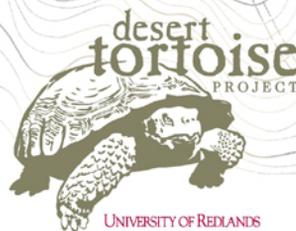


Desert Tortoise Project Program Design



Desert Tortoise Project

Program Design

Draft Report

September 2002

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Project Abstract

The purpose of the research proposed in this document is to provide better science-based estimates of desert tortoise *populations, habitat, and threats* generally within the West Mojave Recovery Unit (WMRU), and specifically, within the context of the proposed Ft. Irwin National Training Center (NTC) expansion area. The advancement of desert tortoise science, by itself, will not achieve the goal of tortoise recovery in the Mojave Desert. Policy makers and managers will play a crucial role in that regard. As a result, we will consider *management and policy* implications in the development of our science based research activities. And finally, the *information science* component of the project is primarily intended to provide infrastructure and support for the desert tortoise science, management and policy support components. The following three key project research objectives have been identified:

- Facilitate better understanding and integration of desert *tortoise science* and its application to *population* estimates, *habitat* evaluation, and *threats* assessment;
- Enhance the integration of science with *management and policy*; and
- Through the use of *information science* technologies including knowledge management, data discovery, modeling and decision support tools, provide an integrated information infrastructure and support for the organization, dissemination, and synthesis of desert tortoise knowledge, information, and data to the scientific, management, and policy community.

In order to meet these objectives we have identified four research goals. It is through these goals that the above research objectives will be addressed. These goals will be used as milestones to assess project development and progress. The goals are as follows:

- Improve access to desert tortoise scientific information;
- Facilitate understanding of desert tortoise science: threats, population, and habitat;
- Evaluate new and emerging technologies for use in assessing the status of the desert tortoise; and
- Evaluate and develop tools and methods for knowledge management, knowledge discovery, modeling, and decision support.

The following activities have lead to the development of the research objectives and goals outlined in this document, and will be presented at our Army Research Office Annual Review Meeting, 10 September 2002:

- Project Development;
- Scientific and managerial community acceptance;
- Development of formal and informal ties with various organizations and agencies (i.e. NTC Department of Public Works, Mojave Desert Ecosystem Program, Desert Managers Group, United States Geological Survey, etc.);
- Completion of the Program Design;

- Stakeholder Needs Assessment; and
- Pilot program development (for the purposes of “proof of concept”).

In addition, we have implemented a standard adaptive management strategy/methodology for all levels of project development—from conceptual design to product development. The following methods will be applied iteratively as the project continues to evolve:

- Needs Assessment;
- Design Strategy;
- Implementation Strategy; and
- Evaluation.

This document is the first half of a Strategic Plan—the Program Design. As such, it outlines objectives and processes for which we can develop the second half of the Strategic Plan—the Implementation Strategy. The Program Design is structured to provide a contextual Introduction; Stakeholder Interview Summary, which provides a framework for supporting our research agenda; Research Goals for assessing project development and progress; Methods for current and future project development and refinement; and finally, Research Activities designed to meet research objectives and goals.

Most of the activities to be carried out by the DTP will require intensive involvement of key existing players among the desert tortoise stakeholder community. It is intended that this draft Program Design will be refined based on review and feedback from the community, including the identification of specific key partners from among them who will provide guidance, advice and direct assistance with respective components of the project. Once this has been established, DTP staff will work with those partners to establish the detailed institutional arrangements, timelines, milestones and products to be generated. This implementation strategy will then be combined with the Program Design to a final DTP Strategic Plan working document. The plan will be reviewed and progress formally evaluated with the key stakeholders every 6 months or more often as needed to ensure that the DTP project objectives and products continue to align with the interests and needs of the desert tortoise community, the NTC expansion efforts, and the desert tortoise recovery process.

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1. Introduction

The threatened status of the desert tortoise, *Gopherus agassizii*, is one of a number of major considerations in the proposed expansion of the National Training Center at Fort Irwin (NTC). The NTC and its proposed expansion area falls within the West Mojave Recovery Unit (WMRU), one of six such areas as designated by U.S. Fish and Wildlife Service (USFWS) in the *Desert Tortoises (Mojave Population) Recovery Plan* (1994), and within the context of the West Mojave Planning Area (WMPA), one of three regional planning areas within the California Desert Conservation Area (CDCA). In addition, approximately two-thirds of the expansion area falls within USFWS designated desert tortoise Critical Habitat. While the status, trends, and future viability of desert tortoises within the expansion area will carry considerable weight as the USFWS and the California Department of Fish and Game (CDFG) issue their Biological Opinions (BO) on expansions, these decisions must ultimately be based on the status, trends, and future viability of desert tortoises within the entire WMRU.

1.1 Background Information

1.1.1 Desert Tortoise

The desert tortoise was listed as a California state threatened species on 03 August 1989, and federally threatened on 02 April 1990. In the case of the federal listing, only the Mojave Population (an administrative designation for animals living north and west of the Colorado River) was listed as threatened. Critical Habitat was designated 08 February 1994, and the *Desert Tortoise (Mojave Population) Recovery Plan* (hereafter referred to as the *Recovery Plan*) was completed 28 June 1994. The Mojave Population was listed because numbers were declining precipitously in many areas due to deterioration and loss of habitat, collection for pets and other purposes, elevated levels of predation, loss of desert tortoises from disease, and the inadequacy of existing regulatory mechanisms to protect tortoises and their habitat (USFWS, 1990). Various activities can be attributed to the deterioration or loss of habitat, including urbanization, livestock grazing, motorized vehicle recreational activities, mining, agricultural development, and roads. In addition to upper respiratory tract disease (URTD), which was recognized by the recovery team as a potential cause of desert tortoise mortality and population declines, more recently discovered diseases (i.e. herpes virus and cutaneous dyskeratosis) have also been implicated.

The Mojave Population of the desert tortoise occurs primarily on flats and bajadas characterized by scattered shrubs and abundant inter-space supporting herbaceous plants, with soils ranging from sand to sandy-gravel. Desert tortoises are also found on rocky terrain and slopes, and there is significant geographic variation in the way desert tortoises use available resources (USFWS, 1994). Due to this and variation in genetics, morphology, behavior, ecology and habitat the *Recovery Plan* identified six recovery units or "ecologically significant units" (ESUs). Within each of these ESUs one to four Desert Wildlife Management Areas (DWMAs) were proposed, resulting in a total of 14. The idea to designate ESUs and manage via DWMAs was to increase the probability of

recovery and long-term sustainability of desert tortoises and their habitats across the entire listed range. The final designation of Critical Habitat by the USFWS was based upon these DWMA recommendations.

1.1.2 Fort Irwin

The National Training Center (NTC) at Fort Irwin, California, is the only Department of Defense (DoD) instrumented training area in the world suitable for force-on-force and live fire training of brigade-sized military forces. Over 75,000 soldiers a year travel to and train within the 642,000-acre NTC facility, making it one of the Army's busiest installations. Its mission is simple, provide a realistic combat training environment on a brigade-size level. In 1985 the Army concluded through a land use requirement study (LURS) that additional training lands were necessary to keep pace with technological advances in modern warfare and to continue to meet the NTC mission. This study identified a short fall of 238,000 net maneuverable acres (defined as areas with a 20% or less slope). As a result, expansion of the NTC was proposed in 1988. A preliminary draft environmental impact statement (EIS) was completed in 1989. Public input was obtained through numerous public scoping meetings and written public comments. Another LURS, prepared in 1993, reaffirmed the need for additional NTC training lands, as did an earlier 1990 General Accounting Office report. A final draft EIS was released in December 1996. The listing of the desert tortoise as threatened by the USFWS in 1990 was instrumental in shaping the process leading up to the 1996 final draft EIS and the final document itself.

Subsequent to the listing of the desert tortoise, the Lane Mountain milk-vetch (*Astragalus jaegerianus*) was federally listed as endangered in October 1998, and Congress passed legislation in December of 2000 calling for a joint Department of the Army (DA) and Department of the Interior (DOI) proposed plan for the expansion of the NTC. The plan, known as the *Key Elements Report*, was provided to Congress 12 January 2001. As directed by this same piece of legislation, the USFWS responded with a *Preliminary Review of the Key Elements* on 28 March 2001. The listing of the desert tortoise and the Lane Mountain milk-vetch, the subsequent Congressional legislation, and numerous other factors lead to the Army publishing a *Notice of Intent* (NOI) in the *Federal Register* in October 2001 to prepare a supplemental draft EIS for the proposed expansion. The supplemental draft EIS has allowed for additional public input via public scoping meetings and written comments. The National Defense Authorization Act Fiscal Year 2003, (signed 11 January 2002) authorized the Fort Irwin Military Lands Withdrawal Act of 2001. Presently, the SDEIS and desert tortoise Biological Assessment for the proposed NTC land expansion is being prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) and other relevant environmental legislation.

1.1.3 University of Redlands, Redlands Institute

The Redlands Institute for Environmental Design, Management and Policy is the largest research unit within the University of Redlands (UoR). Based in the Center for Environmental Studies, it coordinates and supports grant-funded projects related to a

broad range of multidisciplinary topics. Much of this work has focused on the development and environmental application of advanced geographic information systems (GIS) and related decision support technologies.

1.1.4 Outreach

In addition to the basic and applied research agenda of the DTP, the University of Redlands can also contribute a significant supporting role in facilitating communications, interdisciplinary collaboration, and data sharing among the desert tortoise community. This "outreach" function has several dimensions, as described below, both in direct support of the desert tortoise stakeholder community, and in promoting the academic value of the DTP within the University of Redlands. It is recognized that understanding the nature of the desert tortoise, and the implications of military training expansion and other human activities in the Mojave Desert ecosystem represents only one part of an effective recovery strategy. An active and focused dialog among all the stakeholders is important towards deriving common understandings and scientifically based consensus regarding a variety of issues, including the species and its biological characteristics and habitat requirements, the specific and cumulative impacts of human activities on the species and its supporting environs. This common understanding can provide a foundation for more synergistic and effective mitigation and recovery action planning and land management activities among all the involved government agencies, institutions, and other stakeholders. In addition, the DTP provides a parallel opportunity for enhancing the academic teaching and learning mission of the University of Redlands and the Redlands Institute, by integrating student and faculty participation in substantive and direct ways. The outreach functions that are integrated within the DTP program include the following:

- Enhance the University's undergraduate and graduate teaching mission through direct interaction with the DTP;
- Promote collaboration between desert tortoise scientists;
- Enhance student intern experience through direct involvement with real world scientific, management and policy related components of the DTP;
- Provide opportunities for University faculty research involvement; and
- Provide for technology transfer of methods, tools, and data where these can benefit the DoD and other stakeholders.

1.1.5 Major Desert Tortoise Stakeholders

While the focus of the present project is centered on the expansion of training activities at Ft. Irwin, this must ultimately be considered in the larger context of range wide desert tortoise recovery, particularly within the West Mojave Recovery Unit. However, for the sake of expediency and focus, an effort was made to consider those issues and stakeholders that are most closely related to the proposed NTC expansion and related issues, without losing sight of the bigger picture. In addition to the Department of Defense, there are a select number of other government, institutional, and private stakeholders that will be most affected. Some of the major parties, in addition to the

NTC and its associated Land Expansion Office, that will play a significant role include the following:

- Desert Managers Group;
- Mojave Desert Ecosystem Program;
- Bureau of Land Management;
- U.S. Fish and Wildlife Service;
- California Department of Fish and Game;
- U.S. Geological Survey;
- Desert Tortoise Preserve Committee; and
- Desert Tortoise Council.

This list is not exhaustive, but has been used as the starting point and focus for the University of Redlands in defining priorities for the Desert Tortoise Project and related interactions with the community of stakeholders that will provide critical input to this process.

1.2 Research Objectives

Desert tortoise recovery can only be achieved through the dynamic interplay of science, management, and policy. In order for this to happen, desert tortoise science must continue to advance, management must be adaptable (i.e. adaptive management), and policy development must be equally balanced between scientists, managers, and stakeholders. Desert tortoise recovery efforts have reached a critical threshold where scientists, managers, and policy makers recognize the need for better integration of scientific information and enhanced coordination. At this point, heavy demands have been placed on scientists and science organizations to compile, synthesize, and produce data for science-based solutions to recovery without crossing the line of policy and management recommendations.

The purpose of the research proposed in this document is to provide better science-based estimates, enhanced scientific clarity and consensus regarding desert tortoise populations, habitat, and threats within the West Mojave Recovery Unit (WMRU) and within the context of the proposed NTC expansion. Effective management for desert tortoise recovery is a complex challenge that requires the integration of many aspects of basic and applied environmental science, data inventory and assessment, planning, policy-making, environmental law, decision support, operations management, outreach, communications, education, monitoring, and adaptive management. Using an integrated team of environmental, information, and desert tortoise scientists, managers and GIS experts from within the Redlands Institute (RI) and stakeholder community we will seek to optimize methods and technologies for the collection, compilation, analysis, management, synthesis, visualization, and dissemination of desert tortoise-related information and data. The University of Redlands contribution will seek to further strengthen and enhance the significant efforts that have been carried out relative to the desert tortoise by a variety of important stakeholders for over two decades.

The three main objectives of the research proposed in this document are to:

- Facilitate better understanding and integration of desert *tortoise science* and its application to *population* estimates, *habitat* evaluation, and *threats* assessment;
- Enhance the integration of science with *management and policy*; and
- Through the use of *information science* technologies including knowledge management, data discovery, modeling and decision support tools, provide an integrated information infrastructure and support for the organization, dissemination, and synthesis of desert tortoise knowledge, information, and data to the scientific, management, and policy community.

The Redlands Institute Desert Tortoise Project (DTP) will benefit from existing RI infrastructure, expand on that infrastructure where appropriate, coordinate with other important Mojave Desert organizations such as the the Mojave Desert Ecosystem Program (MDEP), the Desert Managers Group (DMG), the NTC Department of Public Works, Environmental and the NTC Land Expansion Office, and consider our efforts in light of regional coordinated management plans, in particular the West Mojave Planning Area (WMPA). We will employ a variety of advanced technologies including GIS, remote sensing, knowledge management software, integrated environmental modeling, simulation and visualization software, spatial data analysis techniques and The Redlands Institute's own "Cross-Media Database (XMDB)TM" infrastructure. Methods, tools, and data generated through the DTP will, wherever appropriate, be made available to the desert tortoise stakeholder community, the NTC, the Civil Engineering Research Lab (CERL) and selected others for potential application to DoD needs, or the needs of other key entities.

2. Stakeholder Interview Summary

A series of stakeholder interviews were conducted with twenty-one state and federal agency scientists and managers, and interested scientists involved in desert tortoise research and management. Interviews focused on:

- Developing an understanding of the role and mandates of organizations and individuals with primary involvement in desert tortoise recovery efforts, and their interactions (Appendix A);
- Identifying the current and likely near-term activities of each organization/individual that might have some significance for, or could be supported by, the DTP biological, information science, and/or management and policy research activities;
- Identifying of past, ongoing and planned desert tortoise related scientific studies and data gathering activities; and
- Identifying of other data sources that might be used to support various aspects of the DTP.

The twenty-one interviewees, represented by twelve agencies and organizations, expressed forty-nine different suggestions that have been used as input to further frame and refine the basic DTP agenda. It is expected that the DTP will continue to work closely with these stakeholders throughout the project to refine and further evolve selected parts of the DTP program activities where appropriate.

Stakeholder suggestions varied from the specific (i.e. provide recommendations for placement of weather stations within the Mojave National Preserve), that would require very little project investment of time or resources, to the general or more complex (i.e. a Mojave-wide decision support system) that would require significant investment by the DTP and intensive interaction and input from the stakeholder community to implement in a comprehensive manner. Priorities, resource requirements, dependencies, timing issues and other factors are being considered in the development of the implementation strategy for the DTP program.

The following summarizes the suggestions articulated by the various individuals and provides a framework for the development of project objectives discussed in the Activities section. The reported stakeholder suggestions are listed and organized by the three main DTP objectives:

- Desert Tortoise Science;
- Information Science; and
- Management, Policy and Decision Support.

2.1 Desert Tortoise Science

A large number of stakeholder suggestions fell under the Desert Tortoise Science category. Suggestions were summarized and loosely divided between "habitat,"

"population," and "threats" subcategories. Suggestions were filed under just one category, though most can be logically applied to multiple categories.

2.1.1 Habitat

- Characterize threats to habitat
 - Grazing
 - Off-road vehicles (OHV)
 - Other human impacts
- Assess and quantify habitat degradation and loss (in the context of WMPA implementation evaluation)
- Assess the effects and impacts of the NTC Expansion on habitat

2.1.2 Population

- Conduct spatial data analysis of Line Distance Sampling (LDS) data
- Compare historic presence/absence surveys and other methods used to estimate densities within the context of LDS
- Collect data on juvenile tortoises and hatchlings in high-risk areas (e.g. water guzzlers)
- Compare desert tortoise densities with existing road networks
- Create new demographic models addressing age, size, sex, etc.
- Study the temporal variability of signs of disease in animals that have been tracked and monitored over long periods of time
- Study animal take in the context of the WMRU

2.1.3 Threats

- Compile and map prevalence, occurrence, and future projections of:
 - Disease
 - Ravens
 - OHVs
 - Human populations/development
 - Air pollution
 - Pesticides
- Map distribution of construction, development, and other projects requiring CDFG 2080 permits or USFWS Section 7 consultations
- Conduct comprehensive analysis of cumulative effects of threats on desert tortoise populations

2.2 Information Science

A larger majority of stakeholder suggestions fell within the Information Sciences category, thus underscoring a prevalent interest among stakeholders for increased data collection, sharing, and analysis. Requests were summarized and loosely divided into four categories.

2.2.1 Data compilation, archiving, access and retrieval

- Compile, archive, and inventory the following information in a central database for general access:
 - Scientific/research documents
 - Grey literature (i.e. papers of the Desert Tortoise Council Proceedings, military studies)
 - CDFG and USFWS research and construction permits and BO's
- Ensure the longevity of a central database by creating projects that will provide funding and maintenance for the existing infrastructure
- Assess data legacy issues
- Create geospatial data of studies and desert tortoise data

2.2.2 Collaboration

- Facilitate collaboration among the desert tortoise research community in the storing, sharing, and dissemination of data
- Assist in securing copies of studies on behalf of the military

2.2.3 Internet

- Assist in the design, development and deployment of a desert tortoise web site for public education and outreach in collaboration with the Desert Managers Group (DMG) and Desert Tortoise Management Oversight Group (MOG)

2.2.4 Field data collection, analysis and documentation

- Develop a standardized method to track, monitor, and display changes in the physical landscape
- Provide recommendations for placement of weather stations at the Mojave National Preserve
- Develop metadata standards for desert tortoise related scientific studies;
- Assist Ft. Irwin in data standardization, data collection, and system integration methods

2.3 Management, Policy, and Decision Support

A limited number of stakeholder suggestions relate to management, policy, and decision support. Though all of these suggestions could have been catalogued under Information Science, they were uniquely identified as being able to inform management and policy through decision support. Request were divided into Information needs, Implementation evaluation, and Decision support

2.3.1 Information needs

- Identify information gaps and define priority information needs
- Determine and coordinate priority efforts on a regional scale in the context of overall desert tortoise conservation activities
- Provide access to latest scientific information to be used to inform the CDFG and USFWS permitting process

2.3.2 Implementation evaluation

- Evaluate consultation, mitigation, and implementation actions
- Conduct management plan reviews
- Evaluate mitigation measures

2.3.3 Decision support system

- Use the desert tortoise as a conceptual model and pilot study for determining the feasibility of a Mojave-wide decision support system

3. Research Goals

GOAL 1. Improve access to desert tortoise scientific information.

The Mojave desert tortoise was first studied in detail by Woodbury and Hardy (1948), however, the majority of the existing data and related information was collected within the past 30 years, representing a large cumulative investment by agencies, institutions, and individuals. These data exist today in a wide variety of forms and media, and much of this information is not generally accessible, limiting the consensus building among scientists, policy makers, and managers. To date, there has been no systematic inventory, consistent descriptive cataloging, or comparative assessment of these data, outside of traditional annotated bibliographies. The DTP will work with biologists to 1) explore the development of a “metadata” standard that can be used to describe studies and the data generated from those studies; 2) document historic and current studies, and data according to the metadata standard; 3) assess the feasibility of extracting useful insights through data mining; and, 4) if feasible, carry out a systematic data mining exercise and demonstrate the results and benefits to current tortoise investigations.

The DTP recognizes that access to this data may be limited or even denied, much of this data may not be in digital format, metadata may be lacking, geographic coordinates may be inaccurate and imprecise, and data were collected using different methods and protocols. However, the development and comprehensive inventory, standardization, and documentation of this information in a consistent form using established metadata standards is the best way to determine whether there is cumulative or historical value that can be extracted from this existing information. The longer this information remains inaccessible and segregated the less valuable it becomes, as knowledge regarding its acquisition decays.

The resulting desert tortoise data, knowledge, and information will be integrated with the extensive geospatial database that has already been compiled by the MDEP through past and ongoing data sharing and resource management collaboration efforts. The RI has already developed an innovative environment for tracking and searching among a wide variety of information sources, called the “Cross-Media Database (XMDB)[™]”. The XMDB[™] stores metadata about a variety of information “resource” types, including GIS data, bibliographic data, media, people, organizations, events, web sites, imagery, models, and studies. The XMDB[™] framework will be used to catalog desert tortoise-related information throughout the timeframe of the project. The XMDB[™] is similar to an annotated bibliography, but with sophisticated storage, search, retrieval and relational capabilities.

Benefits to the NTC:

- The NTC and the Land Expansion office have expressed the need for greater access to desert tortoise studies and data primarily collected within their boundaries, or that they financially supported.

- Through greater access to data, data mining and other knowledge discovery methods and tools may be applied to derive value from NTC legacy desert tortoise information.
- The systematic and standardized cataloging required to affectively provide greater access to NTC studies and data may lead to discoveries that were not apparent from original studies or from individual studies alone.
- Within the larger framework of desert tortoise recovery efforts, access to data outside of the context of the NTC will only enhance the quality and value of NTC specific data, especially through exploratory search and discovery.

GOAL 2. Facilitate understanding of desert tortoise science: threats, population, and habitat.

The current wealth of desert tortoise data and information can be overwhelming in its magnitude and obscured by its general inaccessibility, leaving land managers and policy-makers handicapped in their decision-making processes. In this complex mosaic of desert tortoise recovery activities, managers typically have access to a few pieces of information, such as a selection of published papers or agency reports. In order to successfully manage for recovery, land managers must overcome scientific information gaps, incorporate new scientific findings and understand their implications for management. The advancement of science for science sake, will not achieve the goal of desert tortoise recovery in the Mojave.

The DTP will address these issues by applying a variety of integrative techniques and technologies to facilitate the compilation, analysis, synthesis and visualization of complex information surrounding the desert tortoise. Beyond providing tools for access, as outlined in Goal 1, we will strive to develop an interactive environment allowing for advanced search and discovery. Since MDEP already possesses significant tools and resources for information search and discovery, further discussion is needed to assess appropriate protocols and procedures for information sharing. This process will require close collaboration with scientists to develop the necessary confidence and trust to archive, share, and disseminate their data and publications.

Results and findings derived from the analyses and syntheses will be translated into visually compelling and comprehensible products. Using the existing RI infrastructure of data management and analysis tools, the DTP will develop new tools for communicating issues and alternatives in informative, graphically compelling, and understandable forms that can be readily provided to both technical and non-technical audiences, including: public representatives and policy makers, community decision-makers, scientists, government and non-government organizations, commercial interests, private landowners, and the general public.

Benefits to the NTC :

- The greatest short term benefit to enhanced understanding of desert tortoise populations, habitat, threats, and their interactions is in the development of a science-based framework to evaluate NTC desert tortoise recovery, conservation, management and mitigation efforts in the context of the WMRU.
- In the long term, opportunities to develop or expand military activities in the Mojave may depend upon scientific demonstrations of the viability of various desert tortoise populations. Given the 20 to 25-year generation times of the desert tortoise, de-listing will require many years of study, and the integration of these studies across space and time.

GOAL 3. Evaluate new and emerging technologies for use in assessing the status of the desert tortoise.

The world of technology is continually changing, with advances being made at an unprecedented rate. The DTP recognizes two categories of emerging and advancing technologies: field data collection systems and data management systems. The first will be addressed in the context of Line Distance Sampling (LDS), and will involve the evaluation of broad and diverse types of “technologies” such as alternative methods for data collection, remote sensors, and even dogs for locating tortoises. Remote sensors may include satellite and airborne sensors, radio-telemetry and bio-sensors for field data collection and assessment. The utility of these devices will vary between the sub-research activities of desert tortoise threats, population, and habitat.

The second category includes the tools and technologies for managing data and conducting analysis. This large and broadly defined category includes tools to deal with our understanding of data, information, and knowledge. Examples include GIS, knowledge bases, and discipline-specific metadata standards. Advanced data, knowledge and information management tools and technologies will enhance the ability of scientists, managers, and policy makers to integrate, synthesize, manage, analyze, and visualize complex information regarding desert tortoise population, habitat, and threats; and finally provide them with the ability to effectively consider the science in the context of management and policy.

Benefits to the NTC :

- As evidenced from their LDS monetary support, the NTC obviously values the need for determining range wide estimates of desert tortoise population status. Any activity designed to improve and/or enhance the value of LDS data directly benefits the NTC by further leveraging or “matching” their monetary contributions.
- The Fort Irwin Military Lands Withdrawal Act of 2001 explicitly states that the “...Army shall prepare, in consultation with the Secretary of the Interior, an environmental baseline survey, characterizing the environmental conditions, at the

time of the withdrawal, of the lands withdrawn and reserved..." The use of satellite and airborne remote sensors, radio-telemetry and bio-sensors will help the Army and the NTC to meet this mandate, at least with respect to desert tortoise habitat, populations and threats.

- If the Army proposes to consider translocation as a mitigation tool to offset expansion, advanced telemetry and bio-sensors will be essential for monitoring translocated tortoises.

GOAL 4. Evaluate and develop tools and methods for knowledge management, knowledge discovery, modeling, and decision support.

Emerging concepts within the information science discipline are yielding approaches and tools that may have significant implications for science, management and policy issues in general, and consideration of the NTC expansion proposal specifically. Knowledge management (KM) has been described as "The systematic process of finding, selecting, organizing, distilling, and presenting information in a way that improves comprehension in a specific area of interest" (KM Answers, 1998). KM provides methods and tools for codifying scientific and other "knowledge" in ways that were not previously possible. Likewise, the emergence of knowledge discovery (also called "data mining") approaches provide methods for processing historical information to glean new insights. Contemporary simulation modeling tools can support the habitat, threats and population analyses that are proposed within the DTP research agenda. A related branch of information science collectively called "decision support" provides tools to analyze the implications of various decision scenarios and priorities. While each of these fields is advancing rapidly on its own, there is simultaneously a growing convergence of principles and integrated information architectures that support the treatment of all these issues within an integrative environment.

While many of the fields listed above are becoming well established in business, engineering and other disciplines, the application of these methods and tools to capture and manage environmental science knowledge and consider the impacts of policy and management actions is still in its infancy. Knowledge is supported by data and scientific exploration and provides the foundation that is needed to inform decision-making processes. Thus KM is an important part of decision support systems (DSS). Tortoise-related "knowledge" exists in scientific reports, models, databases, manual files, and in the heads of scientists, managers, policymakers, and other stakeholders. Building on the work of the Mojave Desert Ecosystem Program (MDEP) and the Jones and Stokes (1999) DSS study, the DTP, working with desert tortoise scientist and managers, will explore the application of existing KM and related methods and tools to the desert tortoise issue. The purpose of this component is to determine how effectively these tools can be used to capture, describe, and qualify what is known, levels of certainty, consensus, divergence or convergence, and what is recognized as knowledge gaps regarding Mojave desert tortoise populations.

Based on this research, the DTP will lay the groundwork for developing a model of what is known about desert tortoise populations, habitat, and threats as a contextual framework for understanding what is known about the desert tortoise, and as the basis for selected modeling and simulation efforts. This process will include the development of a desert tortoise knowledge management system that would involve the application of a selected knowledge management toolset or combination of toolsets to represent a portion of the conceptual tortoise knowledgebase and demonstrate associated analytical, visualization, data access and knowledge building collaborative tools. These modeling efforts will be integrated with the results of research on policy and management issues for the purpose of developing decision support systems that can be productively used by members of the desert tortoise science, management, and policy community.

Benefits to the NTC:

- Advanced knowledge management and integrated spatial analysis techniques, simulation and visualization methods and tools will enhance the understanding of the tortoise situation in the context of military sustainability and other desert management concerns in general, and the NTC expansion proposal specifically.
- Research findings and supporting evidence can be used to evaluate tortoise-related issues arising in military operations, planning and development. This is likely to improve opportunities for consensus building among NTC expansion stakeholders and, even in the absence of consensus, enhance the ability of informed participants to become more effective in bringing science to bear within an atmosphere historically plagued by fragmented information and political controversy.
- The development of decision support systems will assist NTC expansion stakeholders and other desert managers and policy makers in their decision making processes by integrating knowledge of desert tortoise science, policy, and management in ways that are easily understood and fully adaptable for use in "if-then" assessments.

4. Methods

A structured, incrementally refined approach is being used for the implementation of the DTP. The initial program that was defined prior to project initiation is being confirmed and refined against more detailed interaction and input from the desert tortoise stakeholder community. The process of developing a more detailed understanding of the most important issues surrounding desert tortoise science, management, policy, and recovery relative to the NTC expansion and surrounding contextual issues is outlined below.

4.1 Stakeholder Assessment

A series of stakeholder interviews was conducted with state and federal agency scientists and managers, and interested scientists involved in desert tortoise research or management activities. Interviews focused on identifying the current and likely near-term activities of each organization that could be supported by the DTP environmental and information science research activities. The interview process included the following general steps:

- Conduct review of background information (Appendix A);
- Prepare questionnaire (Appendix B);
- Conduct interviews; and
- Synthesize information.

4.1.1 Conduct Review of Background Information

In this first activity, the DTP conducted a systematic review of relevant background information concerning the biology of the desert tortoise, its environmental context, and the nature and extent of land use and landscape change in the Mojave Desert. The main purpose of this investigation was to provide the DTP team members with background and understanding of the primary issues surrounding the desert tortoise, prior to their participation in the interview task described next. This general background review relied heavily on synthesized material from a variety of sources including the NTC Land Expansion Office, the Desert Managers Group (DMG), the *Recovery Plan*, and numerous scientific papers.

As part of this task, and in consultation with several key advisors, the DTP Team compiled a list of the primary stakeholders involved in the tortoise issue in the Mojave. This list served as the foundation for identifying what groups or individuals should be included in the interview task that followed.

4.1.2 Prepare Questionnaire

In preparation for the interviews, a questionnaire was developed that focused on the identification of organization interests and information needs related to the desert tortoise. The questionnaire was used as a tool for soliciting information on desert tortoise

programs and activities within each organization; and most importantly the types of information required to support such programs and activities. In preparation for the interviews, existing printed and electronically disseminated information on each organization or individual was reviewed. This background information provided context for agency mandates and individuals' interest, as well as initiating dialog. Examples of the types of materials collected were:

- Organizational charts and descriptions of departmental mandates and duties;
- Annual reports;
- Newsletters; and
- Related reports or other background material.

4.1.3 Conduct Interviews with Key Stakeholders

The next task involved conducting interviews with primary stakeholders involved in the desert tortoise issue in the Mojave. In April 2002, DTP staff began conducting interviews. Information from the interviews was compiled in a standard format and provided back to interviewees for review. The interview process was finalized at the end of July 2002.

The purpose of the interviews was to gain a familiarity with the range of agencies, institutions, scientists, and non-government organizations who have been most involved in the tortoise issue, the scope of their involvement, responsibilities and interests, tortoise-related activities, information resources used or generated, and decision-making processes. The interview process and background information gathering process were designed to address the following information needs:

- Agency mandates and activities;
- Data specifics;
- Information produced;
- Additional data and information needs;
- Current technology;
- Interaction with other agencies;
- Special concerns and issues; and
- Redlands Institute involvement.

Other topics and issues were explored based on the specific situation of each interview. Interview summaries were documented and returned to the interviewees for review and confirmation. Information collected during the interviews was then compiled and synthesized to be used as input in the development of this Program Design.

4.1.4 Synthesis

Interviews were documented in narrative write-ups intended to capture organization administrative context, identify and describe programs and activities, and articulate the

opportunities and constraints to collaboration from the perspective of each interviewee. The initial write-ups were provided to interviewees for review.

Interviews were collectively compiled and synthesized for further analysis. Products developed included a series of matrices summarizing the interviewee requests and how they fit into the overall DTP project goals and related activities. Data needs and gaps are identified and discussed in more detail in the data inventory and evaluation section of this document.

4.2 Conduct Data Inventory

As part of the interview process, an inventory of the most important tortoise-related data stores used or generated by the stakeholders is being compiled for use in the "Data Inventory/Metadata" research component described later. At this stage, basic background information about each relevant data store is being recorded, and where possible samples of the actual data have been collected. This list is being compiled into a digital database to be used as the starting point for a more intensive data inventory and metadata compilation effort to be addressed later.

4.3 Needs Assessment and Requirements Analysis

The information collected in the previous tasks has been used as input to the refinement of the DTP research agenda. This has involved synthesizing the information and opinions expressed in the previous tasks to a structured outline of tortoise-related issues, opportunities and challenges that can realistically be addressed within the context of the DTP. As expected there are both areas of consensus, as well as widely differing views and opinions regarding what is known and not known about tortoise biology and behavior, habitat requirements, the present status of the desert tortoise, population estimating techniques, location and characterization of threats, impacts, and influences, trends and indicators, management impact mitigation options, and other issues. This requirements analysis has not attempted to fully substantiate or resolve any of these issues, but has sought rather to identify the range of issues, information gaps, confluence or differences of opinion, and other topics in a manner that could help to focus the DTP research program design.

4.4 Strategic Planning

The results of the requirements analysis have been used in the development of the present Program Design. This draft is to be circulated to a selected number of reviewers and advisors who will be expected to provide additional critical feedback and guidance. Some issues are better defined than others, thus the characterization of these and the development of a specific program for addressing them are more developed. Other issues will require significant additional study. In all cases, it is expected that the DTP will need to work closely with domain experts within the desert tortoise community to further define and address the identified issues.

Once the primary elements of the Program Design have been confirmed and/or refined, a strategy for their implementation will be developed. The combination of the refined program design and the implementation strategy will comprise the Strategic Plan for the DTP, and will serve as a roadmap for the next stage of project development.

4.5 Evaluation and Adaptive Management

It is expected that as the next stage of project development is undertaken, new insights and priorities will necessitate periodic course adjustments and refinement to the DTP program design and implementation strategy. An effort will be undertaken every 6 months to assess the current status of the project and to determine the need for such adjustments. This will be carried out in close cooperation with the project reviewers and advisors.

5. Research Activities

The following section is divided into three parts: Desert Tortoise Science, Information Science, and Management and Policy. These three sections exactly mirror the three overarching DTP research objectives as outlined in the Introduction. Each section is further divided into topical areas, each with their own series of related activities, sub-activities, and future tasks. It is expected that selected "domain experts" from the desert tortoise community will be integrated directly into each component of this process both to leverage existing expertise and to ensure that the program process yields results that will be directly useful in addressing desert tortoise issues in general, and specific to the NTC.

5.1 Desert Tortoise Science

The classic model suggests that if science, policy, and/or management actions are to influence desert tortoise recovery then their influence must be registered through a change in reproduction, immigration, emigration, and/or mortality. This classic model of *population* dynamics provides a framework for population change, but carries little information about why populations change (Williams *et al.*, 2002). Change is affected by abiotic, biotic and/or human mitigated factors. Abiotic factors include physical and chemical components of an animals environment such as temperature, soil and vegetation type, precipitation, and natural disturbance regimes (e.g. flood and fire), and are typical considerations when describing *habitat*. Biotic factors are explained in terms of natural interspecific and intraspecific species competition, though natural interspecific competition is not likely to be a significant factor for the desert tortoise. Human mitigated changes typically manifest themselves in the form of *threats*, rarely affecting a positive change in population dynamics except possibly in the case of invasive and/or opportunistic species. Because desert tortoise recovery is influenced simultaneously by population dynamics, abiotic (i.e. habitat), biotic and human mitigated threats, there may be limited value in trying to ascertain which is most relevant. Instead, a holistic approach balancing the interactions and effects of habitat and threats on population dynamics is warranted, and our primary biological research mission.

5.1.1 Population

The desert tortoise is one of four North American tortoises in the Testudinidae family (i.e. terrestrial turtles). Desert tortoises can trace their ancestry back 65 million years. The desert tortoise as we know it today, has been present in the southwest since the late Pleistocene (Bramble, 1973; Van Devender, 1986). With an average life span of 50 to 70 years and delayed reproduction (between 12 to 20 years) (Grover and DeFalco, 1995), desert tortoises are "K-strategists," (MacArthur and Wilson, 1967). Most of their adult life is spent underground in burrows reaching depths of up to 10 meters. Adults will typically use 7 to 12 burrows at any given time, though some are used for very short periods of time and are replaced frequently (Boarman, 2002b). Desert tortoises emerge from their burrows during the spring and late fall, and sometimes after summer storms (USFWS, 1994).

Desert tortoises are iteroparous, reproducing many times throughout their life time. Females can lay multiple clutches (1-3) per year, and approximately 4-6 eggs per clutch. Eggs are laid primarily in the spring activity season, and are environmentally incubated in the sub-terrain burrows until neonates hatch in late summer and fall (Boarman, 2002b). Hatchlings and juveniles have different environmental requirements than adults, and can remain active during their first winter season (Wilson et al., 1999). Juvenile survivorship is low, estimated to be only 1-2%, for pre-reproductive adults (USFWS, 1994). In contrast, adult survivorship is very high, though human induced threats have likely increased normal adult mortality rates (Boarman, 2002b).

5.1.1.1 Research Objectives

Our primary population research objectives are:

- Assist range wide population monitoring efforts; and
- Assess population parameters in the context of habitat and threats.

5.1.1.2 Activities

1. Population Monitoring: Line Distance Sampling (LDS) Support.

The 1994 *Desert Tortoise (Mojave Population) Recovery Plan* outlines numerous recovery objectives, strategies, and actions as well as de-listing criteria for the desert tortoise. As a result of directives outlined in the *Recovery Plan* and decisions ultimately made by the Desert Tortoise Management Oversight Group, Line Distance Sampling (LDS) was chosen as the method for determining range wide population status. This multi-year coordinated effort was initiated in 2001, under the direction of the U.S. Fish and Wildlife Service (USFWS) Desert Tortoise Recovery Coordinator. Surveys were conducted in 2001 and 2002, and are to be conducted consistently over the next several decades until sufficient baseline data are established to determine population status (i.e. increase, decrease, or stabilization). Distance sampling software is used to estimate tortoise densities on an individual Desert Wildlife Management Area (DWMA) basis. Scientists from the U.S. Geological Survey (USGS) are conducting the statistical analyses, in collaboration with the USFWS Desert Tortoise Coordinator. In addition, the Mojave Desert Ecosystem Program (MDEP) provides data management and data storage support.

Current Sub-Activities and Status

- *LDS Data Collection Methodology.* In cooperation with the MDEP, USGS, and the USFWS, the DTP worked to develop a database and electronic field data collection system for the 2002 LDS field season. As part of this effort, the DTP team supplied personnel to assist with logistics, training data analysis, and field crew support in the use of the new data collection system. This database and data collection system will be further refined, customized, and integrated into a GIS.
- *LDS Statistical Data Analysis.* Line distance sampling data analysis to date has focused on density estimates alone. This analysis can be done independent of

geographic coordinates, and thus does not include any spatial data analysis. The USFWS, USGS, and MDEP have all expressed the need for spatial data analysis of the LDS data. Using leading industry GIS technologies we have begun to look at the distribution of sample transects and tortoise observations in relationship to geographic and topographic variables (i.e. geomorphology, vegetation, elevation, slope and aspect).

- *LDS Monetary Support.* In sample year 2002, the DTP supported USFWS LDS efforts by contributing \$50,000. This contribution made up almost 10% of the total amount spent on LDS for the year 2002 and allowed USFWS to obtain valuable data from a DWMA that would have otherwise gone unsampled. If this DWMA had gone unsampled it would have devalued the 2001 data from that area and the range wide data, as well as the entire 2001 and 2002 data set as the methodology is intended to provide range wide estimates of tortoise densities.

Future Tasks

- Hire a qualified individual to conduct field studies to determine desert tortoise activity budgets and oversee the G_0 modeling efforts
- Develop an innovative, cost effective, and statistically predictable model of desert tortoise activity budgets
- Integrate the model into the G_0 LDS parameter

2. Evaluation of historical population estimates and methodologies in context of LDS estimates and data.

The DTP will compile and assess past and current desert tortoise population estimation methodologies and data in the context of LDS. The intent is to derive value from this legacy data in support of the continued use of LDS methodologies.

Current Sub-Activities and Status

- Sub-Activity not yet initiated.

Future Tasks

- Compile information regarding past tortoise population estimates
- Investigate and assess the usefulness desert tortoise legacy data in light of LDS estimates

5.1.2 Habitat

Regardless of geography, desert tortoise habitat must include sufficient suitable plants for forage and cover, and suitable substrate for nest sites and burrows (USFWS, 1994), or adequate burrow/cover sites from natural rock crevices and/or caliche caves. However, within the various geographic regions of its range, there is significant variation in available resources and how desert tortoises use these resources (USFWS, 1994).

The Western Mojave is the largest, most varied, and heterogeneous of all the recovery units. Desert tortoises within the West Mojave Recovery Unit (WMRU) must contend with a regime dominated by fall and winter precipitation. Above ground activity occurs primarily in the spring in order to take full advantage of winter annual production. Summer activity is primarily dependant upon rare summer rainfall events. Within the WMRU desert tortoises occur primarily on flats, valleys, bajadas, and rolling hills in saltbush, creosote bush, and scrub steppe communities, generally from 600-1,000m in elevation, only occasionally found above 1,250m (USFWS, 1994; Weinstein, 1989; Watts, 1996). They prefer surfaces covered with sand and fine gravel, typically avoiding coarse gravel, pebbles and desert pavement, playa's, sand dunes, plateaus, steep slopes (>20%), and areas with many obstacles to free movement (Weinstein, 1989; Boarman 2002b). Soil friability is important for nest site and burrow construction, however all things being equal, productivity of plants is more important (Wilson and Stager, 1992).

5.1.2.1 Research Objectives

Our primary habitat research objectives are:

- Improve upon existing desert tortoise habitat models;
- Expand the context of habitat to include the results of independent estimates of population parameters and threats modeling; and
- Compare spatial habitat modeling results to population and threats modeling and analyze results.

5.1.2.2 Activities

1. Habitat Assessment.

Attempts to quantify and model desert tortoise habitat have been problematic. GATF (1996) had only marginal success modeling desert tortoise habitat along the southern boundary of the NTC, including lands within the proposed expansion area. In short, their model showed that desert tortoises prefer creosote bush scrub vegetation on soils derived from granitic or granitite conglomerate parent materials, and avoid steep rocky areas, or calcareous soils with cemented layers. Desert tortoise preference was inferred from abundance estimates.

Weinstein et al. (1987) and Weinstein (1989) attempted to quantify the relationship between desert tortoise abundance (estimated using total corrected sign [TCS] counts) and habitat characteristics. Simple correlation, multiple regression, and discriminant analysis (DA) identified various combinations of the following characteristics as important indicators of habitat: elevation, winter rainfall, longitude, vegetation composition, diversity and cover, soil particle size, micro topographic variability, food availability, soil friability, longitude and degree of stream-washing. Though the various statistical methods used did not contradict each other, variable outcomes and the inconsistent DA cross-validation results reiterates the complexity and difficulty of characterizing desert tortoise habitat.

Current Sub-Activities and Status

- Compile information regarding past tortoise habitat modeling efforts

Future Tasks

- Investigate and assess the usefulness of desert tortoise legacy data for habitat analysis
- Characterize previous model inputs for cross-comparison
- Prepare habitat analysis typology

2. Habitat Modeling.

Through the application of spatial and temporal GIS data analysis techniques to legacy, and new and emerging desert tortoise data, we will investigate the potential for improving existing habitat models, as well as develop our own, for use in such activities as LDS, translocation, recovery and restoration. Though unknown at the onset, these models and methods will most likely utilize information science tools developed for managing knowledge, data and decisions.

Current Sub-Activities and Status

- Sub-Activity not yet initiated

Future Tasks

- Define scope and modeling process
- Conduct habitat analysis pilot
- Conduct workshop with key domain experts and use results to generate best practice model

3. Habitat Model Validation.

Certain events or activities, such as an increase in susceptibility to disease or in raven densities, can cause desert tortoise populations to follow trajectories quite different from those of their habitat. As a result, modeling desert tortoise habitat cannot be based solely upon desert tortoise abundance, as abundance is dependent on more than just quality, size and shape of habitat. In addition, human mitigated threats, as well as demographic and environmental stochasticity can contribute to population densities being substantially more complex than simply based upon habitat quality alone, especially in fringe or harsh environments such as the Mojave Desert. While habitat is essential to the survival of all species, by itself it does not guarantee the long-term fitness and viability of populations (Morrison et al., 1998).

Current Sub-Activities and Status

- Sub-Activity not yet initiated

Future Tasks

- Integrate habitat modeling results with evaluations and assessments of desert tortoise population and threats status

5.1.3 Threats Assessment

The need for an assessment of the geographic extent, cumulative effects, and synergistic properties of threats to the desert tortoise and tortoise habitat has been identified in a number of forums. The idea and justification for a threats assessment is based upon:

- Recommendations from the RI Pre-MOG meeting (30 October 2001);
- Formal and informal conversations with tortoise biologists and land managers;
- *Desert Tortoise (Mojave Population) Recovery Plan* (1994);
- Desert Tortoise Management Oversight Group Technical Advisory Committee *Recommended Priorities for Future Desert Tortoise Research* (March 1997 and reviewed April 1998);
- Ft. Irwin Tortoise "blue ribbon" Panel recommendations released 15 March 2000 (based upon meetings held 18-19 January and 18 February 2000);
- *Recommendations and Technical Specifications for a Decision Support System for the Mojave Desert Ecosystem* (Jones and Stokes Associates, Inc., 1999).
- *Threats to the Desert Tortoise: A Critical Review of the "Scientific" Literature* (Boarman, 2002a).

The RI DTP meeting, held 30 October 2001, was the first recorded instance of the term "threats map" in the context of a DTP product. Justification for such a product is strongest within the *Recovery Plan* and the *Recommended Priorities for Future Desert Tortoise Research*.

There are a great many threats facing the desert tortoise present and future, not to mention the cumulative effects of threats past. Because of the long-lived nature of the desert tortoise 1) numerous threats may not manifest themselves until many years post their temporal footprint, 2) affected animals/areas may fall outside of the spatial footprint of the threat, and/or 3) cumulative or ripple effects are likely to occur. In addition, manifestation of these various threats 1) are likely to propagate differentially across the landscape, 2) may be dependent on landscape initial condition and its changes through time, and 3) are likely to change under different threat combinations.

5.1.3.1 Research Objectives

The purpose of the research outlined is to evaluate the effects of spatial and temporal threats on the Mojave Desert ecosystem and the long-term sustainability of the desert tortoise. The following research objectives will be addressed:

- Identify the possible spatial and temporal threats to the desert tortoise;
- Develop ways to describe and characterize threats and threat interactions (i.e. threat typology);
- Develop and evaluate methods for predicting threats spatial interactions and propagation over time;
- Develop and evaluate innovative methods for the visualization and display of individual and interactive spatial and temporal threats; and

- Apply these methods of prediction, visualization, and display to assess the geographic extent, cumulative effects, and synergistic properties of spatial and temporal threats.

5.1.3.2 Activities

The activity and sub-activities are presented below.

1. Identify known and possible spatial and temporal threats to the desert tortoise.

A variety of spatial and temporal threats to the desert tortoise have been identified and assessed through a review of targeted scientific literature, gray literature, management documents, and stakeholder interviews. Initial documents selected for review include Boarman (2002a), U.S. Fish and Wildlife Service (1994), Lovich and Bainbridge (1999), the BLM California Desert District Bioregional Plans, in particular the WMRU, and Chambers (1990).

Current Sub-Activities and Status

- Identified known and possible threats, and begun to investigate their spatial and temporal components.

Future Tasks

- Identify and convene science team for threats assessment
- Conduct Threats Workshop to confirm and/or refine the identification and characterization of known and possible threats

2. Prepare threats analysis typology.

This sub-activity will involve the development of a method to describe and characterize desert tortoise threats and threat interactions (i.e. threat typology). There are numerous ways to categorize/characterize threats, including spatial distribution, frequency, return interval, rotation period, predictability, intensity, severity, impacts, and synergism. They can also be characterized based upon the prevailing social and political climate, such as ease of mitigation or controversy. Based upon existing scientific evidence and the best available scientific opinion on the possible consequences of various threats to the desert tortoise and its habitat, the DTP will develop a threats typology. Products will highlight dependencies and relations between threats and associated effects (direct and indirect) and will serve as a starting point for visualizing threat interactions. The DTP team will also consider the logical and hierarchical structure of threats and its potential application to a threats knowledgebase and modeling implications.

Current Sub-Activities and Status

- Initiated dialogue with the desert tortoise Management Oversight Group/Technical Advisory Committee (MOG/TAC) with regards to threat typology
- Begun development of a threat typology with selected MOG/TAC members

Future Tasks

- Present draft threat typology to the MOG/TAC
- Finalize threat typology

3. Develop and evaluate methods for predicting threat spatial interaction and propagation over time.

Individual threats are often easy to identify and assess (Chambers, 1990), but when threats accumulate and synergies develop over both space and time, assignment of cause and effect, as well as cumulative effects become problematic and predictions or forecasts are difficult. The effects of threats are routinely studied singularly and in situ, without a thorough understanding of local variability in tortoise health, demography and secondary threats.

Current Sub-Activities and Status

- Sub-Activity not yet initiated

Future Tasks

- Study spatial and temporal threat patterns in relationship to existing and newly generated data on tortoise health, habitat, and density
- Extrapolate and predict threat spatial influence, proximity and synergies
- Predict threat cumulative effects and propagation over time

4. Conduct Threats Mapping Pilot .

Geospatial and temporal data management, analysis, and visualization, tools, techniques, and applications, and other relevant information technologies will be used to develop models to map and identify threat footprints, spatial influences, synergies, cumulative effects and propagation over time. These methods of prediction, visualization, and display will be used to assess the geographic extent, cumulative effects, and synergistic properties of spatial and temporal threats. Product development will focus on the areas within the NTC, NTC Land Expansions area, and the Fremont-Kramer and Superior-Cronese DWMA's.

Current Sub-Activities and Status

- Sub-Activity not yet initiated

Future Task

- Assess threat factors and alternative methods for data analysis and visualization
- Implement alternative methods in pilot form for review and assessment
- Assess pilot results with domain experts

5.1.4 Synthesis of Habitat, Population, and Threats

Understanding population parameters are important for understanding and predicting population dynamics, effective population management, and de-listing. However, population dynamics cannot be explained by natural population parameters alone. Desert tortoise recovery must consider population dynamics in the context of habitat and threats.

If after 20 years the results of LDS suggest a decline in desert tortoise populations, then there must be scientifically based explanations for the declines that can be used to effectively inform management and policy decisions.

Within the *Recovery Plan*, scientifically based theories are proposed for how the desert tortoise, or any population for that matter, might become extinct: demographic stochasticity, social dysfunction, extrinsic forces, and genetic deterioration. The DTP is primarily interested in extrinsic forces. Extrinsic forces generally occur when there exist temporal variation and/or spatial disruption of abiotic, habitat, or biotic conditions by natural or anthropogenic activities (i.e. threats) for which populations cannot contend. Extrinsic forces are probably the most important of the four “conditions for extinction” for which desert tortoise must contend (USFWS, 1994).

5.1.4.1 Research Objective

The purpose of this activity is to assess the current state of desert tortoise population science in the context of threats and habitat. Of particular significance will be the spatial and temporal effects on population posed by various habitat and/or threat scenarios. With the use of information science knowledge discovery tools outlined in later sections of this document, we will have the opportunity to capture, describe, and qualify what is known, levels of certainty, consensus, divergence or convergence, and what is recognized as knowledge gaps regarding desert tortoise population biology, habitat and threats.

5.1.4.2 Activities

Current Sub-Activities and Status

- Begun compiling and cross-walking interdependencies of desert tortoise population biology, threats and habitat knowledge, information and data
- Initiated methods for linking habitat, threats and population parameters

Future Tasks

- Conduct comparison analysis pilot
- Assess pilot results with domain experts

5.2 Information Science

The information science effort within this project is primarily intended to provide an infrastructure of data and state-of-the-art tools and methods to support the biological science, management, and policy support components of the program. Many of the following activities cross over extensively with other project components as a result. But, in addition to being a support element for the project, many information science activities contain research opportunities as well, the results of which are expected to provide useful products and ideas that can benefit the NTC, MDEP, CERL and other stakeholders.

The main focus of our information science research agenda will be:

- The collection, organization, cataloging, integration, analysis, and synthesis of desert tortoise knowledge, information, and data to support tortoise recovery. Where appropriate, this information will be made available to the broader stakeholder community through a cooperative arrangement with the MDEP;
- The application and testing of specific Customizable Off-The-Shelf (COTS) tools for integrated knowledge management, knowledge discovery, modeling, and policy/management decision support; and
- The development and presentation of innovative techniques for data and analysis visualization.

A variety of methods and tools will be evaluated and developed for use within the desert tortoise community to provide support for decisions and research at many levels. While the potential audience for such tools can extend to a broad range of scientific, policy and resource management issues, we will direct our efforts to focus on tortoise-related decisions and research in the context of the NTC proposed expansion.

While there exists many significant research opportunities within the information science agenda, these efforts are intended to produce useful tools that relate directly to the NTC expansion efforts and other related stakeholder issues. Usefulness for internal project support and the project stakeholder community (rather than a more research or innovation-oriented objective) will be a primary measure of success in this effort. As such, where possible, we intend to conduct pilot-level projects and involve stakeholders in the design and implementation of project requirements.

Significant efforts have already been conducted to develop Mojave-wide information infrastructure to support Mojave Desert management and science. We will look to these organizations as valuable partners for information sharing, project planning and feedback. Key information collaborators will include, most significantly, the MDEP, but also the NTC, other public agencies, and scientific sources.

The DTP will develop a system called SPINE to provide more effective access to scientific information concerning the desert tortoise for the NTC specifically, and the entire research community secondarily. The SPINE program will provide the backbone or "spine" for a system to compile, manage, and access scientific information via a customized database and easy to use software interface. The RI has developed a "Cross-Media Database (XMDB)[™]" concept and technical database and software interface architecture that will be used as the development environment for SPINE. This architecture incorporates and integrates the information metadata standards from a variety of international standards bodies, including FGDC/OGC/ISO (geospatial data), Dublin Core (Multi-Media), and MARC (Library Science). This architecture allows a collection of information resources to be cataloged and related within an integrated database environment that can be functionally linked to GIS and other components of a comprehensive data management and research support environment. Information resources that may be cataloged and managed within the XMDB[™] can include scientific

investigations, tabular and statistical databases, photographs, GIS data, multi-media, websites, people, organizations, events and other types. The XMDB™ concept allows all these resources to be linked and searched in an integrated information exploration environment.

In addition to the XMDB™, the DTP team will apply the Ecosystem Management Decision Support (EMDS™) v3.0 system to develop and demonstrate a common platform for integrated knowledge management, modeling and decision support. EMDS™ has been built as an integrated application environment that includes the NetWeaver knowledge management system, the ArcGIS geographic information system, and Criterium Decision Plus™ decision analysis system. EMDS™ has been structured to accommodate the integration of these data management and analysis systems in an integrated and complementary fashion that may provide significant benefit to the DTP project and its stakeholders.

Unlike previous information projects for the Mojave, we intend to focus our efforts on data, information, and tools specific to the desert tortoise, tortoise recovery efforts, and the NTC. As some overlap will inevitably exist, particularly in basic data for the Mojave, we intend to identify and pursue partnership opportunities where possible. Where appropriate it is intended that the results of the information science component of the DTP will be made available for broader use by the desert tortoise stakeholder community, primarily through the MDEP. These methods, tools and data will also be made available to CERL and other organizations for application to other issues related to the desert tortoise and beyond.

5.2.1.1 Research Objectives

Our primary information science research objectives are:

- Develop metadata standards for desert tortoise scientific data and studies;
- Provide methods and tools to facilitate desert tortoise knowledge management;
- Provide methods and tools to facilitate desert tortoise information search, discovery and visualization;
- Provide methods and tools to model and analyze desert tortoise population, habitat and threat issues; and
- Provide methods and tools for desert tortoise policy and management related decision support.

The means to achieve these objectives are outlined within the activities listed below. These activities do not correspond one-to-one with the above objectives, but provide a logical process of steps by which to achieve these objectives.

5.2.1.2 Activities

1. Develop metadata standard for desert tortoise scientific data and studies.

With ever increasing volumes of information, the need for access to past studies for scientists and decision makers grows. Key in promoting information access and sharing is a common framework for describing past studies and data to enable future users to assess availability and appropriateness of past study results for analysis. This effort not only necessitates a metadata format – the information required to describe and catalog an information resource – but also procedures and methods for participating in producing and sharing metadata records.

While significant efforts have been made in many disciplines in the development of metadata standards – notably the library and GIS communities – these standards do not always address some of the discipline-specific descriptors that may be needed by scientific researchers. As a result, participation from the desert tortoise scientific community in the development and implementation of a metadata standard to specifically describe desert tortoise studies is essential. The development of a draft standard will be based on a thorough review and assessment of existing desert tortoise studies that have been carried out over the past 30 years. This draft "standard" will be reviewed and refined in collaboration with the desert tortoise scientific and management community, and in consideration of existing information science standards.

Based on some preliminary pilot efforts internal to the project, as well as past efforts on the part of the Desert Managers Group, we will involve the stakeholder community by facilitating a dialog to develop and refine a desert tortoise data and study metadata standard and implementation strategy. Key issues among the scientific community – such as the importance of protecting proprietary or in-progress studies and data while still communicating content and methods – will be addressed.

Once developed, the desert tortoise metadata standard will be incorporated into the SPINE database and application environment.

Current Sub-Activities and Status

- Assess past studies and develop a pilot metadata format for desert tortoise data and studies

Future Tasks

- Identify existing stakeholder groups to participate in development of a metadata standard
- Facilitate workshop-format discussions
- Formalize a standard and process for desert tortoise metadata
- Publish and communicate standards among the scientific community
- Incorporate the standard as a component of the SPINE database and interface
- Provide for access to SPINE database through MDEP or other mechanisms as appropriate

2. Data inventory and assessment

Many of the activities discussed in this design document have extensive data requirements. To support these activities, a focused inventory of available data will be conducted. It should be emphasized that while some data may be collected as a result of this effort, we will focus primarily on identifying sources and characterizing their usefulness for our research efforts. This characterization will be largely based on our stakeholder assessment, project requirements, and metadata standards.

This record of available data alone may prove a promising resource for study. As part of our biological science investigations, we intend to assess the current state and historic trends in tortoise habitat, population, and threats research. This assessment requires a thorough listing and assessment of previous studies. Data and study resources will not only provide material for our research, but may also aid in identifying trends in past studies and methods, convergence or divergence in scientific approaches, and gaps or opportunities for further scientific research. Information will also be assessed in terms of information science best practices, including but not limited to data structure, normalization, opportunities and constraints for data automation, data standardization, integration issues among related data topics, opportunities and constraints for spatial and temporal data analysis and visualization, and other issues.

Current Sub-Activities and Status

- Preliminary inventory conducted during stakeholder assessment

Future Tasks

- Further assess project data requirements
- Inventory available data
- Assess suitability of available data against existing project needs
- Develop data collection, integration and automation strategy

3. Metadata cataloging

Several levels of metadata cataloging will be pursued. Internal project needs, support for project stakeholders, and various special collections will be addressed.

In the course of this project, significant data and publications will be referenced. As an ongoing part of the process of identifying data and documents for our research, we will record basic metadata. These internal information requirements will contribute a significant portion of our metadata cataloging.

As part of establishing a metadata standard (Information Science Activity 1), we will evaluate options for promoting use and distribution of tortoise-related metadata. As such, we must evaluate the feasibility and usefulness for extending our metadata cataloging facilities to external users, primarily scientists and resource managers in the stakeholder community.

Various special collections of tortoise-related information exist. NTC study project archives (i.e. scientific studies supported by the NTC), for example, hold numerous place

specific studies and data on the tortoise. Many scientists possess private collections of their own research. We will identify and prioritize these resources for inclusion in our own cataloging efforts.

Current Sub-Activities and Status

- Significant infrastructure has been implemented in previous RI grants to support cataloging of various metadata standards
- A number of new metadata have been created, including basic cataloging of Desert Tortoise Council Symposia publications

Future Tasks

- Use data inventory results (Information Science Activity 2) to identify new resources and special collections for cataloging
- Ongoing cataloging of project resources
- Investigate options for distributing cataloging capabilities

4. Data and document archival and digitization

Parallel to metadata cataloging, a process for archival of the source document or data will be developed. This might include document scanning, optical character recognition, or microfilm. Various archival methods may be employed for different source material and project priorities. Given the volume of information available for archival, some priorities must be developed.

Other programs, notably MDEP, have already made significant investment in data archival for the Mojave. The RI has significant spatial data archived for southern California. While there are substantial amounts of data available from these previous efforts, some additional infrastructure costs will be incurred by the project to organize and store data for analysis and reuse.

Current Sub-Activities and Status

- Significant infrastructure exists within the Redlands Institute for this capability

Future Tasks

- Develop archival workflow and re-evaluate current tools and systems
- Refine existing RI cataloging tools and data store to integrate a more automated archival workflow
- Develop methods for prioritizing archival needs based on project research objectives

5. Information search and discovery

Access to metadata records requires tools for searching a metadata archive and methods for discovering records. Simple keyword or full-text searching is one very basic level of information search. Other methods, such as spatial and temporal searching and topical hierarchies will be evaluated. More sophisticated search and discovery techniques, such as collaborative filtering or importance ranking may also be addressed.

We intend to make accessible this search and discovery service, and the subsequent studies and data records where appropriate, to our project audience. A web-searchable interface is one possibility for accessibility. Other methods for sharing the metadata catalog with other information repositories will be considered as well.

Many libraries and private companies have implemented Z39.50 transfer protocols, XML, or web services to share information catalogs. Since MDEP already possesses significant tools and resources for information search and discovery, further discussion is needed to assess appropriate protocols and procedures for information sharing.

Current Sub-Activities and Status

- SPINE System Development. As described previously, significant infrastructure has been implemented in previous RI grants for search and discovery of cataloged information via the XMDB™. Current project efforts, such as the SPINE pilot project, extend this capability with tools for spatially referencing, searching, and retrieving tortoise-specific studies and data. This concept has been used to develop a standalone SPINE pilot project that will be presented to the stakeholder community in the context of the draft Program Design review process.

Future Tasks:

- Refine initial stakeholder requirements based on feedback from current tools and SPINE pilot
- Review previous functional design for RI information search tools against new requirements
- Develop new design and implementation strategy
- Develop, deploy, and refine new functionality

6. Access to digital resources

Beyond accessing a description of a resource, tools for accessing a digital version of a study, document, or data, was identified as a need through our stakeholder interview process.

In accessing metadata, use permissions are generally more lenient than accessing the source material. Security and access concerns for various metadata fields (such as location of sensitive information and copyrighted abstracts) as well as use-restricted documents and data will need to be considered. Current tools within RI for resource cataloging and network security provide some level of access control. New requirements will arise as we identify user needs and implementation options.

There has been additional discussion of developing a data model for integrating diverse tortoise-related data for synthesis. Any future efforts for data integration would likely follow a successful data collection and automation effort, and require significant dialog on potential application requirements.

Current Sub-Activities and Status

- Existing infrastructure for storing and retrieving diverse digital file types via the web
- Current project efforts, such as the SPINE pilot project, extend this capability with tools for spatially referencing, searching, and retrieving tortoise studies and data

Future Tasks

- Refine initial stakeholder requirements based on feedback from current tools and SPINE pilot
- Review previous functional design for R information search tools against new requirements
- Develop new design and implementation strategy
- Develop, deploy, and refine new functionality

7. Knowledge Management, Modeling and Decision Support

The knowledge management, modeling and decision support element of this program design is much more experimental than other elements. While the concept of using information technology for decision support is not new, applying it to the desert tortoise for the Mojave decision-making community is not yet proven. Several years ago, MDEP sponsored a substantial review and synthesis of decision support opportunities for Mojave Desert management activities. Many of the stakeholder requirements still bear discussion today. While technology has advanced in the area of decision support since then, there is still much to be gleaned from the study in concept. Within the context of this project, we have the opportunity to be much more focused in our evaluation. Addressing decision support as it relates to the tortoise, tortoise recovery, and the NTC expansion, lends itself well to vetting the concept of decision support tools for implementation elsewhere in the Mojave. As mentioned previously, the DTP will utilize the Ecosystem Management Decision Support (EMDSTM) software suite as the foundation for this activity.

It is anticipated that this decision support activity will require significant guidance from the Mojave Desert scientific and decision-making community. A process will be established to involve these communities in various design stages and project feedback.

Several related components make up the decision support activity for this program:

- Knowledge management;
- Modeling;
- Policy/Management analysis and decision support;
- Synthesis; and
- Information visualization.

Knowledge management. Knowledge management, in the context of this project, will focus on organizing expert input to describe various factors and

interrelations between desert tortoise habitat, population, and threats. This will result in a codified body of scientific knowledge intended to support decision-making.

A working desert tortoise knowledge base will assist in:

- Identifying divergence or convergence in scientific knowledge and opinion;
- Identifying knowledge gaps and their impact on management and policy decisions;
- Providing input to modeling applications ;
- Promoting discussion and collaboration among the scientific community and between scientists and decision-makers;
- Informing research budget priorities; and
- Providing input to decision support models.

Current Sub-Activities and Status

- Investigate applicability of EMDS tools and method.

Future Task

- Use knowledgebase tools to codify and compare scientific knowledge concerning desert tortoise habitat, threats, and populations
- Use knowledgebase to support and integrate habitat, threats and population modeling and policy/management scenario analysis

Modeling. Input into various models is an additional use of a knowledgebase of desert tortoise population, habitat, and threats. These types of models have been applied in management of sensitive species elsewhere. Knowledgebase-driven models result in a series of ‘truth values’ for propositions in the knowledgebase. These results tend not to include probabilities or exacting measures, but do serve to rank relative to each other various decision alternatives.

Other modeling efforts will also be considered, including evaluation of advanced sensor technologies, such as habitat classification from remote sensed imagery. Evaluation of various population methodologies, including results from line distance sampling efforts will also be pursued.

Current Sub-Activities and Status

- Pilot EMDS™ presentation
- Develop Design Studio class to support further exploration into the design and application of knowledgebase tools for modeling
- Develop Policy Clinic class to support further exploration into the design and application of knowledgebase tools for policy/management scenario analysis

Future Task

- Refine initial stakeholder requirements based on feedback from current tools and EMDS™ pilot

- Document results of Design Studio and Policy Clinic studies and review with appropriate experts within the desert tortoise stakeholder community
- Use knowledgebase to support and integrate habitat, threats and population modeling and policy/management scenario analysis
- Synthesis: In addition to publication and synthesis of our own project research, we will also provide synthesis of other desert tortoise science for decision makers. This may take the form of presentations, briefing documents, workshop discussions, or other communication formats.

Information Visualization. Many of the problems facing the desert tortoise are exceedingly complex and difficult to communicate to the decision-making community or general public. We will explore methods for organizing and displaying spatial, topical, and temporal relationships.

Current Sub-Activities and Status

- Activities not yet initiated

Future Task

- In the context of various pilot applications, demonstrate the use of innovative methods for analyzing and visualizing spatial and temporal information related to specific desert tortoise issues

5.3 Management and Policy Analysis

The advancement of desert tortoise science, by itself, will not achieve the goal of tortoise recovery in the Mojave Desert. Policy makers and managers will play a crucial role in that regard. In order to enhance recovery prospects, managers will need decision support systems that integrate knowledge of desert tortoise science, policy, and management in ways that are easily understood and fully adaptable for use in "if-then" assessments.

The DTP will investigate policy and management issues affecting desert tortoise populations, habitat, and threats in the context of recovery efforts, especially as they pertain to the West Mojave Recovery Unit, in general, and the Ft. Irwin expansion area, in particular. Research on management and policy issues will be a secondary activity and will complement the team's primary mission of facilitating better understanding of desert tortoise science and its application to population estimation, habitat evaluation, and threats assessment.

In carrying out its investigation of policy and management issues, the DTP will utilize both faculty and student resources. Efforts will focus on identifying key issues and actors, evaluating management consequences for long-term tortoise viability, developing management and policy components of decision-support systems, and evaluating selected biodiversity threats and land management plans that could affect tortoise recovery.

A combination of "design studios" and "policy clinics" will be used to give students a hands-on opportunity to assist in this research. Clinics and studios are problem-driven, collaborative research teams, composed of 6-15 students and faculty members who prepare a report or major presentation about a specific environmental improvement strategy for government clients or groups of public and private stakeholders. The design studio usually includes applications of GIS, modeling tools, and other methods of analysis to assist in the planning and design of effective responses to a wide range of environmental challenges. The policy clinic deals with a similar range of issues, but from the perspectives of environmental governance and management. It focuses on the conditions of political, economic, and managerial feasibility that must be met in order to resolve environmental controversies.

5.3.1.1 Research Objectives

Research on policy and management issues will be conducted in a manner that facilitates systematic integration of results with biological and information science activities. Our primary management and policy research objectives are to:

- Provide syntheses of relevant data and information to managers;
- Evaluate current land management activities with the intent to identify opportunities for cost-saving collaboration and cooperation in tortoise recovery efforts; and
- Evaluate the policy and scientific implications of select desert tortoise management strategies in terms of political, economic, and environmental tradeoffs, both short-term and long-term.

Because the treatment of management and policy needs in the research plan are in many ways driven by science needs and threats assessments covered in other components of the plan, the activities listed here will be managed and revised in the context of the biological and information science research agendas.

5.3.1.2 Activities

1. Provide synthesis of relevant data and information to managers.

There are a wide variety of documents, plans, studies and data sets that have contributed in one form or another to the assessment of desert tortoise status, recovery planning, and on-the-ground management activities over the past 30 years. This information presently exists in many forms and locations, and there is no single, comprehensive inventory or repository for accessing such information. This activity will undertake several sub-activities to collect and catalog all the best available data, to synthesize key aspects of this information as it relates to the DTP research agenda, and wherever possible to provide desert managers and other stakeholders with access to this information through the SPINE system.

Current Sub-Activities and Status

- Initiated acquisition of key information documents, printed and electronic versions (e.g. DoD Integrated Natural Resources Management Plans, NPS General Management Plans, BLM Regional Management Plans, Biological Opinions and related NEPA documents)
- Restructured desert tortoise Management Oversight Group/Technical Advisory Committee “Recovery Task Completed” form and provided back to Mr. Phil Medica, USFWS Desert Tortoise Recovery Coordinator

Future Tasks

- Continue acquisition of key information documents
- Synthesize and summarize key information documents in relation to desert tortoise recovery
- Integrate resulting information to the SPINE system for common access and use

2. Evaluate current land management activities with the intent to identify opportunities for cost-saving collaboration and cooperation in desert tortoise recovery efforts.

Since the development of the original *Recovery Plan* there has not been a systematic evaluation of the multi-jurisdictional land management activities and mitigations that evolved out of its recommendations, nor of their cumulative effectiveness towards desert tortoise recovery. The DTP will work closely with the land manager stakeholders to identify key issues and actors, and to facilitate a process using state of the art methods and tools to inventory, compare and assess current land management practices as they relate to the purpose, intent, and recommendations of the *Recovery Plan*.

Current Sub-Activities and Status

- Ongoing discussions with the DMG to identify key issues and actors

Future Task

- Assemble team of key policy and managers and stakeholders
- Develop computer-assisted desert tortoise policy analysis and management planning techniques, and work with key stakeholders to apply these techniques
- Convene a broader management and policy forum to discuss findings
- Co-publish findings with key partners

3. Evaluate desert tortoise policy and management interactions in terms of political, economic, and environmental tradeoffs, both short-term and long-term.

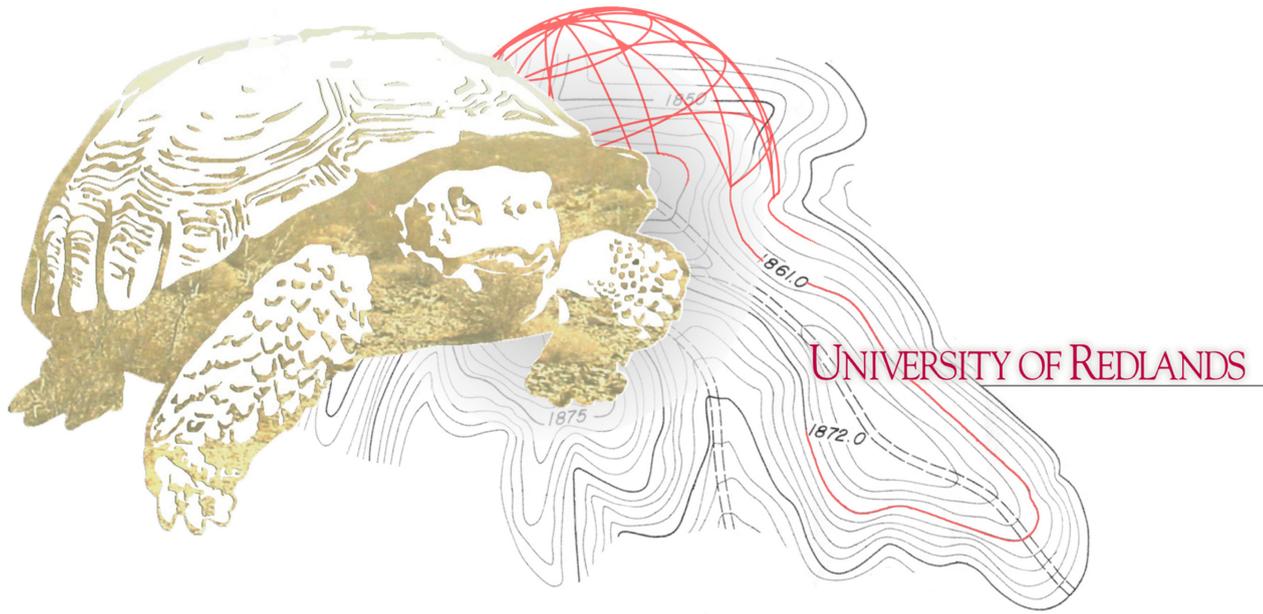
The recovery of the desert tortoise is dependent upon the coordinated actions of land managers and other users of the Mojave Desert. There are many overlapping geographic and topical jurisdictions involved, thus complicating any comprehensive coordination intent. The DTP will facilitate a process with key desert manager stakeholders to apply state-of-the-art methods and tools to inventory the relationships among desert managers and to assess the likely short and long-term outcomes of various coordination scenarios and the political, economic, and environmental tradeoffs that might be involved.

Current Sub-Activities and Status

- Sub-Activity not yet initiated

Future Task

- Assemble team of key desert managers and stakeholders
- Identify and characterize the political, economic and environmental management implications of threats mapping, translocation, head-starting programs and other management activities towards desert tortoise impact mitigation and recovery
- Develop computer-assisted desert tortoise management best practice assessment, and work with key stakeholders to apply these techniques
- Convene a broader management best practice forum to discuss findings
- Co-publish findings with key partners



Appendix A

Stakeholder Interview Analysis

Appendix A: Stakeholder Interview Analysis

1.1 Stakeholder Needs Summary

A series of stakeholder interviews were held with state and federal agency scientists and managers, and interested scientists involved in desert tortoise research or management activities. The selected stakeholders were not intended to be an exhaustive nor static list, but simply to provide a core group of interested desert tortoise scientists and land managers. Additional stakeholders will be identified and interviewed as the project evolves. The results of these core stakeholder interviews provided a foundation for the DTP program design development and prioritization of future application development plans. The following describes the participating agencies and their mandates, and summarizes their roles and responsibilities regarding desert tortoise research and management activities.

1.2 Organization Assessment

The 12 organizations, agencies, and academic scientists interviewed varied widely in terms of their mandate, jurisdiction, functional activities, and interest. The characteristics and relevant issues associated with these different stakeholders is important for understanding their capacity and motivation for participating in data sharing or collaborative research, monitoring, and data management initiatives.

Primary considerations include:

Organizational Mandates. Legal, chartered, or otherwise committed mandates may affect an organization's ability or inclination to collaborate with other organizations. For example, a resource protection mandate may require both a general approach to monitoring the status and trends of a resource, as well as a specific approach to addressing problems.

Jurisdiction. Organizations may have topical and geographic jurisdiction. Topical jurisdiction refers to an agency's legal or chartered responsibility to monitor or administer a specific function. Examples would include U.S. Fish & Wildlife Service's topical responsibility to protect wildlife, or California Fish and Game's responsibility to administer permits for dealing with Threatened and Endangered species (Section 7 consultations).

Geographic jurisdiction represents an agency's responsibility for a specific geographic area. Examples include Fort Irwin National Training Center's mandate to carry out training activities within the Fort Irwin military boundaries, or the Mojave National Preserve's jurisdiction over natural resources within the Preserve's lands.

Some organizations, such as universities, have no specific jurisdiction, but topical concerns dictated by research interests or funding. Organizations with topical jurisdiction desire information that supports their specific issues or concerns. Their funding source may not allow a broad based data collection over the longer term, rather focused data collection only. Organizations with geographic jurisdiction, on the other hand, may only be concerned with data that are specific to their lands, and not to issues outside their boundaries. Thus, coordinating monitoring and research efforts over a large area becomes challenging where multiple agencies have various types of jurisdictions and mandates.

The 12 agencies interviewed are categorized by organizational/administrative types as follows:

Federal Agencies. Federal law generally mandates the activities of federal agencies. Some agencies, like the U.S. Geological Survey (USGS), are focused on the collection and dissemination of various sorts of geographic and environmental data and are more likely to have developed the technical and administrative infrastructure needed to share data with others. Also, due to its broad mandate, the USGS is more apt to participate in cooperative efforts. Other federal agencies, like the Fort Irwin National Training Center (NTC) are project focused and therefore usually are involved in joint data collection and research efforts where it directly supports project objectives. U.S. Fish and Wildlife and other such resource protection or management agencies may only be interested in monitoring activities where the locations and species are consistent with their mandate. Often times, federal agency monitoring and research efforts are fund source specific thus limiting the scope and duration of the project. Federal agencies in this stakeholder assessment included:

U.S. Department of Defense (DoD)

Fort Irwin National Training Center (NTC)

Department of Public Works
Land Expansion Office

U.S. Department of Interior (DoI)

National Park Service

Mojave National Preserve

Bureau of Land Management (BLM)

California Desert District

U.S. Geological Survey (USGS)

Western Ecological Research Center

U.S. Fish and Wildlife Service (USFWS)

Mojave and Great Basin Deserts
Southern Nevada Field Office

Other Government Agency Organizations

Desert Managers Group
Mojave Desert Ecosystem Program (MDEP)

State Agencies. These agencies can be topical or jurisdictional in nature and also have responsibilities mandated by State law. They may also respond to specific issues through the Governor's office or State legislature. State agencies included:

California Department of Fish and Game

Region 6

Universities. Universities perform basic or applied research, almost always through grants or contracts. Basic research will focus on the agenda of the Principal Investigator, whereas applied research will usually be carried out to support a project or policy issue. Universities included:

California State University Dominguez Hills

Drexel University

Non-Government Organizations. Non-government organizations are typically structured for a purpose other than profit. Their funding is based on the dues contributed by the public, scientists, conservation organizations, or other groups. Advisory committee members or council members dictate the research and monitoring efforts. Organizations included:

Desert Tortoise Preserve Committee

1.3 Organization Summary

1.3.1 Fort Irwin National Training Center (NTC)

Department of Public Works (DPW), Environmental (Natural Resources Division).

The DPW Environmental (hereafter referred to as DPW) at the Fort Irwin National Training Center (NTC) leads the desert tortoise research and monitoring activities on the military lands. The staff maintains strong professional relationships with the military and with federal and state regulatory agencies. Management is based on sound stewardship through conservation, protection, and enhancement of natural resources with a focus on threatened and endangered species recovery.

Specific major activities related to the protection of the desert tortoise include:

- Ensure compliance with regulations pertaining to natural resources;

- Perform tasks in support of the proposed NTC expansion;
- Integrate innovative approaches to data collection;
- Oversee and support research;
- Survey, monitor, and control exotic plant and wildlife species;
- Participate in cooperative plans and programs;
- Provide educational awareness and public outreach;
- Produce natural resources management plans, biological reports, standard operating procedures, and maps.

Land Expansion Office. The Land Expansion Office is responsible for all legal procedures regarding land acquisition and expansion at the NTC. The Expansion Office identifies those lands necessary to meet the Army's training needs and recommends conservation measures intended to promote the survival and recovery of the desert tortoise and other endangered or threatened species and their habitats in the West Mojave Desert. The U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish And Game (CDFG) collaborate closely with the Expansion Office to assure consistency with Endangered Species requirements.

Specific major activities being carried out by the Fort Irwin Expansion Office include:

- Conduct consultations with USFWS and CDFG under Section 7 of the Endangered Species Act (ESA) to determine mitigation measures;
- Support surveys on desert tortoise densities in and around the Fort Irwin NTC lands;

Future research objectives include:

- Inventory all desert tortoise studies (past, current and future) in and around Fort Irwin NTC;
- Assess the past, current, and future threats to desert tortoises in and around the expansion area and compare with historic desert tortoise densities.

1.3.2 National Park Service (NPS)

Mojave National Preserve. The NPS conducts various ecological monitoring programs to assess management actions and comply with environmental regulations. The programs are carried out under the jurisdiction of the individual park units. As part of the NPS, the Mojave National Preserve receives funding for research and management projects in the same manner as other parks, and is responsible for maintaining the natural and man-made resources found within its boundaries.

Specific major activities being carried out by the Mojave National Preserve include:

- Purchase grazing allotments within Preserve boundaries and retiring them;

- Conduct baseline monitoring of environmental indicators to assess potential future impaired resources;
- Collaborate with desert tortoise biologists in data collection for LDS projects.

Future research objectives include:

- Conduct monitoring and research programs to assess road mortality (impacts of roads on wildlife), non-point source pollution, diseased animals, and predation;
- Assess and quantify the amount of OHV use within the preserve boundaries.

1.3.3 Bureau of Land Management (BLM)

California Desert District (CDD) - Box Springs Office. The BLM California Desert District (CDD) manages 10.5 million acres of the roughly 25 million acre California Desert Conservation Area (CDCA) and 300,000 acres of scattered parcels outside the CDCA in Los Angeles, Riverside, San Bernardino, Orange, and San Diego Counties. The District is divided into five resource areas: Ridgecrest, Palm Springs/South Coast, El Centro, Barstow and Needles.

The CDD Box Springs office is primarily responsible for providing training and technical support to field biologists, providing written guidance for land use planning efforts, and developing policies for management activities in the desert. Currently, three main regional land use plans are underway – the West Mojave, Northern & Eastern Mojave and the Northern & Eastern Colorado Coordinated Management Plans. When completed, these plans will update the CDCA Plan (developed in 1980) and provide for the recovery of the desert tortoise and other species listed as threatened. The Box Springs office deals primarily with the West Mojave plan (WEMO).

Research and survey work is typically contracted out to U.S. Geological Survey. These contracts may include such varied topics as project mitigation, scientific research, monitoring, restoration, and management.

Specific major activities being carried out by the Box Springs office include:

- Evaluate projects conducted on BLM lands;
- Prioritize research and monitoring efforts on BLM lands;
- Develop implementation measures to enhance desert tortoise (and other endangered species) recovery efforts;
- Establish special management areas to ensure preservation of sensitive resources;
- Support the development of bioregional plans, in particular the WEMO Plan;
- Evaluate the impacts of various WEMO implementations on desert tortoises.

1.3.4 U.S. Geological Survey (USGS)

Western Ecological Research Center (WERC) – San Diego and Box Springs Field Offices. The Western Ecological Research Center is one of 18 Centers of the Biological Resources Division (BRD) of the USGS. All research projects carried out through the WERC are categorized by the primary "Program Element" that defines the areas of science within the BRD and the research focus. A Program Element consists of a group of projects addressing similar, broad areas of science - Endangered and At-Risk Species, for example. Scientists at the San Diego and Box Springs Field offices conduct research in the Mojave and Colorado deserts on the desert tortoise, its habitats, long-term population trends, causes of ill health and high mortality rates, and threats - in particular raven predation. This information is provided to land managers to support and inform their decision-making processes throughout the Mojave and Colorado deserts.

Specific research subjects addressed by the San Diego and Box Springs Field offices include:

- Develop scientific and statistically reliable methods and protocols to assess the status and trends of desert tortoise populations;
- Assess health and disease conditions of desert tortoises;
- Assess demography and populations trends in desert tortoises;
- Assess the causes of biological and ecological trends and predict the ecological consequences of management practices;
- Assess the anthropogenic effects on desert tortoise populations and critical habitats;
- Develop technologies needed to synthesize, analyze, and disseminate biological and ecological information;
- Assess short- and long-term changes in the Mojave and Colorado desert ecosystems.

1.3.5 U.S. Fish and Wildlife Service (USFWS)

Southern Nevada Field Office. The Southern Nevada Field Office houses the desert tortoise recovery coordinator and is responsible for monitoring and coordinating all desert tortoise management and research plans for the Mojave Region to effectively address issues of desert tortoise recovery.

Specific major activities being carried out include:

- Oversee and coordinate management activities that involve the desert tortoise;
- Oversee and coordinate recovery actions implemented throughout the Mojave Region (e.g. road fencing, road closure, predator control, disease, etc.); and
- Prioritize research, monitoring, and implementation activities.

Mojave and Great Basin Deserts Division. The Mojave and Great Basin Deserts Division is primarily responsible for issuing permits and conducting fieldwork within its jurisdictional boundaries to protect threatened and endangered species. Eighty percent of the workload covers desert tortoise related efforts, and twenty percent covers other species, including mammals, birds, fish, reptiles, and plants. The majority of the work relates to Section 7 consultations, mostly for the California Department of Transportation and the Bureau of Land Management. Section 7 outlines terms of conditions to minimize effects of proposed actions on threatened and endangered species.

Specific major activities being carried out include:

- Evaluate projects and file Biological Opinions;
- Conduct presence or absence surveys;
- Develop protocols for project assessments; and
- Address litigation measures and issue safety recommendations and regulations for construction projects.

1.3.6 Other Government Agencies Organizations

Desert Managers Group (DMG). The Desert Managers Group (DMG) provides a forum and communication structure for managers from a broad range of agencies to communicate, share ideas, and facilitate progress in their roles as managers in the California Deserts. Participating agencies include: National Parks Service (NPS), Bureau of Land Management (BLM), United States Fish and Wildlife Service (USFWS), United States Geological Survey (USGS), Department of Defense (DoD), California Department of Fish and Game (CDFG), California Department of Parks and Recreation, and the California Department of Transportation. The DMG develops guidelines and programs that land use agencies can incorporate into their own operating procedures.

Smaller work groups are established to accomplish specific tasks. These groups are comprised of staff members from the participating agencies, and funding is provided through allocations made by each of the participating agencies. A list of the current work groups include:

- Data Management Work Group (DMT) (currently inactive);
- Desert Information Resources Work Group (DIRT);
- Desert Lands Restoration Work Group (DLRT);
- Hazardous Materials Work Group (HMT);
- Law Enforcement Work Group (LET);
- Noise and Overflight Work Group (NOT);
- Paleontology and Cultural Resources Work Group (PCRT);
- Science Work Group (ST); and
- Wilderness Work Group (WT).

These work groups are the primary means through which DMG goals/guidelines are carried out.

Specific major DMG activities being carried out include:

- Develop coordinated and complimentary management guidelines, practices, and programs;
- Coordinate and integrate efforts in the California Desert to:
 - Conserve and restore desert resources;
 - Provide high quality recreation, public education and visitor services;
- Develop and integrate the databases and scientific studies needed for effective resource management and planning;
- Promote compatibility in the application of each agency's mission;
- Identify opportunities for innovative and cooperative management of California desert resources;
- As needed, establish interagency work groups/ad hoc committees to implement DMG goals, objectives, plans and initiatives;
- Facilitate resolution of significant conflicts and issues among the participants and develop consistent direction on desert-wide issues within and between participating agencies.

Mojave Desert Ecosystem Program (MDEP). The MDEP is responsible for the creation and maintenance of a geospatial database for the entire Mojave Desert. Geospatial data, reports, and documents are electronically stored in-house, and accessed via the Internet. The MDEP also works with local and regional stakeholders to develop partnerships and data sharing initiatives. Recently, the MDEP has been collaborating with scientists from U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), and the University of Redlands, to develop a relational database and electronic field data collection system to expedite data collection and reduce inherent data errors for Line Distance Sampling (LDS) efforts.

Specific major activities being carried out by the MDEP include:

- Enhance informed decision making for sustainable land management across the entire Mojave eco-region;
- Collaborate with stakeholders to develop data sharing initiatives;
- Expedite field data collection through the development and promotion of relational databases and electronic field data collection systems; and
- Develop standards for data collection and data documentation.

1.3.7 California Department of Fish and Game (CDFG)

Region 6 – Palmdale Office. Region 6 covers Imperial, Inyo, Mono, Riverside, and San Bernardino Counties. Divisions within the region include: Habitat Conservation, Colorado River Program, Wildlife and Inland Fisheries, Lands and Facilities, Special

Projects, and Conservation Education and Enforcement. Much of the Habitat Conservation Division's activities, within the desert area, are focused on issuing permits and providing consultations to agencies and private entities, commonly in close collaboration with the U.S. Fish and Wildlife Service. The Palmdale office deals primarily with permits addressing the desert tortoise and Mojave Ground Squirrel. Monitoring work is contracted out to research entities as needed.

Specific major activities being carried out by the Palmdale office include:

- Evaluate projects and file Biological Opinions;
- Conduct presence or absence surveys;
- Develop protocols for project assessments;
- Address litigation measures and issue safety recommendations and regulations for construction projects; and
- Identify and prioritize research and monitoring efforts.

1.3.8 Universities

California State University Dominguez Hills (CSUDH).

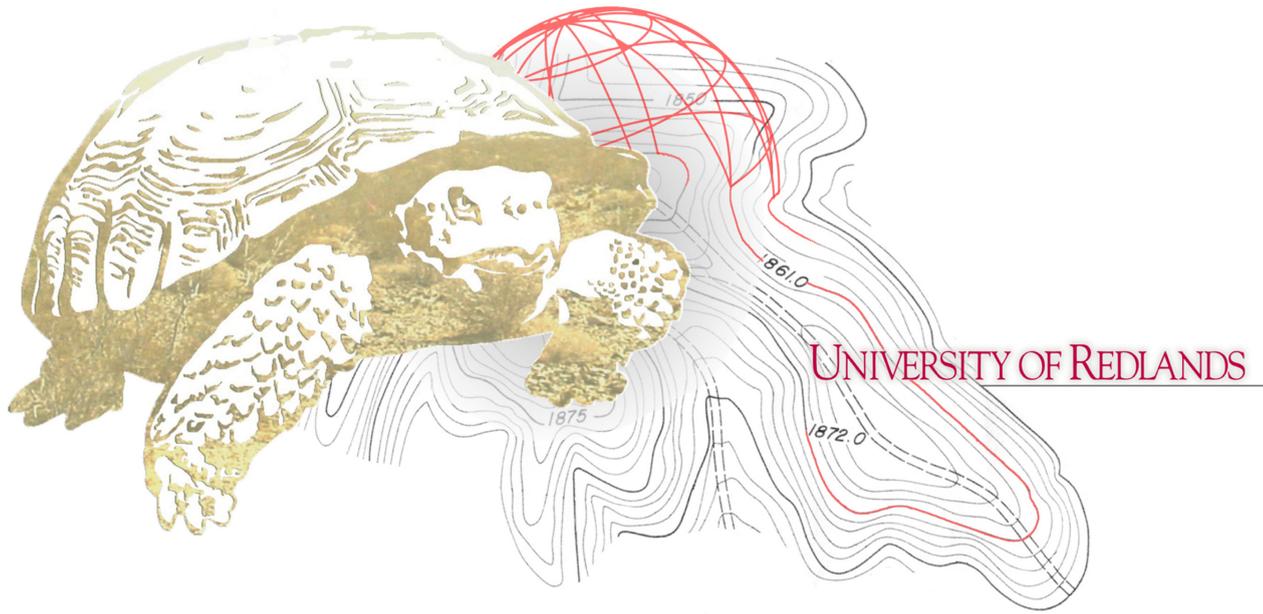
Drexel University (DU).

1.3.9 Non-government Organizations

Desert Tortoise Preserve Committee (DTPC). The Desert Tortoise Preserve Committee is a non-profit organization formed to promote the welfare of the desert tortoise in its native wild state. The DTPC acquires land for tortoise preserves in areas of prime habitat using funds raised from the public, from conservation mitigation efforts, and through the operation of a land bank. The Committee was instrumental in establishing the Desert Tortoise Research Natural Area (DTNA) in Kern County, California, and continues to acquire adjacent lands in collaboration with the Bureau of Land Management and the California Department of Fish and Game. The Committee is also active in conservation education and in facilitating research that helps protect the desert tortoise and its habitat. In addition, the DTPC carries out 1-2 ongoing research projects; the primary focus is on Ground Squirrel and other small mammals, and desert tortoise.

Specific major activities being carried out by the DTPC include:

- Establish desert tortoise preserves;
- Develop and implement management programs for desert tortoise preserves and adjacent areas;
- Develop long-term plan - in collaboration with BLM - for the management of biological resources, resource conservation, and restoration of critical habitat on desert tortoise preserves; and
- Develop educational and research programs.



Appendix B

Stakeholder Questionnaire

Appendix B: Stakeholder Questionnaire

Interview Outline

General Contact Information

Agency name:

Address:

Telephone:

Fax:

Web site:

Contact person

Name:

Address:

Telephone:

Alternate telephone:

Fax:

e-mail:

Agency Mandates and Activities

What are the main activities of your organization?

What is the organizational structure?

(examples: current team configuration and responsibilities; coordination methods and protocols within the team; coordination methods and protocols with other stakeholders)

What programs exist within your organization?

Describe each program and its purpose (attach additional information, if appropriate).

Data Collected

What type of data does your organization collect?

Please provide samples if possible.

How are the data collected?

(examples: using GPS technology, recording in field journal)

Where are the data collected?

(examples: FT. Irwin expansion area, selected sampling sites)

How are the data stored and retrieved?

(examples: Excel spreadsheets, hardcopy reports, Access or GIS database)

Information Produced

**What types of information products are used to meet the organization's mandates?
Who uses these products?**

(examples: lists, documents, maps, reports, scientific papers)

What data are used to make these information products?

How do these information products satisfy your organization's mandates?

Are these information products used to support decision making? If so, what decisions are dependent on them?

Interview Outline

Additional Data and Information Needs

Are there any additional information products that the organization needs to satisfy its mandates?

(examples: threats map, habitat models)

**What data are needed to make these information products? What are the data gaps?
What data are available and where are they?**

What data are wanted from other agencies?

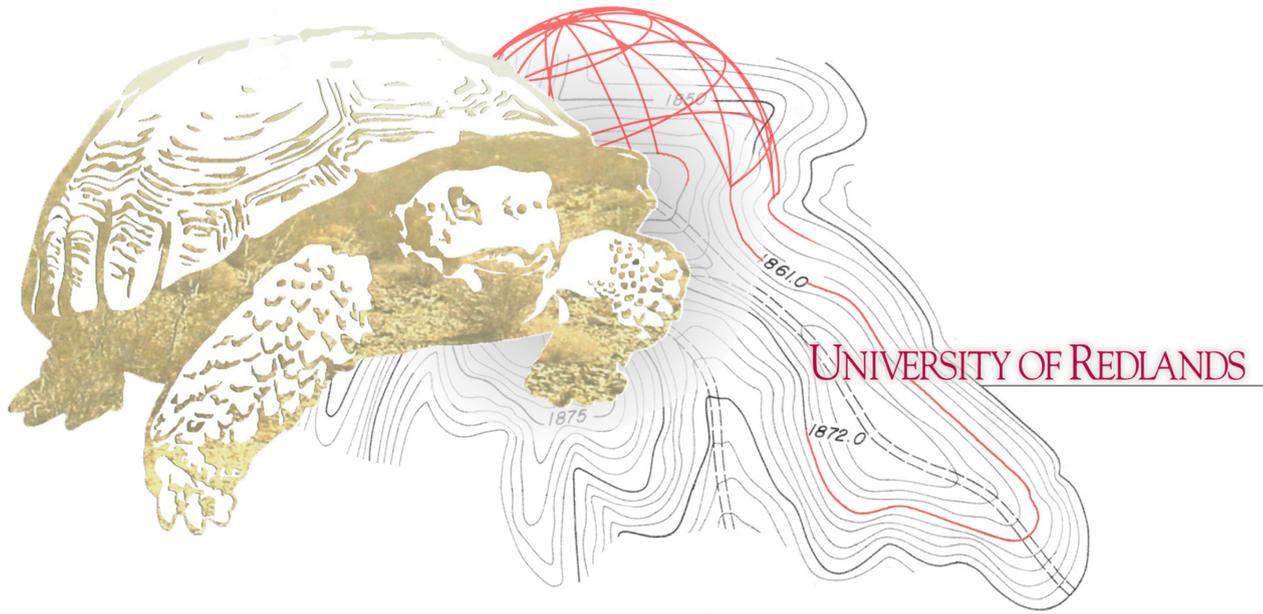
Current Technology

What type of computing infrastructure is currently in use or planned?

What is the human resource capability, including staff experience with general computing and GIS?

Interaction with other Agencies

Special Concerns and Issues



Appendix C

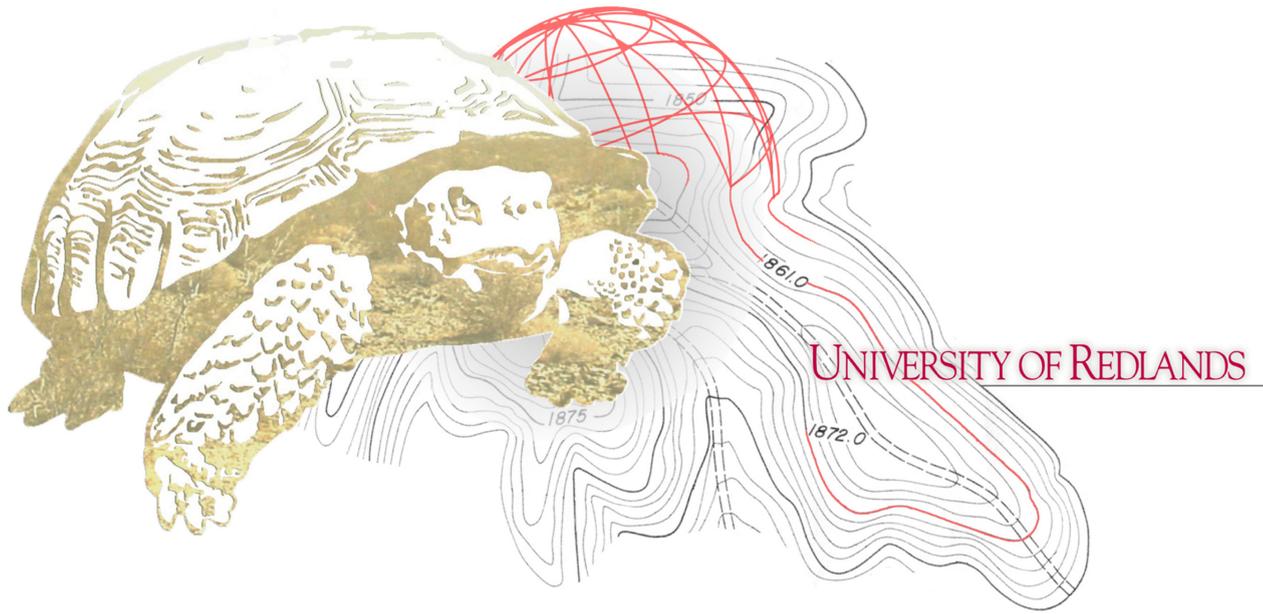
Stakeholder Suggestions

Appendix C: Stakeholder Suggestions

- Study animal take and habitat loss in the Mojave, particularly in the context of the WEMO implementation evaluation, possibly to influence the creation of a standard data sheet for monitoring habitat loss.
- Study the cessation of sheep grazing in the DWMA's and compare grazed versus ungrazed areas.
- Conduct a habitat assessment for the desert tortoise.
- Quantify and map disturbed habitat.
- Identify and articulate the effects and impacts of the Ft. Irwin expansion area on the desert tortoise and habitat.
- Acquire and utilize aerial imagery, geo-spatial data, DTNA tortoise/burrow data, and DTNA human impact surveys to conduct trend analyses of human impacts on the desert tortoise within and outside of the DTNA.
- Compare presence/absence survey results with monitoring results.
- Present and map LDS data.
- Conduct spatial analysis of LDS data.
- Create data on hatchlings in areas with water guzzlers.
- Facilitate a comparison between desert tortoise densities and existing road networks.
- Create new, updated demographic models, addressing age, size, sex, etc. and analyze the relationships of age classes to population demographics.
- Compare slides of known diseased animals with previously taken slides, to determine the temporal extent of diseased animals.
- Assemble disease information and map prevalence and occurrence.
- Compile and map raven distribution patterns in order to target areas for action.
- Discover and articulate individual threat impacts to further a comprehensive understanding of their cumulative effects on desert tortoises.

- Assist with an OHV use assessment with GIS and remote sensing techniques.
- Work to determine desert tortoise mortality as related to permitting projects and impacts.
- Create future projections of human populations/demographics and related development expansions in counties and cities.
- Inventory and archive scientific/research documents in a central database and make accessible to a broader public.
- Develop methodologies for multiple studies to evaluate the effectiveness of implementation measures.
- Compile grey literature (i.e. papers of the DTC proceedings, military studies) for general access.
- Create the Cross-Media Database (XMDB)TM.
- Develop a DMG Website with general and accurate information on desert tortoise for general access.
- Develop a centralized method to track, monitor, and display changes in the physical landscape.
- Digitize spatial data.
- Assist in securing copies of scientific studies on behalf of the military.
- Continue to develop metadata standards for desert tortoise related scientific studies.
- Provide recommendations for placement of weather stations at the Mojave National Preserve.
- Compile and map data of threats and habitat for the desert tortoise.
- Assist the NTC Department of Public Works in data standardization, data collection and system integration methods.
- Through a position of neutrality, facilitate collaboration among the desert tortoise research community in the storing, sharing, and dissemination of data.
- Insure the longevity of a central database by creating projects that would provide funding and maintenance for the existing infrastructure.

- Identify a "cheerleader" for the desert tortoise community to encourage researchers to store and archive their data in a central location.
- Through data collection, identify information gaps, define priority information needs, determine and coordinate priority efforts on a regional scale in the context of overall desert tortoise conservation activities.
- Research air pollution and/or compile known sources of air quality data.
- Research pesticides and/or compile known sources of pesticide information and data.
- Measure stored data quality by reliability/probability.
- For organizations such as USFWS, identify and provide access to a current list of desert tortoise projects in order to apply the latest scientific information in the permitting process.
- Compile all available air pollution data to determine how much air pollution has increased in the previous 30 years.
- Assemble disease information and map prevalence and occurrence.
- Create data on hatchlings in areas with water guzzlers.
- Compile management plans of multiple agencies.
- Study feasibility of a Decision Support System for the California deserts.
- Through the Redlands Institute management and information science tracts, use the desert tortoise as a conceptual model and pilot study for implementing a Mojave-wide management system.
- Critically evaluate the mitigation measures implemented to present.
- Promote the interaction of RI DTP with undergraduate students.
- Promote collaboration with Ft. Irwin researchers and outside researchers.
- Enhance collaboration of student interns on external projects.
- Provide financial assistance and academic collaboration for projects.

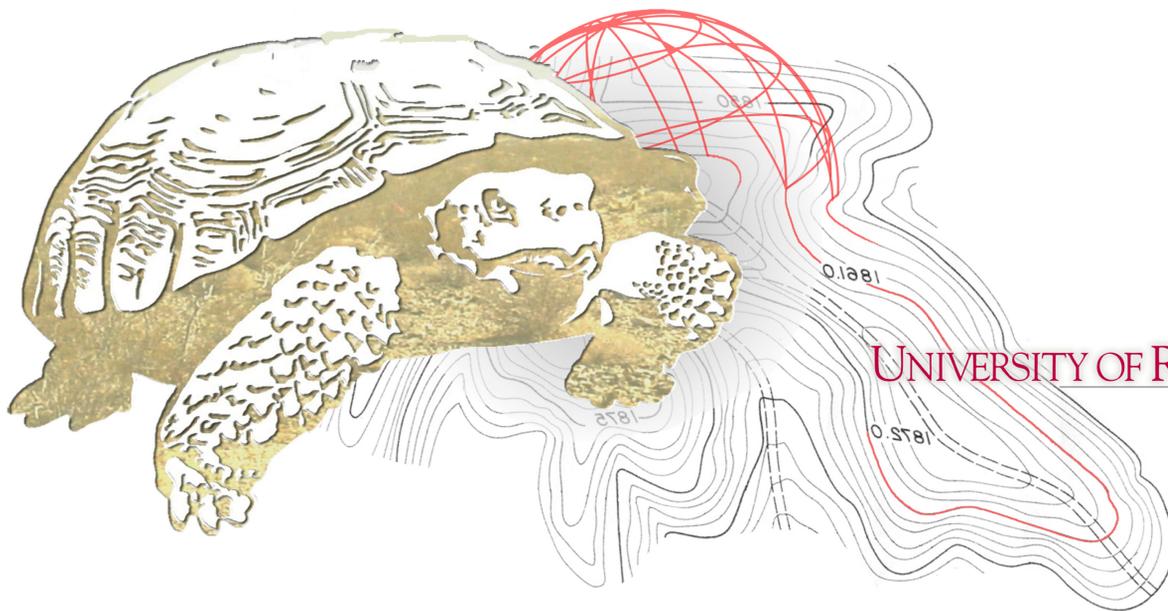


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