Final Report

Increasing Effectiveness and Economy in Density Monitoring of the Desert Tortoise

Project Number 2003-UNR-BRRC-257-P

EXECUTIVE SUMMARY

Featured Project:
Increasing Effectiveness and Economy in Density Monitoring of the Desert Tortoise

Project Type:
Monitoring, research

Species Addressed:
Desert tortoise (*Gopherus agassizii*)

Summary Project Description:

This project was developed at the request of the Fish and Wildlife Service and the Desert Tortoise Management Oversight Group's Technical Advisory Committee (MOG-TAC). The objective is to make range-wide desert tortoise monitoring more precise and more efficient. Increased efficiency and precision will benefit management and conservation of tortoises. It will allow for adaptation of management actions. The research will benefit the Clark County MSHCP, federal land management agencies, and the Fish and Wildlife Service's Desert Tortoise Recovery Program.

Project Status/Accomplishments

Several models have been assembled and compared, but not with the complete data set. We should have a model that can be used for monitoring in the range-wide modeling of 2007.

Partners

Phil Medica – U.S. Fish and Wildlife Service
Roy Averill-Murray - U.S. Fish and Wildlife Service (2005- present)

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Funding

$312,000

Completion Date or Status

All field work is completed. Due to the current hold on USFWS desert tortoise distance sampling, this research can be used to guide the implementation of predicted g(0) values when sampling is resumed.

Documents/Information Produced

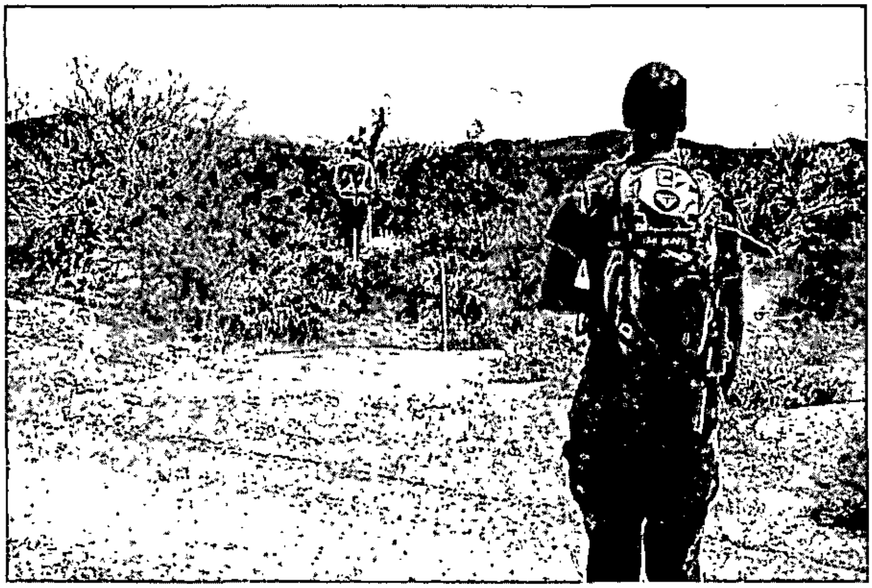
Reports previously submitted

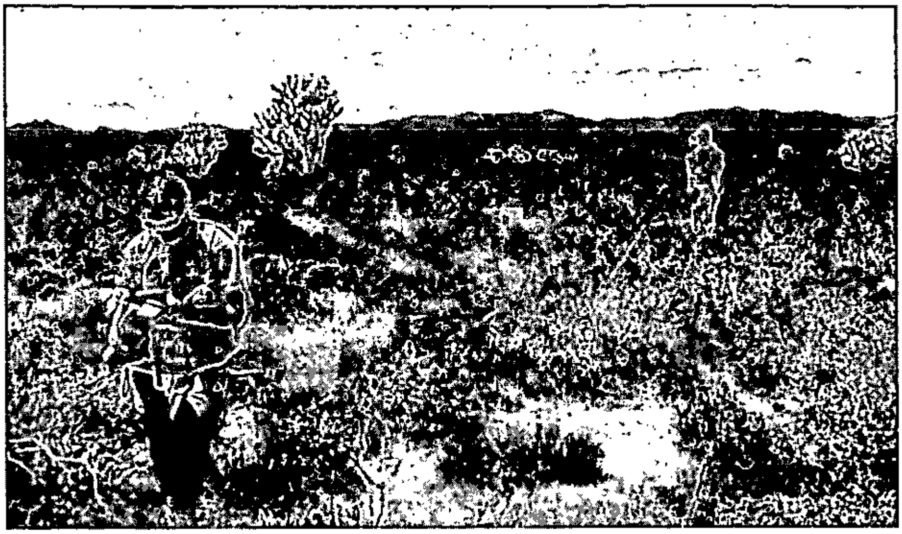
2003–UNR–BRRC–257–P–1967–03–1
2003–UNR–BRRC–257–P–1967–03–2
2003–UNR–BRRC–257–P–1967–03–3
2003–UNR–BRRC–257–P–1967–03–4
2003–UNR–BRRC–257–P–1967–03–5
2003–UNR–BRRC–257–P–1967–03–6
2003–UNR–BRRC–257–P–1967–03–7

Attachments

Range-wide monitoring of the desert tortoise: 2001-05 summary report
March 22, 2006 draft report by the Desert Tortoise Monitoring Committee
(Roy C. Averill-Murray, Melissa Brenneman, Paul Stephen Corn, Clarence Everly, Jill S. Heaton, Ron Marlow, Philip A. Medica, Kenneth E. Nussear, and C. Richard Tracy)

Project Photos





INTRODUCTION

Description of Project

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. Recent implementation of range-wide monitoring has illustrated the need for increasing efficacy and economy in monitoring techniques. The Fish and Wildlife Service and the Management Oversight Group and the Management Oversight Group, Technical Advisory Committee has asked that we undertake studies to increase the efficacy and efficiency of current density monitoring techniques.

Background and Need

Many species present difficulties for studying both behavior and abundance due to their elusiveness. Individuals may be cryptic and/or hidden, or their behavior may preclude them from being detected at certain times or under certain circumstances. In surveys estimating densities, elusive species can bias estimates by tricking observers in to skipping and/or not counting present individuals. This sampling bias can result in either reduced or inflated abundance estimates (Burnham et al. 1980, Anderson et al. 1985, Buckland 1985, Anderson et al. 2001, Freilich et al. 2005). Desert tortoises (*Gopherus agassizii*) are elusive because they can remain underground in burrows for approximately 90% of their lives (Woodbury and Hardy 1940, Barrow 1979, Bickett 1980, Bury 1982, Bartholomew 1993, Bulova 1994, Bury et al. 1994, Lovich 1995, Eubanks et al. 2003) where they can be hidden from sight and undetected in surveys. If survey methods do not account for this life history trait, population size and density estimates would be nearly worthless and almost impossible to use in any conservation application.

If certain diseases (e.g., Upper Respiratory Tract Disease, herpes, or shell dyskaratosis) cause behavioral changes that influence an individual's propensity to remain underground and hidden from surveys, range wide prevalence and frequency (of a particular disease) may be underestimated. This may also lead to an underestimated population size, and reduced density estimate. Before desert tortoise populations were thought to be declining, their elusive behavior intrigued scientists to study their behavior in great detail. In fact, extensive research on activity (Burge 1977, 1978, Barrow 1979, Morafka et al. 1980, Ruby and Niblick 1994, Ruby et al. 1994, Wilson et al. 1994, Garner et al. 1996, Christopher 1999, Duda et al. 1999, Wilson et al. 1999a, Eubanks et al. 2003), thermal ecology (Zimmerman et al. 1994, Reiber et al. 1999, Wilson et al. 1999a), energy budgets (Medica et al. 1975, Nagy and Medica 1986, Henen 1997, Henen et al. 1998, Henen 2002) has provided much knowledge on the behavior of desert tortoises under varying environmental conditions. In general, desert tortoises regulate their body temperature by moving among positions within the micro-environment thereby changing their exposure to air temperature and solar radiation (Tracy and Christian 1986, Zimmerman and Tracy 1989b, Zimmerman et al. 1994).

To assess population size and status, the 1994 USFWS recovery plan identifies the need for a long-term monitoring plan capable of estimating population trends over a 25-year interval (approximately one tortoise generation). Previous modeling work has shown that trends in population growth can not be detected when the coefficient of variation around the trend is close to 40% (Tracy et al. 2002). That is, with a known increasing population trend of 2% per year, sampling efforts will be unable to detect the trend if the precision and accuracy of sampling efforts introduce a coefficient of variation (error) of close to 40% in the estimates. Thus, the ability to estimate population density (or abundance) *precisely* is critical for assessing desert tortoise population status.

Distance sampling has been used extensively since its earliest known use by J. E. Gross in 1907 (Buckland et al. 2000) with bird surveys in Illinois (Forbes 1907, Forbes and Gross 1921), and has become a common method for estimating abundance of vertebrate animals (Buckland et al. 2000). Line distance sampling uses multiple transects that are walked, flown or driven (boats, cars, snowmobiles, etc) to locate individuals that occur on, or within, a specified distance from the transect being traversed. There are several assumptions made in the analysis of distance transect data, including that individuals further from the transect will be observed with a decreased frequency (Gates 1979). The most important aspect to distance sampling that this research is concerned with is the use of an 'availability' or 'probability of detection on the line' parameter, g(0). This parameter allows distance sampling to be used with species that can avoid detection for periods of time (Buckland et al 1993), such as whales spending time under water, or desert tortoises spending time under ground in 118 burrows. This method, (line distance sampling) has been chosen and is currently being implemented by the USFWS to address the need for an assessment of desert tortoise population status. This multi-year survey effort was initiated in 2001, and will be continued as long as desert tortoises are a listed species. In this application of distance sampling, the elusiveness of desert tortoises is accounted for (or at least addressed) by the use of a direct multiplier, g(0), in the final density calculations using program DISTANCE (Thomas et al. 2005).

Our research is addressing the temporal and spatial variation in activity by creating a predictive model that will predict activity at several temporal and spatial scales. The current implementation of distance sampling uses a small group (8-10 individuals) of radio-telemetered animals within each Critical Habitat Unit (USFWS 1994) to calculate the proportion of the total tortoise population that is available to be counted by field crews, or g(0). Each focal animal group is monitored periodically throughout the sampling season, at which time each individual is tracked a few times throughout the day, and its behavior and position in the microhabitat is recorded. This monitoring occurs each day that crews are conducting distance transects in a particular CHU. For example, on the days when transects are being walked in the Superior-Cronese CHU, the Superior-Cronese focal animal group is also being monitored by an additional field crew. These observations are then pooled with the focal observations from the other CHUs and are averaged to create the g(0) parameter used in program DISTANCE.

Recent technological improvements have led to the development of many new animal attached remote sensing devices capable of logging countless environmental and physiological parameters (Ropert-Coudert and Wilson 2005). Combined with increased data storage capacity, these devices are becoming instrumental in the analysis of organism behavior (Fedak et al. 2000, Ropert-Coudert et al. 2001, Aguilar et al. 2003, Shaffer et al. 2003, Hays et al. 2004, Block 2005, Ropert-Coudert and Wilson 2005), and physiology (Marcinek et al. 2001, Kawabe et al. 2003, Costa and Sinervo 2004, Block 2005, Ropert-Coudert and Wilson 2005), and are allowing scientists to ask questions which were previously too difficult or complex to answer.

Our research is building upon work completed in 2004 at two study sites located in the western Mojave, in California. We created a simulation model capable of predicting population activity (% population above ground) using only: daily average precipitation and 15-minute averages of solar insolation, soil temperature and air temperature. This model has an R^2 value of 0.73, indicating that it can explain approximately 73 percent of the variance in the activity (with respect to animals being above or below ground) of the 35 radio-tagged individuals in 2004.

Following a similar design to the work completed in 2004, this study is making use of small dataloggers affixed to several groups of desert tortoises to remotely monitor activity and behavior over two years at a study site in the eastern portion of the Mojave desert, in Clark County, NV. Descriptive and predictive statistics will be used to identify correlations between microclimate conditions and individual as well as group behavior. Time series analyses will be used search for temporal patterns not previously identified in desert tortoise behavior. Data from each year will be used to create a predictive model specific to each particular year. Each of the two models will then be tested for generality on data from the other year, in addition to data from the previously completed 2004 study. In addition, auxiliary datasets from past years (1997-2000) from additional sites in Nevada will be used to test the flexibility and robustness of each model. Figure 1 gives an overview of the three primary steps involved in this research.

Management Actions Addressed

Research on monitoring a covered species

Goals and Objectives

The outcomes of this research will provide 1) increased precision of density estimates, 2) new methods for estimating activity periods in large herpetofauna, 3) increased understanding of the relationships between local climate variation and tortoise activity and energy consumption. Implications for this research span conservation biology, behavioral ecology and novel methods for quantifying activity in large herpetofauna.

METHODS AND MATERIALS

Field Methods

The field methods for this research involve establishing a study site in Clark County, NV (as permitted by USFWS) with 10-20 individuals fitted with radio telemetry transmitters and dataloggers, installing a local weather station, and recording field observations of each individual.

One Campbell Scientific weather station has been installed at the study sites to record local climate. The location for each weather station should be determined by several characteristics, including: 1. Visibility-the weather station should be hidden from any main access roads to help prevent vandalism. 2. Climatic extremes-the weather station needs to include the two extremes of temperature (hot and cold), 3. Representative-the location should be typical for the area contained in a given study site (average topography and vegetation). By including the two temperature extremes in the weather station location, it will be possible to define the environmental thermal minima and maxima, thereby defining the min and max operating temperatures. Each weather station will record data at 15-minute intervals starting on the hour 24:00, and will be chronologically synchronized to a field laptop. Parameters recorded include: wind speed (m/s), solar insulation (W/m^2), relative humidity (RH), precipitation (mm), air temperature (C) in the sun and shade at 3 different heights (10, 20, 40cm), soil temperature (C) in the sun and shade at 4 different depths below the surface (0, 10, 30, 70cm).

Miniature dataloggers attached to each animal to record the microclimate experienced by each individual. The loggers record temperature, relative humidity, and solar radiation. The loggers are set to record data every fifteen minutes and will be synchronized with the local weather station.

In conjunction with the USFWS line distance sampling monitoring effort, multiple field crews will collect behavioral observations on datasheets to record the microhabitat position of each radio tagged individual several times daily. In addition to microhabitat position, a number of other attributes are recorded at each observation to provide adequate behavior and climate information for modeling purposes. A sample datasheet with all attributes is attached in appendix B. During the activity season (March – June), individuals will be observed daily as often as possible given funding and field logistics. In June, observations will be reduced to coincide with anticipated reduced activity levels, and emphasis will be placed on morning and evening observations. Each datalogger will be downloaded every two weeks to prevent data loss.

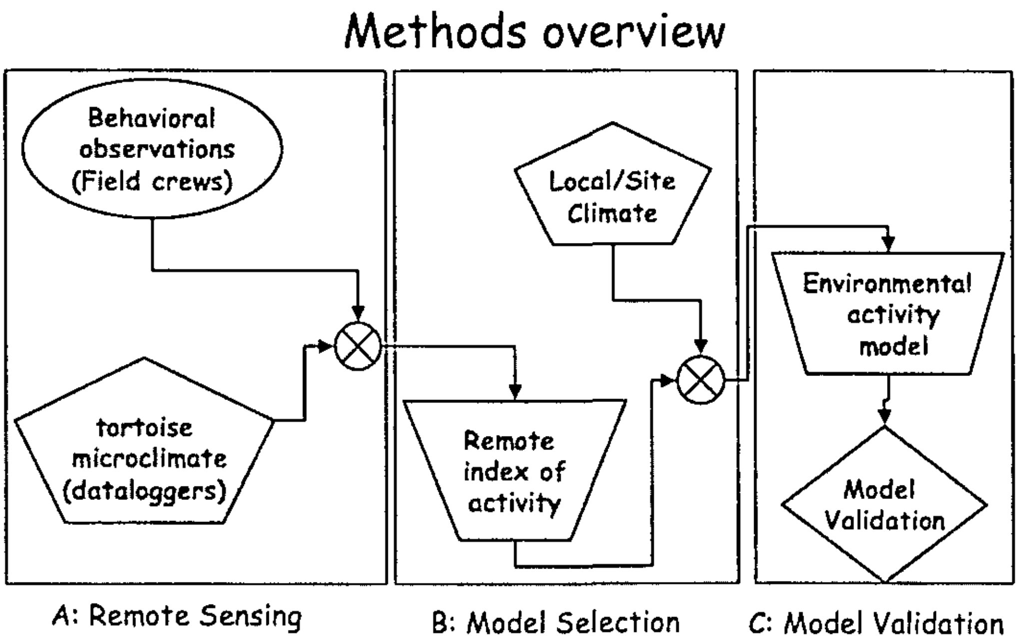


Figure 1. Methods overview. The first step combines field observations of tortoise behavior with remotely-sensed microclimate data (from dataloggers) to create a remotely-sensed index of activity. The second step involves modeling the remotely-sensed index of activity with local climate data. The third step involves validated each model with data from a different year (2004, 2005, 2006) or site (west Mojave [2004] east Mojave [2005, 2006]).

Analyses

Many methods show promising properties for answering the questions posed in this research. In the first step (see Figure 1), regression (logistic) and classification (discriminant function and ordination) methods will be used to properly interpret the microclimate data from the dataloggers into tortoise positional data (above or below ground, and open, burrow, mouth of burrow, pallet or vegetation). To test and account for pseudoreplication, random samples of the field observations and tortoise microclimate data will be drawn and modeled. Multiple replications will ensure a robust model. With an appropriate model, the remaining microclimate data (15 minute intervals from each individual) will be used to estimate the position of each animal for the entire period that the datalogger was capturing microclimate information. This will create a historical record for each animal in the study, given its position at each 15-minute interval. Using this historical account of each individual, and the local climate data from the study site weather stations, I will model tortoise behavior on multiple temporal scales using a number of new and old methods. A number of different artificial neural networks will be used as non-linear regression methods to incorporate the temporal history of the local climate, as well as the temporal history of each tortoise. Artificial neural networks have advantages over many other methods due to their ability to account for multiple poorly known but complex relationships between input and output variables (Padgett and Roppel 1992, Principe et al. 2000, Aitkenhead et al. 2003). In addition, other methods such as superposed epoch analysis, spectral analysis, ARIMA models, and probability state modeling will be used to account for the temporal patterns in these time-series data.

RESULTS

All field work will be completed after this field season. Several models have been assembled and compared, but not with the complete data set that we'll have after this field season. We should have a model that can be used for monitoring in the range-wide modeling of 2007. The outcomes of this research will provide several advances and benefits to the scientific and desert management communities. These include 1) a new method for quantifying, estimating and predicting activity in large herpetofauna, 2) an increased precision of desert tortoise density estimates, and 3) an increased understanding of the relationships between local climate variation and tortoise activity and behavior. In addition, the increased sample size and extended observation periods will provide a finer resolution and a more comprehensive explanation of tortoise behavior than previous desert tortoise thermal ecology studies. And due to the current hold on USFWS desert tortoise distance sampling, (sampling will not be conducted until 2007) this research can be used to guide the implementation of predicted g(0) values when it is resumed in 2007.

EVALUATION/DISCUSSION OF RESULTS

This project will be complete in early 2007.

CONCLUSIONS

This project will be complete in early 2007, and conclusions will be possible at that time.

RECOMMENDATIONS

This project will be complete in early 2007, and recommendations will certainly be made at that time.

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