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Clark County Department of Air Quality and Environmental Management
Desert Conservation Program

DELIVERABLE TRANSMITTAL AND TRACKING FORM

Contractor Deliverable Information – to be Completed by Contractor/Agency		
Contractor Name: UNR-BRRC	Project # & Title (per contract): #2003-UNR-BRRC-252-P Desert Tortoise Baseline Monitoring	
Deliverable Date: Unclear, cover letter appears to be incorrectly dated, received by DCP on 27 September 2006.	Deliverable # (per contract): NA	
	Deliverable Title (per contract): Final Report	
Deliverable Due Date (per SOW): End of contract	Contact Person(s):	Deliverable Status: ☐ Draft ☒ Final
Date Mailed: unclear Hard Copies: 1 copy Electronic Copy: none		Electronic Copy: ☐ CD/DVD attached

Deliverable Monitor *(For internal use only)*			
Date Received: Hard Copy: 27Sep2006 CD Copy:	Received By: DCP	Path/Filename: NA	Hard Copy Located in: contract file
Project Manager: Sue Wainscott			Date to PM: Oct 10, 2006

Reviewers *(For internal use only)*

Comments are to be returned to the Project Manager no later than _____.

Reviewers:	Date Returned	Forwarded Documents:
☐ _____	☐/_____	
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Project Manager Review *(For internal use only)*	
Did deliverable meet contractual requirements? ☒ Yes ☐ No	PM Recommendation: ☒ Approve ☐ Reject
Comments:	
Signature: Sue Wainscott	Date: Oct 11, 2006
Before forwarding to Contract Manager, ensure folder contains: ☒ Copy of deliverable ☒Copies of all supporting documentation (e-mails, comments, reports, pictures, etc.) ☒Draft approval/rejection letter for CM signature (emailed to Jodi Oct 10, 2006 ☒Library Submittal Form	Date to CM: Oct 11, 2006

Contract Manager Review *(For internal use only)*		
☒ Approved ☐ Rejected	Signature: Jodi Bechtel	Date: 10/11/06
Date Submitted to Library (only final accepted):		

Library Submittal Form

Submitted By: Sue Wainscott	Date Oct 11, 2006
Project Title: #2003-UNR-BRRC-252-P Desert Tortoise Baseline Monitoring	
Document Title: Final Report	Electronic File Path: N/A
Document Type: ☐ Internal Only ☒ Incoming ☐ Outgoing	Doc Date: 27Sep2006 (Use the date shown on the document or the date received at the project office)
Document Description: Final Report Keywords: Desert Tortoise, Monitoring, Adaptive Management	Originator/Author UNR-BRRC
Special Instructions ☐ Sensitive / Confidential ☐ Replace previous version ☐ Save previous version ☐ Other:	Originating Office: ☐ Project Office ☐ Federal Stakeholder ☐ Control Agency ☐ Sponsor ☐ User / Stakeholder ☐ Prime Contractor ☒ Consultant ☐ HHSDC ☐ Other
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July 28, 2006

Jodi Bechtel, Sr. Management Analyst
Clark County Desert Conservation Program
Department of Air Quality & Environmental Management
Phone: 702 455-5529
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E-mail: jbechtel@co.clark.nv.us

Re: Interlocal Contract/Collection Agreement between Clark County, Desert Conservation Program and University of Nevada, Reno – Biological Resources Research Center (UNR-BRRC) for Baseline Tortoise Monitoring Program #2003-UNR-BRRC-252-P

Of concern is the statement on page 13 of the final report: "*Tortoise densities in Clark County have steadily decreased since the DCP has been established. This may be due to drought, but that is not scientifically established. At the very least, Clark County needs to be cognizant that their management actions are failing, and new approaches to recovery are desperately needed or else the flagship and federally listed species in the CCMSHCP will go extinct, and Clark County will be held responsible.*" The preceding paragraph in this final report, and chapter 5 in the Desert Tortoise Recovery Plan Assessment Committee Final Report (Tracy et al 2004), describe many threats to desert tortoise populations. Given that information, we are not able to understand your statement fully. We request the following information to clarify that statement:

1) Please describe the data and analyses you used to establish a causative relationship between establishment of the Desert Conservation Program (DCP) and steady declines in tortoise population from 2001-2005.

2) Please further describe the data and analyses you use to ascribe sole or primary responsibility for tortoise population declines (and extinction of other unnamed flagship and federally listed species in the CCMSHCP) to the actions (or inactions) of the DCP.

3) Finally, please describe how these two conclusions have been reached given the actions you recommend on page 16 of this final report for the purpose of establishing correlations between management actions and tortoise density.

We do not consider this final report to be complete as submitted on July 28, 2006 until these three points are addressed. You have until September 15, 2006 to rectify these issues and resubmit this deliverable.

The authors of this final report were not sensitive to the fact that the language used could be misinterpreted to be critical of the DCP. Actually, the words suggested that the cause of population declines could be a natural result of drought. The additional rhetoric was written with the intent to alert Clark County to the need to adapt administration of the program such

that future management of tortoise populations should include novel approaches in response to clear evidence that tortoise populations continue to decline in spite of all efforts on the part of the DCP to benefit these populations. In other words, even if the cause of declines is partly due to the natural consequences of drought, ensuring the persistence of desert tortoise populations in the face of natural phenomenon and anthropocentric stessors appears to require a change of management. This "alert", thus, is the intended deliverable from the project insofar as the project is meant to provide guidance from the information accumulated as a result of this project. Thus, we have revised the final report with different language in the paragraph mentioned in your letter (see above), and we feel that the revision should be acceptable to the DCP. In particular, the paragraph in question has been rewritten as:

> "Tortoise densities in Clark County have steadily decreased since tortoise populations have been monitored by the DCP (about eight years, albeit, not equally in all parts of the County). These population declines may be due to drought, but that is not scientifically established. At the very least, Clark County needs to be aware that the management actions supported by the DCP (e.g., retiring cattle grazing, fencing roads, rehabilitating disturbed habitat) have not been effective in preventing declining tortoise populations, and new approaches to recovery are urgently needed to prevent the flagship and federally listed species in the CCMSHCP from going extinct. This adaptive management is exactly the approach proposed in the MSHCP, and adjusting management at this stage should be seen as responsible, and should lauded as the appropriate approach for this covered species."

The entire revised report is submitted with this missive.

Sincerely,

Cindy Kiel
Executive Director
Office of Sponsored Projects

ac'd contract file

Library Submittal Form

Submitted By: Sue Wainscott	Date Oct 11, 2006
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Final Report

Baseline Density Monitoring: Southern Nevada Desert Wildlife Management Area Populations of the Desert Tortoise

Project Number 2003-UNR-BRRC-252-P

EXECUTIVE SUMMARY

Featured Project:

Baseline Density Monitoring: Southern Nevada Desert Wildlife Management Area Populations of the Desert Tortoise

Project Type:

Monitoring, research

Species Addressed:

Desert tortoise (*Gopherus agassizii*)

Summary Project Description:

This project, Baseline Density Monitoring: Southern Nevada Desert Wildlife Management Area Populations of the Desert Tortoise, implements the permit requirement to monitor desert tortoise population trend. In addition it establishes a baseline against which future estimates can be compared. The project uses standard transect methods for population sampling and several data analysis approaches.

Project Status/Accomplishments

This project is an on-going requirement of the Permit. To establish population trend, monitoring must occur regularly over the duration of the Permit (30 years).
Partners

Project Contact
Richard Tracy

Funding

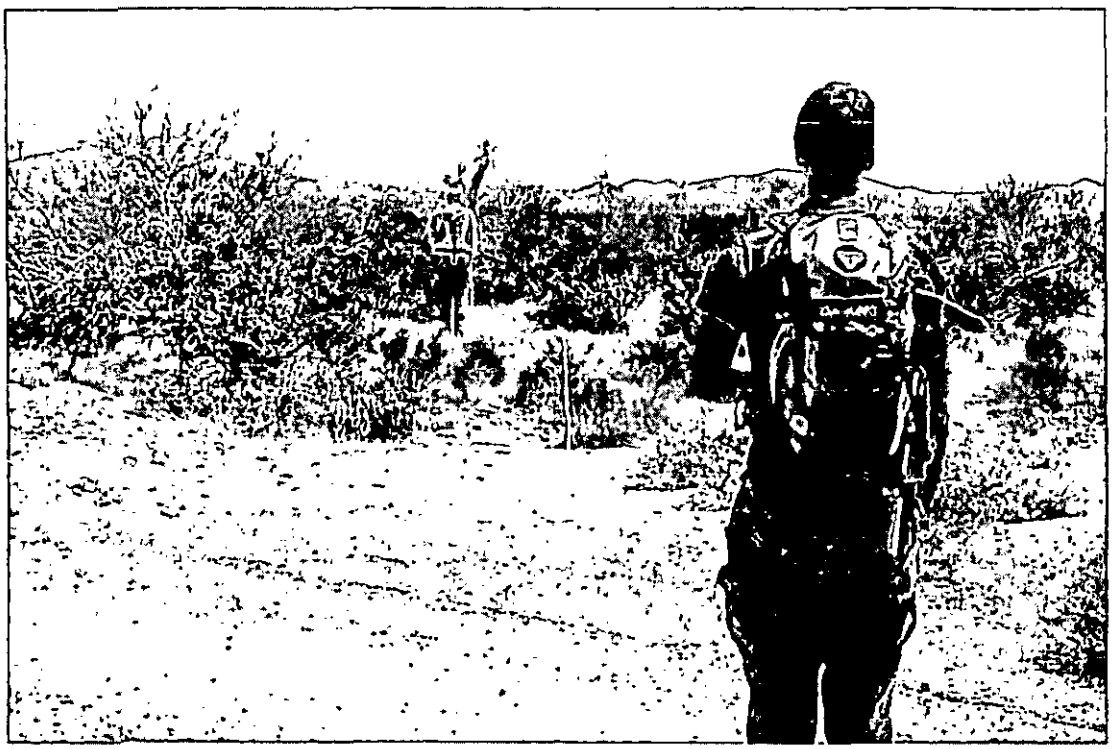
$810,000

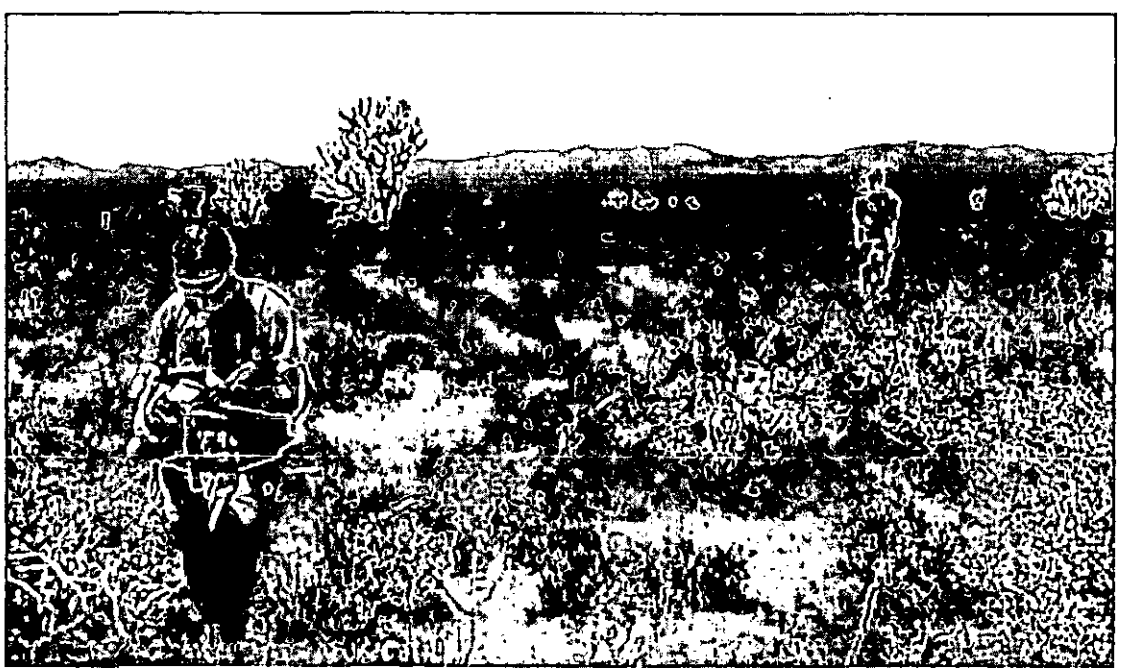
Completion Date or Status

This project is an on-going requirement of the Permit and will not be completed until the termination of the Permit.

Documents/Information Produced

Project Photos





INTRODUCTION

Description of Project

This project, Baseline Density Monitoring: Southern Nevada Desert Wildlife Management Area Populations of the Desert Tortoise, implements the permit requirement to monitor desert tortoise population trend. In addition it establishes a baseline against which future estimates can be compared. The project uses standard transect methods for population sampling and several data analysis approaches.

Background and Need

The Clark County Short-Term Desert Tortoise Habitat Conservation Plan, the Desert Conservation Plan and the Multiple-Species Habitat Conservation Plan all identify monitoring desert tortoise populations as an essential element of desert tortoise conservation. The Desert Tortoise Recovery Plan has recommended that monitoring desert tortoise populations is an essential part of any sound conservation or management plan. We have collaborated with the Fish and Wildlife Service, the United States Geological Survey and colleagues at St. Andrews University in conducting tortoise monitoring in Southern Nevada, improving monitoring techniques and in evaluating and developing new and better monitoring techniques.

The FWS has requested that we monitor range-wide compliance with protocols and that we evaluate data as it is collected. This will require that we receive data electronic files and hard copies as they are collected, or within a few days. The protocols currently being followed are sensitive to certain types of observer error. This type of error can, in some cases, be detected by ongoing evaluation of data collection and corrected. We will evaluate the data sets forwarded to us by other field workers and report the results to the FWS.

At the request of the FWS we have undertaken an evaluation of current monitoring techniques. We have developed and exciting new approach to monitoring tortoise population density. This new technique was presented to the Technical Advisory Committee of the Desert Tortoise Management Oversight Group (MOG-TAC) in the fall, 2001. We proposed that a revolutionary approach to monitoring procedures and a new approach to data evaluation may lead to improvements in the accuracy of density estimates and a significant decrease in cost. Simulations of this technique have shown great promise. The MOG-TAC enthusiastically approved field evaluations of this new approach.

This project was developed at the request of the Fish and Wildlife Service to assist in training for rangewide desert tortoise monitoring. The training described in the proposal conforms to the Fish and Wildlife Service desert tortoise monitoring protocols (see attached Draft Training Manual). The training will benefit the Clark County MSHCP and the Fish and Wildlife Service Desert Tortoise Recovery Program.

Management Actions Addressed

Monitoring covered species

Goals and Objectives

METHODS AND MATERIALS

Density Estimation Monitoring

Tortoise density monitoring in Southern Nevada is initiated in the early spring and the field aspects of monitoring continues for approximately 2--3 months. Sampling is initiated within some or all of the Piute Desert Wildlife Management Area (DWMA), the Cottonwood DWMA, the Eldorado Valley DWMA, Coyote Spring DWMA, Mormon Mesa DWMA, Gold Butte DWMA, the Pakoon DWMA, the Large-Scale Translocation Study Site (#1, South), the Large-Scale Translocation Study Site (#2) and throughout areas of the Lake Mead National Recreation Area. The sampling techniques currently followed are those discussed at the "Monitoring Workshop" held in Laughlin, NV in November 1996, and a variety of subsequent meetings including the most recent MOG-TAC meeting December 11, 2000. Transect surveys have consisted of lines 1600 m. or 3200 m. in length arranged in squares. As a result of evaluation of past monitoring efforts, this year's transects will be 4000 m long (final protocol and techniques are continuing to be refined by us and approve by the Desert Tortoise Coordinator). The location of the transect start points within the DWMAs has been determined randomly. Currently, we are measuring encounter rates in all of the proposed Desert Wildlife Management Areas (DWMA) in Nevada. It is necessary to estimate encounter rates to plan the monitoring effort in each DWMA necessary to obtain an adequate sample size to statistically estimate density. At the end of the 2001 field season, we will be able to project the necessary sampling effort in each DWMA necessary to estimate density.

Tortoise observers navigate to the start points form the nearest road using Global Positioning System (GPS) instruments. At the start point, a 100 m. tape will be stretched along the ground and a 2-person team will thoroughly search along the tape. Tortoise encountered will be weighed, measured, have sex determined, have health assessed and location recorded. The stretching and searching of the line will continue until the transect length has been completed.

Focal Animals

While the transect teams search for tortoises, an additional 1 or 2-person team will monitor radio transmitter equipped tortoises, "focal animals" to determine tortoise activity. This measure allows the density estimate to be calibrated for variations in tortoise activity levels. A sample of approximately 10-20 tortoises will be equipped and monitored in each of the DWMAs. Each focal animal team consists of a technician or graduate student and one Student Conservation Association volunteer. These individuals work closely together each day using two radio receivers to document tortoise activity.

Presently, we have focal tortoise samples in Piute Valley, Bird Springs Valley, the Large Scale translocation Study Site (South). Additional focal tortoises may need to be located and equipped with transmitters. Current transmitters will need to be maintained, replaced when nearing the end of their battery life and refurbished for future use.

The monitoring of tortoise activity through focal tortoises is expensive and time consuming. We believe that tortoise activity can be modeled to provide the Program DISTANCE with the necessary calibration. We have discussed with the FWS the need for a Post-Doctoral level research effort to analyze our data and that of other researchers to model tortoise activity. The FWS will be submitting a proposal for this project.

RESULTS

The report on range wide tortoise monitoring is appended. All Clark County data and analysis are part of that report, and the complete details of methods and relationships to other parts of the species range can be found in that report. Here, the results of monitoring in the Northeastern Recovery Unit are presented as a means to inform the Clark County MSHCP concerning the effectiveness of its management actions. The Northeastern Recovery Unit is the area monitored by Clark County. The Northeast Mojave RU includes the Beaver Dam Slope, Coyote Springs, Gold-Butte-Pakoon, Lake Mead NRA (North), Large-Scale Translocation Site (LSTS), and Mormon Mesa strata. The Beaver Dam Slope stratum includes designated critical habitat and associated DWMAs and ACECs in Nevada, Utah, and Arizona (BLM, 1998a, 2000). The Coyote Springs stratum includes the Coyote Springs and Kane Springs ACECs (BLM, 1998b, 2000) and associated critical habitat. The Gold Butte-Pakoon stratum includes the Gold Butte DWMA/ACEC (BLM, 1998b) in Nevada, the Pakoon Basin and Virgin Mountain ACECs in Arizona (BLM, 1998a), and associated critical habitat in both states. The Lake Mead NRA (North) stratum includes NRA lands in Nevada north of U.S. Highway 93. The Mormon Mesa stratum includes the Mormon Mesa ACEC (BLM 1998b, 2000) and associated critical habitat. The LSTS stratum is an approximately 104-sq.-km area on the west side of Interstate Highway 15, just north of the California state line. Given that tortoises salvaged from the Las Vegas Valley are translocated into this area, we exclude this stratum from regional (RU) density estimation. The field component of the annual training workshop occurred at the LSTS.

Because of the change in technique for conducting transects beginning in 2004, as well as differences in sample area between years, comparisons of some of the statistics from the DISTANCE analyses should be undertaken cautiously. All analyses used adult tortoises (MCL ! 180mm). All DISTANCE analyses used a detection function that pooled all observations within each year. Because of the change in transect technique. However, the three-fold increase in transect length (4 km to 12 km) more than compensated for the slight reduction in ER, so that the number of observations of tortoises increased in 2004 and 2005, resulting in increased precision of the detection functions. The capture probabilities, the proportion of tortoises detected between the transect centerline and the truncation distance, were about 60% for both transect methods. The analyses used some other conditions that varied from year-to-year.

The degree of sampling in Clark County is given in the tables below:

Table 1 – Area of monitoring and number of transects implemented as part of density monitoring in 2001

2001	Area (sq. km)	# of Transects
Beaver Dam Slope	773	53
Coyote Springs Valley	529	51
Gold Butte/Pakoon	1603	65
Lake Mead NRA (North)	774	12
Morman Mesa	870	47

Table 2 – Area of monitoring and number of transects implemented as part of density monitoring in 2002

2002	Area (sq. km)	# of Transects
Beaver Dam Slope	201	27
Coyote Springs Valley	162	12
Gold Butte/Pakoon	162	12
Lake Mead NRA (North)		
Morman Mesa	258	24

Table 3 – Area of monitoring and number of transects implemented as part of density monitoring in 2003

2003	Area (sq. km)	# of Transects
Beaver Dam Slope		
Coyote Springs Valley	152	42
Gold Butte/Pakoon	162	70
Lake Mead NRA (North)		
Morman Mesa	258	65

Table 4 – Area of monitoring and number of transects implemented as part of density monitoring in 2004

2004	Area (sq. km)	# of Transects
Beaver Dam Slope	827	10
Coyote Springs Valley	638	56
Gold Butte/Pakoon	1923	37
Lake Mea NRA (North)		
Morman Mesa	957	48

The maps of transects for each year between 2001 and 2004 are given in the maps below (2005 data are still not reduced).

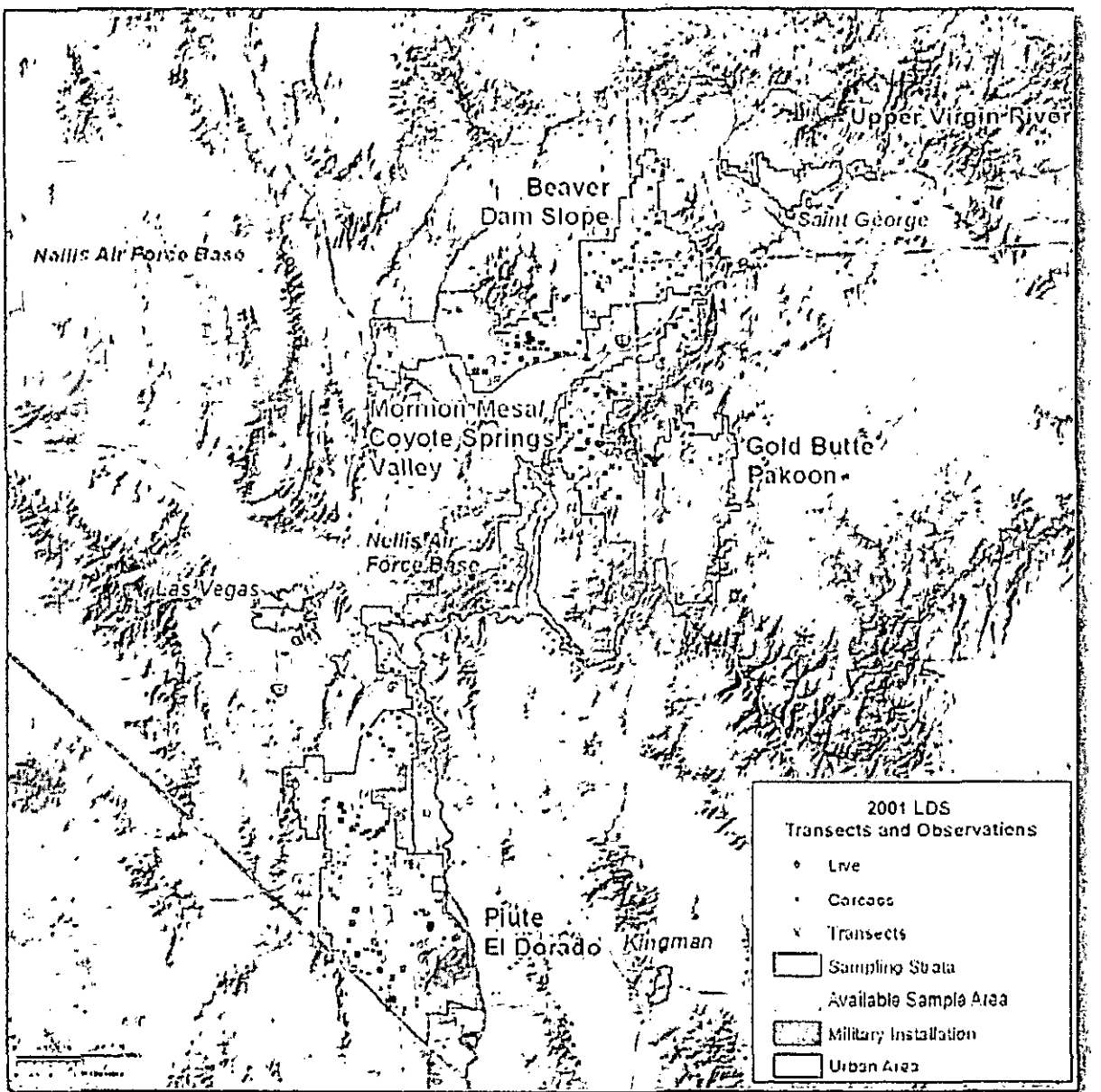


Fig. 1 – Map of transects implemented in 2001.

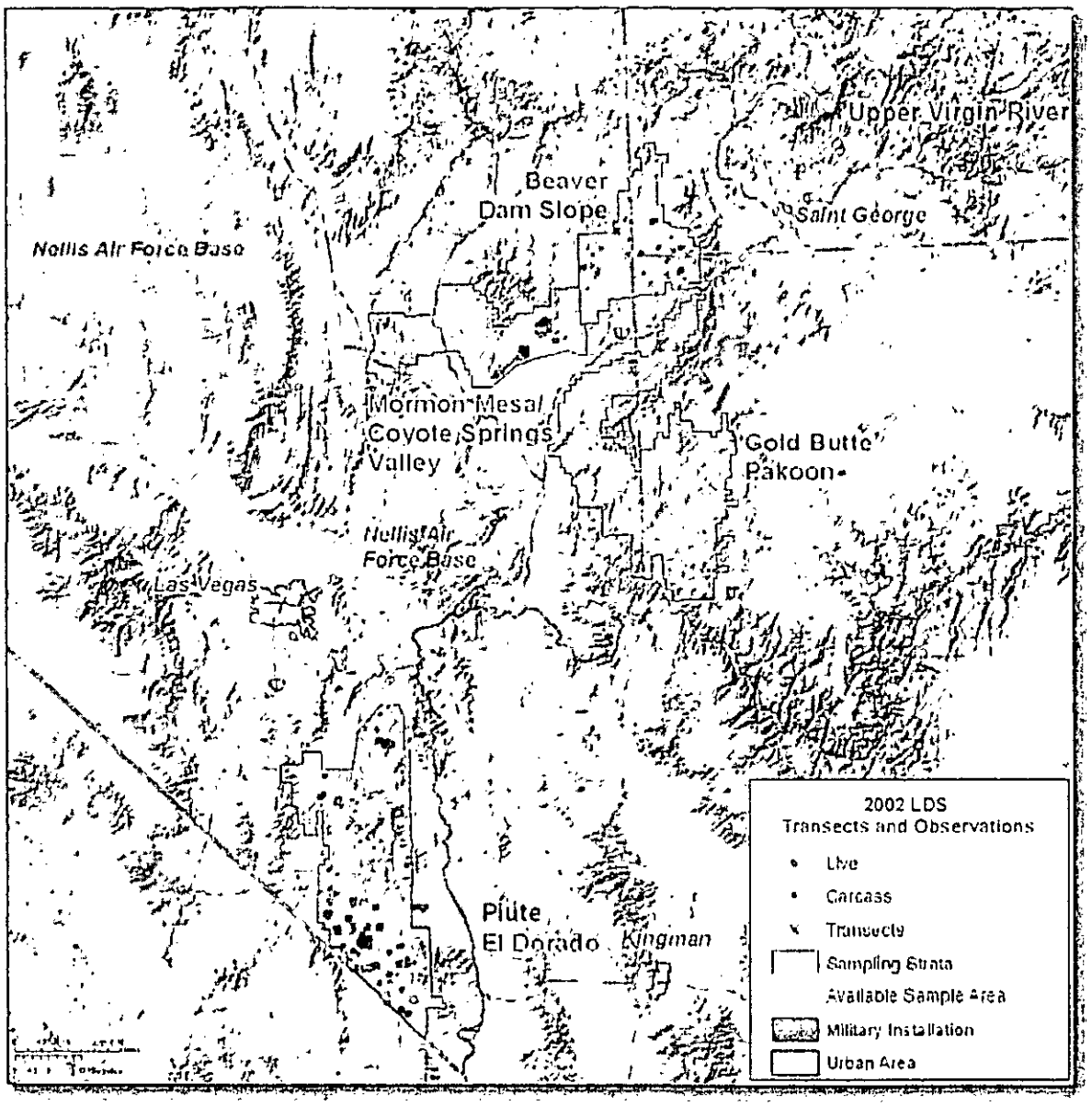


Fig. 2 – Map of transects implemented in 2002.

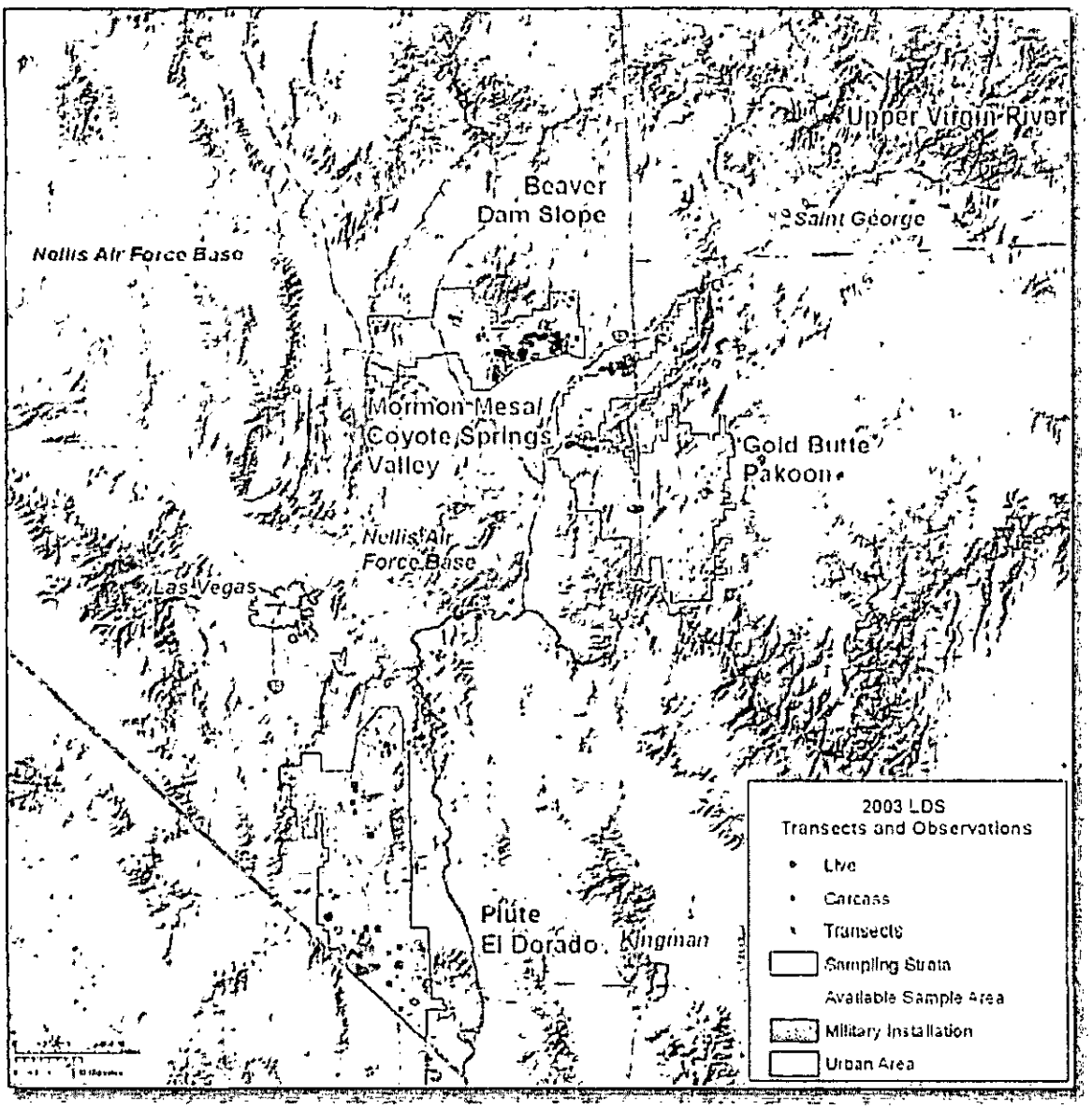


Fig. 3 – Map of transects implemented in 2003.

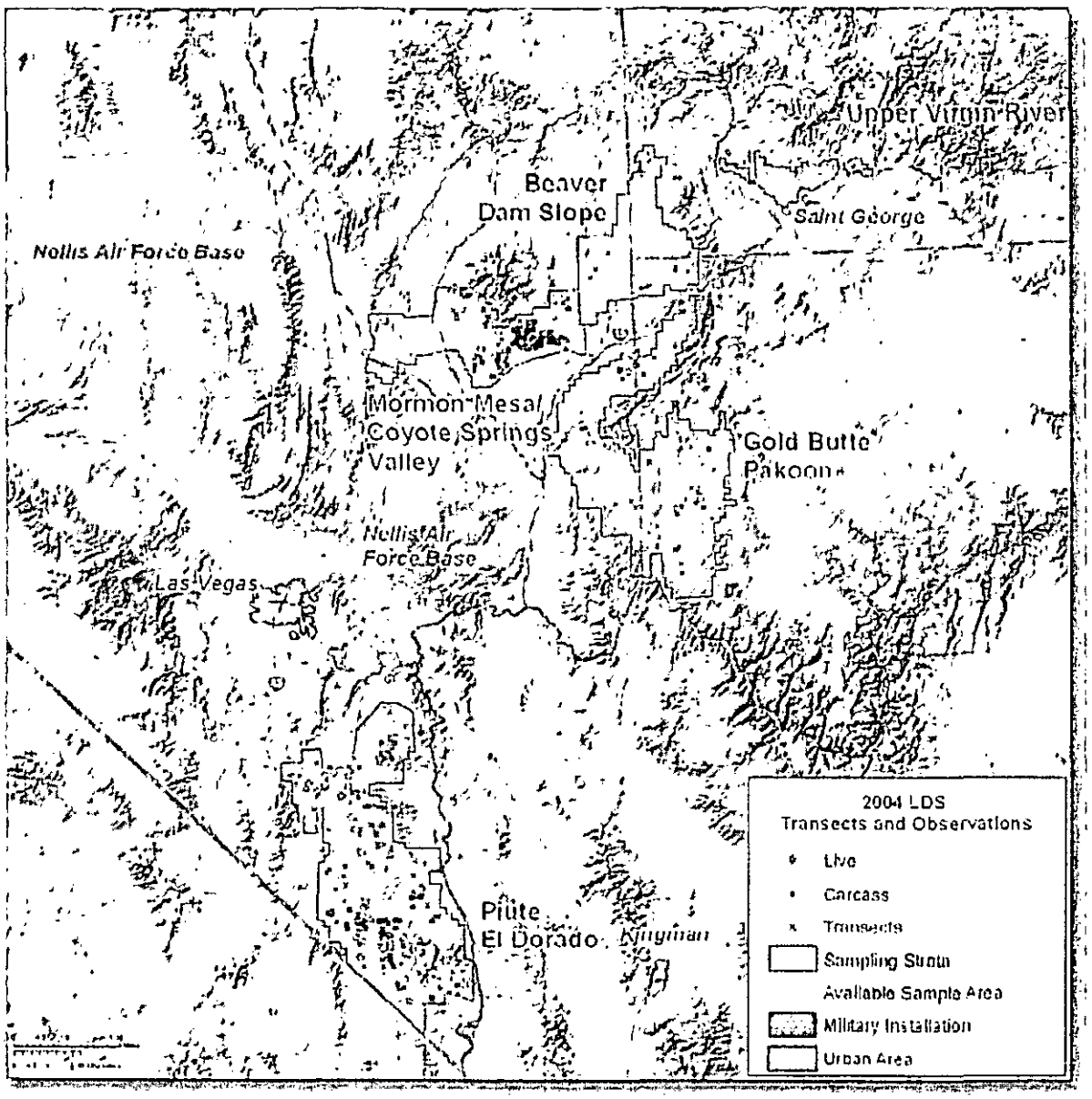


Fig. 4 – Map of transects implemented in 2004.

EVALUATION/DISCUSSION OF RESULTS

Clark County sampling of desert tortoises from 2001–2005 allows estimation of abundance over extensive areas of the Mojave Desert. Detection functions were based on observations of tortoises !180 mm MCL and the pooled observations produced coefficients of variation in the range of about 15% which is not as good as that in other parts of the range (due to sparce populations in Clark County (CVs other places range between 2.8% and 4.1%). No year has entirely used the same methods as yet, so it is difficult to have confidence in observed trends in population densities.

The density estimates from 2001–2005 are considerably lower than densities estimated from long-term 2.6-km^2 study plots in the Mojave Desert (e.g., Young et al., 2002; BLM, 2005), or from categorical estimates of density created by using transects for tortoise sign as indices of abundance calibrated in areas of known density (Luckenbach, 1982; Berry and Nicholson, 1984). Densities at long-term study plots cannot be directly compared to regional estimates of abundance, because these plots were not established using a probabilistic design, but instead were located intentionally in areas with high tortoise abundance. The categorical estimates of abundance from sign transects are likely imprecise. Indices of abundance suffer from numerous problems, including most significantly, unknown variation in detection probabilities (Anderson, 2001). Because the relationship between tortoise sign and density is calibrated on the long-term study plots, the relationship is established only at high densities, and the index likely overestimates abundance at larger scales. Krzysik's (2002) multi-scale sampling design estimated burrow and scat densities at the same time as tortoise density. He used the estimates of burrow and scat densities to calibrate overall tortoise density to the local scale. It may be informative, however, to display graphically long-term plot trends or sign transects on current maps of live and dead tortoise distribution to place these historical data within the current landscape context. Comparing areas of carcass and live tortoise concentrations from the current LDS data (*cf.* Tracy et al., 2004) with individual study plots may provide insights into larger scale declines relative to those reported from some plots (plot declines located within larger area of high carcass concentration but low live tortoise concentration). Conversely, more isolated declines may be identified within larger areas of high live-tortoise concentration.

The density estimates from 2001–2005 are also low, because tortoise populations throughout the Mojave Desert have continued to decline since the species was listed as Threatened in 1989. Threats to tortoise populations from human encroachment into the desert have been identified (USFWS, 1994), but the ability of management to address these threats may be compromised by increased mortality of tortoises caused by longterm climate change. Desert tortoises are more vulnerable to drought than was appreciated 15 years ago. Several recent studies have documented vulnerability of juvenile (Wilson et al., 2001) and adult tortoises (Peterson, 1994, 1996; Henen, 1997; Longshore et al., 2003) to drought. Range-wide sampling was initiated during a severe drought that intensified in 2002 and 2003. It is possible that this drought was the primary cause of the decline in

population densities.

Tortoise densities in Clark County have steadily decreased since tortoise populations have been monitored by the DCP (about eight years, albeit, not equally in all parts of the County). These population declines may be due to drought, but that is not scientifically established. At the very least, Clark County needs to be aware that the management actions supported by the DCP (e.g., retiring cattle grazing, fencing roads, rehabilitating disturbed habitat) have not been effective in preventing declining tortoise populations, and new approaches to recovery are urgently needed to prevent the flagship and federally listed species in the CCMSHCP from going extinct. This adaptive management is exactly the approach proposed in the MSHCP, and adjusting management at this stage should be seen as responsible, and should lauded as the appropriate approach for this covered species.

The results of monitoring using distance sampling has shown a steady decline in population density. Piute/Eldorado Valleys have a longer history of monitoring and the decline is even more dramatic over that time period.

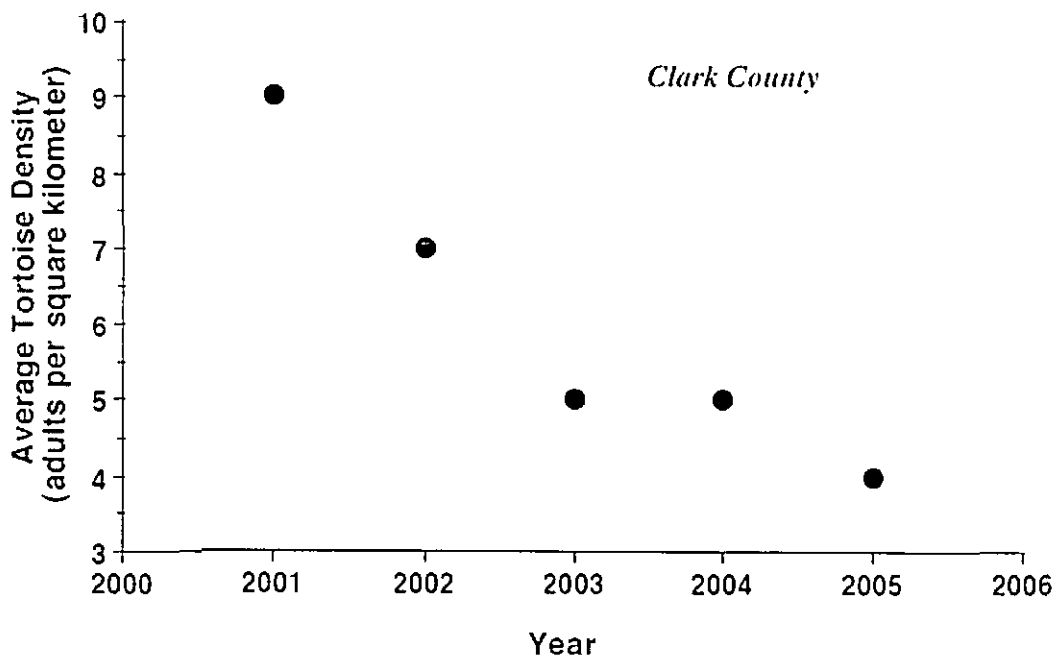


Fig. 5 – Results of distance sampling since implemented in 2001

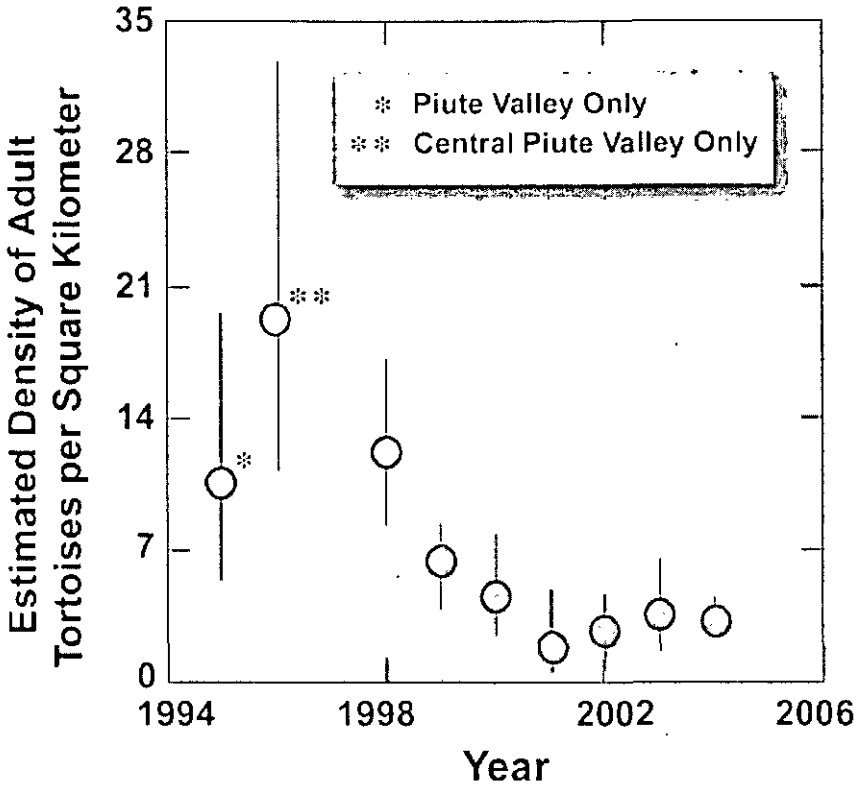


Fig 6. Estimated population densities in Piute Valley

The only location in Clark County that has a stable population is in the LSTS. This indicates that population supplementation is apparently a viable strategy to prevent extinctions as we mitigate threats as we know them. Even the LSTS has anthropogenic threats as people are apparently entering the LSTS to poach tortoises as several marked tortoises translocated into the LSTS have been picked up by the Clark County pick up program a second time. This is only possible if people are moving tortoises from the LSTS to Las Vegas Valley. These data should signal a need for adaptive management of desert tortoise. Thus, the DCP science coordinator needs to develop a new plan for managing desert tortoise.

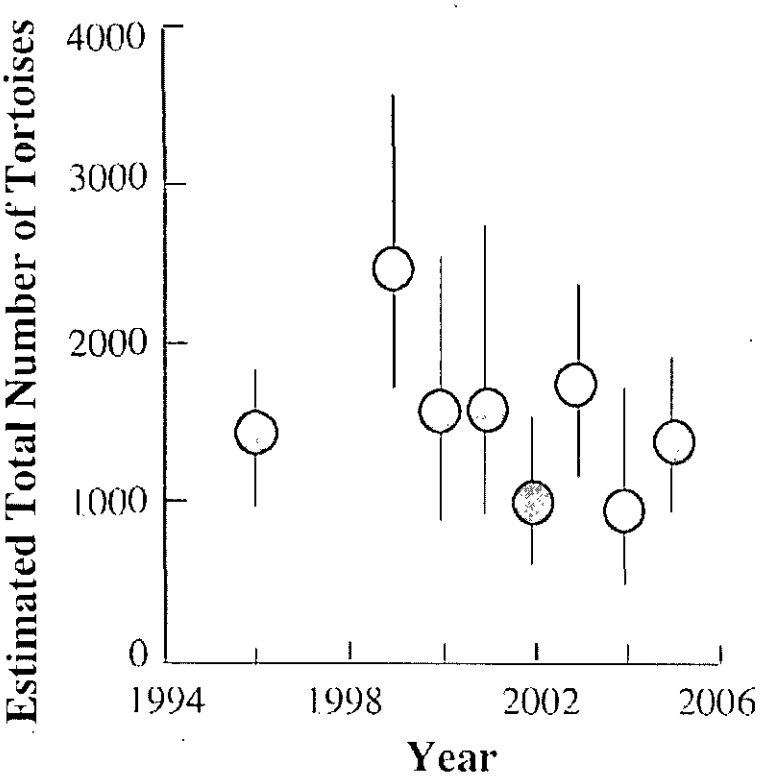


Figure 7. Estimated numbers of adult tortoises (with 95% confidence intervals) occurring within the boundary of the LSTS.

Monitoring and Management

Population monitoring should be relevant to on-the-ground management and recovery. The 1994 Desert Tortoise Recovery Plan identified five criteria that must be considered before delisting of the tortoise:

(1) As determined by a scientifically credible monitoring plan, the population within a recovery unit must exhibit a statistically significant upward trend or remain stationary for at least 25 years (one desert tortoise generation);
(2) enough habitat must be protected within a recovery unit, or the habitat and desert tortoise populations must be managed intensively enough to ensure long-term viability;
(3) provisions must be made for population management within each recovery unit so that discrete population growth rates (lambdas) are maintained at or above 1.0;
(4) regulatory mechanisms or land management commitments must be implemented that provide for long-term protection of desert tortoises and their habitat; and
(5) the population in the recovery unit is unlikely to need protection under the Endangered Species Act in the foreseeable future.

The current range-wide monitoring program addresses directly only criterion 1 and the detection of lambda in criterion 3 but not the management to achieve that number. The remaining criteria must be addressed by habitat and threats monitoring and effectiveness monitoring for management actions. Meeting criteria 2-5 will require monitoring of habitat parameters or habitat quality indicators, tortoise threats, and the effectiveness of management actions to alleviate threats and to protect or enhance habitat. These are enormously complex challenges. The recovery plan briefly described some of the management actions in the identified recovery units and in the desert wildlife management areas as of the early 1990s. Tracy et al. (2004) also included a more recent summary of recovery action implementation, but this information was very general and, in some cases, incomplete. We need a current empirical description of management that will allow stratification of density estimates by classes of management.

Data collection experiments in Nevada in 2004 and range-wide in 2005 included for the first time several variables on habitat and putative threats (e.g., number of roads and trails, trash, invasive plant species, ravens, free-ranging dogs, disease). These data need to be summarized to provide spatial baselines for several variables and correlates to tortoise populations at a landscape scale not previously available. These summaries should provide a basis from which to identify relevant management actions, as well as hypothesized responses of tortoise populations to those actions. However, we need the assistance of the land management agencies in identifying current management and uses of land being monitored for tortoise density. Development of a centralized recovery database will facilitate the collection of information on recovery implementation in a format that would allow post-stratification on recovery implementation activities and comparison of trends in tortoise populations between categories. In this way, the monitoring program can provide more adaptive feedback to managers on the effectiveness of long-term recovery implementation actions.

For example, the Clark County Multiple-species Habitat Conservation Plan, as part of its obligation to minimize and mitigate "take" of tortoises in urbanizing areas, has purchased all but two of the cattle and sheep grazing allotments in the County from willing sellers. This action was based upon the Recovery Plan identification of cattle grazing as a potential threat to desert tortoises. More than a million acres previously subject to cattle and sheep grazing are now unencumbered. We need an empirical survey of activities on public lands such as grazing, roads and highways (with traffic counts), and recreation (with visitor counts) that will allow stratification of density estimates by classes or degree of use. Comparing tortoise population trends between different management or use categories, in combination with more directed and specific research, will help evaluate the effectiveness of those management actions.

Future Directions

Prior to the 2007 field season, data from the 2001-05 surveys will be analyzed more comprehensively to ensure that the monitoring program is designed and implemented to provide the best information possible to inform managers on recovery progress. Importantly, the range-wide monitoring program should dovetail with the ongoing recovery plan revision. The monitoring program should be responsive to modified recovery criteria, as necessary. Below, we describe various issues already identified for evaluation prior to 2007 surveys.

A powerful monitoring methodology provides a means to analyze data in different ways. For example, Tracy et al. (2004) presented results of spatial analyses from the 2001 data, showing areas of concentration of live and dead tortoises. Tracy et al. (2004) also emphasized the importance of multi-dimensional monitoring, including tortoises, habitat, and impacts/threats. Further investigation of spatial analyses based on the entire current database, including the 2005 habitat and threat data, will provide a more robust assessment of live and dead tortoise concentrations across the landscape. This assessment will also identify preliminary patterns and correlations of habitat quality and threats with tortoise populations. This type of spatial information will also facilitate directed recovery action implementation by land and wildlife managers.

Additional analyses should identify levels of sampling or stratification necessary to accurately reflect spatial distribution and maximize precision of estimates. Desert tortoises occur in clumped or aggregated distributions (Duda et al., 2002; Krzysik, 2002). A better understanding of habitat characteristics that may contribute to clumped tortoise populations would allow stratification on those characteristics and lead to more precise density estimates. Incorporation of burrow and scat estimates, which are observed at higher frequencies than live tortoises, may also provide estimates of local variation in population density within RUs (Krzysik, 2002).

Several technical issues of LDS as the technique for range-wide monitoring still need to be resolved. Effects of variation in detection probability (P_a) between survey teams, time, and space need to be evaluated and corrected, if necessary. Effects of variation in P_a between tortoises above and below ground also need to be evaluated (*cf.* Duda et al., 1999; Freilich et al., 2000; but see Burnham et al., 2004, for a discussion of pooling robustness). Effects of variation in the availability of tortoises for sampling (G_0) across time and space need to be evaluated and corrected, as well as determining minimum sample sizes necessary to estimate this parameter, if necessary (*cf.* Krzysik, 2002). Other topics that should be investigated include the use of covariates, spatial models, and adaptive sampling, among others (Buckland et al., 2004).

Practical aspects of the current monitoring program that need to be evaluated include the use of different, independent field teams to survey different parts of the tortoise's range. Even with mandatory pre-season training for all teams, the use of different survey teams has led to inconsistencies in data collected, which has contributed to protracted time spent on the data quality control process. Solidifying funding early enough to effectively plan

the annual survey effort is also critically important. A key recommendation of a 2002 audit of the desert tortoise recovery program was that the Departments of the Interior and Defense work with other agencies and organizations "to identify and assess options for securing continued funding for rangewide population monitoring, such as developing memorandums of understanding between organizations" (GAO, 2002).

The spatial scale of the monitoring program needs to be evaluated. Sample areas have varied from year to year, with the most consistent monitoring occurring in designated critical habitat and associated DWMAs or ACECs. Large areas outside critical habitat have not been regularly sampled (e.g., national parks; Desert National Wildlife Refuge; Pahrump Valley, Nevada), yet these areas are also important to recovery and are subject to tortoise management actions.

Relevant to all of these issues is the potential for incorporating "occupancy estimation" (MacKenzie et al., 2006) into the range-wide monitoring program. Modeling occupancy identifies the proportion of an area occupied by a species, rather than absolute or relative numbers of that species, and may be useful for monitoring changes in desert tortoise distribution over larger landscapes than is possible with LDS. The potential for overlaying occupancy estimation onto the current (or modified) LDS program should be evaluated, as well as the possibility of integrating occupancy estimation at a different spatial scale than LDS (e.g., applying occupancy estimation rangewide, but LDS at more focused geographic areas of interest).

CONCLUSIONS

RECOMMENDATIONS

1. Improve training lines by:
    a. adding a greater number of sizes of tortoise models, and
    b. developing alternate layouts or additional lines in different environments.
2. Develop a range-wide recovery database to integrate land management and use data with population data.
    a. Conduct an empirical survey of management by DWMA that will allow stratification of density by classes of management.
    b. Conduct an empirical survey of activities on public lands such as grazing, roads and highways (with traffic counts), and recreation (with visitor counts) that will allow stratification of density estimates by classes or degree of use.
3. Conduct spatial analyses of live and dead tortoise distribution across the range.
    a. Compare historical study-plot and sign-count data to current patterns of live and dead tortoise concentrations.
    b. Summarize the 2005 habitat and threat data and compare with patterns of live and dead tortoise concentrations.
4. Expand individual health data collected in 2005 to develop a method to assess stress in tortoises.
    a. Correlate stress and immune competence in tortoises.

b. Develop a spatially explicit model of areas in which tortoises are stressed to the point of being vulnerable to disease and assess temporal trends in vulnerability to disease.

5. Refine LDS techniques to improve sampling efficiency and estimates of trends.
    a. Investigate sampling levels or stratification needed to maximize precision of estimates.
        i. Investigate factors contributing to aggregated population distribution.
        ii. Develop a desert tortoise habitat model.
    b. Evaluate effects of variation in detection probability between survey teams, time, and space, as well as between tortoises found above ground and below ground.
    c. Evaluate effects of variation in g_0 across time and space.
    d. Investigate the use of covariates, spatial models, adaptive sampling, and other innovative approaches to distance sampling.
6. Evaluate the spatial scale of the monitoring program.
    a. Consider areas not regularly sampled to date.
    b. Evaluate multi-scaled sampling to relative density estimates within RUs.
    c. Evaluate the potential for incorporating occupancy estimation into the monitoring program.
7. Evaluate the use of independent field teams in order to improve data consistency and quality.
8. Refine and formalize/document the QA/QC process.
9. Identify and assess options for securing continued funding for range-wide population monitoring, such as developing memorandums of understanding between organizations.

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