈8000 square miles [= 20,720 km^2].

North of the Grand Canyon the transect sites were primarily bajada dissected to various degrees by washes with occasional exposures of consolidated gravel with cavities.

Elevations transected ranged from 2000 to 3800 feet [= 610-1159 m].

Area A south of the Grand Canyon was topographically varied and included alluvian fans, bajadas, sand dunes, mesas, isolated hills, foothills, and mountain ranges. On slopes, exposed rock formations were common. Principle rock types were Precambrian granite, Precambrian gneiss with varying amounts of granite; and Cretaceous to Quarternary volcanics consisting mainly of andesite and basalt.

Major biotic communities included Mojave Desertscrub, Semi-desert Grassland (scrub grassland), Interior Chaparral, and Lower Colorado Valley and Arizona Upland subdivisions of Sonoran Desertscrub (Brown and Lowe, 1974*a*).

METHODS

Plotting Transects and Establishing Site Criteria

The principle approach to coverage of the areas to be transected was that of regular distribution of the total number of transects within the total area designated. Sites were plotted in advance on county planimetric-general highway maps which showed a high percentage of available access routes. Subsequent, on-site changes were made as necessary. Density of plotted locations averaged between 1 and 2 sites per township. Site locations were limited to those accessible by established roads. Elevations above 4600 feet [= 1,402 m] were excluded.

Once in the field, plotted sites were deleted or shifted as necessary due to access changes or denials due to road conditions or ownership. Agricultural land and extensive mine operations were not transected. Although mining sites were numerous, the majority were small-scale, abandoned, or apparantly worked infrequently and many were so localized as to be without evidence on the initial approach to a site. Construction sites and concentrations of buildings were avoided. The potentially decimating effect of paved roads (heavy traffic) upon tortoise density (Nicholson, 1978) was usually avoided by choosing sites that were at least 1 mile from paved roads. Unimproved and graded roads were the most common, and sites by unimproved side roads were chosen whenever possible. Depending upon the implied amount of traffic, transects were started 25-400 m from unpaved roads.

Grazing livestock (primarily cattle) were ubiquitous, and transecting grazed areas was unavoidable; however, in a few instances sites were elininated because of extreme denudation and compaction apparently due to grazing. Sites chosen appeared to display homogeneity of topography and vegetation.

Transect Dimensions

Initially, 800, 1-mile [= 1.6 km] transects 10 yards [= 9.1 m] wide were to be made and the first 69 transects were each 1 mile. For more reliable sampling (to be explained later) transect length was increased to 3 miles [= 4.8 km] beginning with Tr#70-72.

Where a predetermined heading could be followed -- on flat and rolling topography -- the transect shape was a straight line (1 mile) or an equilateral triangle (3 mile). Two 1½-mile [= 2.4 km] equilateral triangles were made when a field assistant was present. When strict headings were used, washes encountered were transected as depressed discontinuities of the topography much as low ridges, occasional outcrops and dikes were considered as raised discontinuities. Raised and depressed features were crossed on the heading chosen. Transects over hills and mountains were seldom straight. Following a given heading was virtually impossible because changes were necessary to secure safe footing and circumvent impasses. A switchback pattern was more the rule. Controlling the distance travelled was done by counting paces, adjusted as appropriately as possible when walking on slopes.

Recording Data

Data were recorded in two major categories: (1) description and evaluation of the site; and (2) the presence of tortoises and sign (see sample form Appendix A).

Vegetation at each site was classified to biotic community according to site location on the vegetation map (Brown and Lowe, 1977) and visual appraisal. Beginning with Tr#349-351 sites were classified further to the Association level (Brown and Lowe, 1974*a*, 1974*b*).

The substrate was described in relation to the presence and relative abundance of exposed rock, including: (1) outcrops of consolidated gravels, agglomerate, and welded tuff in addition to outcrops of granite, basalt, etc.; (2) talus and the relative amount of pebbles, cobbles, and boulders; (3) cavities -- primarily those formed by water action though subsequent improvement by various animals may be indicated; and (4) crevices -- eroded joints in outcrops or spaces beneath and between boulders. A cover site potential value (CPV) was assigned based upon an evaluation of the amount and functional value of the above for tortoise cover; for example, the size of the crevices where rock alone was involved, the presence of soil under outcrops and boulders, the stability of the talus, the accessibility and mean opening size of cavities on slopes or wash banks, and the extent of negotiable, contiguous pathways among obstructing rock formations. Relative only to the rock formations present, a site was rated 1 (poor), 2 (fair), 3 (good), or 4 (excellent). The apparent availability and suitability of soil for burrowing was described or implied in the general description of the surface.

The number of cattle, sheep, burrow, horses, and deer seen were recorded. For each species the abundance of tracks, trails, and droppings were evaluated collectively and recorded according to the following scale: 0 (absent), 1 (uncommon), 2 (occasional), 3 (common), and 4 (abundant).

Tortoises found within reach were measured (carapace length in millimetres) and those $\geq$ 180 mm [= 7 in], sexed. Extensive injuries and any that may have been predator caused were described. Anomalies of unusual degree were noted. Behavior or situation was described and if feeding, the food plant, identified.

Tortoise remains were listed in 1 of 3 categories indicating relative time of exposure or at least degree of disarticulation. Shells (length) were measured and sexed if possible. Disarticulated bones were named and age estimated as adult (>214 mm [= 8.4 in]), subadult (180-214 mm [= 7-8.4 in]), large juvenile (100-179 mm [= 4-7 in]), small juvenile (<100 mm [= <4 in]), or hatchling.

Scats were counted and listed as being of the current season, dark, faded (partially), or white -- indications of relative duration of exposure. Adherent scats were tallied as 1 (1 scat group) with the number of scats in the group circled (typically 2 or 3). Visible scats in cover sites or at the opening and apparently excavated from inside were counted as accurately as possible but were not included in sign totals. The surfaces of pack rat (*Neotoma*) middens were scrutinized for scats and remains, and wherever found coyote and fox scats were examined for tortoise remains.

Tortoise eggshell fragments were recorded by location and microhabitat. The number of eggs represented was estimated. The inner surfaces were examined for indications of embryonic development, i.e., eroded as opposed to convoluted. This relationship has been described by Burge (1977*a*). The adjacent soil surface was examined for additional fragments and indications of the nest site.

Mating depressions, track or shell impressions other than those at cover sites were noted.

The presence of tortoises inhabiting alluvial fans and bajadas in the Mojave Desert of California, Nevada, and southwest Utah is typically indicated by the presence of cover sites (pallets and burrows) dug in soil by the tortoises (Berry, 1972, 1974*a*; Burge, 1978; Camp, 1916; Woodbury and Hardy, 1948). The characteristic half-disc shape of the opening may be altered by predation, predator or rodent use, and weathering, but with sufficient sampling recognizable burrows and pallets will be evident; for, although tortoises inhabiting alluvial flats do utilize cavities in consolidated gravel outcrops that may occur in the washes, the majority of cover sites are those dug in the soil by the tortoises (Burge, 1978; Woodbury and Hardy, 1948).

Where tortoise cover sites (pallets, burrows, and dens) occur almost exclusively among rock formations as in most areas sampled in Arizona south of the Grand Canyon (*see* Results), the cover site is not as obvious and is not always identifiable -- lacking the typical shape of the opening and channel. Some superficial cover sites show little disturbance of the substrate and appear like the numerous potential cover sites. Similarly, outcrops of calichified gravels, agglomerate, and welded tuff tend to form cavities which in some areas are heavily used and improved by tortoises; however, cavity-presence is not necessarily a result of tortoise activity. For the above reasons, only those cover sites that showed definite sign of tortoise use were tallied. The presence of other "possibly tortoise" cover sites was noted as such.

Cover site length (to 200 cm [= 78.7 in]) and width at the base of the opening were measured to at least the nearest 5 cm [= 2 in].

The differences among various groups of data were tested for significance at the 1% level. Tests included: Student's t-test, Chi-square, Spearman's rank correlation coefficient (r_s), and correlation of attribution (r).

Population Density Estimates

A reliable index for estimating tortoise densities based upon comparative number of sign from sample transects on areas of known density has not been developed; however, a systematic study is in progress as part of the desert tortoise studies within the California Desert Plan (BLM, Riverside, CA). In Arizona, density had been estimated at 3 sites of intensive study. Two of the sites were in the Mojave Desert north of the Grand Canyon; the third, in the Sonoran Desert. The sites were used for comparative sampling and were considered broadly representative of tortoise habitat in their respective deserts.

The 2 study areas in the northwest corner of Mojave County are at the southwest edge of the Beaver Dam Mountains. These sites are being studied under the aegis of BLM for present tortoise population status and the history of grazing. Sites are 5 miles [= 8.0 km] apart and had been designated as the Upper Site (2500 ft [= 762 m] elevation) and the Lower Site (2000 ft [= 610 m]). Each is slightly more than 1 square mile of bajada dissected by washes in which cavities in the consolidated gravels are common. Creosote bush (*Larrea divaricata*) and burrobush (*Ambrosia dumosa*) are dominant at both sites but the Upper Site also supports Joshua trees (*Yucca brevifolia*). Estimated tortoise density of the Upper Site, 30-35 per square mile; the Lower Site, 40-50 per square mile (J. Hohman, *personal communication*). To sample each site a regularly spaced grid pattern was plotted to equal 12 miles [= 19.3 km] and four, 3-mile transects were made.

The third site was in the Granite Hills of the northern Picacho Mountains, Pinal County, elevation 2000 ft [= 610 m]; Arizona Upland community. The tortoises at this site were the subject of study from 1975 through 1978 by J. Schwartzmann, graduate student, Arizona State University. The study site is ≈1.5 square miles [= 3.9 km^2] centered on the hills but includes some adjacent bajada. The relatively isolated ridge of hills rises abruptly from the bajada to ≈2200 ft [= 671 m]. Granite outcrops and groups of large boulders are common. Tortoise density had been estimated at 50 per square mile; tortoises spending most of their time on the slopes (J. Schwartzmann, *personal communication*).

The 29 miles [= 46.7 km] of transects were designed to cover the area as evenly as possible but individual transects were irregularly shaped, particularly on the slopes.

RESULTS AND DISCUSSION

No sign was found in the 38, 1-mile [= 1.6 km] transects made in Area B. Of the 31 transects in Area A, 2 were later transected for 3 miles each (repeated); and 5 were included in the multiple transects made at the Granite Hills study area. Of the 19, 1-mile transects that remained unrepeated or incomplete, 4 yielded sign. The following pertains to the results of 3-mile transects.

North of the Grand Canyon

Sign Frequency and Density

Designated area. Within the designated area 12 sites were sampled (Fig. 1). Topographically, 4 sites were designated as flat and 8 as rolling. No major slopes were included. Tortoise sign (which in this report will include live tortoises) was found at 10 sites from elevations of 2000-3800 ft. With the exception of 1 site (Tr#139-141) in blackbrush community (*Coleogyne*), sites with sign were in *L. divaricata--A. dumosa* community; some included *Y. brevifolia*.

Cattle sign was evident at 11 (92%) of the sites and abundant at 4 of them including the site where the most sign was found (42). However, at the site with the next highest number of sign (27) there was no evidence of cattle, only occasional burro sign.

Old and recent off-road vehicle tracks were observed at 8 sites (67%). The total number of tracks crossed was 18 (0-6 per site); all but 2 were 4-wheel tracks.

Sign of potential or known predators was evident at each site and included that of kit-fox (*Vulpes macrotis*) and coyote (*Canis latrans*). Sign included tracks, scats, and an occasional den. Excavated rodent burrows were the most numerous sign. Four of the tortoise burrows showed sign of partial predator excavation; however, the number of extensive predator excavations that were of tortoise burrows was not known. No tortoise remains were found in the 27 canid scats examined and none of the tortoise remains showed definite sign that predation was the cause of death. Accounts of canid predation have been reported by Berry (1972, 1974*a*) and Burge (1977*a*, 1977*b*).

Frequency and density values for each kind of sign are given in Table 1. The mean number of sign per site where sign was found was 10.0 ± 13.9 (1-42). No tracks apart from those at burrows and no mating depressions were observed.

The 3 live tortoises were adults; none were accessible for measuring.

Eleven remains were of adults and 4 of large juveniles. From the condition of the remains the estimated time of exposure was <2 yrs for 7 of the specimens; >2 yrs for 8. Of the 81 neotoma middens examined, 4 (5%) yielded tortoise sign -- 20% of the remains (3) and 14% of the scats (3).

The number of scats of the current season and those that were dark and unfaded totalled 14; those partially faded to white, 8. If this sample is representative of the ratio of recent- to-old scats among populations as a whole, it implies a relatively rapid turnover rate and that scats are representative of the current populations. This is discussed further under Results, south of the Grand Canyon.

The 1 group of eggshell fragments was found on freshly exposed soil of the burrow apron. The amount was estimated to be <1 complete eggshell. The inner surfaces of the fragments were highly convoluted indicating little or no development of the embryo. The nest site probably had been near the burrow opening -- the site most commonly observed for eggshells and one of the types of sites known to be used for nesting (Berry, 1974*a*; Burge, 1977*a*, 1977*b*, 1977*c*; Woodbury and Hardy, 1948).

Of the 59 cover sites, 11 (19%) were in cavities in consolidated gravels, the remainder in soil. Outcrops of consolidated gravels with cavities were not observed at each site and when present did not always yield tortoise sign. The implied use of soil as the primary substrate for burrows was typical of tortoises inhabiting bajadas elsewhere in the Mojave Desert.

<u>Upper and Lower test sites</u>. The results of the 8 sample transects at the 2 test sites outside the designated area are included here as additional data comparable to those sites within the designated area. The values presented in Table 2 include averages of the 4 transects made at each site. The frequency of sign on each of the 8 transects was 100%.

The 6 live tortoises were adults. The remains were probably underrepresented because some of them had previously been removed by the investigator -- <50% of those that she observed (J. Hohman, *personal communication*).

Of the 128 cover sites found, 17 (13%) were in consolidated gravel wash banks; the remainder were in soil.

No mating depressions were observed nor were tracks, apart from those at burrows.

Cattle tracks and droppings were occasional at both sites. Both 2-and 4-wheel ORV tracks were present at both sites.

Predator sign (fox and coyote) were evident at both sites. None of the tortoise remains showed definite sign of predation as a cause of death and none of the 13 canid scats examined contained tortoise remains. Five neotoma middens were examined; only 1 yielded sign.

The percentages of each type of sign from the test sites (Table 2) are close to those from the 10 independent sites (Table 1). Also similar are the percentages of burrows in caliche cavities. The combined values of Tables 1 and 2 are shown in Table 3.

Population Density Estimates

From the results of the 2 test sites, 3 directly proportional projections were made based upon the weighted mean number of each of the following groups of sign: scats, intact cover sites and total sign, each plotted against the mean population density. The projection was used to estimate densities at the 12 sites north of the Grand Canyon where independent transects were made. Each of the 3 sign-groups of each independent site was assumed to represent the mean although there was no way of knowing where the number of sign observed would have fallen in relation to the mean of that site if several transects had been made there. Projected population densities for each of the independent sites are shown in Table 4; Upper and Lower test sites are included for comparison. For the test sites, total sign and cover sites gave the better estimates; scats, the poorest. Scats occurred with 100% frequency but comprised only 11% and 31% of the sign. This density difference between the sites was greater than for cover sites and total sign and therefore their mean was less representative of both.

Cover sites comprised 60% and 69% of the sign at the 2 test sites (Table 2) and 59% of all sign found at the independent sites (Table 1). They occurred with 100% frequency on the test sites and 70% frequency at the 10 independent sites with sign; 100% frequency at sites with more than 1 sign.

Despite the closeness of the estimate for the test sites using total sign, it contains aspects of unreliability because it includes kinds of sign that may not reflect current populations and those sign that do, may do so inconsistently. For example, remains persist and most of those observed were probably older than the oldest scats. At the test site remains were underrepresented by <50% but on the other hand, they comprised a relatively small percent of the total sign. Scats probably reflect the current population -- a function of their fast turnover rate (*see* Results) south of the Grand Canyon. The visibility of live tortoises depends in part upon their activity level which varies daily and seasonally. Cover sites in soil may show seasonal changes such as collapse, particularly during periods of heavy precipitation. They may be excavated by predators or changed because of predator use. Similarly a tortoise may use a kit fox or rodent burrow complex without making discernible changes in the opening and therefore these sites may not be recognizable as tortoise cover sites (Burge, 1977*b*, 1977*c*).

Determining which sign-group provides the best index from which to estimate population densities must await further testing on sites of known density.

Assuming that tortoises may have been present on the 2 sites where no sign was found and that tortoises may no longer be present where only a few old sign were found and considering the possible range (within a given sign-group) that represents a given density of tortoises (Table 2), the first 9 independent sites (Table 4) may have densities up to 20 tortoises per square mile; the next 2 sites, 20-50; and the last site, 75-100. All of the above estimates must be considered highly tentative because of the several sources of considerable potential error which could not be accommodated in the calculations.

South of the Grand Canyon

Granite Hills Test Site

The results and discussion of the test transects in the Granite Hills will be presented first because of the change in methods that resulted -- the increase of transect length from 1 to 3 miles.

Of the 29 miles of transects, 22 were on slopes and 7 on the adjacent flats. On slopes where 96% of the sign was found, the frequency per mile was 86%. Tortoise density had been estimated at ≈50 per square mile. The frequency and sign per mile at both test sites north of the Grand Canyon where densities were estimated at 30-35 and 40-50 per square mile was 100%. Only when transect length at the Granite HIlls site was increased to 3 miles was the frequency of sign 100%.

The differences between samples from the test sites north and south of the Grand Canyon were also reflected in the ranges and standard deviations of total sign on 3-mile transects (Table 2 and Table 5). A factor affecting the standard deviation and range in the Granite Hills slopes was thought to be the localization of sign within transects on slopes as opposed to the apparently more random distribution of sign on flats (observable north of the Grand Canyon).

Assuming that the movements of tortoises living on flats are less dictated by limitations of the microhabitat and that on flats, being less heterogeneous than slopes, tortoises' preferences for sub-areas within a site would be less than in rocky habitats, one would expect sign to be more evenly distributed on flats. This was evident in the Granite Hills where the range of sign per 3-mile [= 4.8 km] transect for 7 transects was 2-26, a variation of 12-fold; whereas, the range for groups of 4 transects made at 2 sites on the flats (Arizona Strip) were 15-18 and 22-34, a variation of less than 2-fold. If localization and relatively extreme variation in total sign from transect to transect was a function of slopes in general, the continued use of 3-mile transects was supported.

As a result of the multiple transects in the Granite Hills, the decision to increase transect length from 1 to 3 miles was supported as possibly necessary (1) to reveal presence of tortoises in areas with density less than that of the Granite Hills; (2) to correct for localization of sign; and (3) to increase the frequency and number of each type of sign, important for developing a density index whether based upon one kind of sign or total sign.

Frequency and density values for specific sign found on the Granite Hills transects are given in Table 5. The 2 live tortoises found were juveniles. Sign on the flats included 2 scats and a weathered fragment of adult carapace. All remains on slopes were weathered fragments -- 2 from adults and 1 from a large juvenile. None of the remains were in neotoma middens. Of the 118 neotoma middens examined, 4 (3%) yielded sign -- 5 scats, 10% of all scats. None of the 85 canid scats examined contained tortoise remains.

Cattle sign was judged "common" on the flat and "occasional" in the hills. There was little evidence of ORV use; however, mining development pits were common.

The Designated Area as a Whole

In Area A, 218 sites were sampled by 3-mile transects (Fig. 1). The Granite Hills lies within Area A and comprised 2 sites. The average values from the slopes and from the flats were included with the following results.

Of the 218 sites tortoise sign were found at 84 (38.5%). The total number of sign was 1380; $\bar{x}$=16.4±23.6 (1-126). Sign included live tortoises, scats, remains, eggshell fragments, and cover sites. No mating depressions or tracks and shell impressions, apart from those at cover sites, were observed.

Site elevations ranged from 900 to 4600 feet [= 274-1,402 m]; sign was found from 1000 to 4400 feet [= 305-1,341 m]. Topographically sites were classified as 1 of 3 types. Flats included valleys, alluvial fans, bajada, mesas, and plateau tops with percent of slope ranging from <1 to ≈10; Rolling topography included series of alluvial knolls or flat-topped ridges of dissected alluvium with ≈10-32% slopes; Slopes included hills and mountains to 80% slope. On slopes, the within-site variation in percent slope was great; tortoise sign was found on from <20 to 70% slopes. The differences among the 3 topographic types were not equal and rolling topography was more similar to flats than to slopes. Slopes comprised 41% of the sites sampled; rolling topography, 17%; and flats, 42%.

Because the number of transects entirely in washes (7) was too small for statistical analysis as an independent class, the data from each of these transects were grouped with the most appropriate of the 3 topographic types.

Five biotic communities were sampled; the percentage of sites represented by each is as follows: Sonoran Desertscrub, 74% (Arizona Upland, 52% and Lower Colorado Valley, 22%); Mohave Desertscrub, 13%; Semidesert Grassland, 7%; and Interior Chaparral, 5%. Although not calculated, the percentage of transects within each community type appeared to be close to the percentage that each type comprised of the suitable and accessible designated area.

Predator sign was observed at all but 3 sites. No remains were found in 1241 canid scats examined. Of the 24 live tortoises that could be examined, 2 showed minor injury, one of them was probably attached by a coyote. On tortoise remains it was not possible to separate sign of predation from that of scavenger utilization.

Cattle tracks and droppings were evident at 177 sites (81%) and of these, common or abundant at 38%. Burro sign was seen at 81 sites (37%) and sheep sign at 5 sites (2%). ORV tracks were seen at 51 sites (23%), 1 to 10 per site.

Sign Frequency

Sign frequency in relation to topography. Sign frequency on rolling sites did not differ significantly from a random distribution (r=0.0529), frequency on flats was significantly less than expected (r=0.4728), whereas, frequency on slopes was significantly greater than expected (r=0.5210) (Table 6).

Of the 22 sites on flat and rolling topography that had sign, only 3 of the sites were not within 2 miles [= 3.2 km] of hills or mountains. Two of those were on the dissected alluvium above the flood plain of the Hassayampa River and the third was on the dunes of the Cactus Plain.

At 16 locations paired transects were made -- 1 on the slopes and 1 on the adjacent flats. The frequency of sign on the flats at paired sites was 19%; at all other flats, 10%. Although the difference was not significant, the influence of adjacent slopes is suggested; however, sign frequency in each group of flats was significantly less than that of slopes.

The presence of sign was examined in relation to cover site potential values (CPV) (Table 7). Where CPV was 0-2 (absent to fair in relation to rock formations) the sign frequency was significantly less than expected; where CPV was 3-4 (good or excellent) sign frequency was significantly greater than expected.

The CPV of all sampled sites were examined in relation to topography. The correlation was negative with respect to flats ($r= -1.0$); less so with respect to rolling sites ($r= -0.50$) and positively correlated with slopes ($r= +0.40$). To show these correlations with respect to sign frequency for each topographic type Chi-square was used. The sample size was too small to give reliable values for flat and rolling sites; however, slopes showed a significant difference from a random distribution of sign -- sites with CPV of 3 and 4 had a frequency higher than expected and sites with CPV 1 and 2, lower than expected (there were no CPV of 0 on slopes).

Frequency of sign at sites with CPV 2, 3, and 4 were compared in relation to composition of rock formations (sites with CPV of 0 and 1 had minimal or no rock exposures). The predominant rock types and those that were compared were granite, granite-gneiss, and volcanic. For each type the difference in sign frequency was not significant.

Six of the 7 sites entirely in washes were on flat or rolling topography; 2 were at the base of mountains. Sign was found in 1 of the 6 washes on flat or rolling topography and in 1 at the base of mountains. These 2 sites and 3 othere where no sign was found had CPV of 3-4 because of numerous cavities in the consolidated gravel banks.

Three transects were made on sand dunes in the region called the Cactus Plain, north of Bouse. Dunes appeared to be of the tranverse type and were stabilized with vegetation (primarily *Hilaria rigida* and *A. dumosa*). Two faded scats were found a few metres apart at the base of 1 dune.

Sign frequency in relation to biotic communities (Table 8). Sign frequency among the 5 biotic communities sampled was significantly different from a random distribution, with Arizona Upland producing the largest effect. Each biotic community was tested separately: Arizona Upland showed a positive correlation (X^2=26.77, r=0.3504); Mojave Desertscrub showed a negative correlation (X^2=9.88, r=0.2129); and Lower Colorado Valley showed a small negative correlation that was not significant at the 1% level (X^2=5.33, r=0.1593); Semidesert Grassland and Interior Chaparral showed no correlation.

Sign frequency in relation to biotic communities and topography. The frequency of sign within each topographic type was examined in relation to community type (Table 9). No sites with sign were observed on flat or rolling topography with Mojave Desertscrub, Interior Chaparral, or Semidesert Grassland (no sites were sampled on flats with Interior Chaparral). Since values for each of the above were too small to test reliably with Chi-square, Arizona Upland and Lower Colorado Valley were tested separately for goodness-of-fit after combining flat and rolling values for each. Frequency of sign in Lower Colorado Valley on flat and rolling sites and on slopes did not differ significantly from the expected frequency distribution; whereas, in Arizona Upland frequency of sign differed significantly -- less than expected on flat and rolling sites and greater than expected on slopes.

The significantly higher frequency of sign in Arizona Upland communities (Table 8) could be the result of topography in part, i.e., 74% of all sites with sign were on slopes and 77.4% of sites with sign on slopes were in Arizona Upland communities. When the ratio of the sites with sign in Arizona Upland on slopes was compared to the ratio of sites with sign for the other communities on slopes, the ratio in Arizona Upland was significantly greater. This, coupled with the greater contribution of sites with sign by Arizona Upland (77.4%) could explain the higher frequency of sign observed in Arizona Upland regardless of inherent qualities of Arizona Upland communities that might function as preferred habitat. In Mojave Desertscrub and Semidesert Grassland where 79% and 75% of the sites sampled were on flat and rolling topography no sign was found at those sites. This appears to reflect the observed relationship of few sign away from slopes (Table 6).

Vegetation classification was made to the Association level at 152 sites beginning with Tr#349-351. Within Sonoran Desertscrub, Arizona Upland communities were subdivided into 15 associations and Lower Colorado Valley into 9 associations. Mojave Desertscrub was subdivided into 7; Semidesert Grassland into 6; and Interior Chaparral into 6.

Of the 43 associations sampled, 34 (79%) were represented by only 1-3 sites. Only 4 associations were represented by 10 to the maximum 21 sites. Representation was considered insufficient for reliable comparisons between associations. Certain relationships were suggested, however. For example, of 21 sites in Mixed Upland association of Sonoral Desertscrub, 11 were on slopes and 10 on flat or rolling topography. The frequency of sign was 10 and 3 respectively, suggesting again the preference of tortoises for slopes over flat and rolling topography.

Sign Density

Sign density in relation to topography. Sign density on flat and rolling topography was significantly less than expected;

on slopes, significantly greater than expected assuming a random distribution (Table 10).

Using Spearman's rank correlation coefficient, sampled slopes shows a perfect positive correlation of sign density with increasing CPV (r_s=+1); rolling topography shows a slight positive correlation (r_s=0.23); whereas, flats show a strong negative correlation (r_s=0.70) and correspondingly, where CPV was 0 through 2, sign densities were significantly less than expected and where CPV was 3 and 4, significantly greater than expected. When each topographic type was tested separately for the relationship of sign density to CPV grouped 0-2 and 3-4, the observed number of sign on flat and on rolling topography was not significantly different from the expected; however, on slopes, where 95%of sign was found, the difference between the 2 CPV groups was significant -- where CPV was 1-2 sign density was less than expected and where CPV was 3-4, greater than expected. The significant difference in sign density between slopes with CPV of 1 and 2 and those with 3 and 4 implies that in spite of available, exposed soil for burrowing, it is the cover site potential of rocks on slopes and not slopes alone that support the most tortoises (Table 11).

Sign density was examined in relation to rock composition at sites with CPV 2 through 4 in the major rock types -- granite, granite-gneiss, and volcanic (Table 12). Sign density was significantly different from a random distribution, granite and granite-gneiss having more sign than expected; volcanics, less. Differences in the mean number of sign among the 3 rock types were compared for those sites where most sign was found (slopes with CPV of 3 and 4). The mean of both granite and granite-gneiss differed significantly from the mean of volcanics. That the difference between the mean of granite and granite-gneiss was not significant is understandable because granite is common to both types. Unlike sign density, sign frequency had shown no significant difference among rock types. The potential for granite and granite-gneiss to support higher densities of tortoises than volcanics is consistent with the observed correlation of CPV and rock type -- granite, r_s=+0.9; granite-gneiss, r_s=+0.7; and volcanics, r_s=+0.23. Spheroidal weathering, typical of much of the granite observed, was one of the major characteristics found associated with granitics assigned a CPV of 3 or 4. The rounded boulders and undercut outcrops with vertical and horizontal crevices form excellent protective openings for tortoise burrows provided that there is contact with an adequate depth of soil or gruss in which the tortoise may burrow. In spite of the above tests and observations, neither the number of identifiable cover sites nor the frequency of additional, possible but questionable cover sites, differed significantly from the expected random distribution among the 3 rock types.

Sign density in relation to biotic communities. Density of sign was examined in relation to biotic communities. Three of these were represented by small sample sizes -- Mojave Desertscrub, Interior Chaparral, and Semidesert Grassland (Table 13). Two of these exhibited a very wide range of sign and high means: Mojave Desertscrub sites showed sign totals of 18, 91, and 126 (the last being the most sign found at any site), the mean was 78.3; Interior Chaparral sites yielded 18, 28, 65, and 91 with a mean of 50.5. Although the range of sign of all transects with sign was 1-126 with a mean of 16.4, only 6 transects yielded more than 39 sign and 4 of these were in the 2 communities just mentioned. For this reason, the values from these 2 communities were considered possibly anomalous and were excluded from the following analysis. When sign densities were calculated proportional to the number of sites with sign in each community and a goodness-of-fit test was performed on the observed densities, only Lower Colorado Valley sites showed a significant difference -- less than half the expected number of sign.

Sign density in relation to biotic communities and topography. On flat and rolling topography only Arizona Upland and Lower Colorado Valley sites yielded sign (Table 14). For each of the 2 communities, sign density was tested with respect to topographic type. Both Arizona Upland and Lower Colorado Valley showed significant differences -- less than the expected number of sign on flat and rolling sites and more than expected on slopes. The results of these tests were consistent with the previously tested relationship of sign density and topography (Table 10); however, on slopes, where most sign was found (95%), the mean number of sign per transect on Lower Colorado Valley sites (5.91) was significantly less than the mean number of sign per transect on Arizona Upland (13.25). The significantly lower number of sign in Lower Colorado Valley communities appears to be a function of something other than topography; very possibly, the relatively poor water relations of Lower Colorado Valley communities and its lower plant species diversity (Shreve and Wiggins, 1951).

Frequency and Density of Specific Kinds of Sign

Frequency and density of each type of sign are given in Table 15.

Live tortoises. A total of 50 live tortoises were observed, 48 on transects. The largest measured adult was a 301 mm [= 11.8 in] male found 10 m [= 32.8 ft] off-transect. A 250 mm [= 9.8 in] female was found walking on a well travelled gravel road within 1¼ miles [= ≈2 km] of 2 transect sites where sign had been found.

Tortoises were found on slopes with the exception of 5 sites. The 5 sites ranged from adjacent to within 2 miles of hills or mountains. Six of the 7 tortoises found on flat or rolling sites were in burrows in various rock formations. One tortoise was found walking along an unimproved road. On slopes, tortoises were found at various locations from base to top.

Of the tortoises found on transects, 26 were not measured. These were adults that were out of reach in burrows.

One tortoise was observed feeding on *Junusia gracilis*.

Sign of relatively recent injury due to predation was observed in 2 juveniles. Only 1 injury appeared to have been severe -- an old depressed fracture of the carapace of a third juvenile. Single soft ticks (*Ornithodorus*) were seen walking on the shells of 2 tortoises.

Considering the tortoises seen on transects as a representative sample of one population (tortoise south of the Grand Canyon), the age-size distribution (Table 16) is similar to other populations whose structures have been reported (Berry, 1976; Burge, 1977*a*, 1977*b*, 1977*c*) in its higher proportion of adults; however, the 79% adults is considerably higher than the ≈50% observed in most other populations. The greater percent of adults may have been the result of the major habitat difference in Arizona where juveniles may be relatively more difficult to see because of the rocky substrate. It is also possible that lower reproductive success and/or lower juvenile survival rate are responsible.

At 20 sites, 1 tortoise was seen; at 8 sites, 2 tortoises; at 3 sites, 3 tortoises; and at 1 site, 4 tortoises. The relationship of number of sign to the number of live tortoises per site cannot be tested with reliability because of the low sample size. When the mean number of sign other than tortoises of the 31 sites where tortoises were found was compared with the mean number of sign from the 53 sites where no tortoises were found, the difference was not significant. Environmental conditions that vary with season and time of day are probably more responsible for the visibility of tortoises than tortoise density.

Remains. Six of the 36 sites where remains were found were on flat or rolling topography, 4 of these were adjacent to or within a mile of hills or mountains. Transport by predator is a consideration and also considering time and the persistence of bone, transport down slope by runoff may have contributed to some of the remains found off slopes. Neotoma may also be a factor, though not necessary unidirectional in effect. Neotoma middens were the source of 48.3% of the remains.

The surfaces of 2,729 neotoma middens were examined for sign; 70 (2.6%) yielded scats or remains.

Of the 50 remains, at least 12 (24%) were estimated to have been exposed for 2 years. The majority of the old remains were comprised of a single limb, limb girdle elements, or single or small groups of shell elements. Estimations of exposure time of disarticulated elements are less reliable than of intact shells and some of the 38 shell fragments and appendages may have been <2 yrs old. The age-size distribution of remains was similar to that of live tortoises; however, more of the remains were of juveniles (Table 17).

Eggshell groups. The fragments of each of the 9 eggshell groups represented no more than 1 eggshell; however, at most sites the eggshells were not very recent and evidence of exposure such as staining and scattering were typical. Disturbance of the sites was understandable as 7 of the 9 groups were found within a few centimeters of burrow openings at which nest cavities were sometimes evident. Two of the eggshell groups were found in the open and no nest site was apparent near either. In 6 of the 9 groups the inner surfaces of the fragments were eroded, indicating embryonic development. At the 8 sites where eggshells were found, total sign ranged from 3 to 26.

Scats. Scats were the most numerous of all sign and had the highest frequency. The average number of sign at the 17 sites where no scats were found was 2.7 (1-7). Neotoma middens yielded 4.1% of scats found.

The numbers of exposed scats that were of the current season and those still dark and unfaded were combined and those partially faded to white were combined. The relationship of relatively recent to old scats was examined. The total number of recent scats (509) was close to that of old scats (611). This ratio implies a half-life of scats of about 1 year; scat turnover is rather rapid. On the other hand, remains tend to persist and accumulate in the area, for the number of old remains (40.9) is 4.5 times as abundant as new remains (9). The relative persistence of different kinds of sign should be considered when sign is used as an index of tortoise density.

Cover sites. Utilization of rock formations as cover sites was typical throughout the 3 topographic types. Of 155 cover sites, 7 were on the flats and 4 of these were in soil at 1 site. Two other burrows in soil were in wash banks near the base of slopes (at 2 sites). The remaining 148 cover sites were in cavities in consolidated gravel, agglomerate or tuff, or under boulders or outcrops with varying amounts of soil or rock particles forming the floor. Cover sites were found at various locations from the top to the base of slopes. It was not unusual for neotoma middens to be found in tortoise cover sites of a variety of lengths. Mean length of 100 burrows ≤200 cm [= 80 in] excluding those of juveniles was 93± 37 cm (30-200) [= 37± 15 in (12-80)].

Cover sites comprised only 11.2% of all sign and were considered under-represented because of the inherent difficulty in identifying them with certainty. Where sign was found, frequency was 58.3% and the mean per site was 3.2±2.0 (0-10), values too low to support the use of cover sites alone as an index for estimating tortoise densities. Recall that in the Arizona Strip (Table 3) cover sites comprised 61% of the sign, were present at 75% of sites with sign, and mean per site was 7.6±9.2 (0-28).

Characteristics of Within-Site Distribution of Sign and Their Relationship to Methods

The localization of sign within a 3-mile [= 4.83 km] transect, apparent during the multiple transects at the Granite Hills site, was evident to varying degrees among sites sampled throughout the survey. For example, at Tr#292-294 the 18 sign were found within 150 m^2 [= 1,614 ft^2] on the lower half of the slope. At Tr#469-471, 22 of the 24 sign were along ≈50 m [= 164 ft]. At Tr#612-614, the 19 sign were in 2 areas >½mile [= .8 km] apart. At Tr#163-165, 19 sign were found on the west-facing slope; 4 on the east-facing slope. At Tr#241-243, 12 of the 14 sign were found in 1 area and 2 sign, a mile away. The most found in the above sites was 28. At the few sites where total sign was greatest (65-126) the hiatuses and concentrations were less apparent. It was also observed that cover sites and live tortoises were not necessarily found where scats were most numerous. Although the effect of runoff on slopes upon the redistribution of scats was seen in a few instances and is undoubtedly operating to some degree upon scats and remains, the above examples probably reflect differences in within-site utilization by the tortoises that appears to be independent of accessibility.

Another type of localization may possibly result in a sampling bias. On most slopes universial access was limited, that is, rock formations themselves which limited movements of a person traversing a slope undoubtedly had a greater effect upon tortoise movements. As a result, tortoises, scats, and possibly other sign probably were more concentrated along the natural pathways between obstructing rock formations. If so, a person committed to these pathways would observe a higher percentage of total sign than if his movements and/or the tortoises' were unrestricted. It should be understood that pathways were typically numerous and anastomosing.

The 3-mile transect was initiated with the intention of moderating the effects of (1) any natural clumping of tortoise sign that might be the result of sub-area preferences on the part of tortoises and (2) the effects of possible sign concentrations as a result of access limitations. Whether the 3-mile transect accomplishes these aims will require further testing (multiple transects on given sites); however, there is little doubt that the 3-mile transect is a more reliable measure of tortoise frequency and density than the 1-mile transect.

Population Density Estimates and Geographical Distribution

Indices derived from the Granite Hills population that were used to project densities for other populations were based upon scats and total sign. Cover sites were not used separately because they were considered to be underrepresented -- frequency 22% on transects at the Granite Hills site, 58% for all sites with sign. On the other hand, scat frequency for the Granite Hills was 71%, 81% for all sites (Table 4 and Table 15) and scats probably reflected the current population (a function of their fast turnover rate). Total sign was of questionable reliability for reasons described previously.

The projection of estimated density is based upon a simple direct proportionality between tortoise density in the Granite Hills and the average number of sign from all transects on slopes and on flats for the sign being considered. The projection to other populations assumes that the number of sign found is directly proportional to the number of tortoises and that this proportionality is the same for the Granite Hills. The combined average from slopes and flats was considered necessary for the following reasons: (1) The sign found on the flats adjacent to the Granite Hills appears to reflect transient use of the flats by tortoises that primarily inhabited the slopes. (2) No density values are available for populations living predominantly on flats (south of the Grand Canyon) and it would appear that throughout Arizona south of the Grand Canyon the few sites and few sign found on flat and rolling sites reflect either transient use or extremely low tortoise densities. (3) There is a similarity in the percentages of sign found on slopes -- 96% at the Granite Hills site; 95% at all sites.

Before the estimates for the remaining sites are presented, the following should be considered: Only the means of the Granite Hills transects have been used (7.3±8); however, the range of scats per 3 miles was 0 to 19 and the range of total sign, 1 to 26. All theoretically represented a density of 50 tortoises per square mile. For all other sites south of the Grand Canyon, 1 transect was made per site. There is no way of knowing where the sign total from a single transect would have fallen in relation to the mean of that site if several transects had been made there. This uncertainty leads to a large potential error which coupled with the large standard deviation of the sample mean of the Granite Hills site must affect the projected estimates considerably. Table 18 gives the frequency distribution of total sign of all 218 sites. No sign was found on 133 sites (61%). Some of these sites may have tortoises but the number is probably small and some of the sites with 1 or 2 sign probably no longer support tortoises or tortoise use is highly transient.

Using the Granite Hills projection, the following estimates were made for tortoise populations at other transected sites (Table 18). Of the 84 sites with sign 49% yielded $\leq$7 sign, indicating a range of 0 to 50 tortoises per square mile. Only 6 sites (7%) had >300 per square mile (450-850).

Using scat numbers (Table 19), the projected population densities range from <50 to ≈1175. For the 6 sites with the most scats (62-118) the estimated densities range from 600 to 1175. All these values must be considered highly tentative because of the several sources of considerable potential error which would not be accommodated in calculating the estimations.

The 6 sites where the most sign were found (65-126) are summarized as follows: All were between 3000 and 4000 feet [= 914.4-1219.2 m] elevation, on slopes of granite or granite-gneiss with CPV of 4. At least 1 live tortoise was seen at each site. Two sites were in Arizona Upland; 2, in Mojave Desertscrub; and 2, in Interior Chaparral. Cattle sign was common at 4 sites, occasional at 1, and uncommon at 1. Geographically, 4 of the sites were in the west foothills of the Hualapai Mountains; 1 was north of Arrastra Mountain in the foothills of the Poachie Range and 1 was ≈10 miles [= 16 km] east of Bagdad (Fig. 2).

Most of the sites with the relatively high densities were located north of the Bill Williams-Santa Maria Rivers in the Hualapi Mountains and in the mountain complex south of Bozarth Mesa (no sign was found on the mesas). These appear to be the major geographic associations; otherwise, most sites with sign were associated with mountain ranges wherever they occurred. Only 9 sites (15%) of those on slopes were on relatively isolated hills -- at least 2 miles from a mountain range, a discontinuous group of hills, or another isolated hill.

North of the Grand Canyon, slopes were neither transected in the designated area nor on the 2 test sites. The primary boundaries of the Upper test site did not include slopes; however, some tortoises on the site apparently utilize at least part of the adjacent slope of the Beaver Dam Mountains (Duna Strachan, *personal communication*). Utilization of slopes by tortoise populations apparently living primarily on flat topography is of interest for its implication in relation to habitats in which tortoises were found south of the Grand Canyon during the present survey; that is, the utilization of slopes by tortoises south of the Grand Canyon may not be unique tortoise behavior but the almost exclusive use of slopes is unique among investigated populations.

Historical references to past topographic distribution of the tortoise south of the Grand Canyon are few. Ortenburger and Ortenburger (1926) reported on field observations of reptiles and amphibians in Pima County during 1923. They observed 20 tortoises, typically found in sahuaro/ocotillo association. "....their favorite haunts were boulder-strewn beds of canyons, always up the canyon some distance from their mouths"; however, one might hypothesize that in the past tortoises lived on the flats as well, suggested by their present widespread but discontinuous distribution; their apparent preference for flats in other parts of their range; and considering the tortoises rigid ventor they would appear to be ill-suited to negotiate slopes where boulders and outcrops dominate the substrate. If, as in other parts of their range, tortoises in Arizona once primarily occupied the flats, then the effects of man's utilization of flat land and long-term climatic changes (Hastings and Turner, 1926) are natural considerations as factors that may have been responsible for the present almost complete absence of tortoises on the flats.

As deciminating factors, agriculture and urbanization are sudden and decisive in effect, but grazing, which has continued for >100 years, is more widespread and its effects insidious. Throughout the present survey it was evident that cattle utilize slopes as well as flats. Cattle sign was found among the steepest slopes climbed. The tortoises' use of higher forage potential characteristic of many slopes is still subject to competition. Some of the numerous, small protected sites for plants among the rocks may be inaccessible to cattle but not tortoises; however, the effectiveness of this potential advantage is not known. The utilization of outcrops and boulders as cover sites or under which tortoises may dig their burrows appears to be a major advantage to slope-dwelling tortoises. Physical protection of the tortoise and of the integrity of burrows under rock formations are enhanced by the use of rocky substrates with high cover site potential; however, the advantages afforded by this habitat feature will not be sufficient to sustain population vigor if forage availability becomes the limiting factor.

SUMMARY AND CONCLUSIONS

1. In areas sampled north of the Grand Canyon, sign was found at 10 of the 12 sites. Slopes were not transected. Eighty-four percent of the cover sites were dug in exposed soil; 16% were in cavities in consolidated gravel banks of washes. Population density at 9 sites was estimated at ≤50 tortoises per square mile; at 1 site, 75-100 per square mile. These values are considered approximate and tentative.

2. Sites sampled south of the Grand Canyon indicate that tortoises inhabit the hills and mountains primarily; use of flats is probably transient.

3. The presence of boulders, outcrops, and natural cavities common to slopes seems to be the major factor determining their suitability for tortoises. Sign density was greater among granitics than among volcanics.

4. Sign was found in each of the biotic communities sampled and from elevations of 1000 to 4400 feet. Arizona Upland communities yielded the highest sign frequencies and densities. The greater proportion of sites sampled on flats in Lower Colorado Valley and Mojave Desertscrub (75% and 79%) is probably the reason that on flats sign frequency was low in the first and absent in the second. The significantly low density found in Lower Colorado Valley sites is probably a function of inherent characteristics which result in habitat that is less suitable to tortoises than, for example, Arizona Upland communities.

5. Fifty tortoises were seen, 77% were adults; only 1 was seen feeding, the plant species was *Janusia gracilis*.

6. Tortoise cover sites were almost exclusively among and beneath rock formations and in cavities in consolidated gravels occasional in washes. The use of exposed soil as burrow sites, although available on slopes, was not observed and similar cover sites on the flats were rare.

7. The cryptic location of cover sites among rocks and their often superficial extent -- under overhanging rocks and with little excavated soil -- made them difficult to find and identify in many cases. For this reason, cover sites were underrepresented and thus were a poor index of tortoise presence and density.

8. The use of scats (the most numerous sign) as a density index was inconclusive, as was total sign. Population density estimates based upon sign number must be considered tentative until additional data are secured.

9. The 3-mile transect was considered necessary to help counter the effect of localization of sign due to apparent heterogeneous distribution of tortoises on rocky slopes. This was inferred from the results of multiple transects in the Granite Hills (estimated density, 50/square mile. In areas with <50 tortoises/square mile, localization would decrease the chance of encounter with sign and presence might not be revealed unless transects were of sufficient length. The possi-

bility that natural pathways between obstructing rock formations concentrate sign and thus bias transect results remains to be determined.

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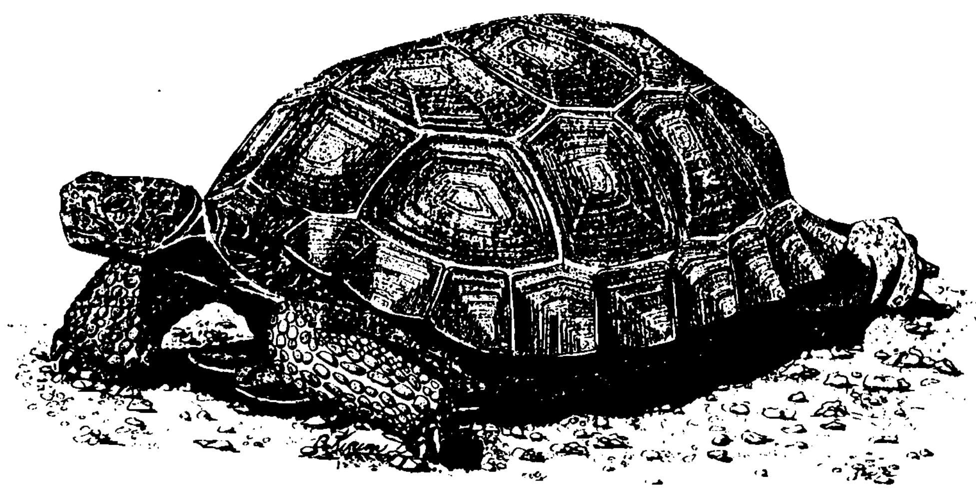


Appendix A

Contract No. YA-512-CT8-108 **DESERT TORTOISE TRANSECT FORM** transects: 3 miles x 10 yds Date Transect # Pg. 1

Recorder Betty L. Burge Co. AZ

Access description and distances ____________________

Map type and name ____ AMS 1:250,000/ Gen. Hiway Planimetric ½"/ mile ____ Co. rg.

Area or site name ____________ S____ T____ R____

% slope____ Aspect____ Elev.____ft Major veg. type ____________

Land form ____________________

CPT:

	#	Sign, old	Sign, recent	Comments
Cattle				
Sheep				
Burros				

ORV sign	# old	# recent	Unimproved roads	Comments
4-wh				
2-wh				

Human refuse and other sign of human impact ____________________

Potential tortoise predators (observed or sign) ____________________

Time (start)______MST Amb. Temp. at 1 m______ Wind (mph)______ Cloud cover______
Time (end)______MST Amb. Temp. at 1 m______ Wind (mph)______ Cloud cover______

TRANSECT SUMMARY

	Obs.	Collec.	Photo.	Lengths (mm): >214	180-214	100-179	<100	Hatchlings
Tortoises: Live								
Remains								
Scats								
Burrows								
Pallets								
Dens								
Tracks								
Mating Depr.								
Eggshell grps								
TOTAL NUMBER								
Plants								

Neotoma middens:

Form # BLB-79-001

Appendix A

Co. AZ Recorder Date Transect # Pg. 2

TORTOISE SCATS

Location	Current Season	Past Season: Dark	Faded	White	Sand casts
In open					
Neotoma middens					
In Burrow					

TORTOISE REMAINS (exposed)

Shell: most sutures tight and most scutes present — Sex, CL or available length(mm)	Shell: most sutures spread and most scutes gone or off — Sex, CL or available length	A few shell elements or extremities only — Sex, Part, Estimated size

TORTOISE REMAINS IN PREDATOR OR SCAVENGER SCATS OR BIRD PELLETS

Number of scats examined: Number of pellets examined:

Positive finds: scat type(species) or pellet(describe) / parts found, sizes, and estimated size of tortoise

OTHER SIGN
(old or recent)

Mating depressions	Tracks or shell impressions other than at burrows	Eggshell groups, convoluted	inner surfaces eroded	Nest sites(loc)

PLANT SPECIES (note if other than perennials; give field number if collected;

Appendix A

Co. AZ Recorder Date Transect # pg. 3

DISCRETE COVER SITES

Burrow Den Pallet	Length(cm) / Width of base of opening (<10 cm, 10-15 cm, >15 cm)	Roof material / Floor material (shrub canopy, fine soil, gravelly soil, consolidated gravel, boulders, other)	Condition: intact, patent; intact, debris; soil filled; collapsed or excavated (all or part, old or recent)	Sign of recent use by: tortoise (T); Neotoma (N); other rodents (R); pred. or scav. (P); other; no recent use (O)

LIVE TORTOISES

Sex: M F J Carapace Length______mm. Shell condition(scutes depressed with age, other)________

____

Injuries or Anomalies of unusual degree(old, recent)________

____

Behavior if mating, egg-laying or feeding(collect food plant)________

____

Comments________

Form # BLB-79-001

Appendix A

Co. AZ Recorder ______ Date ______ Transect # ______ pg.4

LIVE TORTOISES (cont)

Sex: M F J Carapace Length ______ mm. Shell condition(scutes depressed with age, other) ______

______

Injuries or Anomalies of unusual degree(old, recent) ______

______

Behavior if mating, egg-laying, or feeding(collect food plant) ______

______

Comments ______

Sex: M F J Carapace Length ______ mm. Shell condition(scutes depressed with age, other) ______

______

Injuries or Anomalies or unusual degree(old, recent) ______

______

Behavior if mating, egg-laying, or feeding(collect food plant) ______

______

Comments ______

Sex: M F J Carapace Length ______ mm. Shell condition(scutes depressed with age, other) ______

______

Injuries or Anomalies of unusual degree(old, recent) ______

______

Behavior if mating, egg-laying, or feeding(collect food plant) ______

______

Comments ______

Sex: M F J Carapace Length ______ mm. Shell condition(scutes depressed with age, other) ______

______

Injuries or Anomalies of unusual degree(old, recent) ______

______

Behavior if mating, egg-laying, or feeding(collect food plant) ______

______

Comments ______

Figure 1. Distribution of 289 sites throughout Arizona that were sampled by 3-mile or 1-mile transects. Closed circles, 3-mile transects with sign; open spaces, 3-mile transects without sign; closed triangles, 1-mile transects with sign; open triangles, 1-mile transects without sign. Locations of the 3 test sites are adjacent to the asterisks.

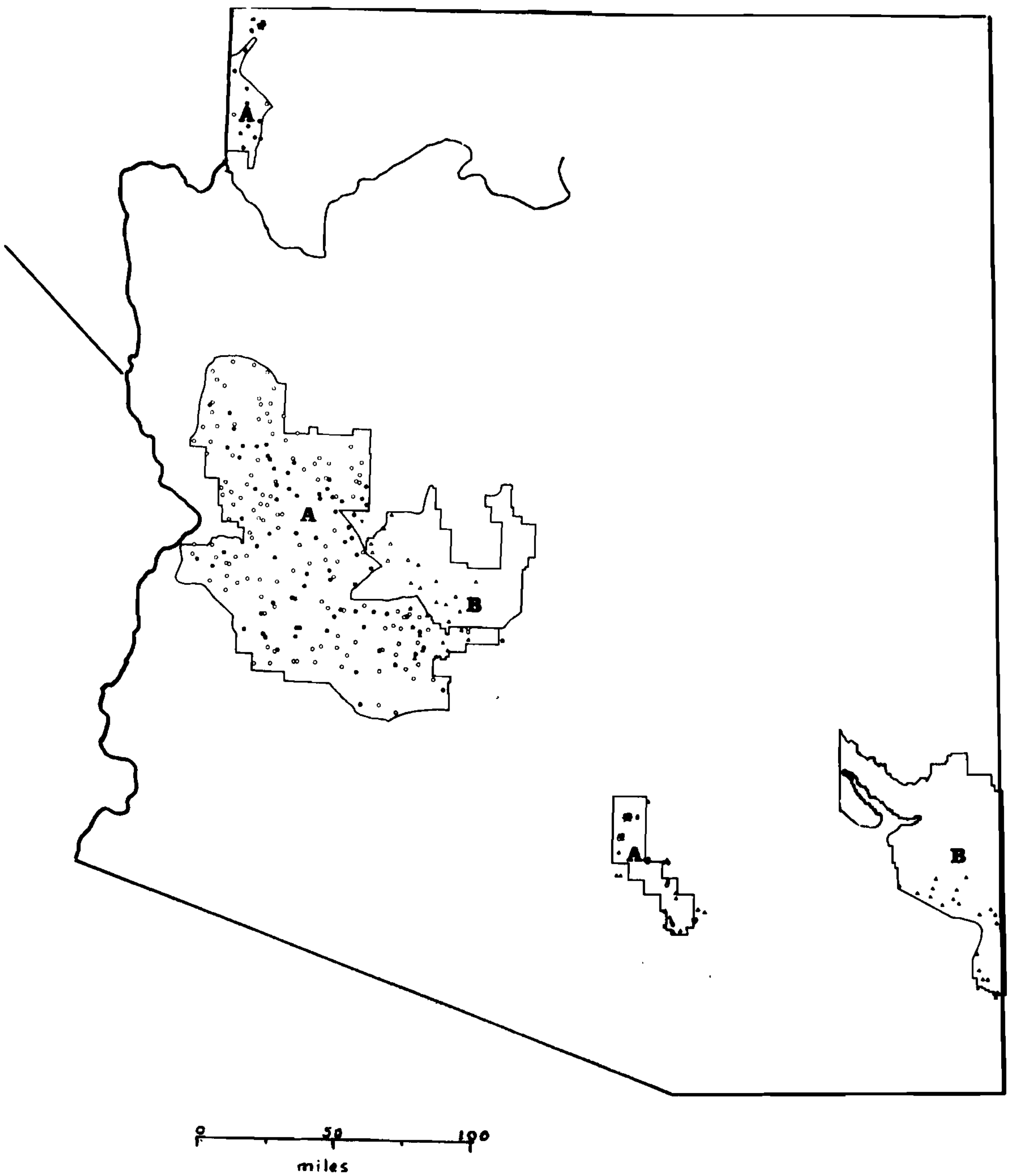


Figure 2. Distribution of 94 sites with sign (3-mile transects). Estimated population density (range) per square mile was projected from total sign and is indicated at each site.

0, ≤50; ●, 50-100; △, 100-200; ▲, 200-300; ⊕, 450-850. Location of each test site is indicated by (*). The 4, 1-mile transect sites are included (+).

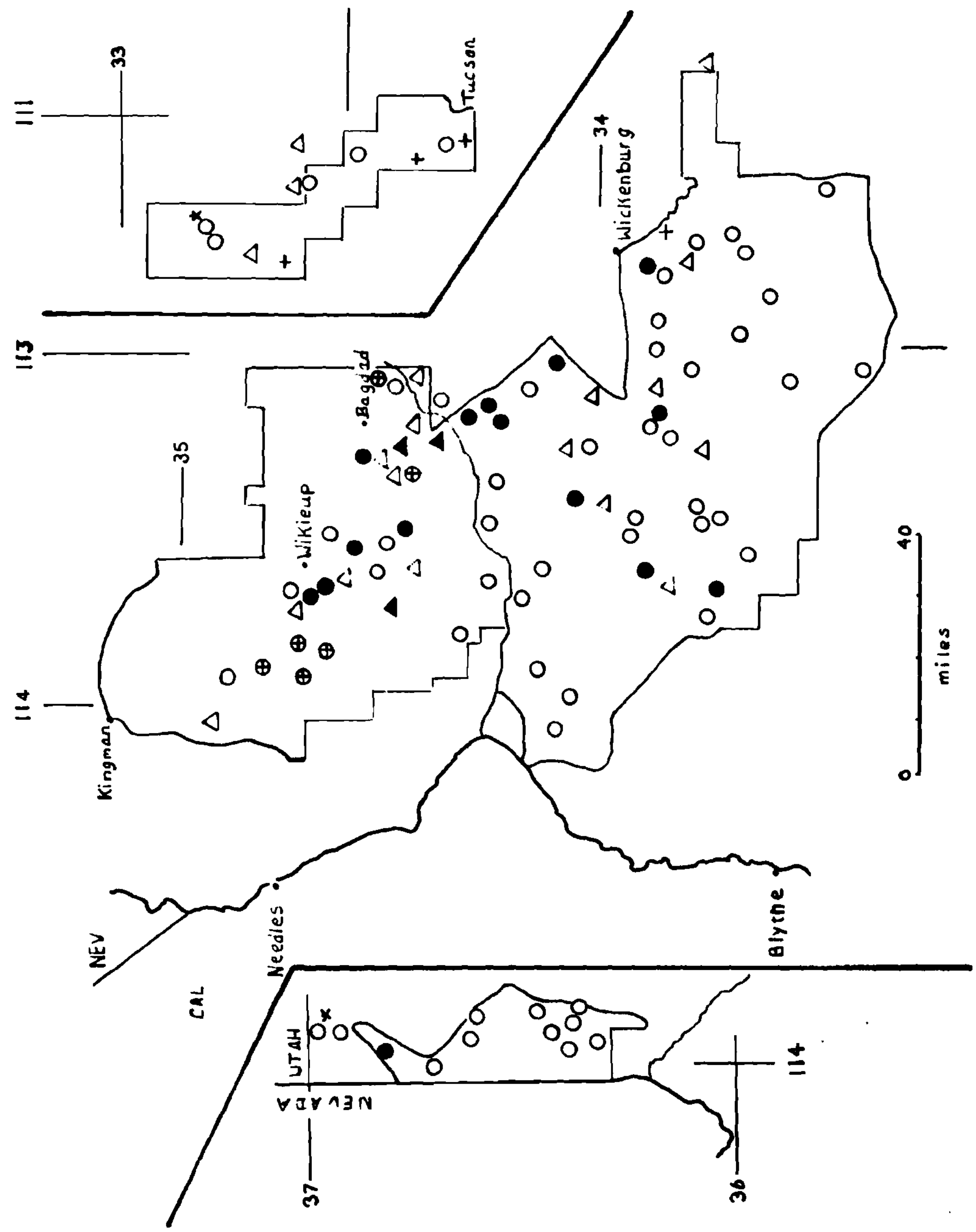


Table 1. Frequency and density values of each kind of tortoise sign found at 12 sites in the designated area north of the Grand Canyon.

	Number of sites with sign	Percent of all sites	Percent of sites with sign	Number of sign	Percent of all sign	Range of sign per site
Live tortoises	2	17	20	3	3	0-2
Remains	4	33	40	15	15	0-6
Scats	8	67	80	22	22	0-8
Eggshell groups	1	8	10	1	1	0-1
Cover sites	7	58	70	59	59	0-28
Totals	10	83	100	100	100	0-42

Table 2. Mean frequency and density values of each kind of tortoise sign found on multiple 3-mile transects at 2 sites of known density outside the designated area north of the Grand Canyon.

	Number of transects with sign	Percent transects with sign	Number per transect ($\bar{x}$)	Percent of sign ($\bar{x}$)	Range of sign per transect
Live tortoises					
Upper site (U)	4	100	1.25	6	1-2
Lower site (L)	1	25	.25	1	0-1
Remains					
U	3	75	2.50	13	0-5
L	4	100	2.50	8	1-4
Scats					
U	4	100	2.25	11	2-3
L	4	100	9.25	31	8-12
Eggshell groups					
U					
L					
Cover sites					
U	4	100	13.75	69	10-16
L	4	100	18.25	60	11-26
Totals					
U	4	100	19.75 ± 3.95	100	15-23
L	4	100	30.25 ± 7.14	100	22-38

Table 3. Mean frequency and density values of each kind of tortoise sign from 14 sites transected north of the Grand Canyon.

	Number of sites with sign	Percent of all sites	Percent of sites with sign	Number of sign	Percent of all sign	Range of sign per site
Live tortoises	4	29	33	4.5	3	0-2
Remains	6	43	50	20	13	0-6
Scats	10	71	83	33.5	22	0-12
Eggshell groups	1	7	8	1	.7	0-1
Cover sites	9	64	75	91	61	0-28
Totals	12	86	100	150 $\bar{x}$ 12.5$\pm$14	100	0-42

Table 4. Population density estimates for 12 independent sites north of the Grand Canyon based upon directly proportional projections from test transect means of 3 groups of sign at 2 sites of known density.

Transects	Observed number: Total sign	Cover sites	Scats	Estimated population density projected from: Total sign	Cover sites	Scats
#142-144						
#118-120						
#136-138	1		1	3		10
#130-132	1		1	3		10
#127-129	3			7		
#145-147	2	1	1	5	7	10
#139-141	2	1	1	5	7	10
#121-123	1	1		3	7	
#133-135	9	5	2	20	12	20
#112-114	12	9	3	25	20	30
Upper site*	20	11	2	35	30	20
#124-126	27	14	5	50	45	50
Lower site*	30	14	9	55	45	90
#115-117	42	28	8	80	85	80

*Test site values included for comparison.

Table 5. Mean frequency and density values (per 3-miles) of each kind of tortoise sign found on multiple transects at the Granite Hills site.

	Number of transects with sign	Percent transects with sign	Number per transect ($\bar{x}$)	Percent of sign ($\bar{x}$)	Range of sign per transect
Live tortoises					
Slopes (S)	2	27	.3	3	0-1
Flats (F)					
Remains					
S	3	41	.4	4	0-1
F	1	50	.5	17	0-1
Scats					
S	7.3	100	6.6	71	2-19
F	2	100	1	33	1
Eggshell groups					
S					
F					
Cover sites					0-5
S	6	82	2	22	
F					
Totals					
S	7.3	100	9.3 ± 8.4	100	2-26
F	2	100	$1.5 \pm .7$	100	1-2

Table 6. Sign frequency in relation to topography.

	Flats	Rolling topography	Slopes	Totals
Number of sites sampled	91	38	89	218
Number of sites with sign	10	12	62	84

Table 7. Sign frequency in relation to cover site potential values (CPV) (0=absent, 1=poor, 2=fair, 3=good, 4=excellent).

CPV	0	1	2	3	4	Totals
Number of sites sampled	64	57	33	52	12	218
Number of sites with sign	2	11	17	44	10	84
	(3%)	(18%)	(52%)	(85%)	(83%)	

Table 8. Sign frequency in relation to biotic communities. Sonoran Desertscrub (SD), Arizona Upland (AZU), Mojave Desertscrub (MD), Semidesert Grassland (SG), Interior Chaparral (IC).

	SD		MD	SG	IC	Totals
	AZU	LCV				
Number of sites sampled	114	48	29	16	11	218
Number of sites with sign	63	11	3	3	4	84
	(55%)	(23%)	(10%)	(19%)	(36%)	

Table 9. Sign frequency in relation to biotic community and topography.

	SD		MD	SG	IC	Totals
	AZU	LCV				
FLATS						
Number of sites sampled	30	31	22	8		91
Number of sites with sign	6	4				10
ROLLING TOPOGRAPHY						
Number of sites sampled	26	5	1	4	2	38
Number of sites with sign	9	3				12
SLOPES						
Number of sites sampled	58	12	6	4	9	89
Number of sites with sign	48	4	3	3	4	62

Table 10. Sign density in relation to topography.

	Flats	Rolling topography	Slopes	Totals
Number of sites with sign	10	12	62	84
Number of sign	27.5*	47	1305.3*	1379.8
	$\bar{x}=2.8\pm2.2$	$\bar{x}=3.9\pm3.2$	$\bar{x}=21.1\pm25.9$	$\bar{x}=16.4\pm23.6$
	(1-8)	(1-10)	(1-126)	(1-126)

*Fractional values are the result of averages from multiple transects at the Granite Hills site.

Table 11. Sign density in relation to cover site potential values and topographic types.

CPV	0	1	2	3	4	Totals
Flats	7	6	9.5	5	0	27.5
Rolling	0	6	20	21	0	47
Slopes	0	4	93	583	625.3	1305.3

Table 12. Sign density within each rock-type group at sites with CPV of 2, 3, and 4.

	Granite	Granite-gneiss	Volcanic	Total
Number of sites with sign	24	24	19	67
Number of sign	662.8	521	158	1341.8

Table 13. Sign density in relation to biotic communities.

	SD		MD	SG	IC	Totals
	AZU	LCV				
Number of sites with sign	63	11	3	3	4	84
Number of sign	834.8	65	235	43	202	1379.8

Table 14. Sign density in relation to biotic communities and topography.

	SD		MD	SG	IC	Totals
	AZU	LCV				
FLATS						
Number of sites with sign	6	4				10
Number of sign	19.5	8				27.5
ROLLING TOPOGRAPHY						
Number of sites with sign	9	3				12
Number of sign	43	4				47
SLOPES						
Number of sites with sign	48	4	3	3	4	62
Number of sign	772.3	53	235	43	202	1305.3

Table 15. Frequency and density values of each kind of tortoise sign found on transects south of the Grand Canyon.

	Number of sites with sign	Percent of all sites	Percent of sites with sign	Number of sign	Percent of all sign	Range of sign per site
Live tortoises	31	14	37	48	3.5	0-4
Remains	36	17	43	50	3.6	0-4
Scats	69	32.1	82	1117	81	0-118
Eggshell groups	8	3.7	9.5	9	0.6	0-2
Cover sites	49	22.5	58.3	155	11.2	0-10
				$\bar{x}=16.4 \pm 23.6$		

* Fractional values are from averages at the Granite Hills site.

Table 16. Age-size distribution of live tortoises observed on transects south of the Grand Canyon

Age-size classes	Size range observed (mm)	Number	Percent of population
Hatchlings			
Small juveniles 100 mm	53, 65	2	4
Large juveniles 100-179 mm	134-168	8	17
Subadults 180-214 mm			
Adults 214 mm	219-297	38	79
Totals		48	100
Adults:	226-279	10 males (8 measurable)	
	219-297	10 females (4 measurable)	
		18 unknown	

Table 17. Age-size distribution of tortoise remains from transects south of the Grand Canyon

Age-size classes	Size range observed (mm)	Number	Percent of population
Hatchlings			
Small juveniles 100 mm	80	2	4
Large juveniles 100-179 mm	174	12	24
Subadults 180-214 mm		4	8
Adults 214 mm	247-265	32	64
Totals		50	100
Adults:	261	1 male (1 measurable)	
	247-265	5 females (5 measurable)	
		26 unknown	

Table 18. Frequency distribution of total sign found at 218 sites south of the Grand Canyon and estimated population densities per square mile projected proportionately from mean total sign of sample transects at one area with known density.

Number of total sign	Number of sites	Estimated population density (range)
0	133	
1	13	
2	5	
3	6	0–50
4	4	
5	5	
6	3	
7	5	
8	4	
9	2	
10	4	
11	1	
12	1	50–100
13	1	
14	2	
15		
16	1	
17	1	
18	2	100–150
19	1	
20	1	
21	2	
22	2	
23	1	
24	1	150–200
25	1	
26	3	
27		
28	3	
29		
30		
31		
32		200–250
33		
34	1	
35		
36		
37		
38	1	
39	1	250–300
40		
41		
42		
65	1	450
76	1	525
91	2	620
101	1	700
126	1	850

Table 19. Frequency distribution of scats found at 218 sites south of the Grand Canyon and estimated population densities per square mile projected proportionately from mean scat number of sample transects at one area with known density.

Number of scats (range)	Number of sites	Estimated population density (range)
0	150	
1-5	28	0-50
6-10	10	50-100
11-15	9	100-150
16-20	7	150-200
21-25	4	200-250
26-30	2	250-300
31-35	2	300-350
36-40		
41-45		
46-50		
51-55		
56-60		
61-65	1	600-650
66-70	1	650-700
71-75		
76-80		
81-85	2	800-850
86-90		
91-95		
96-100	1	940-975
101-105		
106-110		
111-115		
116-120	1	1125-1175

State Report - California

James A. St. Amant
Department of Fish and Game

Severe budget cuts, first from Proposition 13 and second from the Governor's State budget reductions, have resulted in a hiring freeze of seasonal assistants. Subsequently, scheduled work with many species has suffered, including our plans with the State reptile, the desert tortoise. This included a cooperative effort with the Bureau of Land Management (BLM) to complete the tortoise inventory. The Department's part of the study was to cover those lands not owned by the BLM. Most of this work was to be done with seasonal assistants.

Prior to the hiring freeze we were able to hire Alice Karl for approximately 6 months. Two hundred and thirty-seven transects were completed in the Mojave and northern Colorado deserts. Special effort was made to examine military lands and the Joshua Tree National Monument. Transects were made in Edwards Air Force Base, Fort Irwin, Goldstone Tracking Station, and the Marine Corps Training Center at Twenty-nine Palms.

Tortoise populations in Fort Irwin and the Marine Base were found to be severely depressed. Evidence of wheeled and tracked vehicles was very widespread, particularly at Fort Irwin. It appeared that the tortoise population in the Goldstone Tracking Station was slightly depressed compared with nearby populations.

The east half of Edwards Air Force Base was restricted and could not be entered, but transects in the northwest portion found a density of tortoises that averaged 19 burrows per transect.

Other areas having high tortoise densities were portions of the Rand Valley, northeastern Lucerne Valley and Pinto Basin in Joshua Tree National Monument. Generally speaking, the National Monument in the more remote areas had the best tortoise populations. This is not surprising considering its protected status.

Department biologists conducted an additional 16 tortoise transects in Fort Irwin and the western Mojave Desert. Time was also spent on studying the fall behavior of a tortoise population in Shadow Valley northeast of Baker as part of an earlier extensive study.

The Department has recently acquired approximately 640+ acres [= 259 ha] of military surplus land. A management plan, being developed, will emphasize habitat improvement and protection for tortoises.

Captive tortoises turned in to the Department are continuing to be transferred to adoption chairmen for placement with suitable individuals. There are now 12,520 tagged tortoises in California. No decision has been made as to future plans for this program.

Major ancillary impacts of off-road vehicle races have been reported by Department biologist Ron Powell, stationed at Blythe. Aerial and on-ground observations were made of the Parker SCORE 400 race.

This race has been held for the past seven years. It is normally held in February; however, in 1978 it was held in October due to problems with the sponsor getting his insurance. Normally, a February event is felt by most resource management agencies as having the least potential for damage, as the desert has not yet undergone the drying effects of the hot summer months. This factor seems to hold down the dust kicked up by the entrants.

Dust can cause several effects to the resources. Racers behind other drivers find their vision obscured and can't stay on the delineated race course, which then leads to widening of the race course beyond the agreed width. Dust coats adjacent vegetation. This must have some effect on efficiency of photosynthesis, although this dust (most of it) would be removed during the next rainstorm or high wind.

Flour bowls are formed when vehicles dig deeper and deeper into fine particle desert wash soils. They need to be bladed and a single track road reestablished after the event. Erosion is the inevitable result. Flour bowls and multilaning are caused by passing other vehicles and going around deep dusty ruts.

While the effects of the racers themselves are obvious, they are confined (as much as possible) to a delineated race course. An event of this type, on a defined race course with disqualification as a penalty for short-cutting, is within the multiple-use concept of the Public Land Management Agency (BLM).

Where the most serious problems have been noted recently relate to the uncontrolled activities of large numbers of spectators who randomly distribute themselves along the race course on fragile desert environments. These spectators are mostly families out for the weekend in the desert. They may have youngsters along who have their own trailbikes and ATV's (3-wheeled all-terrain vehicles). While the adults may be happy to just relax and sit under a sun shade and view the race, the youngsters are off tearing around all over the adjacent areas on their vehicles.

The Bureau of Land Management is not authorized to control where these spectators, go. The race sponsor, SCORE, attempts to use "volunteers" from the Parker Chamber of Commerce and Jaycees, etc., but their efforts are unsuccessful. Spectators drive right by these guards and ignore their pleas. If these large numbers of spectators (18,000 estimated in 1979) can't be better controlled, then the race is causing an effect which is just too harmful and shouldn't be permitted in the future.

Damage, such as forgetting to put out campfires, is also done to the desert by careless spectators.

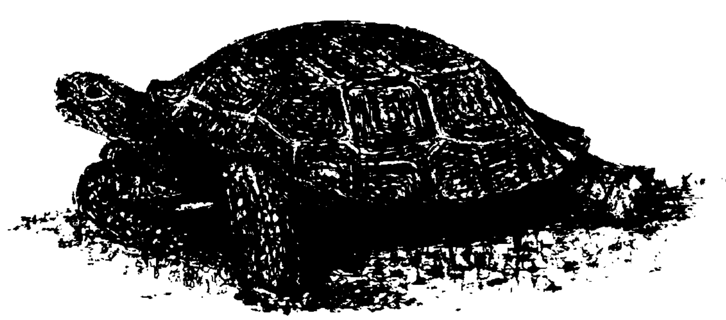
It has become more and more obvious that the racers themselves, while causing some impacts, are not the primary problem. To protect fragile desert habitats, a sincere spectator control effort needs to be developed by the BLM and the SCORE officials.

The Department of Fish and Game has made a proposal to the Fish and Game Commission to ban the commercial trade in native reptiles and amphibians. There is concrete evidence that population densities of native California herptfauna have drastically declined 41 to nearly 100% from levels just 15 to 20 years ago. A dramatic indication is the ever-growing list of species that qualify for Federal Endangered or Threatened status.

There are many factors responsible for the decline of our native wildlife, including habitat loss and modification, but a major cause of depletion of reptile and amphibian populations is present-day market hunting, commercial collecting. Commercial collecting has been described as, "Every living thing that moves which can be sold for a dollar is literally vacuumed from the landscape, leaving a lifeless and wasted environment. Countless acres upon acres of already-depleted habitat are regularly destroyed by commercial collectors armed with steel pry bars, hydraulic jacks, gasoline, and in extreme cases -- dynamite." 1/

1/ On May 25, 1979 the California Fish and Game Commission approved regulations to stop the pet trade of native California reptiles and amphibians.

California Department of Fish and Game
350 Golden Shore
Long Beach, California 90802



State Report - California

William Radtkey
Bureau of Land Management

I have three major topics on which to report. The first is recent progress on managing the proposed Desert Tortoise Natural Area (DTNA). The second is desert-wide management for the desert tortoise, and the third will be a short report on what is happening in Ivanpah Valley in regard to leasing for oil and gas.

1. Desert Tortoise Natural Area

One important area associated with this project is the development of the interpretive facilities. We are planning to construct a small kiosk-type building to house the interpretive and educational materials. The contract for construction of this building has been completed and approved and will be sent out soon. Bids are expected in mid-April. The road to the area where the kiosk will be built has been graded and a parking lot has been prepared. The current budget does not have funds for construction of permanent rest room facilities. Temporary portable toilets will be provided.

We have had several people working near the DTNA this past year. This has helped keep vandalism lower than in previous years. It may be, too, that those who have opposed the natural area are finally accepting that it is here to stay.

Our field crews have been picking up trash and have removed several dump truck loads of debris. Two mining pits have been identified as hazards to tortoises and people and will soon be fenced.

Three contracts have been let to collect the initial data to be used in measuring what effect, if any, will result from use around the interpretive facility. The contractors are: Tim Shields, Jan Bickett, and Tony Rigoni. Data on a fourth area are being collected by Bruce Hird, a Bureau of Land Management (BLM) employee. Acquisition of private lands has been moving rather slowly. One exchange, involving 1580 acres within the DTNA, is in progress. San Diego Gas and Electric is trying to purchase these lands and give them to BLM in exchange for public lands needed for the power plant on the Sun Desert project.

In 1977 the proposal to withdraw the DTNA from various forms of private acquisition was submitted to our Washington office. To date that proposal has not been forwarded to the Secretary of the Interior.

2. Desert-wide Management for the Desert Tortoise

During the past year a status report has been prepared on the desert tortoise. The information in that report indicates that nearly all of the tortoise populations are in serious trouble. Based on the data contained in that report, the BLM State Director did several things. First, he has indicated that he will recommend to the U.S. Fish and Wildlife Service that the desert tortoise in California be listed as a threatened species. He has issued instructions to our field offices telling them that the tortoise will require special management and that they take whatever action is necessary to protect desert tortoise habitat. There are two specific instructions. These are:

a. future actions authorized by BLM must not further jeopardize the continued existence of the species, and

b. positive programs must be initiated to ensure that the downward trends of habitat condition and population numbers are reversed.

One district has hired extra temporary employees to assist in supervising grazing use. As a starting place, we hope to ensure that all grazing is done in compliance with existing regulations and restrictions. Things to be done are:

a. keeping livestock out of closed area such as the DTNA,

b. keeping vehicles on roads,

c. watering and bedding so as to avoid irreversible damage, and

d. preventing overuse of preferred grazing areas.

Because there are so many actions occurring within desert tortoise habitat, we are preparing a comprehensive species management plan. The purposes of this plan are to:

a. provide detailed management objectives for the desert tortoise and its habitat,

b. identify and describe normal or routine practices that may adversely affect the tortoise, and

c. provide standard measures or management prescriptions for reducing, avoiding or removing any such adverse effects.

We hope to have this plan completed by September 1, 1979. This will be the primary document used by our field personnel to evaluate land use proposals and to protect desert tortoise habitat. This will also be used as a basis for preparing individual habitat management plans for the areas we have identified as essential desert tortoise habitat.

3. Ivanpah Oil and Gas Leasing Proposal

One of BLM's jobs is to act as the government's leasing agents for the federally owned mineral reserves.

This is generally done in response to applications to lease from various oil companies or speculators.

Over the past 20 years there have been some leases issued in the Ivanpah Valley. In the last 2 years there has been a considerable amount of increased interest.

Ivanpah Valley is located just inside California as you travel from Las Vegas toward Barstow.

Oil leasing activity here is important to this Council because this valley is in extremely important habitat for the desert tortoise. There are several things that make it important. These are:

a. It is probably the second highest population density of which we are aware.

b. It is a fairly compact unit.

c. Most of the habitat is in federal ownership.

Because of these conditions the area is considered essential habitat for the desert tortoise.

Last year I reported to you that there were some pending lease applications. Because of the importance of the area for the tortoise, a decision was made by the State Director not to approve any of the lease applications, Since that decision was made in May, several things have happened which have caused the State Director to change his decision:

a. There has been a tremendous increase in applications. These are associated with the speculation that a special geologic feature, called an overthrust belt, extends into California. It was previously thought that this formation was confined to Idaho, Wyoming, and Utah. We have received several hundred applications that cover all of the federal lands from Pahrump Valley to the Ivanpah Valley. Fifty-six of these applications are within the Ivanpah desert tortoise essential habitat area.

b. There has been an increasing demand for fossil fuels with a resulting shortage in many areas. Because of these new conditions the State Director is proposing to approve these applications with certain mitigation and protection stipulations. These stipulations are:

1) No activity of any type will be allowed between March 1 and October 15.

2) The leases may be modified or terminated if, as a direct result of exploration and development activities, desert tortoise populations show a declining trend.

3) That lessees submit plans of operations within one year from date of lease issuance.

4) Leases will be limited to surface occupancy and development within 1000 feet either side of center line above existing roads.

Superficially these stipulations appear to provide some measure of protection for the desert tortoise. However, they are based on some assumptions that may not be true. These assumptions are:

1) Tortoise populations do not occur within 1000 feet of the roads in Ivanpah Valley.

2) Impacts to tortoises are all direct; that is that they are run over or packed off.

3) There is no existing evidence that oil and gas development has an adverse affect on tortoises.

4) Very little drilling will be done in the next 10 years; probably less than 10 wells.

5) There is a low potential for discovering commercial quantities of fluid hydrocarbons.

6) Little industry interest in exploring this region.

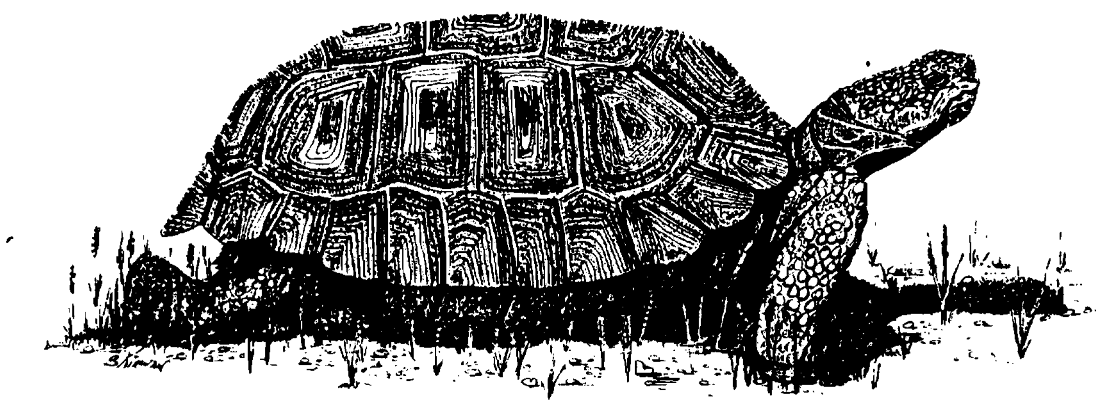
7) Any reservoirs discovered are apt to be small, scattered, and unimportant.

8) Tortoises occur in small pockets or concentration areas which can be avoided.

9) Disturbed areas can be revegetated or restored to pre-treatment condition.

Copies of the environmental analysis and decision on this project are available from the BLM District Manager in Riverside. If you want further information, I encourage you to contact him.

Bureau of Land Management
2800 Cottage Way
Sacramento, California 95825



State Report - California

Kristin H. Berry
Bureau of Land Management

The Bureau of Land Management (BLM) report for the California deserts is subdivided into 4 parts: a summary of a recently completed draft paper on the status of the desert tortoise in California; projects planned for 1979; a status report on the Desert Tortoise Natural Area; and a discussion of oil and gas leasing in Ivanpah Valley. I will cover the first two topics. Mr. William Radtkey will make the presentation on the Desert Tortoise Natural Area and Ivanpah Valley oil and gas leasing.

REPORT ON THE STATUS OF THE DESERT TORTOISE IN CALIFORNIA

The research funded by the California Department of Transportation, BLM, and by private sources during the last 8 years finally has resulted in sufficient information to determine the distribution, densities, and condition of desert tortoise populations within the state. During 1978 alone, more than 700 strip-transects were made by Lori Nicholson (BLM) and Alice Karl (California Department of Fish and Game), and 10 more permanent study plots were established by the BLM and an 11th by John Barrow of Pomona. The efforts brought the total number of strip-transects and permanent study plots for the California deserts to 1153 and 21, respectively. The types of transects and permanent plots were described in the 1978 State Report. Seven of the 1978 study plots were in San Bernardino County in Stoddard Valley, near Calico, Kingston Wash, Shadow Valley, near Amboy, Cadiz Valley, and southern Ward Valley; 3 were in Riverside County in Chuckwalla Valley, in Pinto Valley (Joshua Tree National Monument), and near Cottonwood Springs; and 1 was at Cargo Muchacho in Imperial County. Participants in the studies were John Barrow, Tom Campbell, Dr. Tom Fritts, Margaret Fusari, Howard Green, Robert Goodrich, Loren Hicks, Alice Karl, Tim Shields, and Peter Woodman. In addition Lori Nicholson revisited 6 study plots at Chuckwalla Bench, Ivanpah Valley, Goffs, Fremont Peak (2), and Chemehuevi Wash for 6 to 8 days apiece. Kristin Berry visited an older permanent study plot at the Desert Tortoise Natural Area (1973 to the present) and 1 in Fremont Valley (1976 to present) for 10 to 15 days apiece. Dr. Anne Stewart and Tony Rigoni of Antelope Valley College contributed additional time to the latter plot.

The desert-wide transect and permanent study plot approach has provided sufficient information to draw conclusions about the status of the tortoise in California. Findings have been summarized in a draft report entitled, "The status of the desert tortoise in California" by Kristin H. Berry and Lori Nicholson. The report is being reviewed by the District and State Offices and hopefully will be in final form by late 1979. It covers distribution and densities desert-wide; population parameters such as age/size class structure, sex ratios, and mortality on permanent study plots; and historic and current deleterious influences on populations. The findings are briefly summarized below.

Tortoise populations occur in four major centers in California:

1. the western Mojave from Fremont Valley south and east to Stoddard Valley;

2. the eastern Mojave in Ivanpah Valley;

3. the northeastern Colorado Desert from Fenner Valley south through Chemehuevi Valley; and

4. the Chuckwalla Bench and surrounding parts of Milpitas Wash and Chuckwalla Valley.

They are absent or virtually so from large parts of the far northern, central, and southern deserts.

Densities range from 0 to >97 tortoises/km^2 [= 250/mi^2]. Tortoises in densities >8/km^2 [= 20/mi^2] occur in 15.8% of the California deserts with higher density populations (>39/km^2 [= 100/mi^2]) occurring in 2.8% of the area. In the past, densities were believed to be much higher in some locations (78 to 780/km^2 [= 200 to 2000/mi^2]), particularly in the western Mojave where desert tortoise habitat was estimated to occupy about 15,300 km^2 [= 5900 mi^2]. Sixty percent of that region is no longer suitable habitat for desert tortoises because of agricultural development, urbanization and other human-related activities. This has resulted in an estimated 85 to 96% decline in tortoise numbers in the western Mojave.

Populations on permanent study plots ranged in density from 0.4/km^2 [= 1/mi^2] to >78/km^2 [= 200/mi^2]. All populations were estimated to be declining at rates ranging from 1.9 to 17.2% annually. Decline rates elsewhere in the desert are expected to be much higher than on study plots because levels of disturbance are greater. Using current rates, most populations of 19/km^2 [= >50 tortoises/mi^2] will decline to densities of 2 to 4 tortoises/km2 [= 5 to 10/mi^2] in 5 to 10 years. Populations with 58 to 97 tortoises/km^2 [= 150 to 250/mi^2] will drop to 21 tortoises/km^2 [= >55/mi^2] in 25 years. At that density, populations may be inviable, unless there are higher density populations in adjacent areas which supply a constant influx of new individuals. Even populations of 19 to 39 tortoises/km^2

[= 50 to 100/mi^2] may be below threshhold levels, particularly if sex ratios are imbalanced in favor of males, reproduction is low, and mortality high. Widespread extirpations throughout the desert can be expected in the next 5 to 10 years with almost total loss in 25 years unless several population characteristics change. Decline rates shown above were calculated using densities, mortality measured through shell-skeletal remains, and from percentages of small tortoises present in the population. In the final report, the authors will estimate population condition and potential decline using several other methods. New methods may change the estimates somewhat; however, the general findings and trends are expected to be similar.

Declines are attributed to collections, vandalism, and habitat deterioration and destruction. Collections played the greatest role in depletion from the 1930's through the early 1970's and are still an important factor. Habitat deterioration and loss are now the most serious problems. Virtually no tortoise habitat is pristine. Land ownership is a major stumbling block to good land management. Private lands, many of which are interspersed with public domain, occupy 27.3% of habitat. Where tortoise densities are >97/km^2 [= 250/mi^2], 83% of the habitat is in private ownership. Where densities range from 39 to 77/km^2 [= 100 to 200/mi^2], 36% of habitat is in private holdings. Private land continues to deteriorate in high density habitats in the western Mojave. Urbanization has had the most severe impacts on the western Mojave. Agricultural development accounts for loss of 8000 km^2 [= 3090 mi^2], much of which was probably high density habitat.

Livestock grazing is present on 93% of existing habitat; sheep and cattle have used many areas for about 100 years. Feral burro populations, which are expanding at rates estimated between 15 and 22% per year, graze on 20%.

Paved and earthen roads have been a source of habitat loss and tortoise populations have declined with 0.8 to 1.6 km [= 0.5 to 1 mile] of roads. Earthen roads alone cover 35,200 km [= 22,000 linear miles] of habitat. There is an estimated density of 0.5 km of road/km^2 [= 0.86 mi of road/mi^2] in high density tortoise habitat in the western Mojave. Military operations dating from World War II have had severe impacts on >7800 km^2 [= 2500 mi^2] of habitat. The actual locations and amount of land affected are being calculated using aerial photographs. Off-road vehicle (ORV) use areas occupy 25% of habitat where tortoises densities are >8/km^2 [= >20/mi^2]. Where densities are >97/km^2 [= >250/mi^2], ORVs use 67% of habitat, and where densities are 39 to 77/km^2 [= 100 to 200/mi^2], ORVs use 33%

The future of tortoise habitat is bleak, with losses continuing due to development of private lands for towns, agriculture, and vegetation harvest; leasing of public lands for oil and gas; livestock grazing; and expansion of feral burro populations. Unauthorized ORV use areas continue to expand, and authorized use areas continue to deteriorate, particularly in the western Mojave. Oil and gas leasing and a new utility corridor further threaten the eastern Mojave populations. Vandalism grows with increasing human contact.

The report closes with a proposal to list the desert tortoise as a threatened species under the Endangered Species Act Amentments of 1978, and Critical Habitat is proposed in the 4 population centers in California.

STUDIES FOR 1979

Contracts have been awarded for continued work at 6 permanent plots, all with densities >29 tortoises/km^2 [= 75/mi^2]:

1. Desert Tortoise Natural Area
2. Fremont Valley
3. Stoddard Valley
4. Ivanpah Valley
5. Chemehuevi Wash
6. Chuckwalla Bench

The purpose of these studies is to gather more detailed and precise baseline data on densities, age class structures, sex ratios, and mortality. Techniques generally remain the same, with the exception of a 60-day work period in spring, additional data collection on shell/skeletal remains and shell wear patterns, and more intensive plant sampling.

John Barrow, Margaret Fusari, Alice Karl, Lori Nicholson, Paul Schneider, Dr. Anne Stewart, and Peter Woodman have been awarded contracts for these studies.

In addition to the above 6 plots, a new 7.8 km^2 [= 3/mi^2] plot is being established at the Desert Tortoise Natural Area with the interpretive center as its focus. Part of the plot lies within the fenced Desert Tortoise Natural Area and part lies without. Three people, Tony Rigoni (Antelope Valley College), Jan Bickett (Sacramento State College), and Tim Shields, will work 60 days each at the site. They will gather baseline data in order to determine what impact, if any, future visitor use will have on the tortoise populations. We anticipate that their study will be repeated in 3 to 5 years.

Offices of the BLM in California and Arizona are designing a study concerning the effects of livestock grazing on the desert tortoise. Potential study sites in Arizona and California are under consideration. In California, 2 sites are of particular interest: Ivanpah Valley for a study of the effects of cattle grazing on the desert tortoise, and the vicinity of the Desert Tortoise Natural Area for a study of the effects of sheep grazing on the desert tortoise. A contract may be advertised and awarded later in 1979.

Bureau of Land Management
California Desert Program
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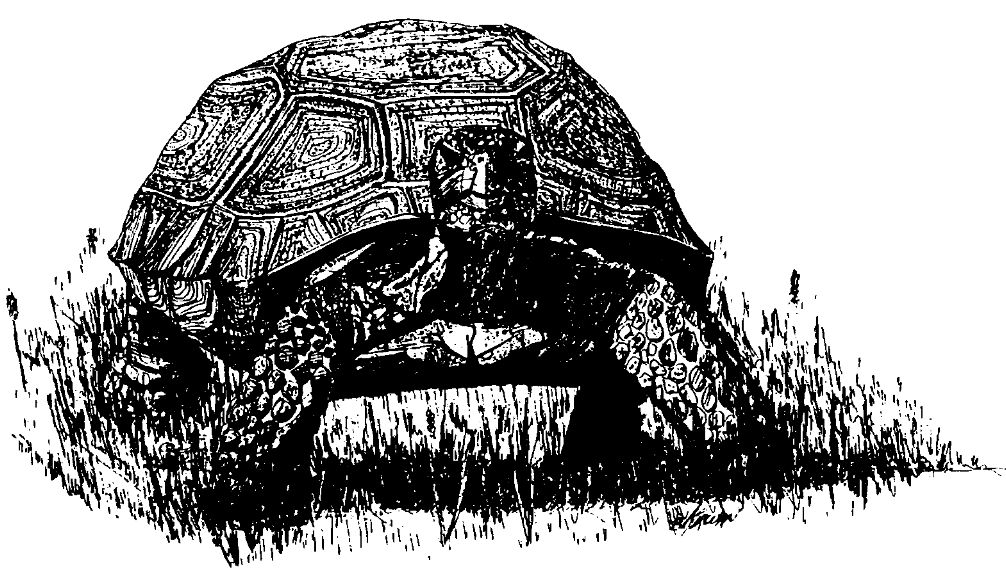

A Caltrans Project

Feasibility of a Highway Crossing System for Desert Tortoises

Margaret Fusari, Stephen M. Juarez,
Glenn Stewart and John A. Edell

The California Department of Transportation (Caltrans) has embarked on a project to study the feasibility of using culverts and fencing to provide a highway crossing system for the desert tortoise. This project will be conducted in the Mojave Desert near Barstow, California during 1979 and 1980.

We will mark and study the movements of desert tortoises in the area of the existing culverts under the freeway (Interstate Highway 15) south of Barstow. We will also set up an experimental system of three different culvert styles in an area nearby and study their effectiveness in permitting free crossing of the system by tortoises.

At this early stage in the project we are seeking advice from interested persons experienced in the habits of the desert tortoise. Through the assistance of such people we hope to maximize our chances of developing a system which will aid in the conservation of the desert tortoise.

A significant number of tortoises are either killed by vehicles or captured by motorists annually along the road systems throughout the deserts of California.

Of major concern is that the most sensitive portion of the population is most affected. Young tortoises start life with a very limited home range of about 2 to 3 acres [= .8.1-1.2 ha]. As the tortoise ages, its range increases up to as much as a square mile [= 2.6 km^2]. A tortoise does not breed until it is 12 to 14 years of age. Therefore, at the same time it is maturing, it is increasing its chance of coming in contact with a road. This creates the situation where the breeding population can be expected to become severely reduced within a mile [= 1.6 km] of the road by the deaths of many individuals. Furthermore, by separating a population of tortoises into two parts, the roads may be preventing or at least severely restricting gene flow within the tortoise population, leading to a reduction in the overall fitness of the species.

Because the western Mojave Desert is both an area of high tortoise density and an area of rapid expansion of human habitation, it has been decided that a cost-effective method of mitigating the effects of future roadways on tortoises is needed.

This paper outlines a research project which will be carried out during the years of 1979 and 1980. The project will evaluate one method for solving the above-mentioned problem and will seek to formulate other possible methods. Our primary purpose in presenting this paper at this time is to solicit advice and suggestions from persons interested in the desert tortoise and its future.

The project design has been developed on the basis of personal observations of captive and wild tortoises by many individuals. It is also consistent with an objective of developing a system which would be cost-effective in terms of roadway construction.

The study site is to be located in the Mojave Desert near Barstow, California in an area with a high density of desert tortoises.

It is anticipated that a single fence and culvert system, approximately 600 feet [= 183 m] in length, will be sufficient to meet the primary objective of the study. The basic design is intended to simulate fencing erected on each side of a roadbed with culverts passing under the bed at 150-foot [= 45.7 m] intervals. We intend to use different types of culverts in order to assess the actual reactions of the tortoises and to determine preferences, if there are any.

Tortoises are most active in the spring months from about mid-March to mid-June and in the fall from September to mid-October. The study will commence in mid-March of 1979 and will continue through the spring season. Additional data will be collected during the fall activity period of 1979 and in the spring of 1980.

Data on tortoise responses to the fence and culvert system will be obtained by visual observation and analysis of tortoise sign.

In addition to the fence and culvert system, we intend to utilize a simple enclosure. We will introduce tortoises into this system for 1- to 2-day periods, during which time we will collect data on the preferences those tortoises exhibit for different types of culverts between the compartments of the enclosure. This system will allow us to test the reactions and preferences of tortoises for different culvert shapes, sizes and floor types. The outcome of this project will be a report that can serve as a guide in the construction of roadway systems safer for the future of the desert tortoise in impacted areas. We hope to include the observations of other individuals having knowledge of the tortoise and its relationships to roads and fence-culvert systems.

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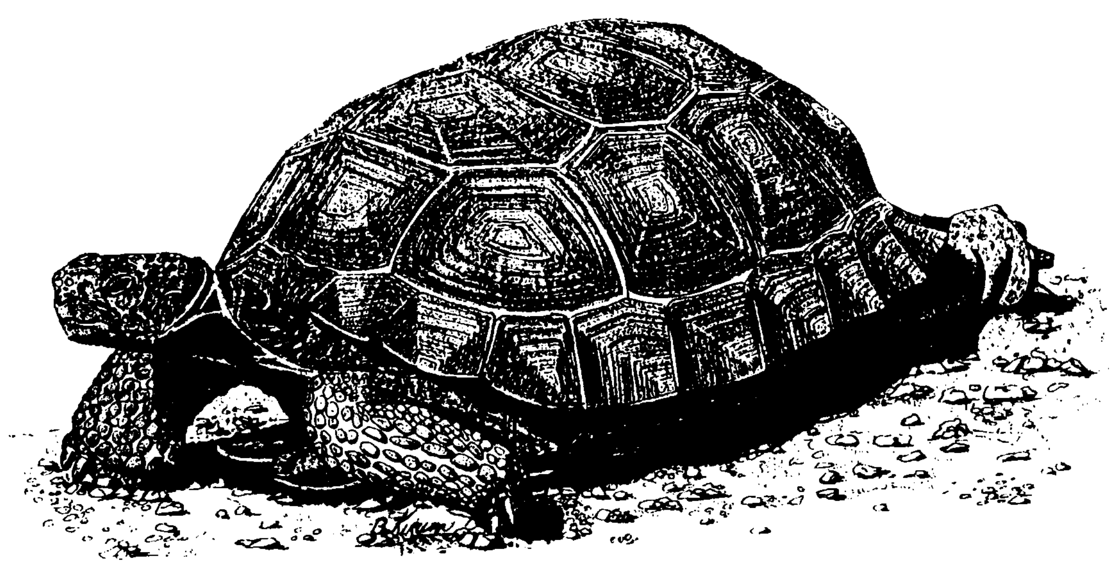

Special Report - California

California Turtle and Tortoise Club

Tom Lackey

I do not have much in the way of statistics, but I would like to tell you about the California Turtle and Tortoise Club.

The Westchester chapter, formed in 1964, is the parent chapter, followed by Foothill, Orange County and San Bernardino chapters. We endeavor to share information with others interested in turtles and tortoises; information regarding health hints, hibernation, feeding, housing, breeding and incubation and hatching of eggs. This is knowledge that we have learned through experience.

Members and interested general public are advised of veterinarians that show an interest in and knowledge of turtles and tortoises.

We have an adoption program where we place turtles and tortoises that have been found wandering the street, or the owner finds that for some reason he can no longer keep the tortoise. We try to place these in selected homes where they will get the best of care and treatment.

We have care sheets on many species of turtles and tortoises for the uninitiated. These include: desert tortoises, water turtles, box turtles, and exotic tropical tortoises, to name a few.

Money is raised for the club through sales tables where turtle-related items are sold. Last year we had a booth at a recreation center, a savings and loan, at Hollywood Park, and the Los Angeles County Fair. Once a year we have a show for sharing with the public and members information on turtles and tortoises, and conservation. Last year the Westchester and Foothill chapters' shows were quite successful and each chapter was able to donate $400 to the Desert Tortoise Preserve to purchase more land. In May we plan a field trip to see where the money is going.

A monthly newsletter called the Tortuga Gazette is printed. It goes to 800 subscribers in 30 states and 3 foreign countries: India, England and Holland.

We work with the California Department of Fish and Game, and are interested in all agencies for conserving and protecting wildlife.

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The Desert Tortoise Natural Area,
Desert Tortoise Preserve Committee,
and The Nature Conservancy

Barbara Hopper

It is a privilege and honor for me to have an opportunity to speak on behalf of The Nature Conservancy, the Desert Tortoise Preserve Committee, and the Desert Tortoise Natural Area.

During the past year, many advances have been made in land acquisition, protection, fund raising, and educational programs. The Desert Tortoise Preserve Committee, under the outstanding leadership of Laura Stockton, is to be especially commended.

From 1976 to 1978 the Desert Tortoise Preserve Committee turned over $53,000 to The Nature Conservancy for inclusion in the Desert Tortoise Preserve Project Fund. This total includes monies from sales, donations, and contributions from the Southern California Chapter of The Nature Conservancy. One fund-raising event of importance to note was a special "Autumn Moonrise Party" trip led by Dr. Thomas O'Farrell, specialist on the desert kit fox. This event netted $4,000.

Other outstanding contributions included the work of the Desert Tortoise Preserve Committee member Leo Novak, who designed and placed desert tortoise road signs in high density areas along highways. Now CalTrans is having him make desert tortoise crossing signs.

Land acquisitions and additions to the Desert Tortoise Natural Area during the last year have included 2 square miles [= 5.2 km^2] of Southern Pacific land. This purchase and acquisition was negotiated by The Nature Conservancy.

A complicated series of negotiations and land exchanges that began in 1978 between The Nature Conservancy, San Diego Gas and Electric, and the Bureau of Land Management will finally culminate this year in the addition of one full section of the Orton property to the Desert Tortoise Natural Area under the jurisdiction of the Bureau of Land Management. An attempt was made to acquire another 1.5 square miles [= 3.9 km^2] (Mendiburu property). The Nature Conservancy has no other acquisitions planned at this time. The entire desert tortoise project is a high priority project.

EDUCATIONAL ASPECTS

Many persons, both on the Desert Tortoise Preserve Committee and Nature Conservancy chapter level, have effectively contributed to the educational program concerning the desert tortoise.

In the past year 55 programs have been given for school, adult, and civic groups. A total of 2,500 persons have been given the presentations. Fifteen tours of the Desert Tortoise Natural Area were given to a total of 515 individuals. A special 16-page booklet was designed by the Desert Tortoise Preserve Committee, devoted to the desert tortoise, its habitat, role in the desert ecosystem, descriptions of the other animals and the many desert plants, together with their unique adaptations for survival. Included are special notes to teachers, selected resource references, and classroom activities, including food web and energy pyramid concepts. Through the Conservation Education and Energy Office of the State Department of Education and the special assistance of Mr. Rudolph Shaffer, 10,000 copies of these booklets and posters were distributed to the schools of California for incorporation into the school program as a special project to begin during Conservation Week. Calling attention to the California State Reptile, these materials arrived in the schools during the first week of March, thus the effectiveness of the program has not yet been determined. Students and classes were invited to join the "burrow brigade" and contribute $.10 to protect the burrow of a horned lizard, $1.00 the burrow of a kangaroo rat and $40 to buy enough land to protect the burrow of a small tortoise. In return for each type of donation, classes and/or individuals receive a certificate.

The idea in designing this project was that it is only through education of our youth that conservation efforts now and in the future can realize effectiveness. I encourage you to look at this material and request a copy from the Committee. These teaching materials may be modified for use in other states wherein tortoise populations reside.

Forthcoming educational events include a special field study course on the desert tortoise given by Dr. Kristin Berry through the University of California at Santa Barbara extension, April 28-29, 1979.

Looking to the future, on-site educational activities will be expanded with the establishment of the interpretive center at the Desert Tortoise Natural Area. $50,000 has been allocated for building of the kiosk. This money will be derived from 9200 funds which come from off-road vehicle use of the desert. A letter from Ed Hastey promises construction of the interpretive center. Nature trails leading out from the center will be scouted out this spring by the Desert Tortoise Preserve Committee and Bureau of Land Management representatives.

The Desert Tortoise Preserve brochure is in the final stages of completion. An additional feature will be the inclusion of a check list of plants and animals on the Preserve.

Although the situation has improved, adequate patrolling and protection of the Desert Tortoise Natural Area and The Nature Conservancy property from vandalism and grazing problems, and controversies regarding hunting, the legality and need thereof, on the Desert Tortoise Natural Area and Nature Conservancy properties continue.

On behalf of The Nature Conservancy, I wish to commend the Desert Tortoise Preserve Committee, the Desert Tortoise Council and especially Dr. Kristin Berry for their meritorious efforts on this project. The Nature Conservancy pledges its continued support.

LEGISLATION OF SIGNIFICANCE

Throughout the 1978 year, representatives of conservation organizations in the State of California worked together on a proposal to establish an office within the Resources Agency to coordinate significant natural areas programs and their acquisition. The need for such an office had grown out of the fact that many different organizations, including the California Native Plant Society, Nature Conservancy, University of California Land and Water Reserve System, the River Council, the Audubon Society, and the Department of Fish and Game, to name just a few, were all working on various aspects of significant natural areas acquisition, and the need for coordination of such efforts was urgent. I am pleased to report that on March 22, 1979 the California Senate Finance Committee passed a bill allocating $115,000 for the establishment of a Significant Natural Areas Office with the Department of Fish and Game. The long-range significance of the establishment of this office and the recognition of this need by the State government at a time when every budget item is under scrutiny, are very important to us. The parameters of the work of this office will include all ecosystems in California and most probably assist in desert tortoise habitat preservation.

In October, 1978 a list of 14 significant and unique wildlife ecosystem areas proposed for acquisition by the U.S. Fish and Wildlife Service through use of California's allocation of offshore oil drilling revenues, was announced. The Nature Conservancy was very pleased that the Desert Tortoise Natural Area was number four on that list. Those monies have not yet been made available due to budgetary cutbacks at the federal level.

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State Report - Nevada

Paul Lucas
Department of Fish and Game

NEVADA LAW AND REGULATION

Six Nevada laws and the Nevada Fish and Game Commission General Regulation No. 1 provide protection, make it illegal to capture a desert tortoise, and designate the species as a rare reptile. Refer to the 1976 Desert Tortoise Council Proceedings for details on current law and regulation.

BIOLOGICAL SURVEYS

Ground surveys continued during spring and fall of 1978 in an effort to determine current distribution, use areas, and key habitats. The northeastern distribution was documented as extending into the upper portion of Pahranagat Valley (T. 6S., R. 60E.) (Fig. 1). Based on vegetative type, the distribution may continue north a few more miles in Pahranagat Valley and to Scotty's Junction north of Beatty. The range extends south to the Arizona and California borders.

No surveys were conducted in the test site or bombing range. The eastern side of the Desert National Wildlife Range and adjacent Bureau of Land Management lands probably provide a refuge.

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

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

All observations of tortoises and sign to date were in the creosote and creosote blackbrush types, on bajadas or hills, and below 5,000 feet [= 1524 m]. Future surveys will probably document additional denning or burrow situations and vegetative types used by desert tortoise.

Tortoise surveys remain limited by budget constraints. Additional funding is necessary for intensive surveys of status and trend.

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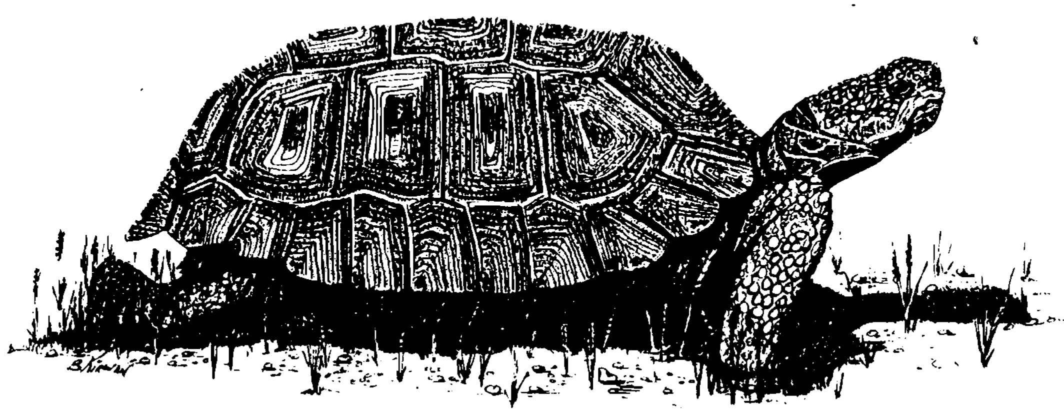

State Report - Nevada

Mark Maley
Bureau of Land Management

As previously reported in the Desert Tortoise Council Symposium of 1978, the Las Vegas District is involved in the completion of 3 environmental statements by 1986; the Caliente, Clark, and Esmeralda.

A draft of the Caliente Environmental Statement is scheduled for public review June 1, 1979. During the inventory phase, manpower and fund shortages prevented the initiation of any studies for the desert tortoise. However, several positive impacts will affect the desert tortoise by 1990 with the adoption of the proposed action. Livestock and wild horse grazing would be reduced approximately 5,079 AUMs (37%) of present use on desert tortoise habitat and the period-of-use on all livestock allotments within desert tortoise habitat would be eliminated from April 1 thru September 15 of each year. This should reduce competition for forage between livestock and the desert tortoise. Also, the 1978 Caliente Management Framework Plan recommends that no competitive off-road-vehicle event be allowed during the activity period of the desert tortoise in Nevada, March 1 thru November 15.

The Clark Environmental Statement area is currently being inventoried for natural resources. As part of this inventory, a contract will be awarded in April 1979, to determine the status of the desert tortoise in Clark Environmental Statement area. The purpose of the contract is twofold: to determine the distribution and relative densities of desert tortoises by the transect method developed by the Bureau of Land Management (BLM) Desert Planning Staff in California, and, to establish two permanent study plots for obtaining quantitative data on the absolute density, age structure and sex ratios of 2 desert tortoise populations.

The Esmeralda Environmental Statement area is scheduled to be inventoried for desert tortoises in fiscal 1980.

A training session was given to the range inventory crew and interested district personnel in the first part of March 1979. Time did not permit the training to be held in the field. Topics included behavior, activity periods, and types of cover sites. Color slides, tortoise skeletal remains, tortoise feces, and egg remains were used during the training session. Trainees were asked to submit tortoise observation reports indicating the following information about each tortoise: time of day, location, behavior and location respect to cover site. Trainees were asked to handle only those tortoises which are in danger of being hit by motor vehicles. This would minimize the chances of upsetting the tortoise's water balance due to voiding. To date, 10 tortoise observation reports have been submitted.

The Desert Tortoise Slide Program prepared by Dr. Kristin Berry of the BLM Desert Planning Staff was presented to a seventh grade class in Henderson, Nevada. The children expressed their curiosity and enthusiasm with many questions. The class especially enjoyed the descriptions of personal experiences with the desert tortoise. Another slide program presentation is tentatively scheduled to be given to an elementary school class in April or May 1979.

We thank Phil Medica of UCLA, Don Seibert of BLM Arizona State Office, Paul Lucas of the Nevada Department of Fish and Game, Betty Burge of the Desert Tortoise Council, and especially Dr. Kristin Berry of the BLM Desert Planning Staff, for their assistance in the development of a desert tortoise program in Nevada.

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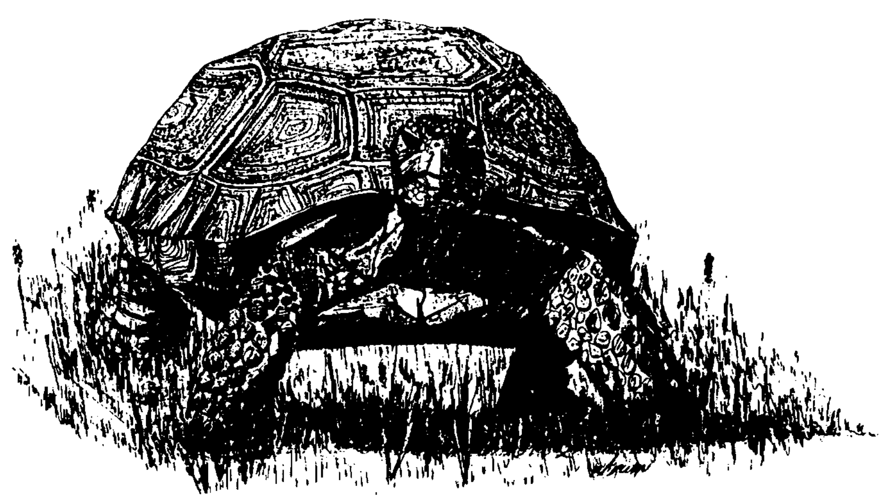

State Report - Utah

Frank Rowley
Bureau of Land Management

Following is a time schedule of the implementation of the Hot Desert Range Management Program:

<u>Day</u>

0	Program Decision Document - to Washington
+21	Letters to permittees to inform them of the implementation of the Range Management Program and set dates for meetings with individuals.
+31	Begin meeting with individual permittees to inform them of changes in authorized use, requirement for reduced or non-use to implement systems in poor condition areas, AMP grazing system, exchange of use, etc.
+40	Agency meeting to present same data as given to permittees.
	Businessmen's briefing (Chamber of Commerce, banks, real estate).
	News release giving details of Range Management Program and brief information of schedule.
+60	Decision issued to permittees. Notices to be signed by AM grant protest to DM within 30 days.
+75	DM issues final, full force and effect decision to permittees who have protested.
+105	Issue 10-year permits

The Desert Tortoise Habitat Management Plan will be written to help improve habitat conditions for the tortoise population on the Beaver Dam Slope. A major project under this plan will be a 3,000-acre [= 9144 ha] desert study area that will be fenced off from livestock grazing and limit other surface disturbing activities. A comparative study will be conducted inside and outside this exclosure to monitor the effects of livestock grazing under a management system on the vegetation and desert tortoise. The studies will monitor sex and age class changes, reproduction, and food habits. Interpretive displays of the deset flora and fauna will be included for the public's benefit.

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United States Department of the Interior

BUREAU OF LAND MANAGEMENT
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March 15, 1979

Ms. Kristen Berry
3610 Central Avenue
Suite 402
Riverside, California 95206

Dear Ms. Berry:

The Desert Tortoise Habitat Management Plan (HMP) is scheduled to be completed September 30, 1979. A preliminary meeting is being scheduled to be held sometime in March with the U.S. Fish and Wildlife Service and the Utah Division of Wildlife Resources. The purpose of the meeting is to establish the objectives for this HMP.

Construction is now underway on the fence for the Woodbury Desert Study Area. It should be completed sometime this spring and will enclose 3,040 acres.

We are presently implementing the Beaver Dam Slope Allotment Management Plan (AMP). The range improvements for this AMP are scheduled to be completed this summer. The livestock operators that run cattle on the Beaver Dam Slope Allotment have met with the Area Manager concerning the AMP implementation. The livestock reductions, as scheduled in the plan, will be reflected in the billing for grazing privileges next fall.

If we can be of further assistance, please let us know.

Sincerely,

M. S. Jensen
District Manager

A Second Report on Survival in Rehabilitated Desert Tortoises

Ann E. Weber, James C. Cook
and Glenn R. Stewart

During June of 1977, the first group of desert tortoises (*Gopherus agassizi*) to complete all or part of the California Department of Fish and Game's (CDF&G) rehabilitation program were released into the Mojave Desert. As of December 1978, these tortoises show a survival rate of 64-76%. The second group of "rehabilitated" tortoises released in May 1978 have had no known losses after 7 months in the field.

The desert tortoise rehabilitation project began as a response to the large numbers of tortoises turned in to the California Department of Fish and Game because of the 1973 law forbidding tortoise ownership without a special license. Because the removal of tortoises from their natural habitat was, and continues to be, a serious problem to populations located in accessible areas, it was felt that perhaps these tortoises could be released into areas which had become depopulated. Until 1977, releases of captive tortoises were somewhat uncoordinated. Desert tortoises were released by zoos, museums, and the CDF&G, as well as by private individuals (M. M. Maris and M. M. McAdams, *personal communication*). Those studies which tried to determine survival rates of released captive or transplanted tortoises proved either inconclusive or extremely discouraging (Crooker, 1971; McCawley and Sheridan, 1972).

Due to these and additional observations, the CDF&G felt that the development of a "rehabilitation" and monitoring program would increase the captive tortoises' chances to survive and form stable populations. The rehabilitation program developed by the CDF&G consisted of inspecting tortoises at the Department's Chino field station, then adopting them out or transporting them to the Palm Desert Living Desert Reserve (Quarterway House). At the latter site, diseased tortoises were medically treated and healthy tortoises were released into an enclosure for additional observation. After a suitable period, the tortoises were moved to Fort Soda (Halfway House) to complete their "rehabilitation". Following a year's exposure to desert conditions and minimum human contact, the tortoises were considered "rehabilitated" (St. Amant, 1976).

The first group of "graduates" was released in June 1977 and a second group in May 1978. Monitoring of these groups continues, although the "rehabilitation" program was discontinued in June 1978.

The tortoise release site is approximately 40 km [= 25 miles] east of Lancaster, California, adjacent to Saddleback Buttes State Park. The area is a Joshua tree (*Yucca brevifolia*) woodland. It had been used previously as a release site for unwanted tortoises (M. M. Maris and M. M. McAdams, *personal communication*) so it was felt that additional releases would not impact a natural population.

The tortoises were released at 20 evenly spaced points in a 3.88-km^2 [= .42 mi^2] area. Of the 51 tortoises released, 22 tortoises carried transmitters, provided by the Los Angeles County Fish and Game Commission, at some time during the study (Cook, Weber and Stewart, 1978). Each transmitter-bearing tortoise was located at least 20 times from May 1978 to April 1979, and repeated attempts were made to locate the tortoises not bearing transmitters.

As previously reported (Cook, Weber and Stewart, 1978), during the period from June 1977 to May 1978, 7 tortoises of the 1977 group died. In the following 11 months (May 1978 through April 1979), 1 large (28.2 cm [= 11.28 in]) male tortoise died, bringing the total known deaths in this group to 8. Thus the survival rate for the 33 tortoises released in June 1977 may be calculated as 76%. If we use only the 14 tortoises of this group that were equipped with transmitters as a basis for calculation, the survival rate is 64% (9/14). We believe that the actual survival rate for this group is close to 70%.

Although there were no recorded deaths in the group of 18 tortoises released during May 1978, we estimate an 89% survival rate for this group between May 1978 and April 1979. The survival rate difference between the first and second groups of releasees may be attributed to 2 factors. First, the physical condition of the second group, due to changes in the holding facility's procedure, was much better. Secondly, the environmental conditions were much more favorable in May 1978, when the second group was released, allowing the tortoises to develop more familiarity with the release area before the onset of summer heat than the tortoises released in June 1977 had.

While we do not feel this study can make a definite statement about the feasibility of reestablishing desert tortoise populations from captive stock, we do believe that it indicates a rehabilitation project might lead to that kind of success.

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Behavioral Interactions of the Desert Tortoise in an Outdoor Desert Enclosure

R. Bruce Bury and Jaclyn H. Wolfheim

Abstract

We observed the behavior of 7 tortoises (4 females, 3 males) for 37 hours from a blind. Several patterns were evident. Males approached other individuals more than did females. Males and females were approached to the same extent. Males performed more bouts of head bobs than females, but the sexes do not differ in the amount of head bob bouts they receive. Males and females were aggressive and were aggressed against to the same extent. Most aggression occurred between females and between males, rather than between the sexes. We also noted: (1) sniffing of soil, feces, and other tortoises; (2) head bobbing bouts in several situations; and (3) some activity during rain.

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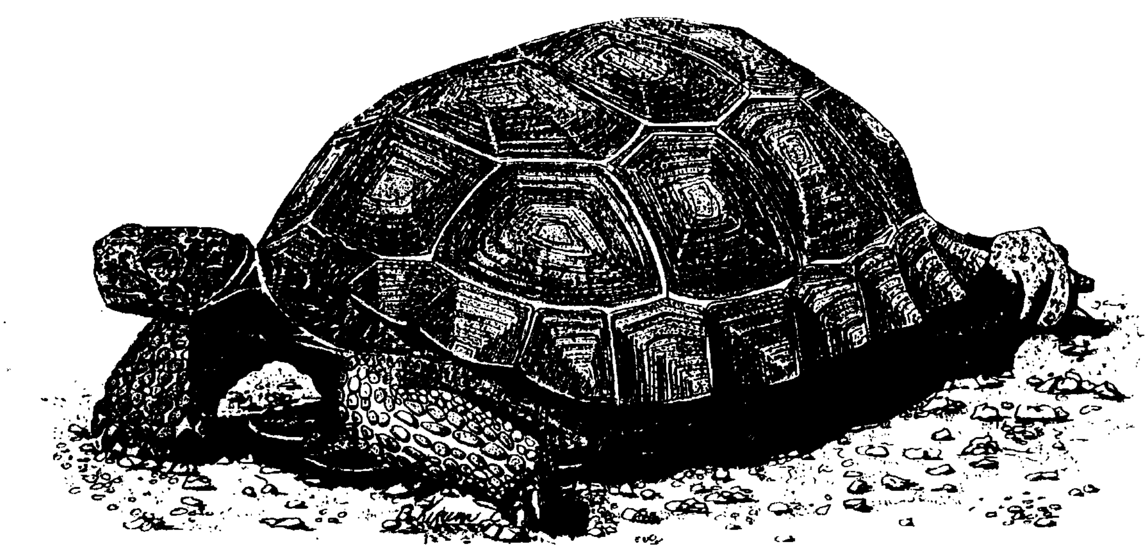


Aspects of Ecology of the Desert Tortoise, *Gopherus agassizi*, in Joshua Tree National Monument, Pinto Basin, Riverside County, California

John Barrow

During 25 days between March 18, 1978 and November 9, 1978, 51 tortoises were marked and released on an area of 1 square mile [= 2.6 km^2]. The tortoise density of the area is estimated at 75 to 80 per square mile. Of the tortoises observed, adults (>208 mm [= 8.3 in] carapace length) comprised 59%; subadults 15.5%; juveniles (101-179 mm [= 4-7 in]) 8%; juveniles (>100 mm [= 3.9 in]) 15.5%; and hatchlings 2%. Skeletal remains of 39 individuals were collected with 18 probably being killed within the last year. Of these 18 individuals, 14 show signs of being killed by predators. One female (210 mm [= 8.3 in]) was observed laying eggs (3). One nest of 5 eggs was found eaten by predators. One coyote scat was located which contained tortoise scuts. The ratio of male to female in subadults was 1:1, in adults 130:100. Very little grass exists in the area. Of the 15 feeding observations, only 1 was on grass. In the spring 8 of these feedings were on *Lotus tomentellus*. In the fall most feedings were on *Allionia ditaxis*. Two coyote scat collected in the fall included large quantities of *A. ditaxis*. Most burrows were <2 m [= 6.6 ft] except in kit fox complexes. Twice tortoises were observed using tunnels in kit fox complexes. The juveniles appear to use rodent tunnels; 1 was observed using 2 different rodent tunnels in a 50 m [= 50 yd] distance. There seems to be a high population of ticks; 11 individuals had 1 or more; of these, 9 were males. None of the 12 fall captures voided or even made an attempt to void; while 30 of the 45 spring captures did. *Erigonum inflatum* covers large areas of the plot and no tortoise has been captured in the area of this tangling vegetation. There are no conflicting uses of this area as it is protected by the National Park Service, still the high death rate seems to indicate the tortoise is endangered at this site.

INTRODUCTION

The desert tortoise (*Gopherus agassizi*) was studied for 25 days at South West Pinto Basin in Joshua Tree National Monument, Riverside County, from March 1978 into November 1978. The major objective of the study was to obtain quantitative data on density, age structure, sex ratios, as well as observe activities of tortoises on the square mile [= 2.6 km^2] plot.

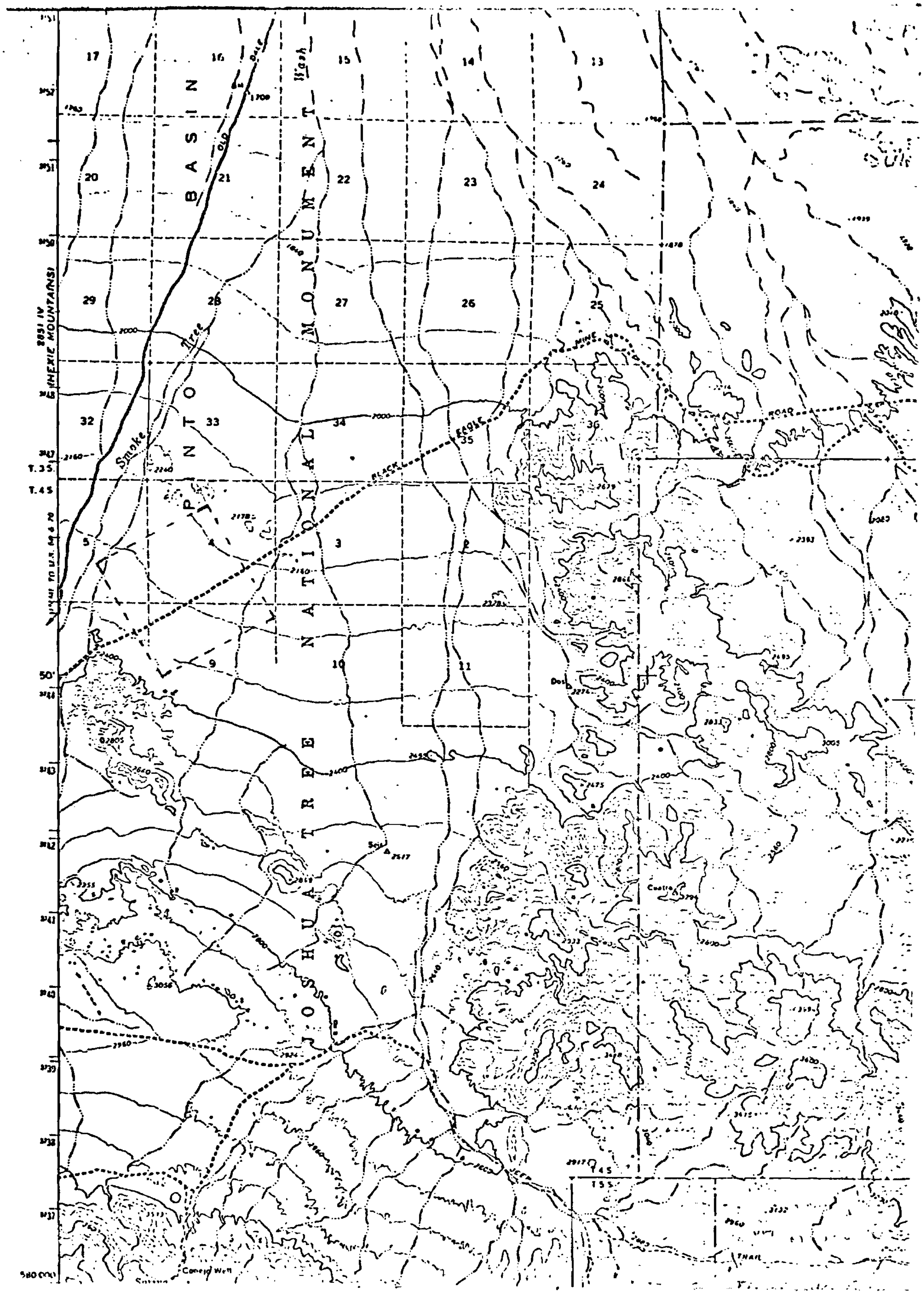
DESCRIPTION OF THE STUDY AREA

In the spring of 1966 an adjacent area to this study plot was the site of a Warner Brothers movie set. At that time, tortoises were observed moving throughout the area. That year several burrows were located by the author and observations of activities were made. In the winter of 1977-78 several reconnaissance hikes were made through the study plot and adjacent areas to locate the areas of major tortoise burrows. The plot (mostly in S4, T4S, R12E) is 2.5 miles [= 4 km] east of the main north south park road. A jeep road runs through the plot which gives access. Since the area has no survey markers, the jeep road (Black Eagle Mine Road) was used as a base line. The study plot is marked out so that it goes 4/10-mile [= .64 km] south of this road and 6/10-mile [= .97 km] north of the road (Fig. 1). In this way the rocky hills in the northeast were kept out of the study plot. Along the south side of the road 1/10-mile [= .16 km] markers were placed. Along the east and west borders 1/10-mile cairns were placed, and a yellow plastic ribbon tie was used in the top of a nearby shrub to mark the corners of the study plot.

The plot slopes downward toward the northeast with Smoketree Wash just dissecting the northwest corner of the study area. Most of the area is a large size sand, sandy alluvial plain (quartz and feldspar), with occasional cobbles. In the northwest there is a one-meter-high, 1/10-mile wide wash dissected ridge which has many rocks, some which are boulder size. The average elevation is 2200 feet [= 671 m], with a 1% slope, some areas even less.

The dominant perennial plant throughout the entire study area is the creosote bush (*Larrea tridentata*). Two additional perennial plants that cover most of the area but not as abundantly are Mojava yucca (*Yucca achidigera*) and holycross cholla (*Opuntia* sp.). In the northeast corner many of the smaller sandy washes have joined together to make larger wider sandy washes that work their way south of and around the 120+ feet [= 36.6 m] high rocky hills that mark the northeast corner of the study area. Here in these larger washes additional perennial plants occur, namely jojoba (*Simmondsia chinensis*); catclaw (*Acacia greggii*); and purple bush (*Tetracoccus hallii*). Appearing occasionally in various areas throughout the study area are the following perennial plants: California joint fir (*Ephedra californica*); cheese bush (*Hymenoclea salsola*); desert senna (*Cassia armata*); bladderpod (*Isomeris arborea*); 1 living (10 ft [= 3 m]), 1 dead, prostrate ocotilla (*Fouquieria splendens*). In the area south of the road there are several clumps of cottontop (*Euchinocactus polycephalus*).

The most abundant annual plant (*Chaenactis carphoclinia*) supplies seeds that are carried great distances by the black ants


JOSHUA TREE NATIONAL MONUMENT
PINTO BASIN
Smoke Tree
Wash
OLD DALE
BLACK EAGLE
MINE
ROAD
T.3S.
T.4S.
50'

to their crater-like homes. The tortoises have not been observed eating this annual. The following table (Table 1) shows the annuals that the tortoises have been observed eating.

Table 1. Annual plants observed being eaten by *Gopherus agassizi* in Pinto Basin

Plants Eaten	Times Observed	
Lotus tomentellus	8	(March-May)
Gilia ochroleuca	6	
Oenothera deltoides	2	
Schismus barbatus	1	
Allionia ditaxis	3	(May-October)
	20	

Additional annuals found in the study area are listed in Appendix 1.

METHODS

The author worked the study area observing and marking tortoises on the following dates: March 18, 21; April 21-23, 29-30; May 5-7, 13-14, 19-21, 27-29; July 1; October 9-12; November 7-9.

The entire square mile study area was covered twice in the spring dates using transects about 45 metres [= 50 yds] apart. These transects ran north and south. In the fall more time was spent in the areas of known tortoise activity with transects running east-west, especially in the north parts and south parts with very little time spent near the road. Most tortoises were spotted in the open areas from a distance of 30-50 metres [= 98-164 ft]. In the fall many captures were gently pulled out of burrows. The tortoises were observed from the distance to ascertain their activities. Many times the tortoise would see the researcher first and would sit watching, obviously disturbed. If the tortoise appeared to be frightened and obviously charging for its burrow, the author would rush to capture it before it went underground.

After capture the following technique was used to measure and record information on each tortoise. A light-weight nylon cord was used as a support sling to hold the tortoise as it was weighed. Careful attention of pressing on the tail to prevent voiding body fluids was maintained whenever the tortoise was moved; therefore, usually very slight voiding, if any, occurred. If large amounts were voided, the tortoise was reweighed, and estimates of the amount of void were recorded. When a later recapture occurred, the tortoise was reweighed. The following measurements (in millileters) were made on each tortoise: MCL, maximum carapace length; M3, width at third marginal plate; M4, width at fourth marginal; M7-8, width at the seam between seventh and eighth marginals; an additional measure of width was made at the flare marginal 8 usually and greatest width was recorded as, Gr W, also with the location of greatest width listed; PL N, plastron length from notch to notch; PL T, plastron length from tip to tip; H, height of shell measured at center of third vertebral plate (see data sheet Appendix 2).

Using a metal file, each tortoise was notched following the standard notching system used by the Desert Tortoise Council. This system is shown in Fig. 2. In addition to the notched number, the tortoise was marked with a black permanent ink number on the first marginal plate. This enabled the tortoise to be recognized when facing outward from its burrow; and the ink number on the eleventh marginal to identify in burrow if facing down tunnel. On juveniles, when marginal plates were too small, the ink numbers were placed on central plate 1 (front) and central 5 (rear) plate. Sex was determined for all adults and subadults, but with juveniles the sex usually could not be determined so the letter "J" was recorded for sex in juveniles. The capture location was plotted on a drawing of the study area which is included as Fig. 3. The measured data for the captured tortoises is included in Table 2.

A 35-mm color slide was made of each captured tortoise carapace with additional views of anomalies, injuries, or other interest points. The specimen was checked for parasites, and when found they were removed and collected in a small plastic container. The amount of new growth was measured and recorded. Behavior of the tortoise was recorded, including plants eaten. Shaded bulb temperatures were taken of the air at 1 metre and 1 centimetre heights and of the ground with the thermometer bulb laying on the ground. Pacific Standard Time was recorded at the beginning and end of each tortoise measuring session, with 15 minutes the average length of time needed to complete the work. The preceding information was recorded on Bureau of Land Management's prepared forms using permanent black ink. A sample is show in Appendix 2.

Tortoise burrows that were located on the study area were measured as to width and height, in centimetres. Depths were

Figure 2. Code system for identifying tortoises.

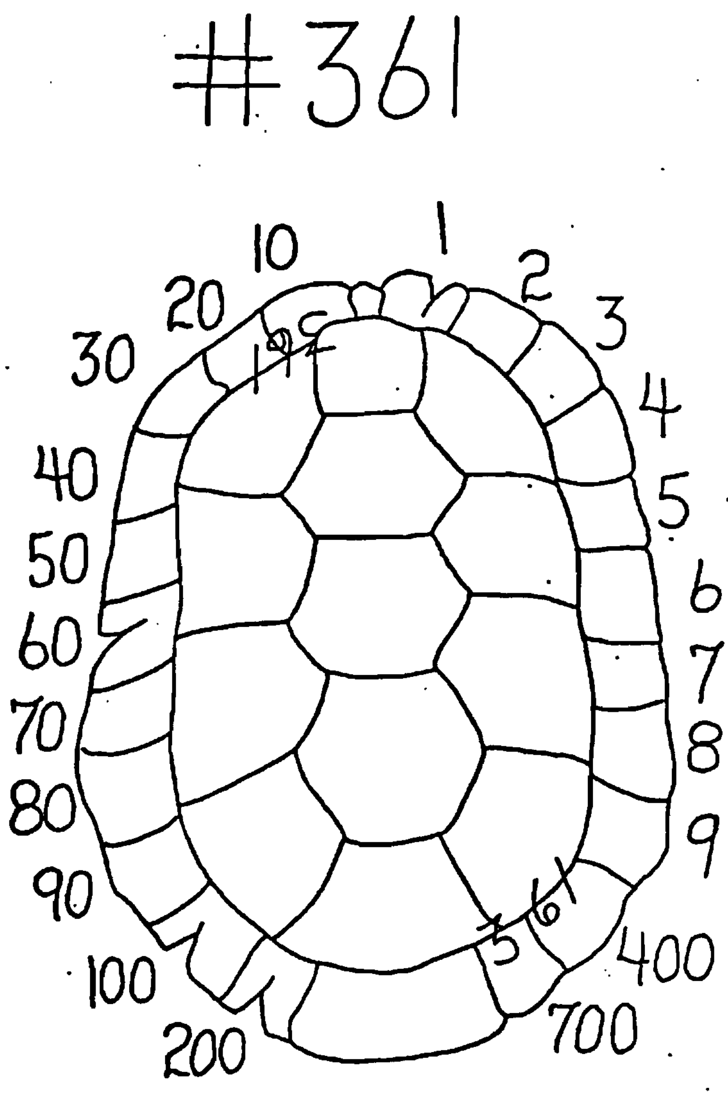


Figure 3. Capture locations of *Gopherus agassizi* in Pinto Basin Joshua Tree National Monument, 1978 by J. Barrow (S4 T4S R12E)

\# location of tortoise and date of capture
----------▶ recapture location

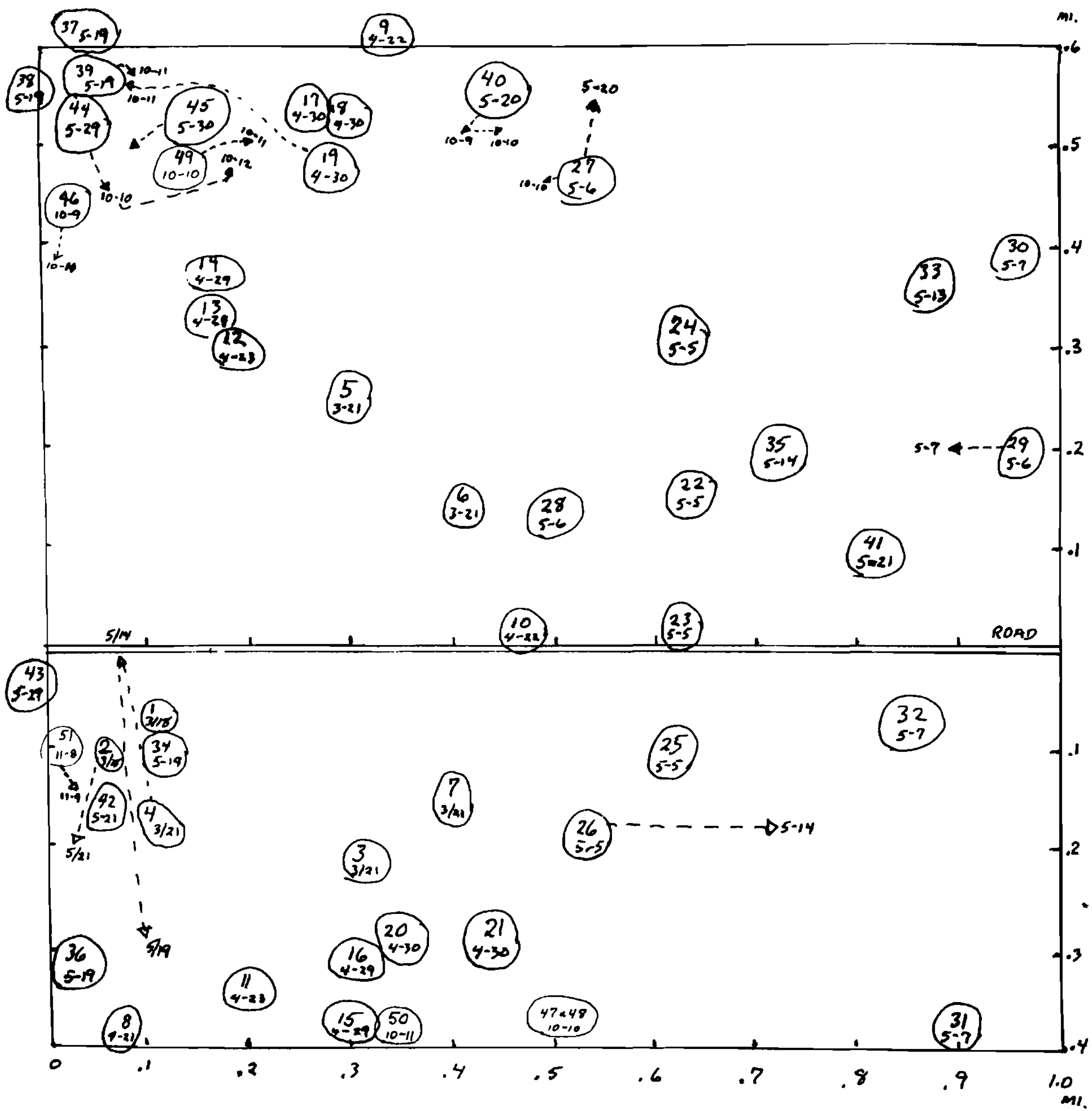


Table 2. Live tortoises - Joshua Tree National Monument - Pinto Basin.

Date	Sex	#	Wt/Kg	MCL	M3	M4	M8	H	PL N	PL T	Notes	Recapture
3-18-78		1		248							Located before data sheets in use	
		2	2.9	243	167	177	189	107	229	252		3-21-78
3-21-78		3		253							Eating *Lotus tomentellus* (no data sheets)	
		4	3.0	237	162	176	197	123	235	252	Ticks	5-14-78 5-19-74
		5		266							No data sheets	
		6		204							No data sheets	
		7		76							No data sheets	
4-21-78		8	2.5	237	141	154	170	102	212	229		
4-22-78		9	1.81	199	137	151	148	96	192	207		
		10	.99	169	111	121	124	74	155	169		4-29-78
4-23-78		11	2.24	216	139	164	166	103	205	227	Shell wear extreme	
		12	3.95	272	171	188	201	119	267	280	Ticks, eating *Lotus tomentellus*	
4-29-78		13	2.55	227	148	160	172	103	211	234	Almost no shell wear	
		14	1.92	213	141	154	158		192	212	Teeth marks on shell, eating *Gilia* sp.	
		15	.05	55	46	47	47	30	56	57	Eating *Gilia* sp.	
		16	.045	60	45	48	48	30	55	58	Eating *Lotus tomentellus*	
		17	.70	145	87	105	111	73	131	146	Eating *Gilia* sp.	
4-30-78		18	.87	161	106	114	119	80	147	163	Eating grass; tick	
		19	3.01	240	161	172	180	113	221	240	Ticks	10-11-78
		20	.16	90	61	69	66	40	85	93		
		21	.05	46	38	45	46	14	44	45		
		22	1.58	200	131	140	143	93	179	195	Eating *Lotus tomentellus*	
		23	3.47	248	165	188	187	115	225	242	Teeth marks on shell; eating *Lotus tomentellus*	
		24	1.61	205	129	146	151	86	185	201	Teeth marks; eating *Oenothera deltoides* (5-29)	5-29-78
		25	.19	92	63	70	72	45	84	92		
		26	3.41	258	177	183	199	115	245	260	Ticks	5-14-78

Table 2. (continued)

Date	Sex	#	Wt/Kg	MCL	M3	M4	M8	H	PL N	PL T	Notes	Recapture
5-6-78		27	2.0	210	126	150	154	93	196	212	Verm active; eating *Oenothera deltoides* (5-20) laid 3 eggs in burrow	5-20-78; 10-10
		28	1.92	217	136	152	159	91	194	216		
		29	.96	165	105	118	123		145	159		5-7-78
5-7-78		30	4.99	279	189	207	225	130	266	284	Ticks; shell wear extreme	
		31	2.67	242	153	176	192	103	221	247	M scutes curle	5-28-78
5-7-78		32	3.15	246	161	177	183	132	233	256	Eating *Gilia* sp.	
		33	3.99	269	171	194	209	115	255	268	Extreme shell wear; tooth marks	
5-14-78		34	.075	62	40	46	52	38	51	59		
		35	1.44	185	134	144	149	86	188	209	Double precentral	
5-19-78		36	4.01	259	170	188	198	112	242	254	Ticks; extreme shell wear	
		37	1.36	191	127	132	135	87	171	185	Ticks; teeth marks	
		38	2.2	225	144	163	172	97	209	228		
		39	2.51	231	142	166	175	104	218	236		10-11-78
5-20-78		40	2.97	239	162	184	193	106	224	241	10-11 eating *Gilia* sp. and *Allionia ditaxis*	10-9; 10-11-78
5-21-78		41	1.43	200	132	142	152	95	179	198		
		42	.095	76	53	62	62	36	70	74		
5-29-78		43	2.49	224	149	162	171	106	204	216	Teeth marks	
		44	1.51	206	129	144	149	92	190	203	Digging pallet (10-10) in burrow (10-12)	10-10-78; 10-12-78
5-30-78		45	3.05	243	158	167	179	110	224	241	Eating: *Allionia ditaxis*	7-1
10-9-78		46	0.02	60	45	48	50	26	55	60	Eating *Gilia* sp. and *Allionia ditaxis*	10-11-78
10-10-78		47	2.55	235	175	184	186	115	221	235	Interest in female #48	
		48	1.85	210	136	154	173	105	190	214	With male #47	
		49	2.15	222	144	162	173	105	211	228	In burrow; ticks; extreme shell wear	10-11-78
10-11-78		50	3.65	273	184	199	212	143	249	274	In burrow; ticks	
11-8-78		51	4.30	271	186	198	217	125	255	279	Ticks	11-9-78

measured using a felxible fishing pole, then measured with a metre stick and recorded in centimetres. If the end of the burrow was not reached as in kit fox complexes, depth was recorded as >200 cm [= 6.5 ft]. The distance to the nearest perennial plant was measured in metres and the plant identified. Figure 4 shows the location of these burrows. All the measured data for this drawing (Fig. 4) are recorded in Table 3.

Tortoise skeletal remains were collected. Shell data cards used by Bureau of Land Management (BLM) were filled out on both sides. A sample card is shown in Appendix 2. Where possible, the carapace length was measured (mm). No attempt was made to estimate carapace length if too few skeletal pieces remained. The locations where skeletal remains were found were plotted in a drawing of the study area (*see* Fig. 5). Information learned from these remains is listed in Table 4. These skeletal remains have been placed in 2 wire cages on the ground of the study area so they will be exposed to the elements and their normal decay process may be observed with, it is hoped, no disturbance from other living creatures.

RESULTS AND DISCUSSION

Population Parameters

Fifty-one tortoises were marked on the square mile study plot (Table 2). Age-class size decreased from adult with 30 tortoises to hatchling size class with 1 tortoise. The larger juveniles class (101-179 mm [= 4-7 in]) were fewer in number (4 tortoises) than the next smaller in size class, very young juveniles (<100 mm [= 3.9 in]) which had twice as many (8) located. This is no doubt significant as the smaller size is more difficult to spot. In a similar study at Chuckwalla Bench, Riverside County (Lori Nicholson) the opposite was true. Also, at a similar study at Goffs Site, San Bernardino County (B. Burge) the opposite was true (Table 5).

Table 5. Pinto Basin juvenile size classes compared with two other areas

Size Class	No. in Pinto Basin	% of Total	No. in Chuckwalla Bench	% of Total	No. in Goffs	% of Total
Very young juveniles (<100 mm)	0	15.5%	9	7.5%	2	2%
Juveniles (101-179 mm)	4	8%	25	32.5%	11	12%

Table 3. Information on tortoise burrows, Pinto Basin

No.	Facing direction	Width cm	Height cm	Cover height cm	Length cm	Location in relation to nearest perennial plant	m.	Notes
1	N	22	7	20	130	*Larrea tridentata*	<1	old, partly filled
2	NE	30	13	6	45	*L. tridentata*	1	#36 in (5-19-78)
3	N	29	13	3	47	*L. tridentata* dead	<1	#4 in opening (5-19-78)
4	NE	26	14	3	37	*L. tridentata*	1	tracks
5	E	30	13	7	180	*L. tridentata*	1	
6	NE	30	12	6	50	*L. tridentata*	<1	tracks
7	E	24	12	4	49	in open	>5	
8	E	26	13	4	50	in open		#39 (5-19-78)
9	S	25	9	3	30			tracks
10	E	34	20	11	200	big rocks		tracks
11	N	32	15	9	40	*L. tridentata*	<1	tracks
12	NW	30	14	11	80	dead *L. tridentata*	1	
13	E	27	11	3	100	*L. tridentata*	1	tracks #13 near (4-29-78)
14	E	24	11	6	50	*L. tridentata*	<1	#13 went in (4-29-78)
15	SE	28	13	7	130	in open		tracks
16	NW	18	7	3	36	*L. tridentata*	<1	
17	NE	20	9	4	20	*L. tridentata*	1	tracks
18	NW	29	13	10	36	*L. tridentata*	<1	
19	N	25	11	5	20	*L. tridentata*	1	tortoise scat near; rodent complex
20	NW	20	11	4	46	dead *L. tridentata*	<1	tracks
21	NW	24	12	7	20	*L. tridentata*	<1	tracks
22	SE	26	23	11	80	in open		spider web
23	W	19	8	3	70	*L. tridentata*	1	tracks
24	S	17	16	7	60	in open		tracks
25	NW	26	12	5	26	*L. tridentata*	1	tracks
26	NW	29	13	5	122	*L. tridentata*	<1	#19 near (4-30-78)
27	N	29	14	8	90	*L. tridentata*	1	animals growing in opening
28	W	17	6	2	25	open area		tracks
29	NW	6	5	1	18	*L. tridentata*	<1	#21 in opening (4-30-78)

Table 3. continued

No.	Facing direction	Width cm	Height cm	Cover height cm	Length cm	Location in relation to nearest perennial Plant	m.	Notes
30	SE	18	9	2	34	*L. tridentata*	<1	#10 in (4-29-78)
31	N	24	12	6	140	*L. tridentata*	<1	
32	S	25	11	8	23	dead *L. tridentata*	<1	old
33	S	21	10	5 part of bush	>110	dead *L. tridentata*	<1	turn at end
34	S	20	17	4	>100	holy cross cholla	<1	#22 in (5-5-78)
35	S	24	14	3	>120	*L. tridentata*	<1	#23 near (5-5-78)
36	S	18	16	3	110	*L. tridentata*	<1	possible trail; spider web
37	SE	20	9	3	56			
38	SE	20	9	1	30	dead *L. tridentata*	<1	
39	SW	20	9	2	42	dead *L. tridentata*	<1	#24 was 3 m. away on 5-5-78
40	NW	20	20	3	>100	dead *L. tridentata*	1	steep slant, deep; may be badger
41	N	19	16	8	80			steep slant
42	SE	24	14	8	84	dead *L. tridentata*	>1	web
43	NW	25	9	7	30	*L. tridentata*	<1	tracks
44	NE	32	19	9	>200	*L. tridentata*	1	#26 went down (5-5-78) kit for complex
45	N	29	16	10	110	*L. tridentata*	<1	tracks
46	W	20	16	10	120	*L. tridentata*	1	high platform, tracks
47	SE	21	12	5	30	*L. tridentata*	<1	tracks
48	NW	16	7	4	140	in open		old
49	NE	20	9	5	85	*L. tridentata*	1	tracks
50	E	20	10	4	66	*L. tridentata*	<1	tracks
51						*L. tridentata*		kit for complex; eaten owl eggs (5) (5-6-78)

Table 3. continued

No.	Facing direction	Width cm	Height cm	Cover height cm	Length cm	Location in relation to nearest perennial plant	m.	Notes
52						*L. tridentata*		kit for complex; one owl (5-28-78)
53	NE	23	25		>200			steep; claw marks side maybe badger
54	SE	20	10	5	50	dead *L. tridentata*	1	#27 in (5-6-78)
55	SE	15	10	10	50	*L. tridentata*		
56	NW	22	9	7	65	dead *L. tridentata*	1	tracks
57	NW	17	9	3	>100	*L. tridentata*	1	tracks
58	E	15	7	1	50	in open		tracks
59	NW	19	16	9	200	holy cross cholla	<1	tracks
60	SW	20	13	3	60	yucca	<1	
61	SE	23	12	4	20	*L. tridentata*	<1	tracks
62	E	31	14	1	54	*L. tridentata*	<1	tracks
63	E	28	18	7	140			
64	W	28	14	4	52			deeper slant
65	NE	18	12	5	74			plants growing in opening
66					>200			kit fox complex
67	NW	32	13	4	13	*L. tridentata*	<1	tracks
68	N	24	11	7	13	*L. tridentata*	<1	
69	NW	29	16	5	80	*L. tridentata*	<1	tracks
70	E	26	13	6	60	*L. tridentata*	1	tracks
71					>200			kit fox complex; red dirt
72					>200			kit fox complex; B. owl

Table 4. Data from tortoise skeletal remains

Date	#	Sex	Carapace length mm	Scutes adhering to skeleton	Scutes loose	Skeleton more or less entire, no scutes	Skeleton disjointed	Bone pieces chipping and breaking apart	Predator chew marks	Notes
4-23-78	1	?						x		
	2	J	90	x					x	
4-29-78	3						x			
	4	?					x			
	5						x			
	6	?					x			
	7	J	104	x					x	
4-30-78	8	?						x		
	9	?					x			
5-5-78	10	?						x		
	11			x					x	
5-6-78	12	?						x		
	13	?						x		
	14	J	75		x				x	
	15	?						x		
5-7-78	16	?						x		
	17	?					x			
	18	?					x			
5-13-78	19	J	74	x						Shell grown together at tail
	20		245		x					
	21						x			
	22		185	x					x	5 m. from burrow
5-21-78	23						x			
5-27-78	24	?					x			
	25		115		x				x	
	26	J	71		x				x	
	27						x			
5-28-78	28		217		x				x	
	29	J	84		x				x	
5-29-78	30		247			x				
	31		224		x				x	
10-9-78	32	J	112	x					x	
	33		168		x				x	
10-11-78	34	J	75		x				x	
	35	?	170?				x			
	36	?	180?				x			
	37	J	84	x					x	
	38		240				x			
10-17-78	39		220				x			

Figure 4. Drawing showing burrow locations, Pinto Basin

☐ = kit fox complex

N

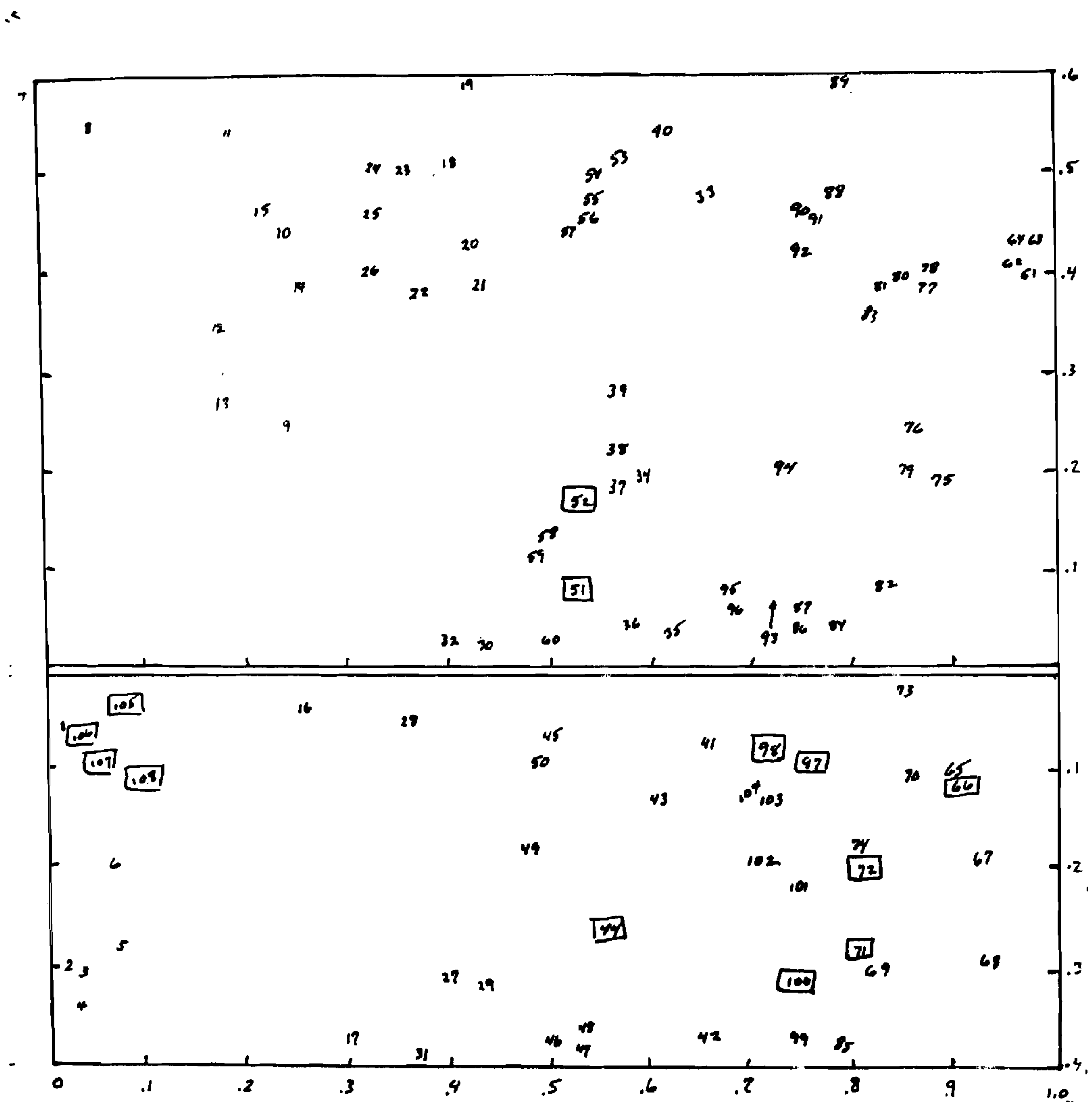
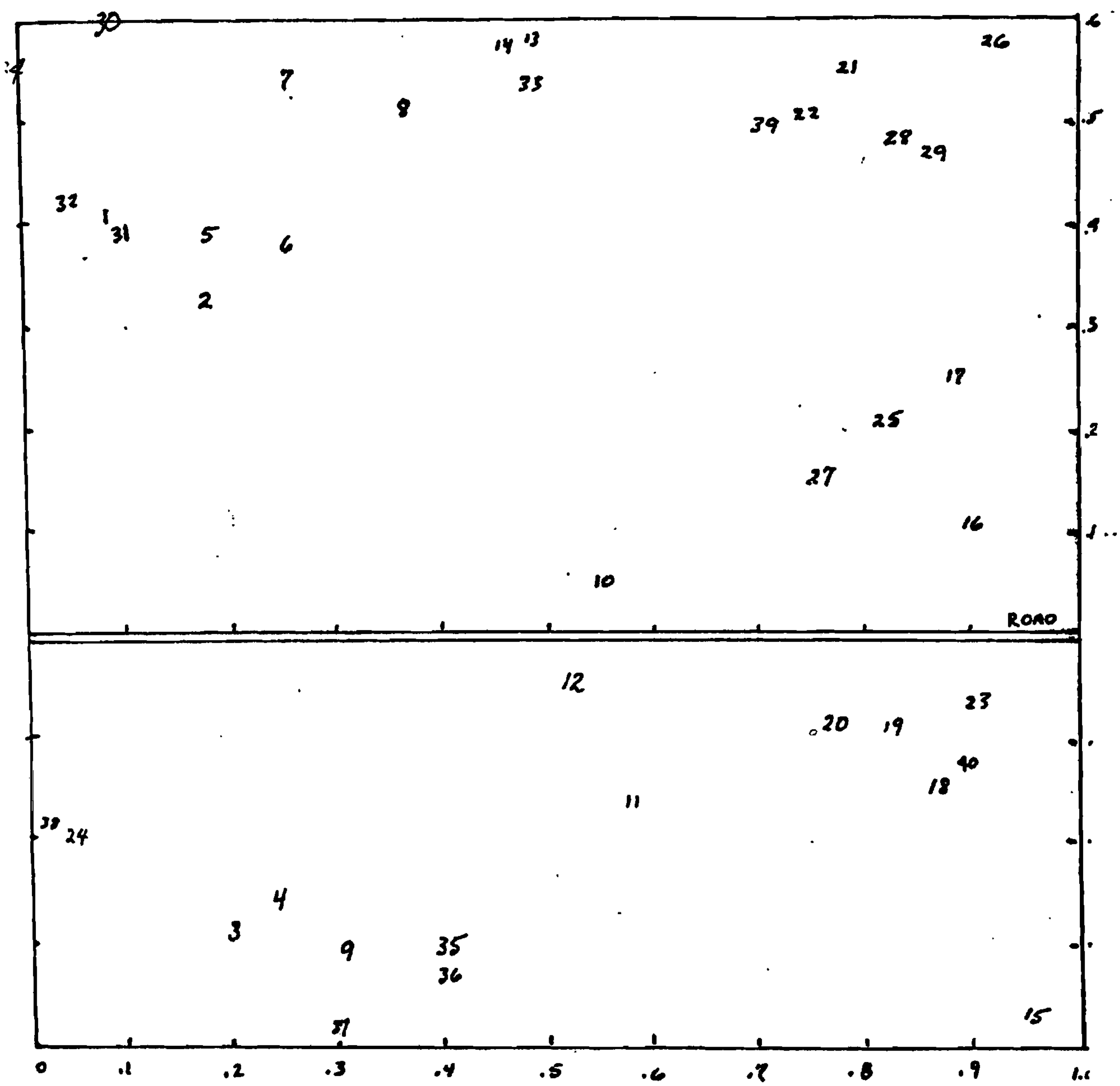


Figure 5. Location of *Gopherus agassizi* remains in Pinto Basin Joshua Tree National Monument, 1978 by J. Barrow (S4 T4S R12E)

#40 = coyote scat with scute



This may indicate the population is declining. In the adult class the males outnumbered the females; their ratio was males 130:100 females. The subadult class ratio was 1:1. Thirty-one and three-tenth percent of the population was recaptured once. Of the 16 recaptures, only 1 was a very young juvenile, and 12 were in the adult class. Recapture of male and female was about equal. Five tortoises were recaptured twice, 9.8% of the total population was handled 3 times each. With this high recapture it is thought that the total population of this study area may only reach 75 to 80 individuals. However, juveniles are difficult to find, so the estimate could be higher. Three days in October (9-11) the most effort spent was searching for hatchlings and during that time none were located. One very young juvenile (46) was spotted twice in that time period. Table 6 shows the size-structure and sex ratios of the total tortoise population.

Deaths and Contributing Factors

Skeletal remains of 39 tortoise shells were located within the study area (*see* Table 4). Of these 39 individuals, 19 were broken and deteriorated so much that estimates of carapace length and often sex were not determined. All 19 were either adult of larger subadult classes. Therefore, if these two classes (adult and subadult) are combined, they make up 62.5% of the skeletal remains located in this study area. Fewer than 6 of these were thought to be killed within the last year. That would mean less than 12% of all dead tortoises were adults which had died within the last year. Both classes of juveniles contained about the same number of dead tortoises (*see* Table 7). These smaller sizes of tortoise shells are not completely bone, much thinner bone, and seem to deteriorate and disappear from the scene more rapidly than the larger adult shells. Because of this, all 15 juvenile shells seem to have died within the year. Thus the total 37.5%, all of the juvenile deaths, seems to be within the year. Even though more adult size shells were located, it seems that more of the juveniles die per year. Seventeen of the total 39 dead tortoises were judged to have died within the last 12 months. This decision was made on the rate of decay of the scutes on the bone (*see* Table 4). To gather more information on the rate of decay of tortoise skeletal remains a field experiment (suggested by BLM) was begun November 7, 1978. In this experiment most of the skeletal remains were placed into two wire cages and left out in the normal weather right on the study plot. One cage was made with 1-inch [= 2.5 cm] opening chicken wire on a 2x4x1 foot [= 5x10x2.5 cm] wood frame. The second cage was the same except the wire opening size was about one-half inch. The wire opening size may determine the amount, if any, small rodents play in deterioration of the remains. Both cages have been filled with skeletal remains ranging from bone pieces

Table 6. Size-structure and sex ratios of Gopherus agassizi during spring 1978 in Pinto Basin, Joshua Tree National Monument (S4, T4S, R12E).

Age, size class carapace length mm	Size range observed	Sex M	Sex F	Sex Unknown	Total number in each class	Percent of population
Hatchlings	46 mm			1	1	2.%
Very young juveniles -100	55-92			8	8	15.5%
Juveniles 101-179	145-165	1	2	1	4	8.
Sub adults 180-208	185-213	5	3		8	15.5
Adults > 208	216-279	16	14		30	59.
Totals		22	19	10	51	100.%

Table 7. Size-structure of tortoise remains collected from Pinto Basin Joshua Tree National Monument 1978 (S4, T4S, R12E)

Age-size class carapace length mm	Size range observed	Sex M	Sex F	Sex Unknown	Total number in each class	Percent of population
Hatchlings					0	0
Very young juveniles -100	71-90			8	8*	20
Juveniles 101-179	104-141		3	4	7	17.5
Sub-adult	185			1	1	2.5
Adults >208	217-247	4	1		5	12.5
Broken shells		3	1	15	19	47.5
Totals		7	6	27	40*	100.0%

* One of these was a scute collected in coyote scat.

deteriorating and chipping to recent skeletons with scutes still tightly adhering to the bone. The collectors numbers have been marked on the shells with permanent black ink.

The coyote (*Canis latrans*) is a known predator of the tortoise in this area. One coyote scat was collected which contained a marginal scute of a very young juvenile tortoise. Once a coyote was observed hunting on the study area, approximately 8:00 a.m. P.S.T. Tracks and scat have been observed throughout the area. Six living tortoises sampled show probable predator toothmarks. Teeth marks on shell-skeletal remains show teeth marks, therefore, predators may have killed 36% or more (some too old to show this cause of death) of the dead shells located. Other predators may be kit fox (*Volpes macrotis*) -- more than a dozen kit fox den complexes are located on the study area; and the badger (*Taxidea taxus*) -- claw marks and typical digs occur. Burrowing owls (*Speotyto cuniculoria*) hunted and nested in the area. Known food included the kangaroo rat (*Dipodomys* sp.) and horned lizard (*Phrynosoma* sp.), but no evidence of tortoise remains was found in owl pellots. One owl was killed and eaten in May. The remains were found near an active kit fox complex.

Shell 19, a very young juvenile, might have died from a shell growth abnormality. Its plastron is joined to the carapace on both sides of the tail opening and the resulting hole is so small body wastes may have been blocked. This shell is completely intact without any predator marks.

Earlier it was noted (*see* Table 5) that there were noticeable fewer juveniles (101-179 mm) located on this study site; however, in skeletal remains both juvenile class seem to be the same. Therefore, there does not appear to be an extra heavy kill on the 101-179 mm juvenile class.

On this study site in Pinto Basin there is a large percent (76%) of dead tortoises compared to living tortoises. Table 8 shows the percent of dead tortoises to living tortoises on two additional study plots for comparison. Because of this high percentage of death one must consider the tortoise to be endangered on this study area at least.

Table 8. Percent of dead to living tortoises on three one square mile [= 2.6 km21 study areas

	Pinto Basin	Chuckwalla Bench	Goffs
Live captures	51	120	152
Skeletons	39	77	94
Total	90	197	246
% of Total	43	39	38

Activities

Tortoises were more active in the spring months with activity decreasing considerably in late May. The length of time activity occurred grew less as the days warmed up to 30° C and the annual plants dried. Thirty-four captures were made by 11:00 Pacific Standard Time, while 17 captures were made in the afternoon. It appeared that juveniles were captured more often in late afternoon but the data show 7 morning captures and 7 afternoon captures. The ratio of captures, juveniles to adults, was higher in the afternoon. High soil temperatures seem to prevent tortoise activity more than light condition or air temperature. Six captures were made with ground temperature 41° or over. The highest ground temperature recorded was 47° C (air, 1 m 36° C 1 cm 39° C). Number 40 was found in burrow opening. Of these 6 captures, 3 were adult males all in burrows, but the other 3 were juveniles all out walking and all seemed to be feeding (42° C).

Twice, courting was observed. Both times the male was aggressive, head bobbing, while the female's only action was to retreat into a burrow. The male followed her into the burrow. On October 10, 1978 #47 male tried to interest #48 female (210 mm [= 8.3 in]) who stayed drawn in. Twenty minutes later there was no change in action. On October 11, 1978 male #19 followed female #39 into burrow. Thirty minutes later both were still in the same burrow.

Laying of eggs was observed on May 20, 1978. Number 27 (210 mm) was in a burrow about 20 cm [= 8 in] down, facing out. When she was removed, she laid 1 egg out of the burrow on the ground as she was being reweighed. When placed back into the burrow, she finished laying -- a total of 3 eggs. No eggs or shells were located when digging in the burrow on October 10, 1978. Another group of eggs (approximately 5) was located at the mouth of another burrow on July 1, 1978; all were eaten out. On May 29, 1978 female #44 (206 mm [= 8.1 in]) was headed into a short burrow, digging. Watching for 30 minutes showed no other action except she stopped digging and walked north toward a larger burrow.

Twenty feeding observations were made. Most often eaten plant was *Lotus tomentellus* (*see* Table 1). The leaves, stems, flowers, and green bean-like seed pods were all eaten. By mid-May, most of the *L. tomentellus* was dried out. It was spotty throughout most of the area but the clumps grew thick and broad, always easy to reach. Grasses were very scarce, with *Schismus barbatus* the only one seen. There was 1 feeding observed on grass. The north-central area has a few more grass clumps than any other section. Since grass seems to be one of the most important tortoise foods, this may account for the low tortoise population in Pinto Basin. Bird cage plant (*Oenothera deltoides*), twice observed used by tortoises, was also used for food by a rather abundant green and black larvae (two-lined spinx moth) which often measured over 70 mm [= 2.75 in] long. These larvae were eaten by coyote, as parts were found in numerous scat. *Gilia ochroleuca* accounted for 6 feedings, and was used even when dry. This plant is widespread and more abundant than most plants used by the tortoise. *Allionia ditaxis* was still green in October and seems to be an important fall food but it is not abundant. Even the coyote may be competing for this plant and its water content,for 2 scat collected contained rather large amounts of it.

Figure 6 shows the large section of the study area covered by the tangling strands of *Eriogonum inflatum*. By comparing Fig. 3 and Fig. 5 with Fig. 6 one will notice that no tortoises are located in this thick, tangled vegetation which covers most of the open areas between the creosote (*L. tridentata*) clumps. Green and still growing in May, *E. inflatum* turns brown in fall and remains into early spring, unless broken and blown by the wind which may spread the seeds.

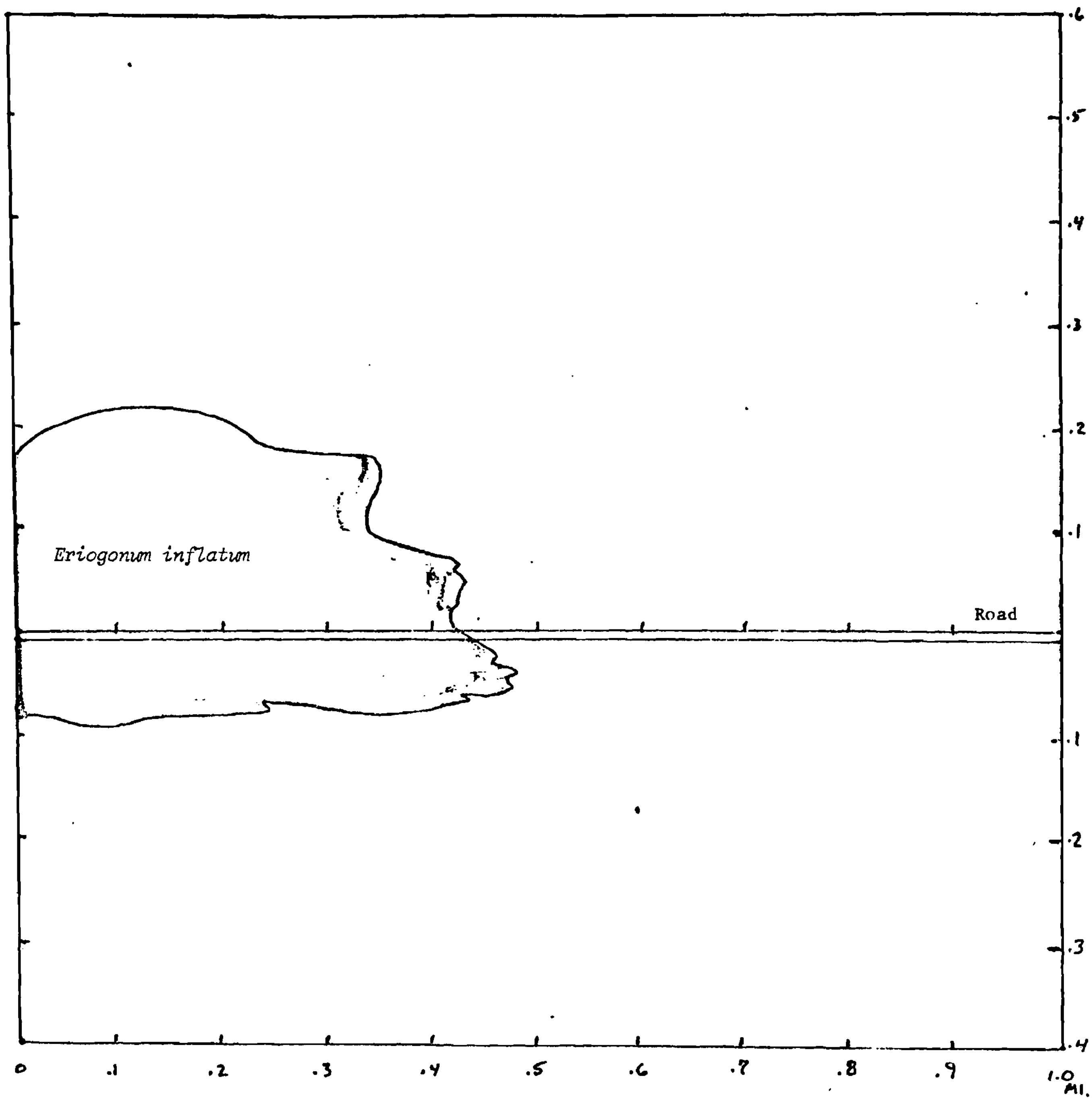
When handled, many of the tortoises started to void material from their bladders. To prevent this, the tail was pushed against the body. Usually this stopped the loss which is considered harmful as it is thought the tortoise can recycle and use this fluid. Occasionally after the tortoise is released, measuring completed and pictures taken or temperatures read, it would void anyway. Juveniles release an almost clear liquid under pressure; adults release pink, pink and white or mostly white solids along with a brown fluid with very little pressure. Thirty of the 45 spring captures either voided or started to do so. None of the 12 fall captures voided, no attempt was made to void, and the tail was not pressed into the body.

Parasites

Eleven tortoises (21.5%) had 1 or more ticks which were usually feeding. As they were removed, they left a wet, needlepoint spot where they were attached. Some were a little larger than 1 mm [= 0.04 in]; more were larger, 2-6 mm [= 0.08-0.2 in]; the largest was 8 mm [= 0.3 in], found on female #18. Almost always the ticks, squarish and hard, were located behind the flair or marginal 8 or 9. Most were located on the growing seam between marginal plates. Male #26 had 20 individuals all sizes, male #30 had 11, male #19 carried 7, while male #4 had 5. Others usually had 1 or 2. All ticks were removed. More male tortoise had these parasites than did females; 9:2 (82% were male). The smallest tortoise with ticks was female #18, 161 mm [= 6.34 in].

One tortoise (approximately 130 mm [= 5.1 in] carapace length) was killed near the study area (5-5-78) north of Smoke Tree Wash on the main park road. Other road kills have occurred in the monument, and several times tortoises have been seen crossing roads. On April 21, 1978 the author removed a male

Figure 6. Drawing showing the large area of *Eriogonum inflatum* (Compare with Fig. 3 and Fig. 5)



(247 mm [= 9.7 in]) from the road approximately 1.5 mile [= 2.4 km] north of Pinto "Y". Maybe caution signs should be posted (Turtle Xing).

On May 27, 1978 a marine helicopter ran out of fuel and landed by the road within the study area. Two others landed to assist. Tracks and high wind from blades seemed to do very little damage. However, in fuel transfer approximately 100+ gallons of fuel were spilled on the ground. This fuel loss was partly killed one once-healthy creosote (*L. tridentata*) approximately 5 feet [= 1.5 m] tall. Another perennial, a 2-foot [= .5 m] desert senna (*C. armata*) was completely killed. Annuals were sparce and drying in this wash so one must wait until spring of 1979 to determine such damage. The spill size was about 5 feet by 25 feet [= 1.5 m by 7.6 m]. On January 9, 1979 the odor of fuel was still present. All in all, there was much less damage to plants from this incident than from an off-road vehicle which drove 0.5 mile [= .8 km] south of road along the study area's west border (in July, August, 1978) and then back to the road.

CONCLUSIONS

In conclusion, considering the high death rate, the relatively low food production and competition for this food, and the small sample of captured tortoises in the 101-179 mm juvenile class, one might conclude that *G. agassizi* in Pinto Basin, Joshua Tree National Monument is endangered. Since the life span of *G. agassizi* is 60 to 100 years, it may take a decade or so to be sure, but at that time it may be too late to do anything to reverse the trend. It is recommended that this area not be used, as in the past, for any of man's activities other than occasionally passing through, and vehicles must stay on the road.

LITERATURE CITED

Burge, Betty. 1977. Aspects of the ecology of the desert tortoise, *Gopherus agassizi*, at Goffs site, Eastern Mojave Desert, San Bernardino County, California. Bureau of Land Management unpublished paper.

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2421 Foothill Boulevard
Laverne, California 91750

APPENDIX 1

Plant List

Perennial Species - Pinto Basin

Scientific name	Common name
Yucca schidigera	Mojave yucca
Hymenoclea salsola	cheese bush
Simmondsia chinensis	jojoba
Isomeris arborea	bladderpod
Cucurbita palmata	gourd
Echinocactus polycephalus	cottontop
Opuntia basilis	beavertail
O. bigelovii	Bigelow cholla
O. ramosissima	holy cross cholla
Ephedra californica	joint fir
Tetracoccus hallii	purple bush
Fouquieria splendens	ocotillo
Acacia greggii	catclaw
Cassia armata	desert senna
Dalea spinosa	smoke tree
D. schottii	indigo bush
Salazaria mexicana	paperbag bush
Sphaeralcea ambigua	mallow
Eriogonum inflatum	desert trumpet
Larrea tridentata	creosote

Annual Species - Pinto Basin

Scientific name	Common name
Lotus tomentellus	
Phacelia crenulata	notch-leaf phacelia
Salvia columbariae	chia
Mimulus bigelovii	monkey flower
Gilia ochroleuca	
Oenothera deltoides	
Schismus barbatus	
Allionia ditaxis	
Chaenactis carphoclinia	pebble pincushion

Appendix 2

Gopherus agassizi

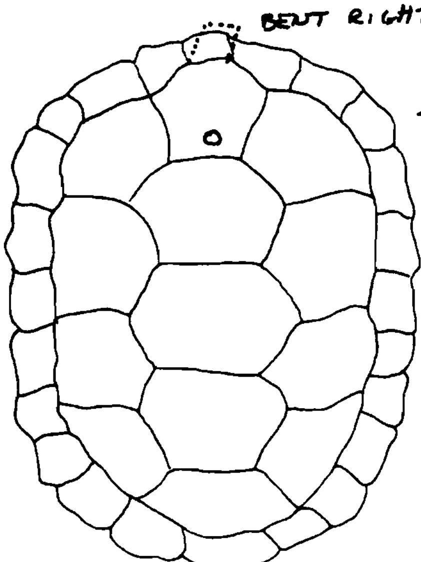
Site PINTO BASIN
Co. RIVERSIDE
SE ¼S 4 T4SR12E
Elev. 2200

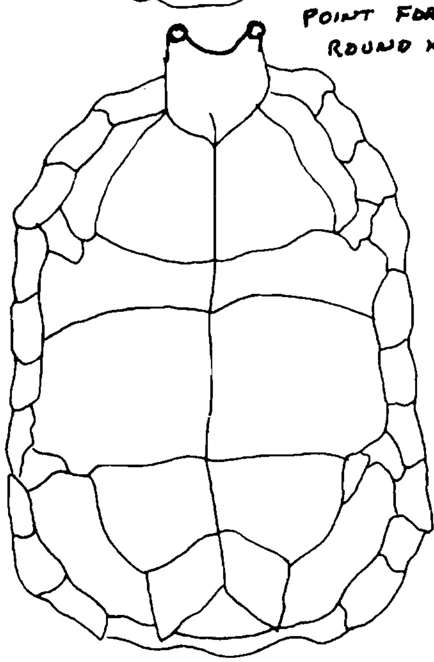
No. 25
Sex J
Date 5/5/78
Time(PST) 1:30

(shaded) Ta 28 (1m); 31 (1cm); T_{gs} 42
wind/cloud cover 15-25 MPH ◑ CIRRUS, ALTO STRATUS

Behavior STOPPED AT LOTUS TOMENTELLUS PLANT MAY HAVE BEEN EATING.

Location .65E .1 S





MCL 92
M3(post) 63
M4(mid) 70
7-8(seam) 72
Gr W @ 7-8
Ht(mid central-3) 45
Pl N 84
Pl T 92
Wt(g) 190
minus
adjusted
Photo: Car. ✓
close-up OF SHELL ANGLE
other
Gular cond.
Shell wear NONE
Injuries

Anom. PRECENTRAL BENT TO RIGHT, KNOB GULAR
Parasites

New growth 1mm
Voided ✓
During weighing
Amount 1ml
Color clear
Insol.
Finish @ 1:45

Note site of epoxied number.

Appendix 2

DESERT TORTOISE SHELL DATA CARD		DATE OF CARD 7-3-78	RECORDER J. BARROW	CARD NUMBER J.T. 5

DATE FOUND	COLLECTOR	SHELL NUMBER	SEX	MUSEUM	MUSEUM NUMBER
4/29/78	J. BARROW	5	♀		

ELEVATION	GEOMORPHOLOGY	SOIL TEXTURE-PARENT MAT'L	OTHER HABITAT USES	VEGETATION
2200	SANDY SLOPE	COARSE SAND / GRANITE		

TOPOGRAPHIC QUAD	NAME	COUNTY	STATE
	PINTO BASIN	RIVERSIDE	CA.

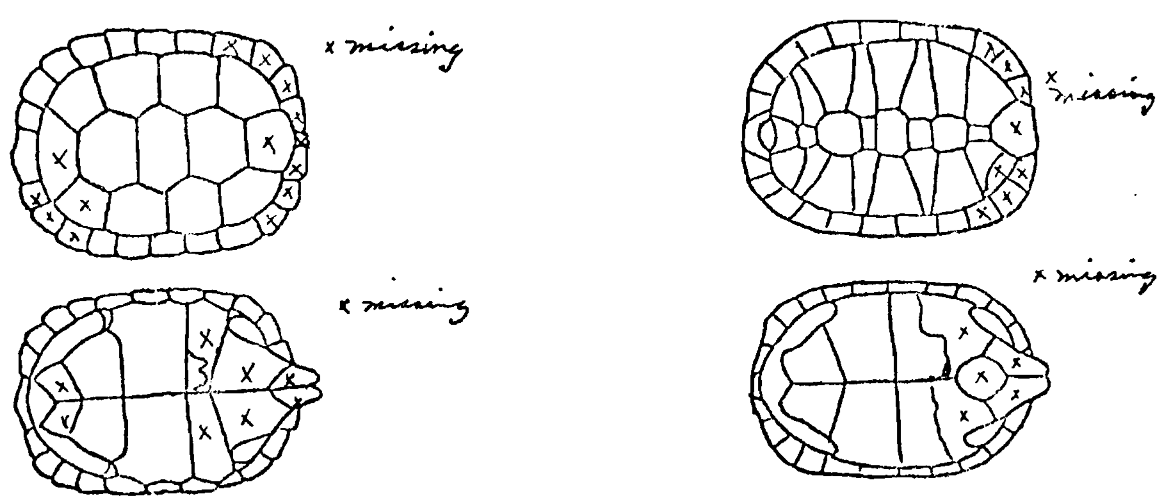
SCALE	TOWNSHIP	RANGE	SECTION	SUBDIVISION	SITE NAME
1:62500	4 S	12 E	4		J.T. N.M. PINTO BASIN

CONDITION OF SKELETON		ENTIRE		LEG BONES		COLOR OF BONE WHITE
AGE OF BONE: SOLID	X	BROKEN	X	PELVIS		OTHER
PEELING & CHIPPING		DISJOINING		HEAD		
CRUMBLING		DISJOINTED		VISCERA		

CONDITION OF SCUTES	NONE		POSSIBLE MORTALITY FACTORS	
NORMAL COLOR			UNKNOWN; NO MARKS	X
ADHERED TIGHTLY TO BONE			PREDATOR; CHEW MARKS	
COSTALS AND VERTEBRALS OFF			BULLET HOLES	
OTHER SCUTES LOOSE & PEELING			VEHICLE	
SCUTE FADED, GROWTH RINGS PEELING	WERE COVERED WITH SOIL + BONE	X	OTHER	
TORTOISE REMAINS IN PREDATOR SCAT				
LIMB OR HEAD PRESENT ONLY				

MEASUREMENTS	UNITS	MAX. P.L.	MIN. P.L.	C.L.	3MW	6MW	FLARE OR 8MW
	MM	90(?)	?	95 (?)	?	79	79

P: PLASTRON L: LENGTH C: CARAPACE M: MARGINAL W: WIDTH



Food Habits and Livestock Competition with the Desert Tortoise on the Beaver Dam Slope, Utah

Eric M. Coombs

An analysis of the food habits of the desert tortoise on the Beaver Dam Slope, Utah, shows that *Bromus rubens* and *Erodium cicutarium*, 2 exotic annuals, are the dominant foods. *Muhlenbergia porteri* is no longer a major food as it was in the 1930-40's. Perennial grasses are the highest preferred food item for both tortoises and livestock even though they comprise a minor portion of the diets and plant communities. The dietary overlap of cattle with tortoises on the Slope is 0.37. *Ephedra nevadensis* and *Ceratoides lanata* comprised about 46% of the cattle diet and only 0.5% cover and about 2% of the species density. *Ambrosia dumosa*, the major forage species allocated to livestock, was not observed in spring of winter samples (n = 300), although it has been observed to be utilized. Management considerations for the Slope should be directed at enhancing and increasing perennial grasses.

The declining populations of desert tortoises on the Beaver Dam Slope are attributed mostly to the effects of competition with livestock, predation, and collection. Livestock compete directly for forage and trample large amounts of the available source.

Indirect problems due to grazing are manifested by changes in the community structure and exotic introductions. Underlying problems may deal with nutrients, water, and electrolyte elimination that may affect growth, survival, and reproduction.

The Utah population on the Beaver Dam Slope has been proposed to be listed as an endangered species and parts of the area identified as critical habitat. The management of the grazing systems within tortoise habitat will play a major role in determining the survival of this dwindling species in the State of Utah.

INTRODUCTION

The food habits of the desert tortoise (*Gopherus agassizii*) in Utah have been studied by Woodbury and Hardy (1948), Hansen et al. (1976), and in recent reports by Coombs (1974, 1977 *a, b*). Livestock food habits were determined by a fecal analysis contracted to Dr. R. Hansen, Colorado State University (CSU), and through the Bureau of Land Management (BLM), reported by Coombs (1977 *a*). Data collection and comparison of tortoise-livestock dietary overlaps were made by direct observation, fecal analysis, and published references.

There are approximately 350 desert tortoises inhabiting some 70 mi^2 [= 181 km^2] of habitat in the extreme southwestern tip of Washington County, Utah (Coombs, 1977 *a*). The area is a gravelly flood-plain about 900 metres [= 2952 ft] in elevation. The dominant flora are: *Larrea tridentata, Ambrosia dumosa, Yucca brevefolia, C. lanata,* and *E. nevadensis.* Woodbury and Hardy (1948) estimated the population to be 36% males, 64% females with a density of 59.5/km^2 [= 154/mi^2]. The population is now 70% male, 30% female and has a density of 10.4/km^2 [= 26.9/mi^2], a figure 5.7 times lower than it was estimated in the 1940's (Coombs, 1977 *b*). The present population structure is 71.0% adult, 18.0% subadult, 9.0% juvenile, and 1.0% hatchling (Coombs, 1977 *a*). The desert tortoise was placed on the protected wildlife list in Utah in 1971, along with the Gila monster. Since that time, government agencies and special interest groups have been concerned with the status and management of the species.

The food habits of tortoises and livestock are difficult to determine because they vary with season, rainfall, and vegetative type. The major foods of the desert tortoise were found to be 2 exotic annuals, *B. rubens* and *E. circutarium*. There are 3 major population areas in the Beaver Dam Slope (referred later as the Slope) which were considered separately -- Woodbury, Welcome, and the Beaver Dam Well. For simplicity and shortness, the discussions and comparisons of diet for tortoises and livestock will be the average of the 3 areas. The reasons for averaging the data are: the area is mostly 1 grazing allotment, the colonies of tortoises in 1 area occur in several vegetation types, and because of the mobility of livestock in that they can range over a large area in a short time.

Because allotment fences controlling livestock are not correlated to tortoise distribution, the livestock fecal analysis under-estimated the actual forage competition as the livestock samples contained food obtained out of tortoise habitat. Trampling of tortoise forage by livestock is not easily measured, thus the impact is higher than depicted by direct forage competition alone.

The food of the desert tortoise consisted of grasses, forbs, parts of shrubs, and miscellaneous animal matter including fragments of carnivore scats, sand and small gravel were also ingested. A total of 39 species of plants were observed in the diet of the desert tortoise (Table 1). An additional 7 species may also be food items, but observations have not yet been made to support this (Table 1). Table 2 shows the plants used as food and the seasons of use by tortoises. The observations of food selection and percent use of 20 plant species are presented in Table 3.

Two separate fecal analyses were done on tortoise scats, 1 contracted to CSU and the other at Utah State University (USU). In most cases the 2 studies correlated closely except for 2 major differences. The CSU study picked up about half as much *B. rubens* and about 10 times the amount of *Tridens* species (Table 4). This was to be expected as the seasons of sampling were different. The CSU sample was primarily a spring sample and the USU a fall sample. The data from the 2 fecal analyses were combined in order to get an annual perspective of the tortoise diet. This was then compared with the spring, winter and combined use data obtained from the livestock fecal analysis (Table 4).

The fecal compositions by volume and weight were highly variable in the desert tortoise. Volumes varied from 75-95% grasses, 3-10% sand and small rock. Some scats were almost entirely sand, which may have served as territorial markers (Patterson, 1971). Scat weights averaged 1.95 grams [= .069 ounce], air dry.

The trophic similarity index of diet overlay was calculated for the study area and found to be: 0.61 tortoise-tortoise, 0.71 cattle-cattle, and 0.37 tortoise-cattle (Coombs, 1977 *a*). The dietary overlap between tortoises and cattle would be much higher were it not for the browse species in the diets of the livestock.

Many of the food species utilized by desert tortoises in Utah were found to be much less important in other states (Burge and Bradley, 1976; Berry, 1976). Berry (1974) observed that tortoises in California eat *B. rubens* and *E. cicutarium* when nothing else is available. It is possible that this is why Beaver Dam Slope tortoises rely on these 2 exotic annuals. The composition of the vegetation shows that perennial grasses are only about 1.0% of the cover of the communities on the Slope (Coombs, 1977 *a*). Woodbury and Hardy (1948) noticed the decrease in perennial grasses during their classic study and forewarned of the problems that would result from heavy livestock grazing. They observed that *M. porteri* was the most abundantly used and important food item. This is no longer the case, as *M. porteri* is no longer a substantial part of the tortoise diet (Coombs, 1977 *a*). Nish (1964) and Coombs (1977 *a*) noted that the cover and densities of perennial grasses on the Beaver Dam Slope were generally low, but were more abundant in less grazed areas. Tortoises show a high preference for *M. porteri* even though it is only a minor portion of the diet. *M. porteri* was once abundant throughout the range of *G. agassizii* and *G. berlandieri* (Hitchcock, 1935).

Perennial grasses are particularly important as they supply both water and nutrients during spring, summer, and fall. Because of the past 100 years of livestock grazing, perennial grasses are in shorter supply. Thus, tortoises are forced to eat dry annuals during the summer and fall, which may create a shortage of water and nutrients, and complicate electrolyte elimination (Coombs, 1977 *b*). These changes in tortoise habitat have occurred during the lifetime of many of the presently remaining individuals.

As a result of these changes in the plant community, including that caused by livestock grazing, the food habits of the desert tortoise in Utah have been forced to adjust to incorporate a new diet (Coombs, 1977 *a*). The major foods, now *B. rubens* and *E. cicutarium*, are annuals and do not provide the nutrients and moisture during summer and fall months that would be obtained from more succulent forage. With perennial grasses in short supply, the tortoises may become dehydrated during the summer, resulting in increased electrolyte buildups in both bladder and blood (Coombs, 1977 *b*). The primary problem arises in the elimination of K^+ ions as noted by Minnich (1977). He observed that if K^+ concentrations in the cells were raised much, the reproductive ability, DNA and vigor were adversely affected. Normally, K^+ is eliminated by forming insoluble potassium urate in the bladder, making water conservation and elimination more efficient, thus maintaining cell vigor and productivity. Perennial grasses are low in K^+ and have moisture available during the summer and fall feeding periods. Many of the substituted forbs and annuals are higher in K^+ and dry up early, thus creating dehydration and K^+ buildups. Also, Minnich (1977) noted that most plants utilized by tortoises are low in nitrogen. Nitrogen is needed to produce urate ions that tie up K^+. If the extra body water of the Slope's tortoises is tied up in surviving electrolyte problems, the shortage may stress females, thus affecting egg production, egg laying, and urination on the nest (Coombs, 1977 *b*).

Urination on the nest was demonstrated to be important as a nest predator defense mechanism (Patterson, 1971). Berry (1974) mentioned that tortoises may only reproduce during years of abundant vegetation, thereby conserving energy instead of wasting efforts during poor years. If livestock grazing is indeed indirectly responsible for the alterations of the diets of desert tortoises on the Slope, through vegetative changes at the community level, the explanations proposed here may account for the reduced rate of reproduction.

In order to avoid excessive water loss, Utah tortoises are forced to aestivate for longer periods than they perhaps would if the water cost was less than the benefit of feeding during summer months. Fortunately, the large bladder and aestivation habits partially check the evaporative water loss during long hot dry periods.

The property of adapting to changing environments belongs to populations, not individuals, which may explain the dilemma of this *K*-selected species.

Based on the data in Table 7 *a*,*b*, the 350 tortoises on the Beaver Dam Slope may consume 2552-5104 kg [= 5626-11252 pounds] of forage per year, depending on the number of active days. These figures are based on a relative minimum daily need of 3.0% of the body weight for BMR, figures for growth, reproduction, and activity would be higher.

Grazing practices on the Beaver Dam Slope have varied from the early uncontrolled flocks and herds to the present grazing systems developed by the BLM. The area has sustained livestock use since the 1860's. During this time, large flocks of sheep and herds of cattle have utilized the area for forage. Woodbury and Hardy (1948) stated that tortoises only had a few weeks in the spring until sheep "swept the carpet clean." Perennial grasses diminished, increaser and invader species flourished along with exotic introductions during the periods of uncontrolled grazing. Berry (1974) mentioned that in some cases changes appeared to occur in tortoise habitat too rapidly for many tortoises to adapt. Hardy's (1976) personal observations have also documented vegetation changes on the Beaver Dam Slope since his earlier studies.

Some exclosures now present on the Slope around wildlife waters show healthy stands of perennial grasses. Those waters that were unfenced did not show any significant differences when compared with the surrounding areas (Coombs, 1977 *a*). Livestock samples were taken to show winter and spring use. *A. dumosa* did not show up in the livestock fecal samples. This is important because the BLM bases part of the range-carrying capacity on this plant and uses it as a key forage species. If this plant is not being utilized much, then additional pressure is placed on other plants. Species such as *E. nevadensis* and *C. lanata* made up 46% of the diet of livestock. The total of both species makes up 0.5% of the cover and 9.15% of the total community composition (Table 6).

The data in Table 5 show the class of vegetation, the percentages of each class in the diets of both tortoises and cattle, and the percent of the total canopy coverage of each vegetation class. The perennial grass group received the highest index value of importance based on the percent of grasses in the diet divided by the cover percentage. A value equal to 1.0 shows that the animal uses a plant for forage in proportion to its density in the community. A value higher than 1.0 demonstrated higher preference relative to the plants' density. The preference indices for perennial grassea are 66.0% for tortoises and 78.9% for livestock of the total preference indices (Table 5). In all of the analyses the importance and preference indices have been highest for perennial grasses for both tortoises and livestock, even though they compose minor portions of both diets and the communities.

The data presented in this report further demonstrate the need and importance of perennial grasses to the desert tortoise, as was brought out by Woodbury and Hardy (1948). The same is also true for the livestock industry. Management objectives should be directed toward increasing the diversity and biomass of perennial grasses on the Slope, instead of emphasizing palatable browse components alone.

The relationships of competition between tortoises and livestock are variable because of seasons of use, vegetative types, and rainfall that accurate interpretations and predictions are difficult to make. However, the general trends and basic impacts have been documented enough to provide insight sufficient to promote better management programs that may benefit both tortoises and livestock. The Beaver Dam Slope is grazed primarily from November through May, depending on forage production and current grazing schedules. Attempts are being made to introduce a rest-rotation grazing system on the Slope in order to give the area one year of rest from grazing every 2 or 3 years. This system would be beneficial if rainfall and forage production were constant from year to year, but they are not. In this desert environment that imposes unpredictable extremes of temperature and precipitation, this type of grazing system will result in livestock being concentrated in larger numbers for shorter periods. If such concentrations are placed on the Slope, the vegetation may not recover before the next time grazing reoccurs if the 2 years in between are dry. This system of concentrated heavy use may not work on the Beaver Dam Slope because the competition between tortoises and cattle is high. Dry years make up the majority of the precipitation patterns. Tortoises would have to endure much higher competition during these critical times and this may have a devastating affect on reproduction, growth, and survival of individuals. The seasonal winter system presently used on the Slope may have a less severe impact overall when compared to rest-rotation. This system allows cattle to harvest old forage, scatter and trample seeds, and promote vigor to certain plants. Spring use (March to June) should be discontinued as there is too much direct competition for forage during the growing season between livestock and tortoises. Also, the effects of trampling on growing tortoise forage species may be more critical than direct forage competition. Livestock grazing could be authorized on a special license when ephemeral blooms occur for a special use period. Complete removal of grazing may also be necessary until the Slope recovers sufficiently to sustain livestock use and maintain or enhance tortoise condition.

Because of the present condition and proposed status of the Utah population of the desert tortoise to be listed as an Endangered Species, the problems of livestock grazing will become a major issue. More studies are needed to determine the diets of both tortoise and livestock, and especially the effects of trampling.

SUMMARY

The food habits of the desert tortoise (*G. agassizzii*) in Utah have been studied by Woodbury and Hardy (1948), Coombs (1974, 1977 *a*,*b*), and Hansen et al. (1976). Livestock food habits were determined by a fecal analysis contract with Dr. R. Hansen at CSU and reported by Coombs (1977 *a*). Data collection and comparison were made by: direct observations of feeding behavior, fecal analysis and published references. The food habits of both tortoises and livestock varied with season, rainfall, elevation and soil types. The major foods of the desert tortoise were two annuals, *B. rubens* and *E. cicutarium* rather than perennial grasses as reported 40 years ago.

Competition, trampling of vegetation, and vegetative composition changes caused by livestock grazing may be seriously affecting this population. Nutrients, water, and electrolyte balances have been altered by a change in food habits. Changes in environmental factors have occurred during the lifetime of many of the presently remaining tortoises.

Computed dietary overlaps on the Beaver Dam Slope areas were: tortoise-tortoise 0.61, cattle-cattle 0.72, and tortoise-cattle 0.37. Both tortoises and livestock demonstrated the highest forage preference for perennial grasses based on the diet and availability. As a result of competition with livestock and other disturbances, the desert tortoise, a *K*-selected species, may face ecological extinction on the Beaver Dam Slope.

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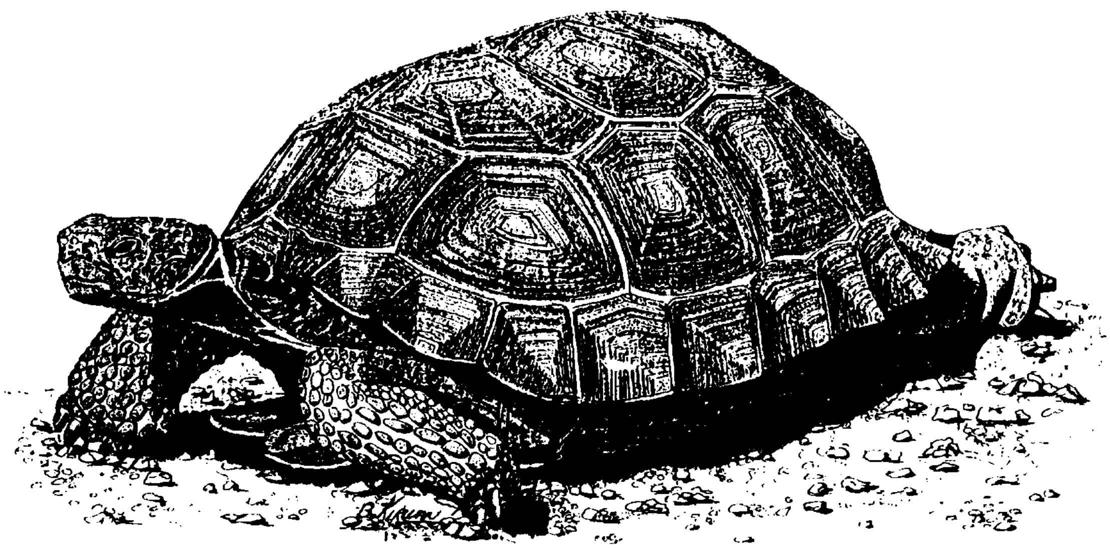

Table 1a. Plant species used as food by desert tortoises.

Species	Species
Eriogonum inflatum	*Krameria parviflora*
Bromus rubens	*Aristida purpurea* 2/
Erodium cicutatium	*Sporabolus cryptandrus*
Leopidium lasiocarpum	*Stipa speciosa* 2/
Euphorbia albomarginata	*Acacia gregii* 2/
Muhlenbergia porteri	*Artemisia filifolia* 2/
Opuntia basilaris	*Astragalus* 2/
Bromus tectorum	*Atriplex canescens* 2/
Tridens pulchella	*Composite* 2/
Coleogyne ramomissima	*Descurainia pinnata* 2/
Plantago insularis	*Ephedra nevadensis* 2/
Cryptantha circumcissa	*Guterizia sorathrae* 2/
Chorizanthe rigida	*Kochia* 2/
Eriophyllum wallacei	*Larrea tridentata*
Cryptantha micrantha	*Leptodactylon* 2/
Tridens pilosus	*Mirabilis* 2/
Oryzopsis hymenoides 1/	*Oenothera* 2/
Hilaria rigida 1/	*Potentilla* 2/
Phacelia fremontii 1/	*Spharelcia grossulariaefolia* 2/
Erigionum deflexum	*Ceratoides lanata* 2/

1/ Observed only in scats, not by direct feeding observation by USU.

2/ Found in scats by CSU, species not given, but speculated here.

Table 1b. Plant species that are likely to be used as food items by the desert tortoise.

Species
Boutelua rigida
Hilaria jamesii
Chorizanthe brevicornu
Lesquerella rectipes
Plagiobethrys arizonicus
Plantago purshii
Delphinium amabile

Table 2. Desert tortoise plant use list to show seasons of use.

Species	Season of use
Eriogonum inflatum	Sp Su
Bromus rubens	Sp Su F W
Erodium cicutarium	Sp Su F W
Lepidium lasiocarpum	Sp
Euphorbia albomarginata	Sp Su
Muhlenbergia porteri	Sp Su F W
Opuntia basilaris	Sp
Bromus tectorum	W Sp
Tridens pulchella	Sp Su F
Coleogyne ramomissima	Sp
Plantago insularis	Sp Su
Cryptantha circumcissa	Sp
Chorizanthe rigida	Sp
Eriophyllum wallacei	Sp
Cryptantha micrantha	Sp
Tridens pilosus	Sp Su F
Krameria parviflora	Sp
Oryzopsis hymenoides	Sp Su F W
Hilaria rigida	Sp Su F W
Phacelia fremontii	Sp
Erigonum deflexum	Sp Su
Aristida purpurea	Sp Su
Sporabolus cryptandrus	Sp Su F W
Stipa speciosa	Sp
*Acacia gregii***	Sp
*Artemisia filifolia***	Sp
Astregalus	Sp
Atriplex canescens	Sp Su F
Composite	Sp Su
Descurainia pinnata	Sp
*Ephedra nevadensis***	Sp
*Guterizia sorathrae***	Sp Su F
*Kochia***	Sp
*Larrea tridentata***	
*Leptodactylon***	
*Mirabilis***	Sp
Oenothera	Sp
*Potentilla***	Sp

** These species may have been accidentally ingested, their significance in the tortoise diet is probably marginal.

Table 3. Direct observation of tortoise feeding behavior with the number of tortoises observed using each species, and the percentage of tortoise use on a species and the area of observed utilization.

Species	No. of observations	Percent
Eriogonum inflatum	11	4.62
Bromus rubens	32	13.45
Erodium cicutarium	39	16.39
Lepidium lasiocarpum	2	0.84
Euphorbia albomarginata	12	5.04
Muhlenbergia porteri	18	7.56
Opuntia basilaris	6	2.52
Bromus tectorum	7	2.94
Tridens pulchella	14	5.88
Coleogyne ramomissima	1	0.42
Plantago insularis	20	8.40
Cryptantha circumcissa	18	7.56
Chorizanthe rigida	10	4.20
Eriophyllum wallacei	1	0.42
Cryptantha micrantha	12	5.04
Tridens pilosus	10	4.20
Krameria parviflora	6	2.52
Oryzopsis hymenoides	8	3.36
Hilaria rigida	6	2.52
Sporabolus cryptandrus	5	2.10
Total (20 species)	238	100.00

Table 4. Comparisons of fecal analysis of tortoises and livestock.

	Tortoise samples			Livestock samples		
Species	CSU	USU	Average	Spring	Winter	Average
Aristida	0.06		0.03		12.30	6.15
Bromus	27.60	54.10	40.85	34.72	5.60	20.16
Bromus seed	1.38		0.69			
Oryzopsis	0.53	0.60	0.57		0.80	0.40
Sporobolus	2.03		1.02		0.21	0.11
Stipa	12.03		6.02		9.03	4.52
Tridens	22.08	1.56	11.821	0.55	0.64	0.60
Acacia	0.29		0.15			
Artemisia	0.06		0.03			
Astragulus	0.07		0.04			
Atriplex	0.15		0.08	4.65	5.10	4.86
Composites	0.21		0.11			
Cryptantha	0.42	2.80	1.61			
Descurania	0.09		0.05			
Ephedra	0.10		0.05	28.43	20.24	24.34
Eriogonum	1.31	7.73	4.52			
Erodium	18.10	20.46	19.28	6.36	0.61	3.49
Eurotia	2.40	1.06	1.73	18.60	26.16	22.38
Gutierizia	0.02		0.01			
Kochia	0.016		0.01			
Krameria	0.10		0.05		0.61	0.31
Larrea	1.61		0.08		0.64	0.32
Leptodactylon	0.04		0.02			
Mirabilis	0.17		0.09			
Oenothera	0.35		0.18			
Opuntia	4.31		2.16			
Plantego	1.75	0.36	1.06			
Potentilla	0.11		0.06			
Shpaerelcia	0.70		0.35		0.39	0.20
seeds	0.96		0.48	1.26		0.63
unknown	0.12		0.06			

Table 4. continued.

Species	Tortoise samples			Livestock samples		
	CSU	USU	Average	Spring	Winter	Average
Yucca	0.07		0.04	2.39	3.87	3.13
Animal parts	0.47	0.86	0.67			
Bromus		1.06	0.53			
Bouteloua		0.70	0.35			
Chorizanthe		4.50	2.25			
Coleogyne		0.01	0.01			
Euphorbia		0.43	0.22			
Hilaria		0.01	0.01		3.40	1.70
Muhlenbergia		3.06	1.53		2.04	1.02
Munroa		0.10	0.05			
Phacelia		0.13	0.07			
Caryx				0.55		0.28
Festuca					0.39	0.20
Poa					0.21	0.11
Sitantion					0.21	0.11
Glosopetalon				1.18	0.21	0.70
Baileya				1.26		0.63

Table 5. Relative preference index for tortoises and cattle based on diet and forage cover.

	# Species		% Diet		Total	Preference index Tortoise		Preference index Cattle	
Class	Tortoise	Cattle	Tortoise	Cattle	cover %	Diet/cover	%	Diet/cover	%
Grasses									
Annual	5	4	42.47	20.75	15.0	2.8	8.8	1.4	7.6
Perennial	7	8	21.00	14.93	1.0	21.0	66.0	14.6	78.9
Forbs	17	4	32.17	7.85	4.0	8.0	25.2	1.0	10.3
Shrubs	10	6	2.09	52.21	80.0			0.65	3.2
Palatable				(51.58)	(25.0)			2.1	
Semi-palatable				(0.32)	(15.0)			0.02	
Unpalatable				(0.32)	(40.0)			0.008	
Other	3	2	2.27	4.26					
Total:	42	24	100.00	100.00		100.00		100.00	

Palatability based on Cedar City District BLM procedures for grazing calculations for forage allocations.

Table 6. Some selected forage species for livestock on the Beaver Dam Slope.

Species	% cover	Density	Percent of diet Spring	Winter
Ambrosa dumosa	4.24	32.43	-	-
Ephedra nevadensis	0.064	0.88	28.43	20.24
Ceratoides lanata	0.44	8.27	18.60	26.16
Muhlenbergia porteri	0.074	0.87	-	2.04

Table 7. Weight approximations and daily forage requirements of the Beaver Dam Wash tortoise population.

Code class	class mm	Population est.	$\bar{x}$ weight (g)	Total in (kg)	$\bar{x}$ kg/day activity
1	250	99	3800	376.2	11.286
2	200-249	153	2500	382.5	11.475
3	140-199	64	1200	76.8	2.304
4	60-139	30	500	15.0	0.45
5	60	5	50	0.25	0.0075
Total		350		837.25 (kg)	

Results of a Two-year Study of Tortoises on the Beaver Dam Slope, Arizona

Judy P. Hohman and Robert D. Ohmart

Abstract

Population structure, density, and feeding habits were determined from a study made during 1977-1978 of a population of desert tortoises on the Beaver Dam Slope in Mohave County, Arizona. Of 73 desert tortoises marked within a 5.18 km^2 [= 2 mi^2] area, 70% of the population was sexually immature. For adult tortoises, the sex ratio favored males by more than 2 to 1. Estimated tortoise density for the study area ranged from 15 to 19 tortoises per km^2 [= 40 to 50 per mi^2]. Microscopic fecal analysis and field observations indicated that the diet of this population for the spring and summer months was composed primarily of forbs. *Plantago insularis* was the major food item consumed and represented more than 35% of the total diet. Slight increases in perennial grass and shrub utilization were noted from April through August.

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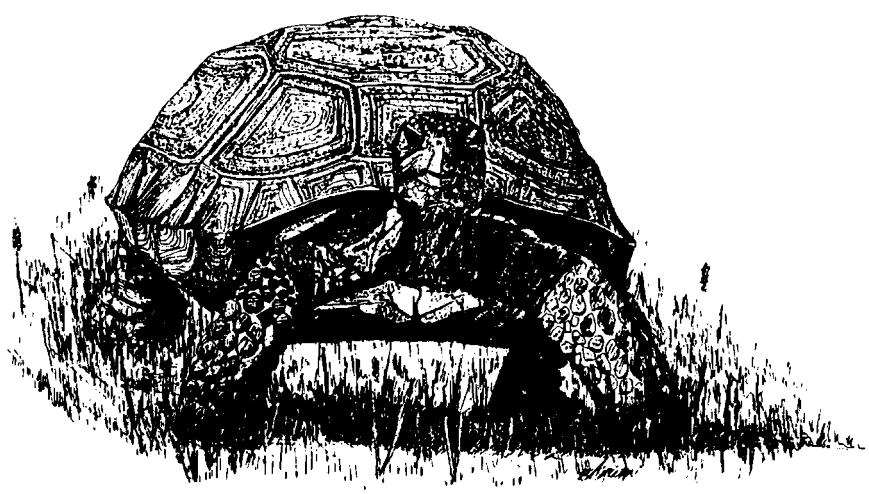

Preliminary Investigations of the Movements, Thermoregulation, Population Structure and Diet of the Bolson Tortoise, *Gopherus flavomarginatus*, in the Mapimi Biosphere Reserve, Durango, Mexico

Gustavo Aguirre Leon, Gary Adest,
Michael Recht and David Morafka

The bolson tortoise, an endemic species of Mexico, is threatened with extinction because of long-term harvesting by man. The Mapimi Biosphere Reserve, recently established within the tortoises' range, has as some of its goals protection, preservation and effective management of this species.

Studies of tortoises have begun and preliminary data are available on several aspects of their biology:

1. Colony distribution, population density and structure: The largest colony in the Reserve is highly dispersed; population density estimates are 1 tortoise/30 ha [= 74 acres]; indirect estimates of age composition reveal 53% adults, 18% subadults and 29% juveniles.

2. Dietary preferences, based upon microscopial analysis of fecal droppings, are discussed.

3. Radio tracking is being used to study thermoregulation, home ranges, activity patterns and burrowing behavior. Preliminary thermoregulatory and field behavioral observations are presented.

INTRODUCTION

The bolson tortoise, the least known species of the genus *Gopherus* and endemic to Mexico, is threatened with extinction. Its populations have been decreasing continuously because of human predation, habitat modification from agricultural practices and animal husbandry, unrestrained trade, and the lack of efficient protective laws.

The Mapimi Biosphere Reserve, recently established within the tortoises' range (about 40,000 km^2 [= 15,440 $miles^2$]) has among its goals protection, preservation and effective management of this species. The size of the Reserve in the state of Durango is, at present, 30,000 ha. The future area of the Reserve is projected to be 108,000 ha [= 74,130 acres] and to include portions of the States of Chihuahua and Coahuila.

The protection of tortoises seems to be improving. On one hand, the Reserve protects the populations included within its boundaries while on the other hand, the endangered status for the bolson tortoise recently assigned by the Fish and Wildlife Service of the United States will hopefully be decisive for restraining illegal trade.

Tortoise studies in Mapimi began by the end of 1977. The first objective was to determine colony status and distribution. In September 1978 a joint program was begun between the Instituto de Ecologia and California State University Dominguez Hills. The participating researchers have identified the issues of individual space requirements and relationships, thermoregulation in relation to suitable habitat and dietary preferences and requirements as critical prerequisites for designing and implementing an effective management program.

MATERIALS AND METHODS

Bioradiotelemetry

Two captive *G. flavomarginatus* were fitted with radio transmitters, released and tracked. The transmitters were noncrystal controlled oscillators which were epoxied to the dorsum of the flared marginals above each hind limb. Each tortoise carried two transmitters: one was light-sensitive and the other thermally-sensitive. The attachment position was selected to provide maximum transmitter-to-burrow clearance. The transmitter operated on the standard FM broadcast band (88-108 MHz) and had a useful range (aboveground) of 200+ m.

Transmitters were constructed in essentially the same manner as described by Shields (1976) except that a bridge circuit was added. This circuit, using a photo-cell or a thermistor as the parameter bypass, provided a variable resistance, permitting the measurement of light levels or ambient temperatures. Each transmitter was operated on a separate frequency for ease of signal identification.

Data were recovered aurally by counting the number of "clicks," or pulses, per unit time and comparing these to a previously calibrated curve. Locational data (loci) were recorded by marking vegetation with numbered tags and taking compass bearings from the loci to reference points in the habitat. Measurements of this sort were used to locate accurately and construct the movement patterns of released tortoises. A Panasonic 1080 multiband portable radio was used as the tracking receiver.

The tracking technique was essentially the peak-null method described by Cochran and Lord (1963), although the use of a whip antenna introduced some minor variations in the procedure. The peak signal was received when the antenna shaft was perpendicular to the source. The null signal (reduced or no reception) was achieved when the tip of the antenna (null cone) was pointed directly at the source.

Thermoregulation

Cloacal temperatures, air temperatures (both sun and shade) and soil temperatures (sun and shade) were monitored on captive *G. flavomarginatus* using Schutheis thermometers. Data were collected on a male tortoise (#64, body weight 4.5 kg [= 9.9 pounds], CL 286 mm [= 11.3 in], CW 226 mm [= 8.9 in]) with no access to subterranean retreat and confined alone to an unroofed courtyard measuring 10 x 25 m [= 32.8 x 82 feet]. The courtyard was planted with native sclerophyll vegetation. Simultaneously, data were gathered on female (#25, body weight 5 kg [= 11 pounds], CL 292 mm [= 11. 5 in], CW 220 mm [= 8.7 in]) tortoise housed in chain-link pen (8 x 8 m [= 26.2 x 26.2 feet]) with a tortoise-excavated partial burrow recessed from the surface 40 cm [= 15.7 in] and extending 50 cm [= 19.7 in] in length. Temperature measurements were made by upending tortoises and inserting the thermometer to a depth of 40 mm [= 1.6 in]. Multiple regression analysis of air temperature in sun, air temperature in shade, soil temperature in sun, soil temperature in shade, air temperature in the borrow and soil temperature in the burrow were performed with cloacal temperature as the dependent variable.

Population Structure

The age structure of tortoises was estimated by measuring active burrow entrance diameters. On the basis of previous comparative measures, it was determined that burrow diameter is, on the average, 37% larger than the maximum straight line width of the occupant tortoise. At the same time, carapace width represents 80% (mean) of carapace length according to holotype and paratype measurements (Legler, 1959) and 40 measurements taken directly from live tortoises and shells (Aguirre, unpublished data). These estimates are crude because little is known of the species age-size characteristics. We have not yet precise data for determining definitive age classes, size at appearance of secondary sexual characteristics, nor do we have detailed information on growth rings, or growth rates under natural conditions. The present analysis was attempted taking into account the adult size given in the species description (Legler, 1959; Legler and Webb, 1961; Auffenberg and Franz, 1978) and extrapolating lesser size classes in relation to those determined for *G. agassizi* (Berry, 1976).

Diet

The method of Sparks and Malachek (1968) was used in order to assess the proportion of plant species eaten by tortoises. This technique has proven to be useful in the study of feeding habits of herbivorous reptiles such as the desert tortoise, *G. agassizi* (Hansen et al., 1976), and the chuckwalla, *Sauromalus obesus* (Hansen, 1974). By means of this technique, relative density (equivalent to dry weight percentage) of plants in the dung can be estimated starting from frequency of discernible epidermal plant fragments appearing in the microscopical analysis of fecal droppings.

A total of 44 fecal samples were collected from 2 areas representing a total of 25 km^2 [= 9.7 mile^2]. These areas were Rancho LaFlor, 15 km [= 9.3 miles] from the Laboratorio Reserve, and an unnamed locality 4 km [= 2.5 miles] west of the Laboratorio. All pellets were analyzed individually after having been collected over an 8 month period from March to October, 1978. Approximately 100 different species of plants from the study area were used in the comparisons of cellular patterns. Most of the fecal droppings were collected from the ground near the burrows and also from burrow entrances. A number were obtained directly from tortoises captured during the summer. These last samples, and those with a freshly dried appearance collected during the summer, probably were deposited during that season. The old and white appearance of most of the scats collected during the other months suggested that the times of deposition and collection differed and the samples were considered of indeterminate age. However, the presence of different phenological stages in these droppings indicated that several seasons were represented.

RESULTS AND DISCUSSIONS

Thermoregulation

Table 1 summarizes the body temperature and basking behavior data for 7 days during September, 1978. Mean ($\pm$ standard deviation and coefficient of variation) cloacal Temperatures (Tc) are compared between the burrowing (#25) and non-burrowing (#64) tortoises in Table 2. Rates of heating during a single day are graphed in Figure 1 and Figure 2 and present a summary of tortoise body temperature regulatory behavior relative to ground surface and air temperatures for a single day.

For both tortoises, the time required to reach a cloacal temperature between 30° and 21° C]= 86°-88° F] is similar. This results from a combination of three factors: initial cloacal temperature (Tc), rate of heating, and behavioral movements.

The nonburrowing tortoise began the day an average of 2-4° C [= 3.6-7.2° F] lower Tc but by prolonged basking and utilization of shuttling between sun and shade mosaics its heating rate far exceeded that of the burrowing animal. These differences in mechanism of achievement of eccritic temperature are significant in several respects. Tortoises with burrows require less surface activity time during early morning hours and low ambient temperatures and thus may enjoy a measure of protection from predation. This may be of particular importance to hatchling and juvenile tortoises with probable high mortality experience and is of wider significance than might be expected since field observations indicate that flooding often destroys the burrows of non-captive individuals. Additionally, burrow protection and shade in the form of vegetation, however limited, may be an important factor during periods of new burrow excavation.

Although the mean daily Tc of both tortoises is very similar (Table 2), 2 sorts of variation exist. The nonburrowing tortoise had a much greater fluctuation in Tc on both a daily basis and overall. This is reflected in the much larger coefficient of variation of the nonburrower's Tc. This variation results from the behavioral differences in locomotor activity of the 2 tortoises. The use of the sun-shade mosaic by the nonburrower exposed it to much greater microclimatic fluctuations than existed within the confines of the burrow of tortoise #25. The additional energy expenditure of a tortoise without a burrow, as reflected in the greater locomotion for thermoregulation, may affect reproductive performance. It is not unusual for flooded burrows to require 30 days or longer to dry out and permit reexcavation. Tortoises which begin construction of a new burrow following flooding of their old retreat may require an equivalent length of time, and certainly an added energy expenditure, for completion. In both cases, energy allocation to egg production may be reduced enough to eliminate a first clutch. Rainfall usually begins in May and may be sufficient to cause burrow damage in June. First clutches are deposited in July and, therefore, the above postulated events have chronological plausibility.

The second sort of Tc variability is reflected in the mean body temperatures between days. Mean temperatures ranged from 20.4° C to 30.99° C [= 68.7° F-87.8° F] (Table 2). September 17, 18 and 21 were bright, sunny days with a low cloud cover. These days exhibited the highest attained clocal temperatures. September 22, 23, 27 and 28 had much higher cloud cover (90-100% during some hours), wind velocity and frequency of drizzles. The effect of rain on body temperature depression is greater than that of wind alone. September 23 and 27 had much higher frequencies of drizzles and, correspondingly, the lowest observed Tc.

Multiple regression analysis revealed that substrate temperature in the shade had the highest correlation with Tc with a first order correlation coefficient of 0.92. All ambient variables together were extremely high correlated with Tc (r = .96).

Population Structure

Mapimi Reserve is located southward of the center of the tortoises' geographic range. Topographical features include low hills and isolated mountains with highly inclined slopes as well as washes and alluvial fans with a stony superficial substrate. The landscape is dominated by interconnected basins whose playas contain a deep, fine-textured substrate of sand. Elevation ranges from 1150 m to 1300 m [= 3772-4264 feet].

The following perennial plant species are characteristic of physiognomic/floristic units in the Reserve (Martinez and Morello, 1977): creosote bush (*Larrea divaricata*), ocotillo (*Fouquieria splendens*), candelilla (*Euphorbia antisyphilitica*), tarbush (*Fluorensia cernua*), agaves (*Agave asperrima* and *A. lecheguilla*), prickly pear cactus (*Opuntia rastrera*), (*O. microdasys*), and (*O. bradthiana*), tobosa grass (*Hilaria mutica*), mesquite (*Prosopis juliflora*), and leather stem (*Jatropha dioica*). Cover values of the dominant plants range from 9 to 38%, *H. mutica* being the species with the highest cover in the grassland.

The entire area is relatively undisturbed. Present utilization is confined to cattle husbandry, an activity that dates back to the 1930's or 1940's. Vehicle traffic is usually restricted to a few unpaved roads, but occasional off-road traffic occurs everywhere.

Total tortoise populations in the Reserve might be as high as 250 to 300 individuals. *G. flavomarginatus* inhabits single burrows; however, natives have reported the uncommon occurrence of burrows with up to 3 tortoises. There seems to be 2 or 3 populations 30 km [= 18.6 miles] northward and northeastward of the Reserve.

By walking and driving, about 70 active burrows have been located. Twenty of these burrows are scattered at the base of low hills in a creosote-dominated vegetation bordering extensive grasslands. Density estimates in this zone are 1 tortoise/20 ha [= 49.4 acres]. The remaining 50 burrows are located in a highly dispersed colony settled in a playa with a tobosa grassland associated with *L. divaricata, Atriplex canescens,* and *P. juliflora.* Within this association, burrow openings are not usually found within pure *Hilaria* stands, but rather at the base of the mesquite and creosote bushes as well as in open area lacking *Hilaria*. A few burrows are also found in the *Hilaria-Suaeda nigrescens* association which is contiguous to the aforementioned vegetation. Natives have reported a very recent establishment of these burrows, about 2 years ago, suggesting colony expansion.

This large colony covers approximately 14 km^2 [= 5.4 $mile^2$]. Burrow distribution is quite irregular and overall density estimates are 1 tortoise/30 ha [= 74 acres]. These values are in contrast with that of 7 tortoises/ha obtained by Morafka (1978) from a colony in Ranchos Benthon and La Ventura, Chihuahua (90 km [= 55.9 miles] northward of Mapimi Reserve), one of the less disturbed places where the Bolson tortoise still exists.

The age structure estimates for the Mapimi population are: 53% adults (carapace length >250 mm [= 9.8 inch]), 18% subadults (200-249 mm [= 7.9-9.8 inch]), and 29% juveniles (<200 mm) (Fig. 3). This analysis clearly shows aspects of population composition that are obscured by using estimated age class data, namely, low percentages of very small juveniles (157 mm CL [= 6.2 inch]) and very large adults (315 mm CL [= 12.4 inch]), and relatively high percentages of moderate size adults as well as juveniles larger than 157 mm [= 6.2 inch] carapace length. In Morafka's analysis of population in Rarchos Benthon and La Ventura, a low percentage of very small juveniles was also found but a high percentage of very large adults was also found (Fig. 4). Both populations contain an adult proportion larger than that of subadults and juveniles, assuming that sexual maturity is attained at carapace lengths of 220 to 300 mm]= 8.7-11.8 inch] in both sexes as stated by Legler and Webb (1961).

Differences between these two populations can be caused by: (1) different sex composition, (2) differential growth rates between populations as occurs with *G. berlandieri* (Auffenberg and Weaver, 1969) and (3) size selection, possibly human predation greater on large adults in the Mapimi population.

Similarities in the 2 analyses exist in the form of very low proportions of very small juveniles (burrow diameters <200 mm [= 7.9 inch]). These may be attributed to problems with reproduction and juvenile and hatchling survival. A potential competition with cattle could exist.

Neither hatchlings nor their burrows have been observed, but there is some evidence of recent reproduction. Egg shell remains have been found near some burrows and natives reported the appearance of hatchlings during summer 1978. In addition, a female slaughtered by the end of the spring 1978 contained 4 completely formed eggs.

Feeding Habits

Feeding habits of the Bolson tortoise have not been quantitatively documented. Hendrickson (1976) reported that *Hilaria mutica* is the primary food plant of the tortoises.

Seventeen plant species were identified in the scats (Table III). Five species, *Bouteloua barbata, H. mutica, Sida leprosa, Tridens pulchellus,* and *Sphaeralcea angustifolia,* make up 80% of the diet of the Bolson tortoise.

The overall average (± SD) number of plant species per dropping was 5.05 ±0.27 (range = 1.9), and the trophic diversity index (*H'*), calculated by Shannon's formula (Brower and Zar, 1977) was 2.14. These values are comparable to those reported for *G. agassizi* diets in Arizona and Utah by Hansen et al. (1976).

An analysis of seasonal variation in diet is also possible. Droppings collected in the summer contain a higher proportion of *B. barbata* than of *H. mutica,* these 2 being the most common grasses eaten by the tortoises. Droppings collected out of the summer season contain rather high percentages of *H. mutica.* These samples may well correspond mainly to the dry months, especially considering that *H. mutica* is the perennial grass with the highest density in the Reserve and that *Hilaria* grasslands exhibit the highest living plant density during the drought (Martinez and Morello, 1977). Thus, it seems that *H. mutica* is the primary food of the tortoises on the Reserve mainly during the dry season. However, other perennial species are also eaten during this time, e.g., *S. leprosa, T. pulchellus,* and *S. angustifolia.*

FUTURE RESEARCH

Future investigations should concentrate on:

1. Study of potential feeding competition between tortoises and cattle and continuation of feeding habit studies.

2. Extensive analysis of population densities and structures, including determination of sex ratios of Mapimi Reserve tortoises and those in Rancho Benton and La Ventura.

3. Radiotelemetric records will continue in order to obtain full data on seasonal home ranges and thermoregulation as well as the thermal requirements of hatchlings and juveniles.

4. Initiating a program of captive breeding of Bolson tortoises in the Mapimi Reserve and reintroduction of tortoises bred in captivity by others.

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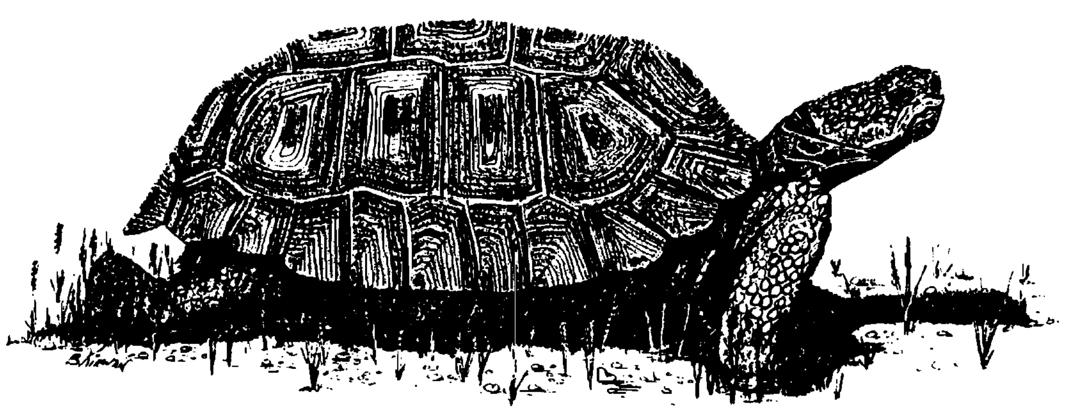

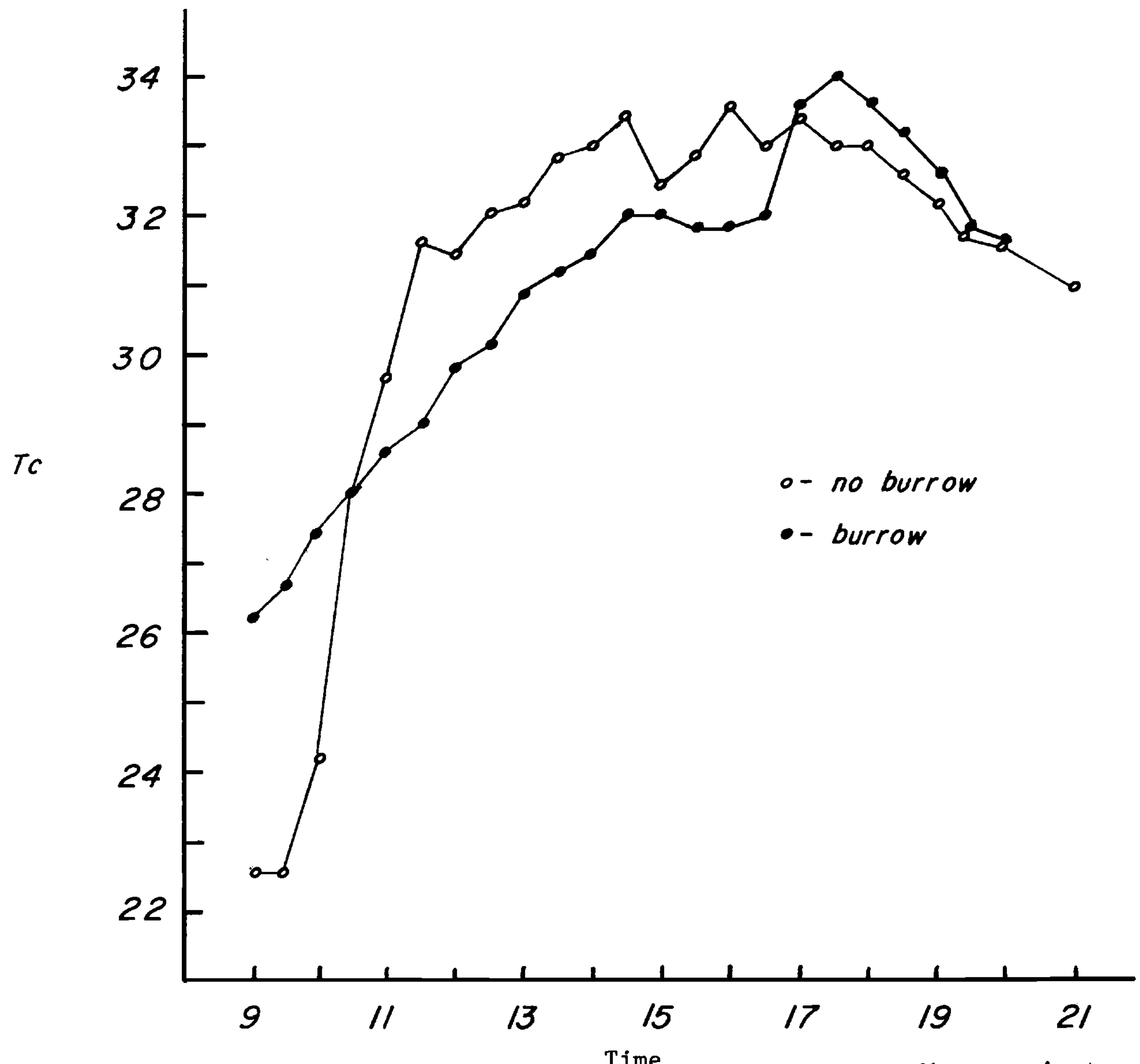

Fig. 1. Body temperature versus time of day for two *Gopherus flavomarginatus*.

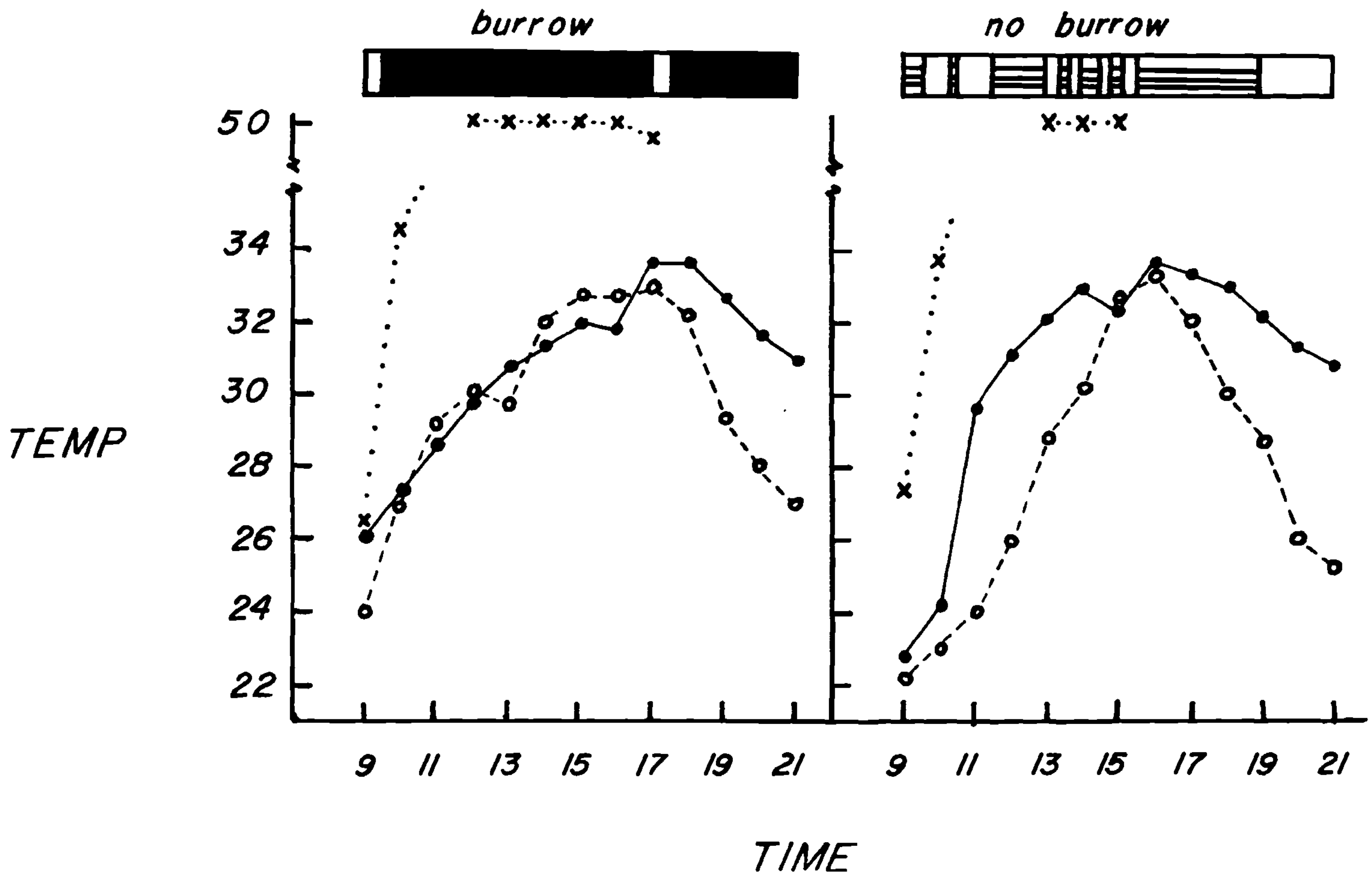

Fig. 2. Temperature versus time for *Gopherus flavomarginatus*
x··x = soil surface temperature in sun
●-●-● = tortoise cloacal temperature
o-o-o = soil surface temperature in shade
Bars above graph summarize tortoise behavior. Unshaded = basking in sun, shaded = in burrow, horizontal stripes = shade of vegetation

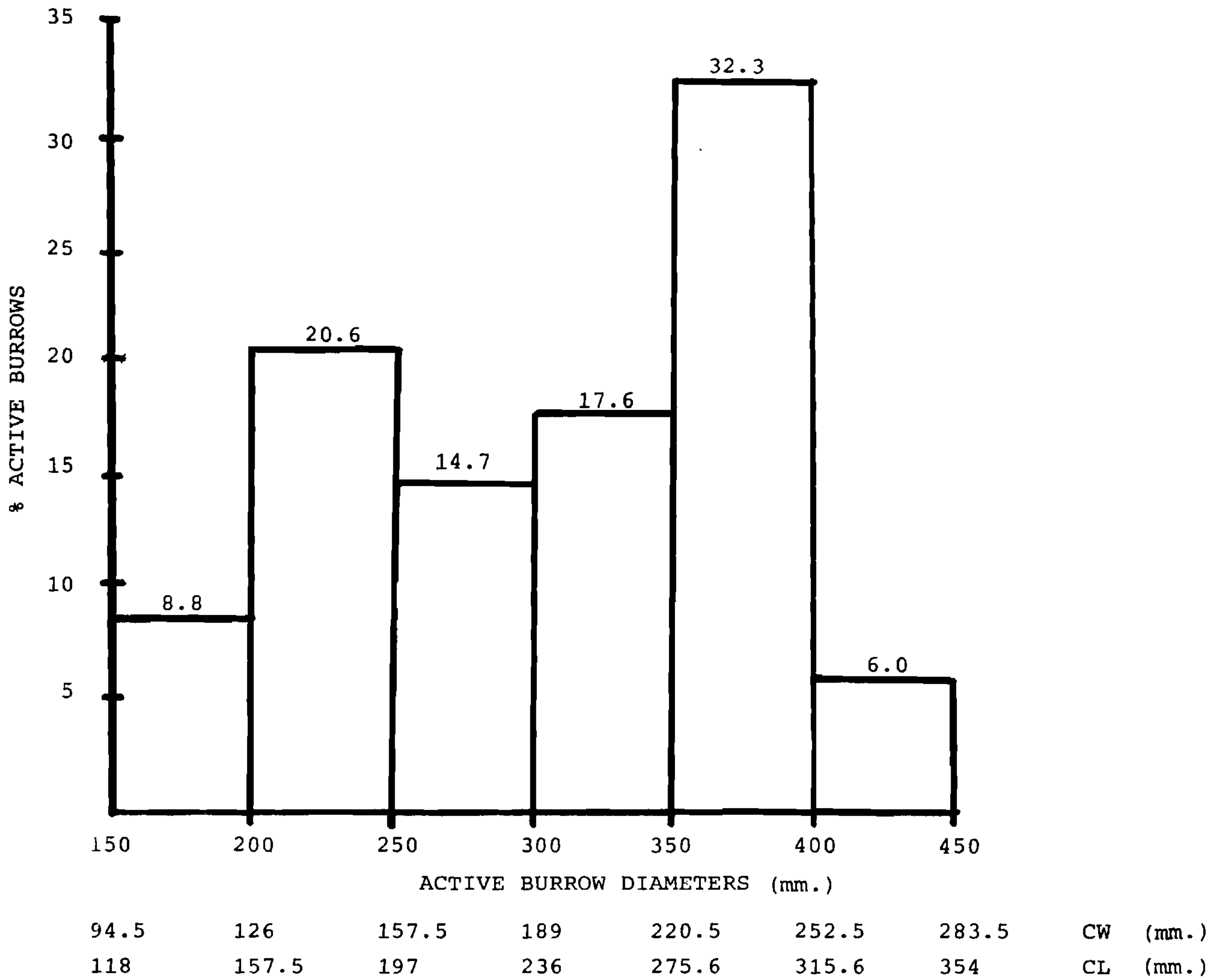

Fig. 3. Size structure of a *Gopherus flavomarginatus* population in the Mapimi Reserve, Dgo. CW and CL, carapace width and length (straight line) corresponding to the burrow diameter.

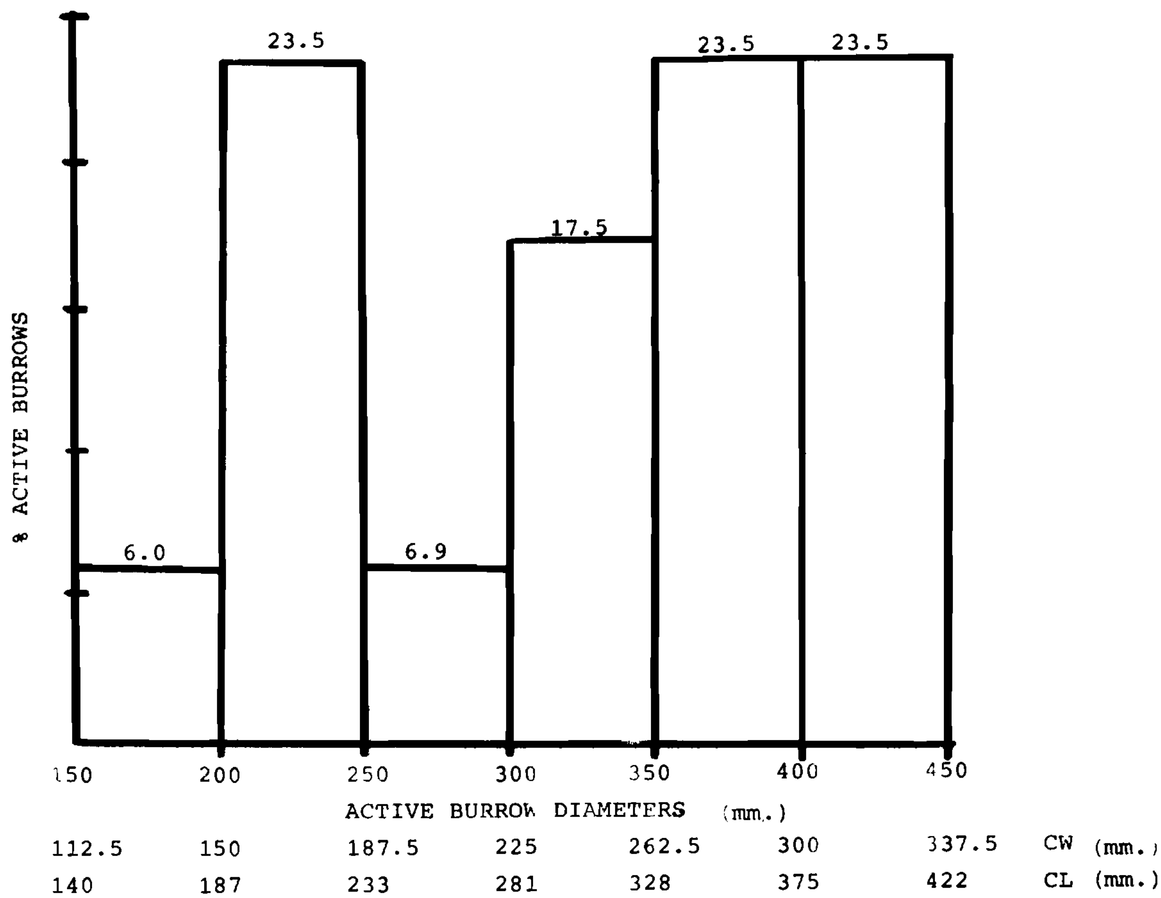

Fig. 4. Size structure of a *Gopherus flavomarginatus* population in Rancho Benthon-La Ventura, Chih. CW and CL, carapace width and length (straight line) corresponding to the burrow diameters.

Table 1. Comparative data of a non-burrowing tortoise and a tortoise with burrow available.

Date	Non-burrowing Tortoise					Burrowing Tortoise				
Sept.	A	B	C	D	E	A	B	C	D	E
17	7.0	22.8	33.4	47.36	3.3	8.5	26.2	34.0	29.77	1.0
18	7.5	24.0	33.8	40.33	1.7	9.5	25.2	34.6	37.30	1.8
21	7.5	22.0	34.0	53.15	1.5	9.0	24.4	33.8	38.52	2.0
22	8.0	22.0	31.8	44.54	4.4	8.0	23.8	32.0	34.45	5.2
23	6.5	19.8	24.2	22.22	1.0	6.0	23.4	25.4	8.54	5.8
27	8.0	18.2	22.0	20.8	3.0	7.0	20.6	22.0	6.79	1.5
28	7.0	17.2	31.6	83.72	9.7	6.5	19.2	32.0	70.83	6.6
$\bar{x}$ =	7.36	20.86	30.11	44.53	3.5	7.79	23.26	30.54	32.32	3.41

A. Time in hours to reach maximal cloacal temperature.
B. Starting cloacal temperature (°C) at 0800.
C. Maximal cloacal temperature (°C).
D. Increasing percentage above starting cloacal temperature when maximal cloacal temperature is reached $\frac{(T_m - T_o)}{T_o} \times 100$.
E. Basking hours during the day.

Table 2. Mean daily cloacal temperatures of two Bolson tortoises (^{o}C)

	T_c $\bar{x}$ ± SD	T_c $\bar{x}$ ± SD	Coefficient of variation SD/$\bar{x}$	
	nonburrower	**burrower**	nonburrower	**burrower**
17	30.99 ± 3.25	30.85 ± 2.18	10.5	7.1
18	30.24 ± 3.59	30.28 ± 3.0	11.9	9.9
21	29.21 ± 4.08	30.0 ± 2.26	14.0	7.5
22	28.56 ± 3.22	29.45 ± 2.31	11.3	7.8
23	22.51 ± 1.37	23.56 ± 0.94	6.1	4.0
27	20.14 ± 1.36	20.94 ± 0.57	6.8	2.7
28	26.1 ± 4.56	26.74 ± 2.94	17.5	11.0
Mean	26.82	27.40	11.2	7.1

Table 3. Plant species (% dry weight ± SD) components of *Gopherus flavomarginatus* in the Mapimi Biosphere Reserve, Durango, Mexico.

Bouteloua barbata	23. 21 ± 4.77
Hilaria mutica	21. 91 ± 4.63
Sida leprosa	15. 96 ± 3.50
Tridens pulchellus	13. 94 ± 3.29
Sphaeralcea angustifolia	5. 57 ± 2.67
Tidestromia lanuginosa	2. 85 ± 1.09
Solanum eleagnifolium	2. 58 ± 1.25
Eragrostis spp.	2. 34 ± 1.73
Larrea divaricata (fruit)	1. 15 ± 0.72
Chloris virgata	1. 01 ± 0.4
Prosopis juliflora	0. 99 ± 0.54
Aristida wrightii	0. 44 ± 0.3
Sporobolus spp.	0. 40 ± 0.2
Muhlenbergia spp.	0. 15 ± 0.12
Scleropogon brevifolius	<0.1
Andropogon saccharoides	<0.1
Digitaria californica	<0.1

Comparison of Maintenance Electrolyte Budgets of Free-living Desert and Gopher Tortoises (*Gopherus agassizi* and *G. polyphemus*)

John E. Minnich

In two previous papers (1977 Proceedings of Desert Tortoise Council) the water relations of free-living desert and gopher tortoises were presented. Maintenance water turnover in gopher tortoises in Florida was 3.1 ml $(100g)^{-1}$ day $^{-1}$ and metabolic water production was 0.2 ml $(100g)^{-1}$ day^{-1}. Since gopher tortoises did not drink, they consumed preformed water in the food at a rate of 2.9 ml $(100g)^{-1}$ day^{-1}. Dietary electrolyte concentrations were 20.6 µEq/ml Na^+, 59.4 µEq/ml K^+ and 58.2 µEq/ml Cl^- and maintenance electrolyte intake was 59 µEq Na^+, 172 µEq K^+ and 168 µEq Cl $(100g)^{-1}$ day^{-1}. Since evaporation rates in gopher tortoises were very slow because of their large size (average weight = 3.18 kg) and high environmental relative humidities (98.7% at 25.5°C in their burrows), gopher tortoises lost most water via fecal and urinary excretion. The predicted excretory electrolyte concentrations are within the known range of their feces and liquid bladder urine. Consequently gopher tortoises obtained all needed water from their food and did not drink rainwater or excrete precipitated K^+ and urate in the urine.

From information on maintenance water turnover in desert reptiles (Minnich, 1979), maintenance water intake of a 1.0 kg desert tortoise was estimated to be 2.0 ml $(100g)^{-1}$ day^{-1} during late spring. Since metabolic water production was 0.2 ml $(100g)^{-1}$ day^{-1}, preformed water consumption in nondrinking desert tortoises was 1.8 ml $(100g)^{-1}$ day^{-1}. Dietary $[Na^+]$ and $[Cl^-]$ were slightly lower than in the diet of gopher tortoises, but dietary $[K^+]$ was much higher (173 µEq/ml). Maintenance electrolyte turnover was 12 µEq Na^+, 312 µEq K^+ and 57 µEq Cl^- $(100g)^{-1}$ day^{-1}. Even when desert tortoises evaporate water at a minimal rate of 0.4 ml $(100g)^{-1}$ day^{-1} the predicted excretory $[K^+]$ is higher than that observed in the feces and liquid bladder urine. Since tortoises lack salt glands, this suggests that desert tortoises, unlike gopher tortoises, must excrete some dietary K^+ in the precipitated urates of the urine.

INTRODUCTION

The water relations of free-living desert tortoises (*Gopherus agassizi*) in the western Mojave Desert (Stoddard Valley, California) and of gopher tortoises (*G. polyphemus*) in central Florida (Archbold Biological Station) were presented in two previous papers of the Desert Tortoise Council (Minnich, 1977;

Minnich and Ziegler, 1977). Since the publication of those papers, additional data have been gathered and analyzed on the electrolyte metabolism of both species of tortoises. Tentative "maintenance" water and electrolyte budgets of both species have been estimated. These data have then been used to explain differences in the excretory physiology and drinking and feeding behavior of the 2 species.

MATERIALS AND METHODS

The study sites, capture and holding of the animals, and analysis of samples have already been presented (Minnich, 1977; Minnich and Ziegler, 1977). In addition, samples of all potential dietary items at the study site of desert tortoises (Stoddard Valley, San Bernardino County, California) were collected on 26 March 1977 and analyzed for content of electrolytes (Na^+, K^+, Cl^-), as described by Minnich and Shoemaker (1970).

RESULTS AND DISCUSSION

Gopher Tortoise

In the previous paper on gopher tortoises (Minnich and Ziegler, 1977) "maintenance" water turnover during summer, 1974 was 3.1 ± 0.18 ml $(100\ g)^{-1}$ day $^{-1}$ for 9 tortoises averaging $3{,}181 \pm 425$ g body weight. Metabolic water production was not estimated directly in that study. Nevertheless, Cloudsley-Thompson (1970) estimated metabolic water production in a captive, juvenile tortoise (*Testudo sulcata*) weighing 303 g to be 0.37 ml $(100\ g)^{-1}$ day $^{-1}$. This tortoise, like gopher tortoises in the study by Minnich and Ziegler (1977), was active and feeding daily on succulent plants. If we apply a correction for differences in body size between the two species, using the information that metabolic rate is related to the 0.82 power of body weight in tortoises (*Geochleone gigantea*) (Hughes et al., 1971), then metabolic water production in 3,181 g gopher tortoises should approximate 0.24 ml $(100\ g)^{-1}$ day $^{-1}$. (This calculation assumes (1) that both tortoises have comparable metabolic rates at a given body size and (2) that metabolic rates vary with the 0.82 power of body weight in gopher tortoises under field conditions.) Subtracting this figure from the "maintenance" water intake (3.1 ml (100 g^{-1} day^{-1}) gives "maintenance" preformed water consumption (2.9 ml $(100\ g)^{-1}$ day^{-1}). Since gopher tortoises were never observed drinking during the study (Minnich and Ziegler, 1977), all preformed water was probably gained from feeding.

Average electrolyte concentrations of the major dietary items of gopher tortoises were 20.6 µEq/ml Na^+, 59.4 µEq/ml K^+ and 58.2 µEq/ml Cl^- (*see* Table 2 in Minnich and Ziegler, 1977).

Multiplying these figures by the "maintenance" preformed water consumption gives "maintenance" electrolyte intake in non-drinking gopher tortoises. These figures approximate 59 μEq Na^+, 172 μEq K^+ and 168 μEq Cl^- $(100\ g)^{-1}$ day^{-1}.

Although evaporation rates of free-living gopher tortoises were not measured by Minnich and Ziegler (1977), they were undoubtedly very low because of the large size of these tortoises and because of the high environmental relative humidities. Extreme relative humidities above ground in standard U.S. Weather Bureau shelters at Archibold Biological Station during 4 selected days of summer, 1974 ranged from 38.2% to 83.1% (U.S. Weather Bureau, 1974). At the soil surface, relative humidities were probably even higher because of the abundant rainfall (Minnich and Ziegler, 1977). In addition, relative humidities in the tortoise burrows were near saturation (98.7% at 25.5 C average temperature) (*see* Table 4 of Minnich and Ziegler, 1977).

If we assume that evaporation rates from free-living, gopher tortoises occur at the relatively high rate of 0.6 ml $(100\ g)^{-1}$ day^{-1} (compared to a rate of 0.4 ml $(100\ g)^{-1}$ day^{-1} in dormant desert tortoises -- *see* Minnich, 1977) then excretory water losses in gopher tortoises should approximate 2.5 ml $(100\ g)^{-1}$ day^{-1} (equal to the total water loss of 3.1 ml $(100\ g)^{-1}$ day^{-1} minus evaporative water loss). As mentioned above, the estimated "maintenance" electrolyte intakes (and losses) were 59 μEq, Na^+, 172 μEq K^+ and 168 μEq Cl^- $(100\ g)^{-1}$ day^{-1}. Dividing these values by the excretory water loss gives "predicted" electrolyte concentrations in the combined excrement (feces and urine). These values are 24 μEq/ml Na^+, 69 μEq/ml K^+ and 67 μEq/ml Cl^-. These concentrations are clearly within the known electrolyte concentrations of both the feces and liquid urine of gopher tortoises (Minnich and Ziegler, 1977; Ross, 1977). Since evaporation rates in gopher tortoises were probably lower than 0.6 ml $(100\ g)^{-1}$ day^{-1}, the actual excretory electrolyte concentrations (Table 3 and p. 135 of Minnich and Ziegler, 1977) were even lower than the "predicted" values.

Desert Tortoise

At the time that desert tortoises were studied (Summer, 1970), all animals were in negative water balance, were dormant and did not eat (Minnich, 1977). Consequently the "maintenance" water and electrolyte budgets were not estimated in this study. The "maintenance" budgets given in the present paper must only be regarded as tentative. They assume that tortoises balance their budgets in later spring after a winter with rain sufficient for growth of spring annuals. This appears reasonable, as Nagy and Medica (1977) observed that desert tortoises in Rock Valley, Nevada were in positive water balance in early spring, 1977 but were in negative water balance in summer. Eventually, observed maintenance water and electrolyte budgets of desert tortoises will be published by Nagy and Medica (*personal communication*).

Recently Minnich (1979) published a summary of water turnover rates in free-living reptiles occupying primarily arid and semiarid habitats (*see* Fig. 5 of Minnich, 1977). He observed that maintenance water turnover (R) in millilitres per day was related to body weight (W) in kilograms by the equation $R = 21W^{0.84}$ in arid-adapted lizards during a warm season (spring or summer). If we assume that desert tortoises weighing 1154 g (the average weight of tortoises used in measurement of water turnover by Minnich, 1977) turn over water at rates similar to lizards of equivalent body size, their "maintenance" water intake should approximate 2.0 ml $(100\ g)^{-1}$ day^{-1}. Although tortoises are not closely related to lizards, this tentative estimate of "maintenance" water turnover appears reasonable, as Nagy and Medica (1977) observed higher water influx rates during early spring (when tortoises were in positive water balance) and lower rates during summer (when tortoises were in negative water balance).

Metabolic water production of desert tortoises in summer was estimated to be 0.22 ml $(100\ g)^{-1}$ day^{-1} (Minnich, 1977). From data on carbon dioxide production of desert tortoises (Nagy and Medica, 1977), metabolic water production appeared to vary from about 0.14 ml $(100\ g)^{-1}$ day^{-1} in dormant tortoises during summer to a maximal value of about 0.27 ml $(100\ g)^{-1}$ day^{-1} in active tortoises in spring. (These figures assume a water equivalent of 0.72 µl H_2O/ml CO_2.) Therefore, an approximate value of 0.2 ml $(100\ g)^{-1}$ day^{-1} appears reasonable in tortoises maintaining water balance in late spring. Subtracting this figure from the "maintenance" water gain (2.0 ml $(100\ g)^{-1}$ day^{-1}) gives preformed water consumed in the food by nondrinking tortoises (1.8 ml $(100\ g)^{-1}$ day^{-1}).

In spring tortoises feed on succulent annual plants (Nagy and Medica, 1977). The electrolyte content of several species of plants, including annuals, at Stoddard Valley during spring, 1977, is presented in Table 1. The average electrolyte contents of the annuals in Table 1 are 20.8 ± 3.11 µEq/g Na^+, 520 ± 40.9 µEq/g K^+ and 95.2 ± 17.3 µEq/g Cl^{-1}. Unfortunately, water content of these plants was not measured. Nevertheless, Nagy et al. (1976) observed an average water content of early spring (March) annuals at a site about 15 km from Stoddard Valley to be about 6.0 ml/g dry weight. In late spring (May) in the Coachella Valley (Riverside County, California) annuals had an average water content of about 2.7 ml/g (Minnich and Shoemaker, 1970). If we assume that the average water content of the annuals in

Stoddard Valley in late spring is 3.0 ml/g, then their electrolyte concentrations at this time will approximate 7 μEq/ml Na^+, 173 μEq/ml K^+ and 32 μEq/ml Cl^- (*see* Table 1). These values are similar to the electrolyte concentrations of spring annuals observed by Nagy et al. (1976). Multiplying these values by the "maintenance" preformed water consumed in the food (1.8 ml $(100\ g)^{-1}$ day^{-1}) gives "maintenance" electrolyte intake (12 μEq Na^+, 312 μEq K^+ and 57 μEq Cl^- $(100\ g)^{-1}$ day^{-1}).

Evaporative water losses in dormant tortoises during summer approximated 0.41 ml $(100\ g)^{-1}$ day^{-1}, since their total water loss at that time was 0.46 ml $(100\ g)^{-1}$ day^{-1} (Minnich, 1977) and little water was lost via excretion. If we assume that evaporation rates from active tortoises are twice those from inactive animals (*see* Minnich, 1970), then evaporation from tortoises balancing their water budgets will approximate 0.8 ml $(100\ g)^{-1}$ day^{-1}. Subtracting this figure from total water loss (2.0 ml $(100\ g)^{-1}$ day^{-1}) gives excretory water loss via feces and urine (1.2 ml $(100\ g)^{-1}$ day^{-1}.

Since tortoises lack salt glands (Schmidt-Nielsen, 1964) all ingested electrolytes must be excreted in the feces and urine. The predicted electrolyte concentrations in the combined excrement (feces and urine) will approximate 10.4 Eq/l Na^+, 260 μEq/l K^+ and 48 μEq/l Cl^-. The Na^+ and Cl^- concentrations predicted here are easily within the observed range of the feces and liquid urine, but the K^+ levels are much higher than in either excrement (*see* Tables 1 and 2 in Minnich, 1977). Even if we assume a minimal evaporation rate of 0.4 ml $(100\ g)^{-1}$ day^{-1} and a minimal dietary K^+ concentration of 86 μEq/l in fully hydrated annuals (520 μE/g -- *see* Table 1 -- divided by 6.0 ml/g -- Nagy et al., 1976), the predicted excretory K^+ concentration (128 μEq/l) is near the upper limit of those observed in the feces and liquid urine (Tables 1 and 2 of Minnich, 1977). While the K^+ concentration could still be higher in the liquid urine (as long as urinary osmotic concentration does not exceed that of plasma), it is unlikely that it will regularly exceed a value of about 150 μEq/l (the highest value observed by Minnich, 1977, was 143 μEq/l). These observations suggest that some of the dietary K^+ in desert tortoises balancing their water and electrolyte budgets must be excreted in the urate precipitates of the urine. The K^+ concentrations in the urinary precipitates of dehydrated, fasting tortoises (Table 2 of Minnich, 1977) easily exceed the predicted excretory K^+ concentrations in feeding tortoises that are balancing their water and electrolyte budgets. Furthermore, the K^+ content in the dried urate precipitates of fed desert tortoises is about four times that of fasted animals (*see* Minnich, 1972, 1977).

SUMMARY AND CONCLUSIONS

Although the "maintenance" water and electrolyte budgets of free-living desert and gopher tortoises are only tentative and contain numerous speculations, they do illustrate that differences in dietary electrolyte concentrations, especially of K^+, importantly influence the excretory physiology and, to a lesser extent, feeding and drinking behavior of tortoises. Free-living gopher tortoises feed on plants with electrolyte concentrations sufficiently low that electrolytes are apparently excreted in the feces and liquid urine without incurring a water deficit. The dietary plants appear to provide tortoises with all needed preformed water. Consequently, tortoises exhibit little inclination to drink, despite abundant rainfall. They feed daily and most animals exhibit growth and positive water balance. Bladder urine is always hypoosmotic to plasma and never contains urate precipitates. The availability of osmotically dilute water in their food, together with the high humidities in their environment, accounts for their comparatively high "maintenance" water turnover (Minnich and Ziegler, 1977).

Desert tortoises, on the other hand, feed on plants that contain high K^+ concentrations, compared to plants in the habitat of gopher tortoises. Most dietary K^+ appears to be excreted in the urate precipitates of the urine, even when tortoises are balancing their water and electrolyte budgets. In summer when dietary plants become dehydrated and dietary K^+ concentrations become very high, tortoises cease feeding and become dormant. Aphagia appears to protect tortoises from accumulating toxic levels of K^+ when insufficient water is available for K^+ excretion. When rain falls, desert tortoises drink avidly, excrete the accumulated K^+ that is stored in the bladder precipitates, and store dilute urine in the bladder. This "water reserve" appears to permit resumption of feeding, since tortoises eat dried plants (mainly grass) after the rain (Minnich, 1977).

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Table 1. Electrolyte content of plants collected at Stoddard Valley, California on 26 March 1977

Species	Part of plant	N	Electrolyte content (μEq/g dry weight) Na	K^+	Cl^-
Perennials:					
Acamptopappus sphaerocephalis	leaves	1	17.6	569	163
	stems	1	30.2	10.6	6.49
Ambrosia dumosa	leaves	2	18.1	961	291
	stems	2	11.9	491	116
Atriplex polycarpa	leaves	1	931	976	763
	stems	1	108	180	64.8
Cassia armata	leaves	1	8.69	509	10.5
	stems	1	15.2	37.6	6.00
Hymenoclea salsola	leaves and stems	1	13.1	457	188
Larrea tridentata	Leaves and small stems	2	11.4	501	89.8
Lycium cooperi	stems	1	8.50	130	56.5
Grasses:					
Oryzopsis hymenoides	leaves, stems, fruit	1	8.57	373	93.7
Schismus barbatus	leaves, stems, fruit	2	12.1	278	110
Annuals:					
Abronia villosa	leaves	1	0	1196	437
	flowers	1	2.95	774	179
Amsinkia tesselata	leaves, inflorescence	1	15.7	745	39.8
Camissonia boothii	leaves, inflorescence	1	53.0	595	134
C. campestris	leaves, inflorescence	1	10.0	394	40.2
C. claviformis	leaves, inflorescence	1	26.1	458	137
Chenactis carphoclinia	leaves, flowers	1	41.4	689	125
C. fremontii	leaves, inflorescence	1	16.4	628	132

Table 1. (Continued)

Species	Part of plant	N	Na	K^+	Cl^-
			Electrolyte content (μEq/g dry weight)		
Annuals:					
Cryptantha angustifolia	leaves, inflorescence	1	52.2	768	55.5
C. dumetorium	leaves, inflorescence	1	64.3	755	122
C. micrantha	leaves, stems, inflorescence	1	33.2	469	24.1
C. pterocarya	leaves, stems, inflorescence	1	42.9	515	48.4
Descuraiana pinnata	leaves, flowers	2	9.87	394	51.0
Dithyrea californica	leaves, stems, inflorescence	1	12.3	204	208
Eremalche exilis	leaves, inflorescence	1	18.9	712	267
Erigononum gracillimum	leaves, inflorescence	1	24.1	507	94.7
E. inflatum	leaves, stems, inflorescence	1	0	538	54.6
E. pusillum	leaves, inflorescence	1	13.6	352	92.9
Eriophyllum wallacei	whole plant	2	15.9	216	52.5
Erodium cicutarium	leaves, fruit	2	9.18	363	20.2
Mentzelia albicaulis	flowers, stems, leaves	1	16.9	516	86.7
Monoptilon beloides	leaves, flowers	1	19.1	535	90.1
Nama demissum	leaves, inflorescence	1	12.0	590	15.5
Oenothera primiveris	leaves	1	26.0	379	7.95
Phacelia fremontii	leaves, flowers	1	10.1	322	27.6

Status and Habits of *Gopherus polyphemus*

Nora E. Dietlein and Richard Franz

Gopherus polyphemus of the southeastern United States is diminishing in numbers throughout its entire range. It is the only species of the genus *Gopherus* that consistently digs a long permanent burrow which slopes downwards at 20° to 30° from the horizontal. Burrows have been found as long as 28 feet [= 8.5 m] and up to 10 feet [= 3.1 m] below the surface. The end chamber terminates above the water table and ensures a constant humidity and temperature controlled environment for the tortoise throughout the year. These burrows with their equable climate and abundant moisture provide protection for a variety of other animals, some of which live communally with the tortoise. Adult gopher tortoises reach 10 to 13 inches [= 25-33 cm] in length and weigh from 8 to 14 pounds [= 3.6-6.4 kg]. The female lays from 5 to 7 eggs in the vicinity of the spoil mound. The young hatch in 80 to 90 days and have considerable yellow coloration with definite ridges in the scutes of the carapace. As they mature, the ridges smooth out and the carapace color fades into a dull blackish-brown. In this paper the present status and habitats of *G. polyphemus* are discussed.

G. polyphemus is the familiar gopher tortoise of the southeastern United States. It is a medium sized tortoise with mature adults weighing from 8-15 pounds [= 3.6-6.8 kg] and measuring 8-14 inches [= 20-36 cm] in length. The average adult gopher weighs from 8-10 pounds [= 3.6-4.5 kg] and measures 9-11 inches [= 23-28 cm]. They are similar in shape to the desert tortoise, having the characteristic dome but flattened carapace, although there are many individual variations.

Coloration of the carapace generally varies from tan to dark brown or black although there are again many individual variations. Some tortoises have light centers in the laminae whereas others don't. Growth rings are very evident in young individuals but become worn away as they mature. The plastron is a yellowish color and the limbs and head are grayish-brown. They have the characteristic flattening of the front forelimbs and an elephantine shape to the hindlimbs; both adaptations which are necessary for digging their long burrows.

There are characteristic differences between the sexes that can be distinguished in the adult gophers. The male has a definite concave plastron which enables him to mount the female during mating. The anal scutes in the male are usually thickened and significantly curved upwards towards the carapace and in some cases they almost touch the carapace. The gular scute is usually longer. The female has a relatively flat plastron and although the anal scutes may be slightly curved, they are seldom thickened as in the male.

When disturbed away from their burrow, they display the characteristic tortoise defense mechanism of withdrawing into their shell until the threat passes.

They are most commonly found in sandy ridge and dune-sand areas where the water table is at least 4 feet [= 1.2 m] under ground. Gopher tortoise density is determined by many factors, but one of the most important is the light density at ground level. Areas with a closed canopy cannot support many tortoises. The highest densities of tortoises are found on well drained sandy soils where the ground light levels are high and there is a diversity of grasses and forbs.

The gopher tortoise excavates a long usually unbranched burrow. Dr. Auffenberg states that moisture is one of the most important factors in determining burrow depth with the end chamber terminating in the moist damp soil immediately above the water table. One of the longest burrows reported was 35 feet [= 10.7 m] long and 12½ feet [= 3.8 m] deep. The angle of declination is usually between 15° - 30°. The burrows are normally rather straight although they curve if an obstacle such as a tree root is encountered.

These burrows, with their equable climate and abundant moisture, provide habitat for a number of other species, some of which live with the tortoise as commensals such as the gopher mouse, six-lined race runner, cave cricket, and gopher frog. Others are there as obligates such as the gopher tick, mite, and dung bettle. Other animals also are known to use the tortoise burrow in times of stress while others take over abandoned burrows. Examples of these are the indigo snake, rattle snake, oppossum, burrowing owl, skunk, fox squirrel, and many others.

Adult tortoises usually occupy a single burrow and remain there permanently unless forced out because of habitat changes or predation by man. They have a well defined home range in which there are usually several well defined feeding trails leading from the burrow to the grazing area.

Breeding begins in the spring with the earliest recorded mating occurring February 18 on Sanibel Island in southwestern Florida. There is a definite courtship behavior. The male begins head-bobbing as he approaches the female; at first slowly, then more rapidly as he nears the female. The behavior of the male then changes from head-bobbing to biting. He begins by biting the front legs but as the female withdraws into her shell, he begins to bite the gular we well. This is followed by the male mounting the female.

The female deposits from 5-8 eggs in the vicinity of the spoil mound of her burrow. The nest is usually situated 8-10 inches [= 20.3-25.4 cm] below the surface and positioned so that the surface of the nest is in the direct rays of the sun.

The eggs are white and spherical in shape and approximately 1½ inches [= 3.81 cm] in diameter. Dr. Auffenberg states that the majority of egg predation occurs within the first week and is probably related to the scents associated with nest building and egg laying. Raccoons and skunks are the major egg predators.

The young begin hatching within 80-90 days when they first crack the shell. It takes another 24-28 hours for the baby tortoise to fully emerge. Once they are free, it takes another 24-36 hours for the egg sac to be completely absorbed. There is a deep transverse flexure running across the plastron that allows the baby tortoise to curl and thus fit inside the shell. It is very apparent after hatching and it takes 2-3 days for the hatchling to completely straighten out. Measurements are usually taken at this stage.

The young have definite striations in the scutes of the carapace and have a considerable yellow coloration both in the shell and the soft body parts. As they mature, the ridges smooth out and the carapace color fades into the typical dull brownish-black. Once the hatchling is free from the nest, it begins to excavate a small burrow within the vicinity of the nest. Sometimes they enlarge existing depressions just enough to cover themselves. However, within a year they have well defined burrows 3-4 feet [= .9-1.2 m] long. There are several predators of the young gopher. Adult indigoes have been known to feed on them and they are preyed upon by hawks, crows and raccoons.

There is increasing concern that gopher tortoise populations are being decimated at an accelerating rate and the reduction in numbers is clearly due to the effects of human exploitation and habitat destruction. The range for the gopher tortoise extends from southern South Carolina to Florida and west along the Gulf coast to Texas.

The present day status and distribution of *G. polyphemus* throughout its range is the work of Dr. Walter Auffenberg and Mr. Richard Franz from the Florida State Museum, University of Florida in Gainesville. The following date presented is a summary of their work.

In Florida the gopher tortoise is geographically widely distributed and is found from just above high tide level along the coast to about 100 m elevation. The major part of the present range occurs in central and northern Florida. In general, the long leaf pine/oak association provides the most extensive habitat in the state, 293% of the total area. Geographically, the greatest loss has been in the central peninsular counties due largely to agriculture and urbanization. However, the extreme southeastern counties have lost proportionately more -- due almost entirely to urbanization -- and have relatively little land left for tortoises. In the northern part of the peninsula and the panhandle, most losses are due to both cropland development and forestry practices. Dr. Auffenberg now estimates the total population for the state at 1.3 million which is a loss of 33%.

Despite the present apparently extensive range of gopher tortoise in Florida, many populations are comprised of very few individuals. As a result, it is highly likely that hundreds of colonies will not remain viable for long. Additionally, of all the land environments in Florida, those inhabited by gopher tortoises are the very ones that will suffer the most extensive alteration in the near future.

While a few of man's activities have been shown to be beneficial to tortoises (such as controlled burning), others are known to be clearly detrimental. The most adverse activities are agricultural clearing, urban expansion, and certain forestry practices. The continued existence of tortoises in any Florida area will depend on the importance of these factors locally. Dr. Auffenberg stated at the Florida herpatological conference in Gainesville last year that unless rapid measures are taken immediately to protect tortoise habitat throughout much of Florida, there will be only approximately 10% of the present-day population left by the year 2000.

In Louisiana little information is available and the tortoise is now believed to be rare. Present-day tortoise populations are limited to a small area in eastern Louisiana which has recently been endangered by forestry practices. Extensive site preparation for the purpose of reforestation and the development of pine monocultures will probably eliminate tortoises from much of their natural range in Louisiana within the foreseeable future.

In Mississippi *G. polyphemus* is associated with an upland area that appears to be a continuation of the long leaf pine hills of southwestern Alabama and eastern Louisiana. They slope from elevations of over 125 m in the north to less than 30 m in the south. Throughout this area, tortoises are uncommon and primarily limited to a small area in southeastern Mississippi. Where colonies do occur, the densities are low and they are threatened because of rapid habitat destruction, particularly by current tree harvesting and reforestation methods.

In Alabama *G. polyphemus* is limited to the southern part of the state. There they are uncommon although the tortoise densities are higher than in Louisiana and Mississippi.

In southwestern Alabama, however, colonies are large with densities nearly twice those found in other areas of the state. They are threatened over much of the state because of forestry practices, particularly extensive site preparation, and the development of pine plantations. Populations in southwestern Alabama, which are the largest, could become threatened if more mechanized forestry techniques are applied.

In Georgia the range of *G. polyphemus* consists of a series of small disjunct colonies occurring south and west of the fall line which are intimately associated with the long leaf pine/turkey oak stands. Barrier island populations are found on Sea, St. Simons, and Cumberland Islands and in the southern part of Georgia's coastal strand. They are threatened over most of their range in Georgia because of habitat modification, elimination of fire from long leaf pine/turkey oak communities, repeated use of off-road vehicles in certain dune areas, and human predation.

In South Carolina populations of gopher tortoises have been reported to Mr. Franz by personal communication from one county in the extreme southeastern part of the state but recent investigations by Mr. Franz found no evidence of tortoises and he surmises that gopher tortoises must be nearing extinction in South Carolina.

The present status of the gopher tortoise in the various states is as follows:

...In Alabama and Louisiana, it has no protection.

...In Mississippi it is listed as a rare species but has no protection.

...In South Carolina gopher tortoises are endangered but near extinction.

...In Georgia it is protected under the state's nongame wildlife law, which means that permits are needed for scientific collecting. In other words, it is protected from biologists.

...In Florida it is listed as a threatened species but it is also listed as a game species with a bag limit of 5. For obvious reasons, this is an embarrassment to the Florida Game Commission and they are considering removing it from the threatened list to a new category under consideration called Species of Special Concern. They are not presently considering decreasing or removing the bag limit. However, they are considering placing it off limits during the breeding season. It has been illegal to have any commercial trade in gophers in Florida for several years and they have recently outlawed the gassing of gopher turtoise burrows.

The lack of overall concern and protection for the gopher tortoise throughout most of its range is one of the prime concerns of the Gopher Tortoise Council and something that we would like to see changed as soon as possible.

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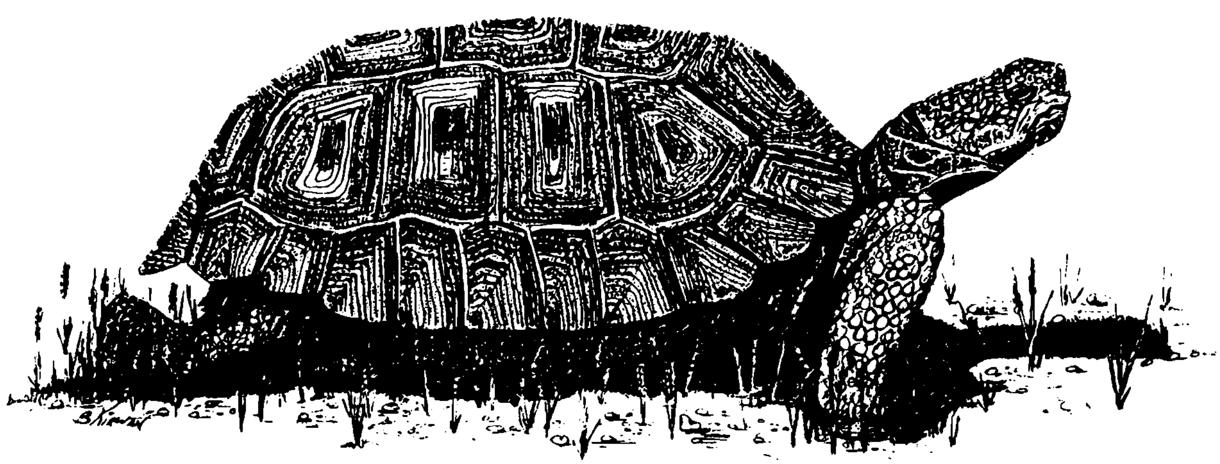

Gopher Tortoise Races
What They Mean to the Tortoise

Nora Dietlein and Adam Smith

Gopher tortoise races have been run in Florida for over 50 years. Presently the Florida Game and Fresh Water Fish Commission issues permits for tortoise races with the following restrictions: tortoises cannot have paint, glue, or decorations put on them; they must be maintained humanely before and during the race; they must be released into suitable habitat immediately following the race.

Virtually no documented information was available on the effects of these races on the tortoises so a study sponsored by the Sanibel Captiva Conservation Foundation was carried out on the 108 tortoises collected last year for the annual tortoise derby held in Ft. Meyers, Florida. The methods and places of capture were determined, where possible. The conditions the tortoises were maintained in prior to the race were observed and the conditions of the animals in regard to decoration and injuries were determined following the race. This paper discusses in detail the results of that study.

Because of our findings and the publicity given to it by the press, the tortoise race has now been permanently cancelled in Ft. Meyers and the Florida Game and Fresh Water Commission is presently reevaluating whether to issue permits for tortoise races next year.

Gopher tortoise races have been run in Florida for over 50 years. Permits to collect and race the tortoises are issued by the Florida Game and Fresh Water Fish Commission with the following restrictions:

1. No decorations, glue, paint, etc., may be applied directly to the tortoise.

2. They must be maintained humanely before and during the race.

3. They must be released back into suitable habitat immediately following the race.

Virtually no documented information was available on the effects of these races on the tortoises, so a study sponsored by the Sanibel-Captiva Conservation Foundation and Captran, Incorporated of Sanibel, Florida, was carried out on the tortoises collected for the 1978 annual Gopher Tortoise Derby held in Fort Meyers, Florida. The methods and place of capture were ascertained by verbal communication with the person holding the official state license to capture, hold and release the tortoises. The conditions the tortoises were maintained in prior to the race were ascertained by the same method and confirmed by personal observation. Following the race, the condition of the animals in regard to injuries and decorations was determined. This paper discusses in detail the results of this study.

Tortoise Collection Procedure

From verbal communication with the permit holder, it was found that the majority of the tortoises had not been collected locally and approximately 30 had come from south Georgia. Two methods of capture were described: catching the animal away from its burrow; backing an automobile up to an active burrow, putting a hose connected to the exhaust pipe down the burrow and running the engine for a few minutes. This, as was explained, "brought out most of the tortoises." No mention was made of capturing with a tortoise hook.

Tortoise Maintenance Prior to the Race

From verbal communication with the license holder, it was found that some of the tortoises had been delivered as early as July of 1977 -- 7 months prior to the race. These and the tortoises subsequently captured for the race were put into a wire-fenced enclosure on ground where they were unable to dig burrows. They were not provided with adequate food, shelter or water. The enclosure area was supposedly secret. However, the licensee informed us that some were stolen for food and he was personally aware of at least 25 animals stolen for this purpose.

One week prior to the race, the remaining tortoises were brought into downtown Fort Myers and placed in a wire enclosure between two buildings. Here they were provided with no shelter, food, or water and, again, they were extremely vulnerable to poachers. The licensee estimated that 200 tortoises had originally been collected. There were 108 remaining on the day of the race.

During the month prior to the race, the weather had been unusually cold for south Florida. The night temperatures were in the mid-30° F [= -1.1 C°] range and the day temperatures varied from 55° F [= 12.8° C] to an occasional 70° F [= 21.1° C].

Race participants could pay an additional fee and collect a tortoise of their choice one week before the race to take home and supposedly feed up and train for the race. These were the tortoises with the most severe violations of the license in regard to decorations applied directly to the shell.

Tortoise Maintenance During the Race

The tortoises were brought to the race in an open trailer 5 feet [= 1.5 m] long, 4 feet [= 1.2 m] wide and 3 feet [= 0.9 m] high. They were piled 5 and 6 deep, all scrambling and crawling to get on top. Race participants that had not paid additional money to preselect their animal could go to the trailer, pick out a tortoise, race it and then dump it back into the trailer after the race.

Following the race, the 108 tortoises were taken to Sanibel Island where, due to the weather temperatures and the decorated conditions of the animals, it was not possible to release them immediately. To provide some protection from the continuing unusually cold weather, they were maintained in a 30 feet X 40 feet [= 9 m X 12 m] garage that was divided into quarters by 1-foot [= 0.31 m] barriers. The tortoises were divided between the bins and straw was provided for them to burrow under in an attempt to psychologically allow them to feel covered. Every day, besides cleaning off decorations and taking individual statistical data, one group was taken outside to a fenced enclosure during the warmest part of the day and given food and water. During the following month, the weather remained unusually cold and the tortoises ate very little food. However, they readily drank large quantities of water when placed in shallow pans of water.

Permit Violations

1. Decoration

   Eighty of the 108 tortoises from the race had foreign material on their shells. This included: water soluble painted designs on the carapace, florist gum used to hold on various decorations, epoxy glue, non-water soluble paint, and fingernail polish on the nails.

2. Injuries Directly Related to Capture or the Race

   During the cleaning, 36 tortoises were found to have flesh wounds similar to those caused from a gopher hook. Fifteen were so severe that the animals could neither use nor retract the injured limb. Many had eye injuries sustained during the day of the race when they were kept in the small trailer piled on top of each other.

All wounds required a minimum of 2-weeks treatment. However, 26 tortoises with severe flesh wounds from hooking required veterinary assistance to open the wounds and remove the necrotizing tissue. All of the injured tortoises survived due to constant attention in cleaning and treating their injuries and only 2 sustained permanent damage. One lost the sight in an eye and another had a permanently impaired front forelimb.

Release Procedures

All tortoises were measured, weighed and numbered prior to release. Three different release techniques were used.

1. They were taken to suitable tortoise habitat where the native inhabitants had previously been removed for food and released down abandoned tortoise burrows. Each tortoise had an observer on the release day and an attempt was made to try and match as closely as possible the size of the tortoise to the size of the burrow entrance. Seventy-five percent of the tortoises immediately accepted the first burrow. However, the remainder had to be placed in as many as 5 or 6 different burrows before they appeared satisfied. Acceptance of the burrow was defined as: immediate effort made to clean out debris and enlarge or suitably modify the burrow. This was then usually followed by a period of basking in the sun at the burrow entrance after which the tortoise would wander off to feed. If at the end of grazing the tortoise returned to the assigned burrow, it was considered acceptance. At this point, the observer left after placing a small branch in the middle of the burrow entrance, so that if further movement occurred out of the burrow before the following day, it could be recorded. All tortoises released in this manner were observed daily for at least 2 weeks and thereafter as often as possible.

2. They were taken to suitable tortoise habitat where no empty burrows existed and released inside a 5 feet X 5 feet [= 1.5 X 1.5 m] wire enclosure down burrows artifically started for them. The artificial burrow was approximately 2 feet [= .6 m] long and when the tortoise had extended it a further 8-10 feet [= 2.4-3.0 m], the wire enclosure was removed. During this period, which took from 10-14 days, they were provided with food and water.

3. They were taken to fill areas at least 6 feet [= 1.8 m] above the water table that contained suitable food sources and released as above.

Results of the Different Release Procedures

Ten were released by Method No. 3 onto filled land and within 1 month of removing the cage, only 2 remained. They were still in the same burrow 10 months later. No trace was ever found of the other 8.

The other 98 tortoises were released equally between Methods No. 1 and No. 2 and a 6-month follow-up survey located 80% in their original burrows.

Extensive continual follow-up was done on a group of 36 tortoises released by Method No. 1 over a 6-week period on a 5-acre tract of land. After 1 month, 35 tortoises were still in their original burrow. No sign was seen of the 36th tortoise. After 6 months, the 35 tortoises could all be accounted for although several had changed the location of their burrow within the same 5-acre area. At this time, 8 hatchlings were observed in the area and it was concluded that successful mating and nesting had occurred. The eggs could not have been the result of delayed implantation because all females were X-rayed prior to release to see if they were carrying eggs.

This group continues to be closely studied and 12 months later (April 1979) all could still be accounted for and considerable mating activity had been observed.

What does all this mean to the tortoise? Without the time and money spent caring for and individually releasing the tortoises, their fate would have been probable death due to the extremely cold weather.

Because of the findings and the publicity given to them by the press, the Fort Myers Pageant of Light Committee decided this year to permanently stop the tortoise race.

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Population Structure, Size Relationships, and Growth of the Texas Tortoise, *Gopherus berlandieri*

Frank W. Judd, Francis L. Rose and Carlton McQueen

Abstract

The population ecology of *G. berlandieri* was studied on a 3.3-ha [= 8.25 acre] study grid near Laguna Vista, Cameron County, Texas, from 1972 through 1976. A total of 102 tortoises was captured on the grid and its surrounding margin. The number of resident tortoises declined from 48 in 1972 to 33 in 1976. The number of resident adult females remained at 15 or 16 throughout the study, thus the decrease in numbers involved adult males and juveniles. Coefficients of similarity showed considerable change in individual females present although total number of females was relatively consistant. Sex ratios generally indicated a greater proportion of males. Growth rates among size classes from hatching to sexual maturity are similar. Growth rates decline markedly after attainment of sexual maturity.

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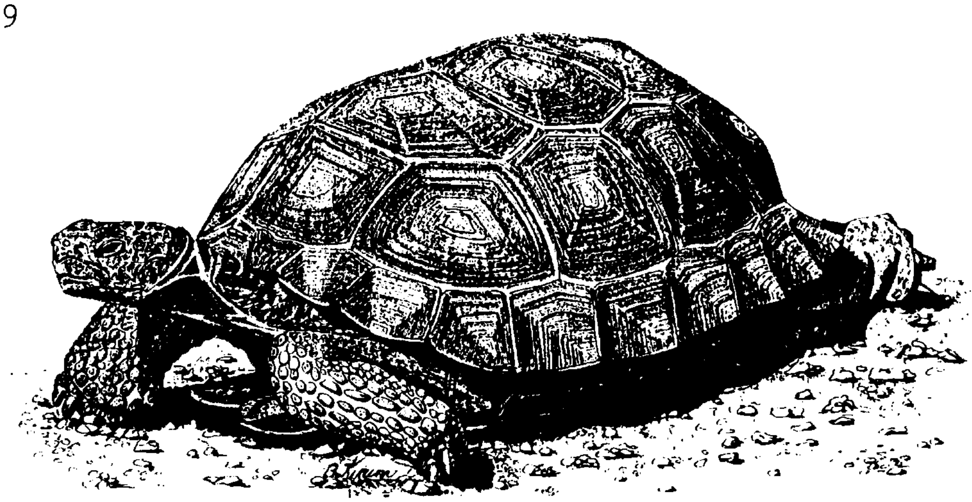

Home Range Estimates of *Gopherus berlandieri*

Francis L. Rose and Frank W. Judd

Abstract

Many male and female *G. berlandieri* inhabiting a free access study grid exhibited a limited area of movement over a 5-year period. This limited area of movement was judged a home range. When the estimated home ranges were compared to a computer-generated random estimate, the tortoises had significantly smaller ranges than what would be expected if their movements were random. Two methods were used to estimate home range size; a one-way analysis of variance was used to evaluate differences between the sexes; and regression analyses were used to evaluate the size of the ranges vs. number of captures and the size of a tortoise.

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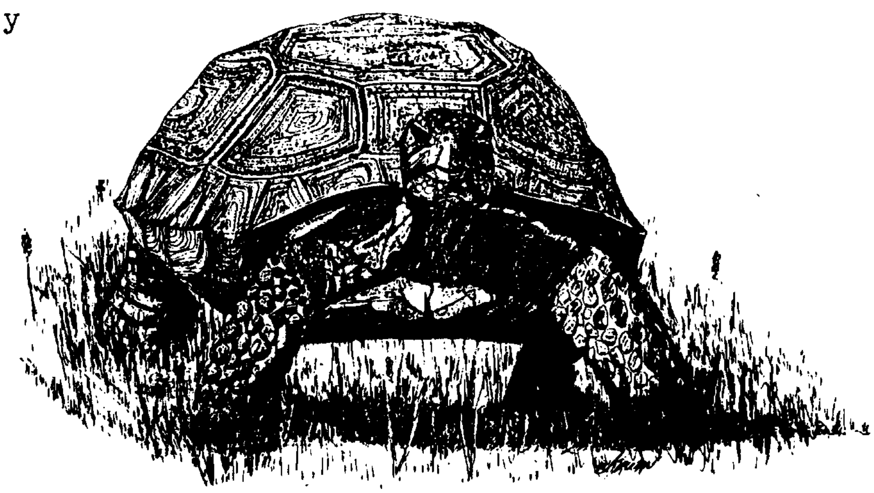

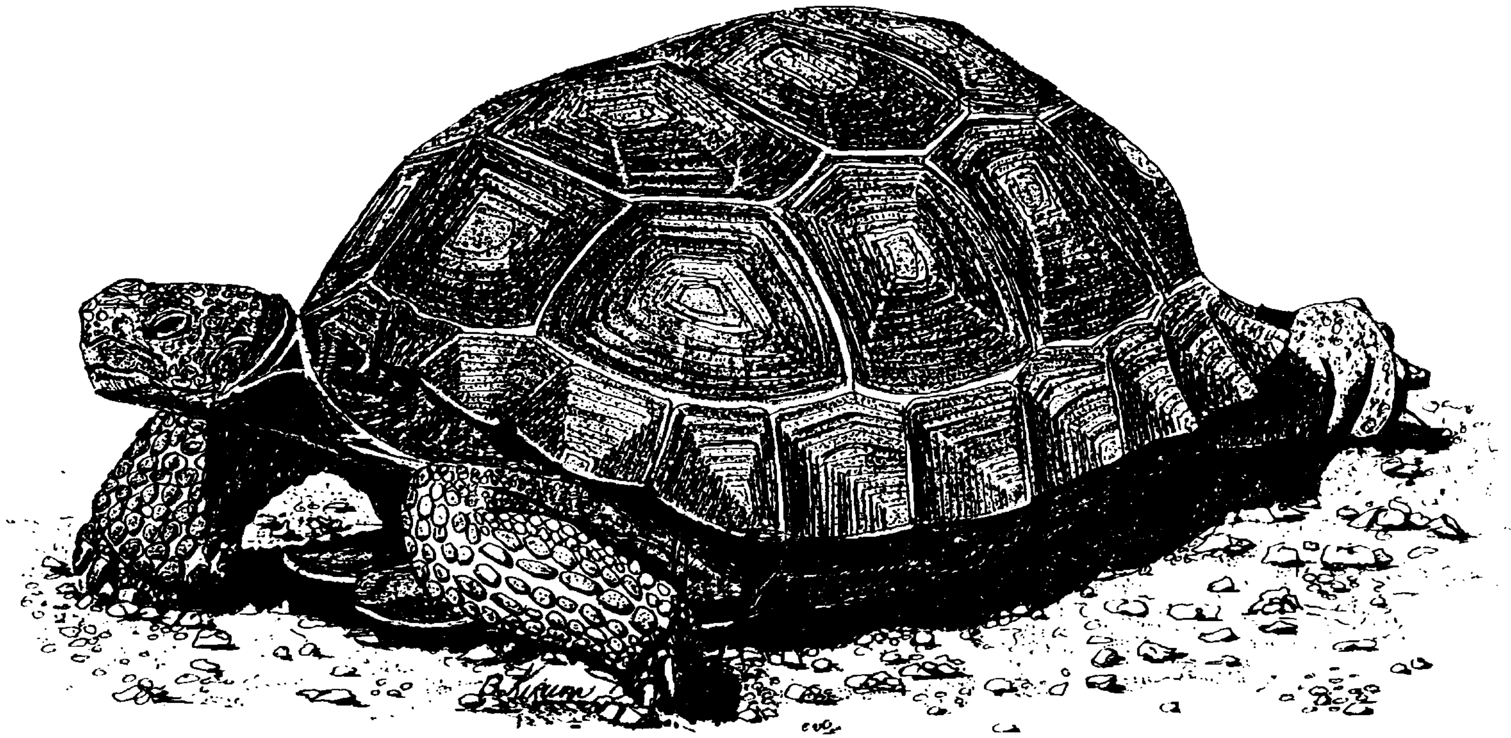

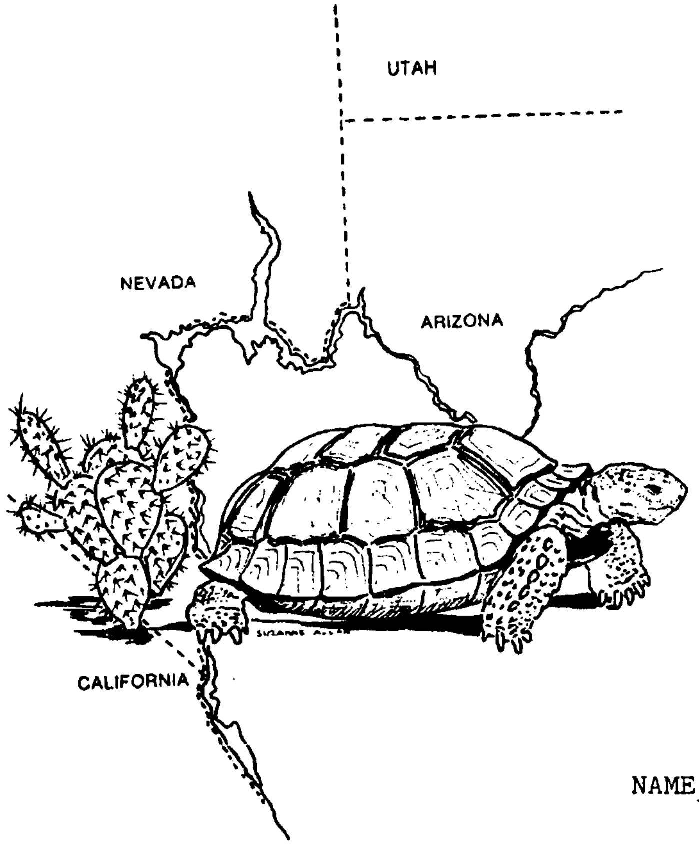

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