DESERT TORTOISE (*GOPHERUS AGASSIZII*) MONITORING
FINAL PROJECT REPORT

PROJECT #2005-USFWS-585A-P
DELIVERABLE D9

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Executive Summary

Several improvements to the 2005 monitoring protocol have been implemented under this project. Some changes have addressed the proposed objectives of increasing precision and developing a mechanism for characterizing the distribution of tortoises in Clark County. This agreement between Clark County and USFWS was not put in place until September 2007, after the 2007 field season. In consequence, the monitoring effort that year had been scaled back due to cost concerns. Rather than using the same resources in 2007 that we had in 2005, the USFWS assigned fewer transects, but did modify one study design element that was not cost-dependent as follows. All transects in each of 4 regions (Figs. 1 and 2) were completed before moving to complete transects in the next region. The 2 regions in Clark County are comprised of 1) Piute-Eldorado stratum with its telemetry site, and 2) the group of strata associated with the Coyote Springs Valley telemetry site: Coyote Springs, Mormon Mesa, Beaver Dam Slope, Gold Butte-Pakoon. The first group also includes three neighboring strata in California. The second group included Mormon Mesa 2 and Beaver Dam Slope 2 in 2008. The previous approach was to complete transects range-wide at random throughout the entire 2-month monitoring period. By confining transects in neighboring areas to a limited period of monitoring (weeks rather than months), the proportion of tortoises above ground was fairly consistent, and the estimate was more precise. Analysis from 2007 and 2008 confirms that we were successful in improving our estimate of the proportion of tortoises above ground and available to be counted. This estimate has been shown to be the most important contributor to density estimates for desert tortoises from 2001 to 2005.

Other improvements, however, are general quality assurance steps that increase confidence in the quality and applicability of the data for answering questions about distribution and abundance of desert tortoises. Training and planning received concentrated attention in 2008, and corresponding improvements were seen in data quality control and in ability to complete transects in hard-to-reach areas (more representative sampling). These important elements of monitoring should continue to be the focus of future quality assurance improvements.

Introduction

Description of the Project

Overview of tortoise monitoring

Projects FWS 585a and UNR 585 resulted in reporting on desert tortoise monitoring in 2007 and 2008. This monitoring is directed at areas where Clark County and federal agency partners are actively directing resources to conserve and recover desert tortoises. Five of these designated areas lie in whole or part within the boundaries of Clark County (Table 1). Because the focus here is not on all public lands in Clark County, but on the tortoise recovery areas in their entirety, this final report covers monitoring activities in entire tortoise conservation areas, not only referring to areas in Clark County.

Figures 1 and 2 show the locations of monitoring strata (tortoise conservation areas) reported under this agreement (585a). Figure 2 and Table 1 also refer to one-year strata (Beaver Dam 2 and Mormon Mesa 2) included in 2008 for a supplemental project with the BLM's Ely district office, and a pair of one-year strata (Pahrump North and Pahrump South) initiated by the USFWS in Nye County. One-year strata are areas where tortoises occur but are not specifically managed to benefit desert tortoises. These areas are therefore not in designated critical habitat.

The actual field season (data collection) occurs during a matter of weeks in the spring, when desert tortoises are most active and visible above-ground or near the mouths of their burrows. Due to the large area monitored and the short time-frame for completing the work, a couple dozen field surveyors must be trained each year. Because the monitoring project in Clark County is part of a larger annual project, training for surveyors in Clark County must be standardized with training for crews in other parts of the range of the desert tortoise. Finally, the project produces a large amount of data, which is verified by field crews before it is submitted and validated independently before creation of spatial and aspatial database products.

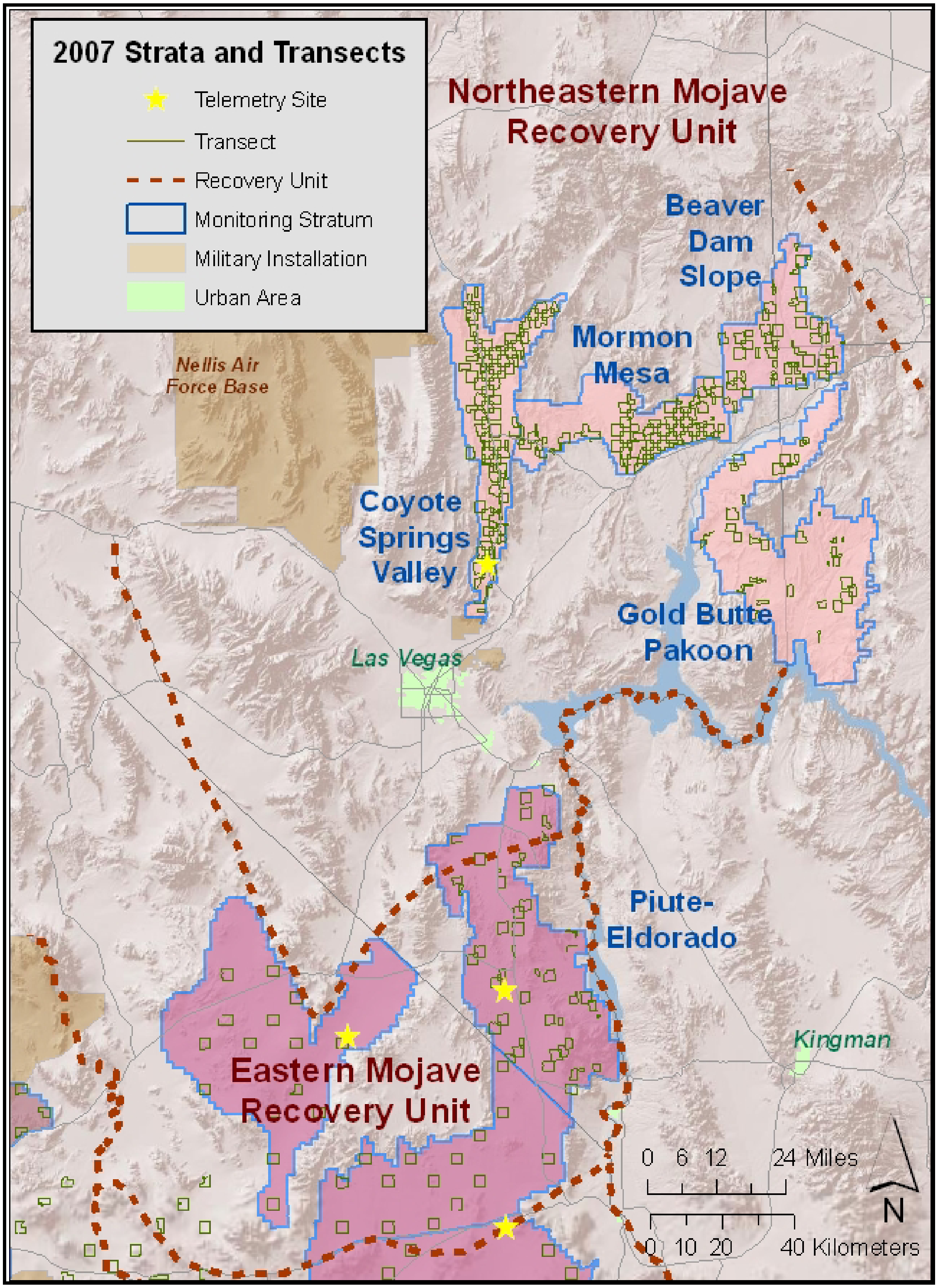

Figure 1. Monitoring strata in and around Clark County in 2007. Color blocks identify groups of strata where transects were completed on the same days. Radio-equipped tortoises at the associated telemetry site(s) were monitored for above-ground activity.

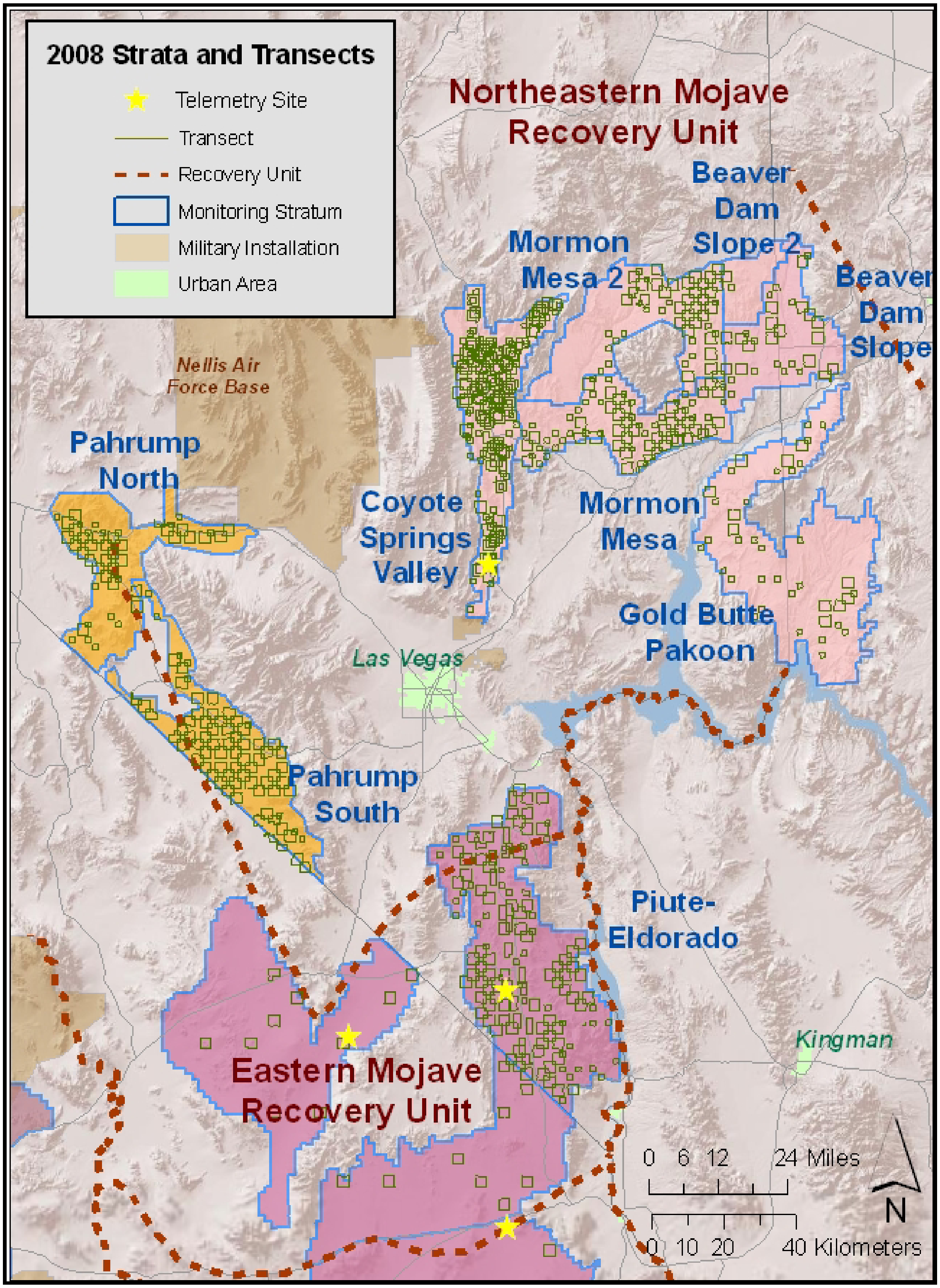

Figure 2. Monitoring strata in and around Clark County in 2008. Color blocks identify groups of strata where transects were completed on the same days. Radio-equipped tortoises at the associated telemetry site(s) were monitored for above-ground activity.

Table 1. Monitoring strata in 2008. Strata associated with Clark County are part of the long-term, range-wide federal monitoring program; 4 other strata were used in 2008 only in Nye and Lincoln counties; these are not part of this agreement. Monitoring strata in 2007 consisted only of the long-term strata listed here.

Recovery Unit	Long-term Monitoring Strata	One-year monitoring strata	County
Northeast Mojave	Beaver Dam Slope (BD)		Clark (partial)
	Coyote Springs (CS)		Clark (partial)
	Gold Butte/Pakoon (GB)		Clark (partial)
	Mormon Mesa (MM)		Clark (partial)
		Beaver Dam Slope 2 (BD2)	Lincoln
		Mormon Mesa 2 (MM2)	Lincoln
Eastern Mojave	Piute-Eldorado (PI)		Clark
		Pahrump North (PN)	Nye
		Pahrump South (PS)	Nye

Relationship of Project FWS 585a to UNR 585

As mentioned above, the comprehensive monitoring project was completed by coordinated efforts of UNR 585 and FWS 585a. The annual cycle for this project requires the following steps, in approximately the order listed in Table 2. "Responsible parties" refer to the lead entity for this element of the project, based on deliverables that were created. The "responsible party" identified in Schedule A of the respective agreements did not always agree between 585 and 585a; so this table is just to provide a point of reference when describing our coordinated work, it is not intended to match either Schedule A. Identifying a single responsible party also belies the fact that successful completion of this project required that UNR and the USFWS and their cooperators/sub-contractors worked closely on most elements. Although the table indicates which parties were responsible for each element, it is of course true that all of the later stages are dependent on how the earlier stages were executed. The grayed rows of the table indicate elements that were completed by the FWS in 2007 although there was no agreement in place with Clark County. Work done by UNR during that period was under agreement with the USFWS, not with Clark County. In this report for FWS 585 and to better understand the final report for UNR 585, however, we do present information from this period. UNR 585 could not have produced density estimates for 2007 unless data collected by the USFWS were provided to UNR in a timely fashion.

Table 2. Basic elements of the desert tortoise monitoring project that contributed to final products for UNR 585 and FWS 585a.

Year	Project element (sequential order)	Responsible party
2007	Survey design	USFWS
	Training	UNR
	Data collection	USFWS
	Quality control (data verification and validation)	USFWS
	Development of final data products	UNR
	Analysis and reporting	UNR
	Tortoise density	UNR
2008	Survey design	USFWS
	Training	UNR
	Data collection	USFWS
	Quality control (data verification and validation)	USFWS
	Development of final data products	UNR
	Analysis and reporting	UNR
	Tortoise density	UNR
	Tortoise distribution	UNR
	Spatial distribution of tortoises and threat indicators	UNR

Background and Need for the Project

Surveying uncommon, cryptic species is not an easy task, and no other efforts have successfully measured tortoise populations at that geographic scale. This project leverages the existing federal range-wide monitoring program for desert tortoises. Monitoring of the desert tortoise poses difficulties due to the large extent of available habitat in tortoise conservation areas associated with Clark County and the limited period of time during which desert tortoises are active near or on the surface and can be counted. The combined effect is that a large number of surveyors must be trained to complete the work quickly, and a resulting large amount of data is generated which must be subjected to quality control and assurance procedures for timely use (USFWS 2006).

The low density of desert tortoises and their inherently slow rate of increase contribute to low precision in density estimates and therefore low power to detect subtle positive or negative population trends (Anderson and Burnham 1996). Consequently, there has been considerable attention and interest in study design improvements to address the precision and costs of tortoise monitoring (Tracy *et al.* 2004, USFWS 2006). These issues impact the range-wide monitoring effort and make surveys even at the relatively smaller scale of Clark County a challenge. Nonetheless, the potential of improvements to allow density estimation in areas the size of a monitoring stratum makes this monitoring program. Anderson and Burnham (1996) also pointed out that the program designed to detect small positive population increases over a long time has much more power (close to 100%) to detect catastrophic declines over 4 years (in their example). Without a regional program in place, the opportunity to respond to such declines would be lost.

The current technique for monitoring desert tortoise population size was vetted and chosen in 1999 by the group of federal and state land managers responsible for recovery of the desert tortoise, the Management Oversight Group (MOG). The MOG is called to meet by the USFWS and in the past year invited county and local governments to participate as full members. The line distance sampling technique has been implemented every since 2001 except in 2006. In 2006, the time was used instead to write up a summary report of the first 5 years of the project, making recommendations for improvements based on the data already collected. The resulting U.S. Fish and Wildlife Service summary (USFWS 2006) describes modifications made each year to increase the number of tortoises surveyed each year, and put forward recommendations that are implemented in both UNR 585 and FWS 585. These projects identify and target elements of monitoring for continual process improvement (for instance, data management, accurate population and distribution estimation). The premise is that improving techniques may be a cost effective alternative to increasing sample size and other costs of the project. This specific project (FWS 585a) implements recommendations to improve the survey design (how transects are distributed and how they are used in conjunction with telemetry data).

Management Actions Addressed

This project will provide the following information essential to a species status report for the desert tortoise:

- Distribution of tortoises within Clark County
- Abundance of tortoises within Clark County

Goals and Objectives of the Project

MSHCP Objectives addressed:
This project will provide the following information essential to a species status report for the Desert Tortoise:

- Distribution of tortoises within Clark County
- Abundance of tortoises within Clark County
- Preliminary description of threat distribution within Clark County"

The Scope of Work (identical for UNR 585 and FWS 585a) sets out the following objectives:

Objective 1: Improve ability to detect changes in Desert Tortoise density.

a. How can study design improve precision of density estimates?

b. Can training be adjusted to increase detection and improve precision of density estimates?

Objective 2: Improve cost effectiveness of the monitoring design.

Can reallocation of samples improve precision of density estimates?

Objective 3: Explore the option of modifying distance sampling procedures as a cost effective way to address recovery criteria for population distribution, habitat quantity and quality, and threat mitigation.

Can distance sampling transects be modified to allow use for describing distribution?
How can information on tortoise density be combined with information on associated habitat and/or threats to tortoises or tortoise habitat?

The above objectives for 585 and the MSHCP objectives as described in the Scope of Work for this project are compatible with those of the range-wide monitoring program. At the federal level, this project is guided by the recovery needs outlined by the USFWS Desert Tortoise Recovery Office (DTRO). The goal of the federal monitoring project is to assure that recovery criteria for the desert tortoise will be addressed in tortoise conservation areas in Clark County, which includes most of the tortoise conservation areas in the "Northeast Mojave Recovery Unit" and part of the area in the "Eastern Mojave Recovery Unit". The current Delisting Criterion 1 states in part that, "As determined by a scientifically credible monitoring plan, the population within a recovery unit must exhibit a statistically significant upward trend or remain stationary for at least 25 years (one desert tortoise generation)… a sampling plan should be instituted in each recovery unit to monitor the progress of recovery" (USFWS 1994). When supplemental information can be collected that is useful for other aspects of desert tortoise recovery, this complementary data collection has also been part of the range-wide monitoring program. For instance, in 2004 and 2005, data were collected to describe tortoise occurrence, but also the occurrence of threats to tortoises along transects. These data are part of the suite examined under UNR 585. In 2007 and 2008, no supplemental data were collected, and the required activities under FWS 585 match directly with those of the range-wide monitoring program.

The goals in the 585 project are:

- Better (less biased, more precise) Desert Tortoise density estimates
- Better (less biased, more precise) description of distribution of Desert Tortoises in Clark County
- Preliminary description of correlations between threat indicators and Desert Tortoise distribution and abundance.

Methods and Materials

Components of the project that can be optimized – quality assurance

The general purpose of the 585 project was to consider more cost effective procedures to achieve more precise estimates than in the first years of desert tortoise monitoring (2001-2005). This type of improvement generally falls under the category of “quality assurance.” These are procedures built into the project that ensure collected data will answer the questions of concern – how many tortoises are there and where are they? Although the Scope of Work for this project mentioned specific approaches to achieving the goals of more precise density estimates and of distribution of tortoises within Clark County, additional improvements to improve precision and distribution information were implemented that were not mentioned in the Scope of Work. Improvements that are not described in the 585 project objectives and therefore described in the following sections are described here (under “Components of the project that can be optimized – quality assurance”) and were implemented for all tasks involved in line distance sampling for 2008.

The pair of projects that have conducted line distance sampling in Clark County for this project (FWS 585a and UNR 585) are built on 1) data management to provide useful and error-free data, 2) training to standardize and improve the quality of data collection, 3) field protocols that assure the most useful data are collected, and 4) coordination of teams with separate tasks or in separate geographic areas.

Data management activities include development of the data collection system. Electronic data systems were redesigned in 2008 to be more user-friendly and to reduce data entry errors. Automated checking systems were also put in place to identify unusual or inconsistent values in specific fields. After collecting data electronically and on paper, field crews recheck these independent records to look for inconsistencies, and check one another’s work. Once data were transmitted to the field team’s data specialists, they identified any remaining inconsistencies in the data; because checks occur on a weekly basis, these errors can often be corrected. Delays in data validation in past years (USFWS 2006) led to data errors that could not be reexamined by the crews that collected them. Not only did data verification and validation occur in “real” time starting in 2007 (when the sister project with UNR was initiated, before this agreement with USFWS was signed), 2007 and 2008 data were the first in the project to finalize data within months of collection. This allows for timely analysis and then distribution of data to land managers including Clark County.

Training has traditionally lasted for one week for experienced crews and up to 3 weeks for inexperienced field crews. However, the written documentation for training from 2001 through 2005 did not identify necessary skills and competencies, so there is no record of consistency in instruction. In fact, the field crews monitoring in California regularly expressed concern that their training was abbreviated and that Nevada field crews received more detailed instruction. In 2008, the USFWS oversaw development of training standards and modules to address each of the specialized tasks for line distance sampling for both experienced and first-year trainees.

As in 2007, transects in 2008 were monitored from approximately April 1 through May 18 during which there were approximately 40 working days. Accounting for lost days due to weather, sickness and other factors, this work required 12 (2007) and 15 (2008) two-person teams to perform the required number of transects in the monitoring strata associated with Clark County (286 transects in 2007 and 383 in 2008). Two other teams used telemetry receivers to monitor radio-equipped tortoises each year. Precision of the density estimate is affected by the number of transects in each stratum of the larger recovery unit. It is also affected by the ability to describe tortoise above-ground activity by tracking a limited number of tortoises and recording their daily activity.

Finally, some quality assurance procedures coordinate products and tasks between various teams, each of which contribute part of the monitoring project. For instance, instruction by trainers should minimize data collection errors that affect data quality, and data collection systems should likewise be designed by database specialists to minimize data entry mistakes.

<u>Objective 1a: Improving study design to improve precision of density estimates</u>

Protocols were evaluated using data from the 2001 to 2005 survey years. Current and conventional monitoring techniques can only detect “active” tortoises or tortoises visible in burrows. While transect teams search for tortoises, additional teams monitor radio transmitter-equipped tortoises, “focal animals,” to determine tortoise activity. This measure allows the density estimate to be calibrated for variations in tortoise activity levels. From 2001 through 2005, a sample of 10-20 tortoises were equipped and monitored in each of several locations throughout the range of the desert tortoise. Monitoring tortoise activity through focal tortoises is expensive and time consuming, so UNR 585 has been exploring the cost effectiveness of modeling tortoise availability instead of measuring it directly (see UNR 585 Deliverable 9, Preliminary Predictive Desert Tortoise Activity Model). These modeling efforts were developed for one area (Piute Valley telemetry site), so it is not yet clear what level of effort would be needed to accurately model tortoise visibility in other parts of the range. However, because local conditions strongly influence tortoise activity, for the immediate future, the program will instead focus on developing new telemetry sites to better describe local conditions.

The 2001-2005 data indicated that much of the precision in density estimates is lost from estimating G_0, and much of the variability (imprecision) in G_0 is due to the range of activity of tortoises at each site over the 2 months of monitoring (USFWS 2008b). For 2007 and 2008, the FWS instituted a change in the monitoring protocol so that all transects in a G_0 area would be completed in a short a time frame as possible. The goal was to reduce the variability in measured tortoise activity, and thereby improve precision of the density estimate.

Other changes to the monitoring protocol address the need to sample for tortoises across all habitat types. Before 2007, per the approved protocol planners and field crews routinely moved transects into flatter nearby terrain. This limits the applicability of density estimates so that only densities in flat areas are estimated. In 2008, crews were trained to walk half-length (6km) transects in rugged terrain. Shorter transects allowed crews to maintain their own safety as well as completing sampling during the period of tortoise activity each day. Some planned transects were still in impassible terrain, and their relative number will be used to assess the proportion of such terrain in each monitoring stratum.

<u>Objective 1b: Adjust training to increase detection and improve precision of density estimates</u>

This project was also developed to assist in training for range-wide Desert Tortoise monitoring. Training improves the quality of the monitoring data. For example, evaluations of the performance of tortoise monitors, both returning and first-year, over several years indicates that there is an initial period of improving tortoise locating efficiency that can last up to three weeks (USFWS 2006). In the past, experienced monitors were trained for only one week and first-year observers for up to three weeks. Training generally involves attendance at seminars, learning handling and search images for tortoises in the desert, developing the specialized search method by training with tortoise models, and practicing transects to integrate all portions of the daily protocol. Development of training for monitors range-wide ensures that monitoring efforts in Clark County are consistent with those throughout the rest of the tortoise's range and that these efforts conform to USFWS Desert Tortoise monitoring protocols.

We believe that longer and more intensive training as well as more intensive assessment and feedback to tortoise monitors is warranted. Although this portion of the project was funded through the UNR sister agreement, the USFWS was heavily involved in training improvements in 2008, which included 1) identifying the full set of specialized tasks that require proficiency to apply line distance sampling, 2) setting objectives for trainees so they and the trainers can determine when the trainee has achieved appropriate competency, 3) developing a comprehensive training manual, and 4) assessing field crews as they practice integration of all of these skill sets.

<u>Objective 2: Reallocation of samples to improve precision of density estimates</u>

The first priority of planning for each field season is to determine the location and number of transects in the tortoise sampling effort. To evaluate long-term trends, desert tortoise monitoring must have a minimum of bias (so the trend estimates are accurate and representative of the recovery unit) and should maximize precision (so that trends can be distinguished from background variability in population counts). For mid- and short-term purposes, tortoise monitoring should adequately cover areas that reflect management and/or land use units. Part of our strategy has been to optimize the distribution of sample transects within recovery units, management, and land use areas.

The inherently low density of tortoises has also been associated with low precision and power to detect long-term population trends (USFWS 2006). One way to improve precision is to increase sample size (transect length or number). A less costly alternative would use transect placement to increase precision. Density and associated variance estimates from the 2001 to 2005 field seasons were used to compare alternative sampling designs for improved precision. One technique to improve precision uses habitat classifications; there should be less variability (more precision) in population density within areas of similar habitat. In 2008, we separated transects depending on whether they occurred in low- or high-relief terrain. As it becomes available, more detailed habitat information will be considered for strata development; we expect the strata to be refined further in later years. This would have the effect of improving precision, but the density estimates will still be comparable year-to-year (no bias will be introduced). Also, the original tortoise monitoring proposal (Anderson and Burnham 1996) proposed that transects should be laid out systematically with a random start point and should be sampled each year. This design was not adopted in 2001, but was adopted under starting in 2007. The effect is to assure that all areas are sampled, but transects are still placed at random with respect to tortoise locations. Moreover, by using the same set of possible transects each year, field crews can benefit from transect descriptions written in previous years. Starting in 2007, crews described how they accessed each transect and any diversions they had to make on the transect.

Note that there are other cost savings that have resulted from project changes this year. Although it was not directly proposed for this project, centralized and standardized data management has emerged as a task that is essential to, and should be coordinated with, the monitoring program that systematically seeks to identify monitoring/research needs, generate hypotheses, design studies, collect data, conduct analyses and report findings. Translating the scientific method into on-the-ground monitoring requires the following activities: planning, training, data collection, data management, analysis and reporting. Each activity is important and supports the other activities, so the efficiency of each step and the effectiveness of its products for subsequent activities greatly affect the entire monitoring project. A draft data management plan was developed before the 2008 field season to guide assignment of specific roles and responsibilities to contractors that collect, verify, validate, and finalize the range-wide dataset. In past years, this data management plan was written after the field season to document activities; finalizing this annual plan well ahead of the field season will be a goal for future years.

Objective 3: Estimating distribution and abundance under the same monitoring project

This objective was addressed by means of spatial analyses as part of UNR's 585 project. See UNR 585 Deliverable 8, Preliminary Assessment of Distribution of Threat Indicators and Tortoises.

Results and Evidence of the Results

The subheadings below correspond to those in "Methods and Materials," above.

Note that whereas UNR was tasked with providing field crew training in 2008 and with data analysis for both 2007 and 2008, the focus of the USFWS effort is with data design and collection for field season 2008. Deliverable 5b (2008 Field Season Summary Report) therefore provides much detail on how USFWS addressed these goals in 2008, and is important supplementary material for this final report. Although FWS 585a did not cover the actual data collection in 2007, Deliverable 5a (2007 Field Season Summary Report) includes the preliminary assessment by the USFWS of program elements to target for improvement in 2008. The 2007 range-wide monitoring report (including areas described for this project) is available in draft form as USFWS (2008b). Although the analysis portion of this project was completed under the UNR half of the project, this draft report contains alternatives to the same analyses, plus others that will be referenced in the text below. Table 3 reports density estimates in each of the Nevada monitoring strata in 2007 (typos corrected from USFWS 2008b). It is not a surprise that densities overall in the Northeastern Mojave (1.9 tortoises per square kilometer) are lower than in the Eastern Mojave. Within the Northeastern Mojave, tortoises are found at higher densities in Mormon Mesa. This number (and any available information from 2008) will be taken into account when allocating transects in 2010 to optimize precision of the density estimate.

Table 3. Density estimates from 2007 for monitoring strata in the Northeastern and Eastern Mojave recovery units. Two of the three strata in the Eastern Mojave Recovery Unit (Fenner and Ivanpah) are

entirely in California and are not otherwise part of this report. Their density estimates are provided for completeness with estimates for Piute-Eldorado.

Monitoring Stratum		Area (km^2)	Transect Total Length (km)	Number of tortoises (n)	Density (tortoises per km^2	% CV (Density)	Density 95% Confidence Interval Lower Limit	Upper Limit
Northeast Mojave		**4917**	**2316.1**	**46**	**1.7**	**25.0**	**1.04**	**2.73**
Beaver Dam Slope	BD	828	478	6	1.2	0.53	0.63	2.31
Coyote Springs	CS	1144	917.9	14	1.4	0.35	1.01	2.00
Gold Butte Pakoon	GB	1977	299.7	4	1.2	0.48	0.71	2.17
Mormon Mesa	MM	968	620.5	22	3.3	0.31	1.79	6.13
Eastern Mojave		**6681**	**803.9**	**34**	**5.8**	**25.0**	**3.56**	**9.34**
Fenner	FE	1862	178.2	10	6.6	0.39	1.27	34.30
Ivanpah	IV	2567	180.1	4	6.5	0.36	1.58	26.86
Piute Eldorado	PI	2252	445.6	20	4.2	0.36	1.54	11.58

The 2008 analysis is also contracted under the UNR 585, so that will not be discussed here, and is not yet available as a draft USFWS range-wide monitoring report. This final report concentrates on study design changes implemented by the USFWS and on any range-wide analysis information that has been developed at this point for the range-wide monitoring reports.

Components of the project that can be optimized – quality assurance

Data management

Before this project began, data were not finalized on an annual basis; all years from 2001 through 2005 were completed in 2006 (USFWS 2006). In 2007, annual data processing was implemented (M3 in 2007 and M12 in 2008: Complete QAQC). In 2007, we also initiated post-season debriefings to collect information from contractors with various tasks. The data management system, which had been in development since 2004, was surprisingly found to be difficult to use and prone to error generation (D5a 2007 Field Season Summary Report). While the data management shortfalls resulted in extra effort required, the debriefing served its quality assurance function, and an overhaul of the data systems were implemented in time for 2008. In 2008, the most error-free data were collected since the start of the program (Deliverable 5b: 2008 Field Season Summary Report).

Training

Training itself is part of quality assurance – a procedure that is designed to ensure usable data. No new approaches were suggested for 2007, and the field season debriefing (Deliverable 5a 2007 Field Season Summary Report) described improvements that were needed for 2008. Training was identified as a needed focus for improvement of the entire project. The lack of written materials made it difficult for trainers cover all material in a series of separate presentations. The experienced crew members felt that they should have more coordinated guidance, rather than assuming they were prepared with little practice. By 2008, a new manual was developed (USFWS 2008a, Milestone 6:2008 Training Manual and lesson plans finalized), packaged into modules with clearly stated objectives and metrics that would be used to assess crew competency. Although training was a task under the UNR sister agreement, the USFWS was heavily involved in rebuilding training for 2008. The debriefing for 2008 (Deliverable 5b) and consistent application of protocols range-wide indicated that the training improvements had a significant impact.

Field data collection

Beginning in 2007, but more formally in 2008, weekly data deliveries by field teams were used to summarize transect start times, end times, completion times, lengths, and to describe the match between transect data collection and tortoise activity periods. Progress toward completion of the number of planned transects was also described. These summaries were used to give crews weekly feedback to improve performance. This was also an opportunity to provide feedback on data errors that were found. The goal was to reduce data errors and repair existing errors in a timely fashion. These reports were drafted by our UNR cooperators, then additional materials were added by USFWS before we submitted them to Great Basin Institute (GBI), the group providing data collection in Clark County.

Objective 1a: Improving study design to improve precision of density estimates

The 2001-2005 data indicated that much of the precision in density estimates is lost from estimating G_0, and much of the variability (imprecision) in G_0 is due to the range of activity of tortoises at each site over the 2 months of monitoring. For 2007 and 2008, the FWS implemented a change in the monitoring protocol so that all transects in a G_0 area would be completed in a short a time frame as possible. The goal was to reduce the variability in tortoise activity, and thereby improve precision of the density estimate. This was a convenient and effective target for improvement in 2007 and 2008, because the USFWS was working with a limited budget for the 2007 field season before this agreement was in place. This study design improvement could be implemented without additional cost. Table 4 shows that the number of days of monitoring in each recovery unit was decreased in 2007 and 2008, and the standard deviation of the G_0 estimate also decreased. This is a measure of improved precision.

Table 4. Standard deviation of G_0 for each recovery unit in 2005 and under the new study design in 2007 and 2008. The large standard deviation in 2005 contributed 60% of the variance in the density estimates that year, so it was the target of improvements in 2007 and 2008.

Recovery Unit	2005	2007	2008	Days*
Eastern Colorado	0.16	0.05	0.07	5
Eastern Mojave	0.16	0.13	0.07	12
Northeastern Mojave	0.21	0.12	0.13	37
Northern Colorado	0.20	0.10	0.37	3
Western Mojave	0.10	0.13	0.13	12

* In 2005, all recovery units were completed over the full 52 days of the field season. The last column in this table indicates days of completion in 2007 and 2008 under the new study design.

Other changes to the monitoring protocol address the need to sample for tortoises across all habitat types. Before 2007, planners and field crews routinely moved transects into flatter nearby terrain (Fig. 3). This limits the applicability of density estimates so that only densities in flat areas are estimated. In 2007, crews were not permitted to move transects, but often could not finish them in rugged terrain or when access could not be identified (Figs. 4 and 5). Access issues are specifically noted in Fig. 3, relating to the Mormon Mesa stratum. In this case, routes were closed in some places where they crossed private lands as well as on public lands where the Union Pacific Railroad controlled access in Meadow Valley Wash. Also as indicated in Figs 3-4, several transects were not initiated, but there was not a mechanism in place to collect information on unsuitability of particular transects. (Note, however, that many of the “planned” transects in Figs 4 and 5 were alternates, not intended to be used unless an assigned transect could not be walked.) For those unwalked transects that were in dangerous terrain, potentially no solution exists. However, access routes were also difficult to identify for many transects, and that is a protocol issue that can be addressed.

In 2008, we began tracking the fate of all assigned transects (Fig. 6) Transects that were shortened to 6km would presumably not have been walked in years before 2008, or would have been moved to different terrain. Assigned but unwalked transects were replaced from a set of alternates in 2008, but represent planning opportunities for future years. These transects were either inaccessible by nearby roads or were deemed too rugged to complete. As noted above, the former problem (accessibility) may be overcome in future years with further planning. Comparison of Figs 3 and 5 indicates that many access issues were solved in 2008 for transects in western Mormon Mesa that had not been walked in previous years.

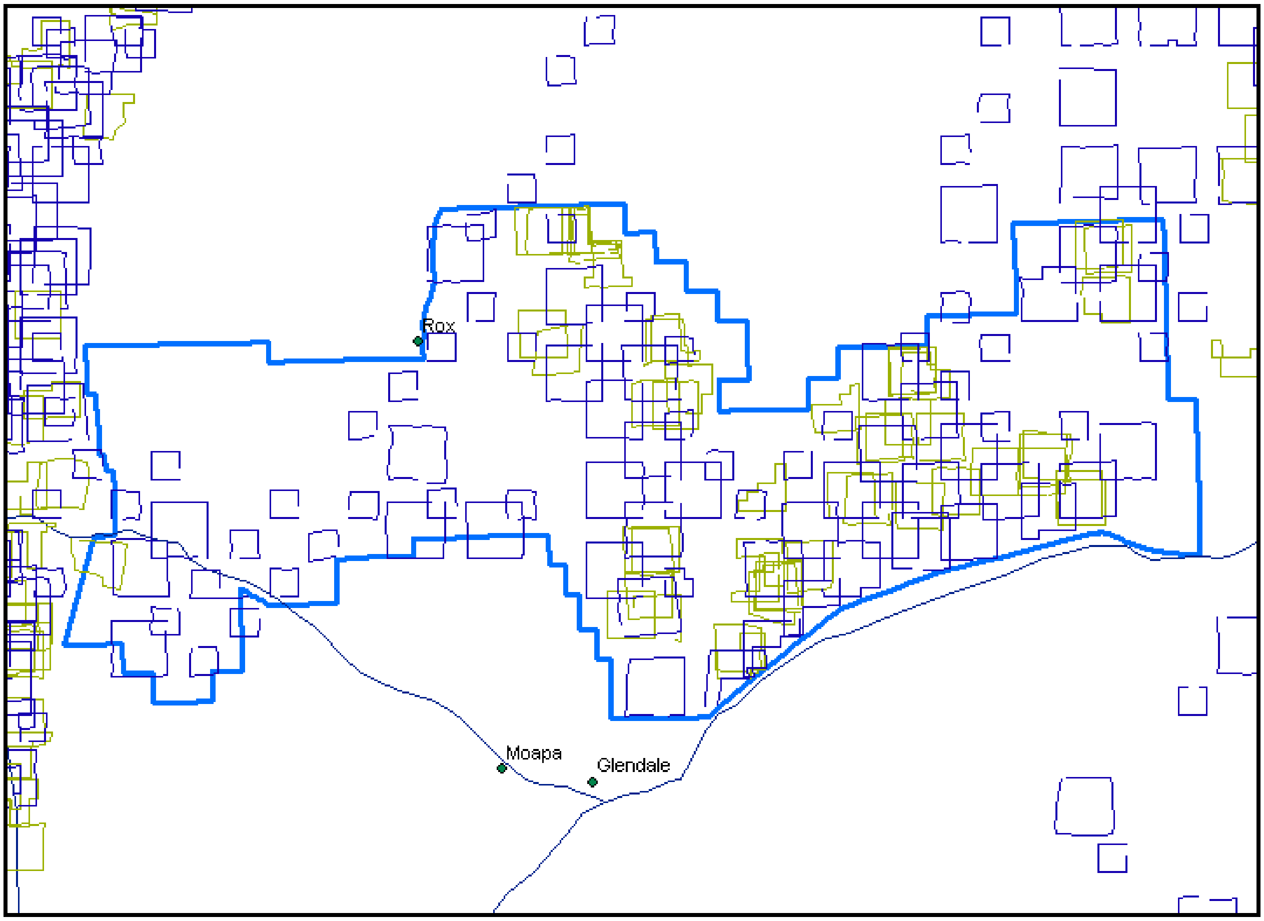

Figure 3. Transects walked in 2004 (green squares) and in 2008 (purple squares) to estimate tortoise density in Mormon Mesa monitoring stratum (thick blue outline). Note that starting in 2004 densities were to be applied to the entire area of each monitoring stratum, but the effective area was actually smaller because transects were frequently “slid” into more accessible and/or attractive terrain. This is seen in the 2004 transect pattern in the western part of the stratum. Lack of transects in the western part of the monitoring stratum in 2008 (and probably in 2004) reflects lack of route access. By 2008, advanced planning of routes as well as rules for modifying transects correctly in rugged terrain resulted in better coverage of the entire stratum.

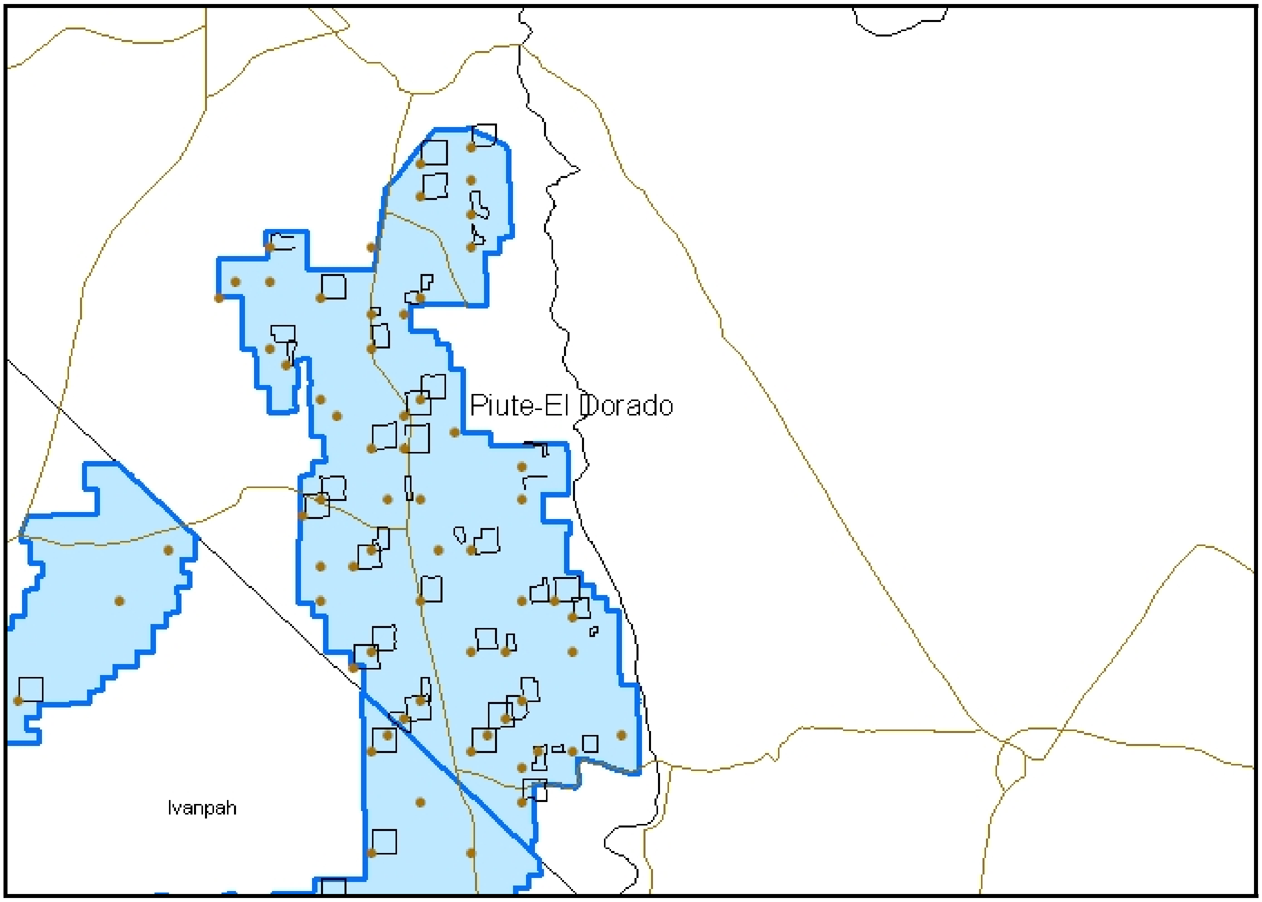

Figure 4. Planned and completed transects in the Piute-Eldorado monitoring stratum in 2007. Brown dots mark the southwest corner of planned transects including about 20% as alternates. Black lines indicate completed transects. Transects in safe terrain should be 12km squares; however, crews were instructed to use various modifications to complete as many kilometers of a transect as possible in rugged terrain. Some assigned transects were too rugged to initiate or access routes were not found.

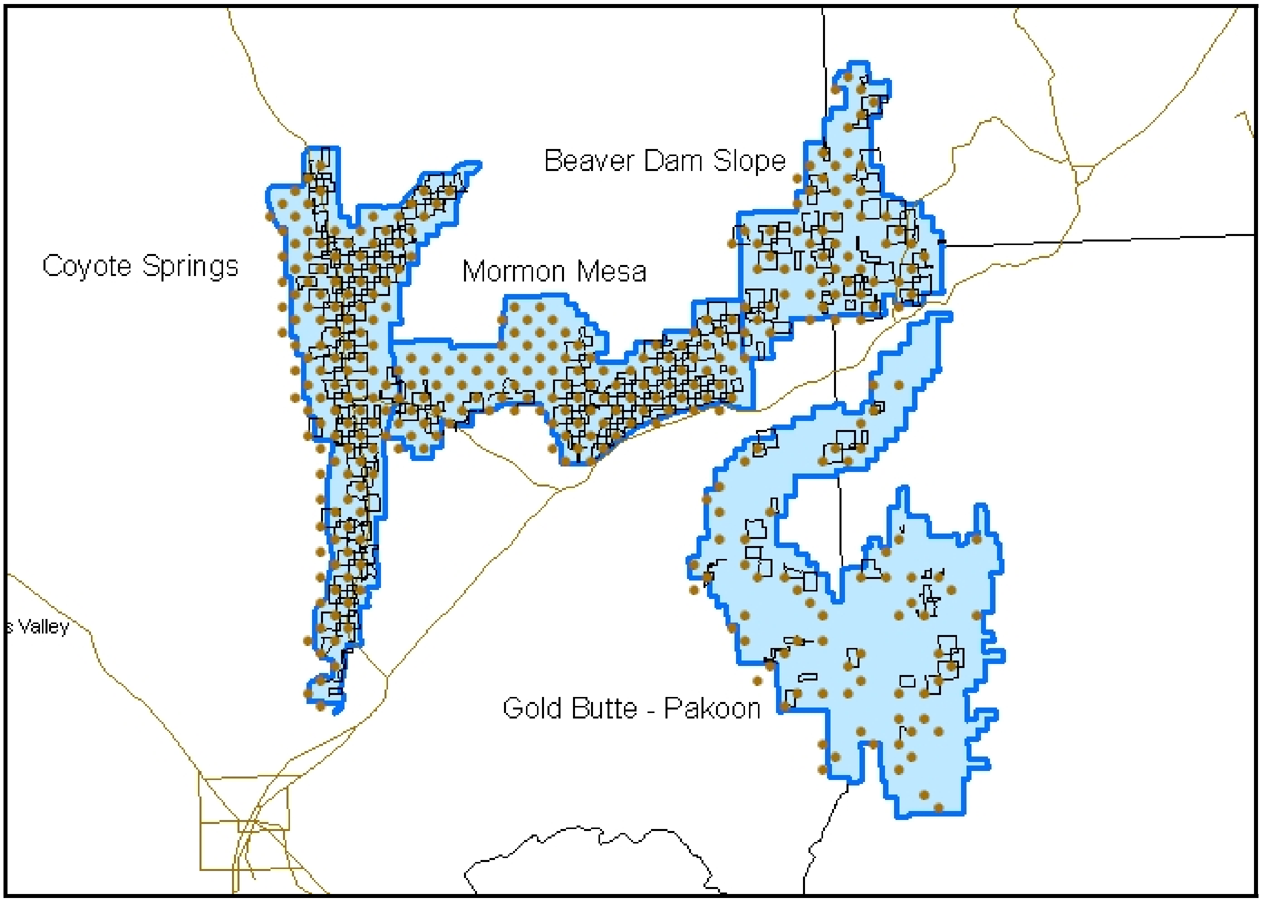

Figure 5. Planned and completed transects in the Coyote Springs, Mormon Mess, Beaver Dam Slope, and Gold Butte-Pakoon monitoring strata in 2007. Brown dots mark the southwest corner of planned transects including about 20% as alternates. Black lines indicate completed transects. Transects in safe terrain should be 12km squares; however, crews were instructed to use various modifications to complete as many kilometers of a transect as possible in rugged terrain. Some assigned transects were too rugged to initiate or access routes were not found.

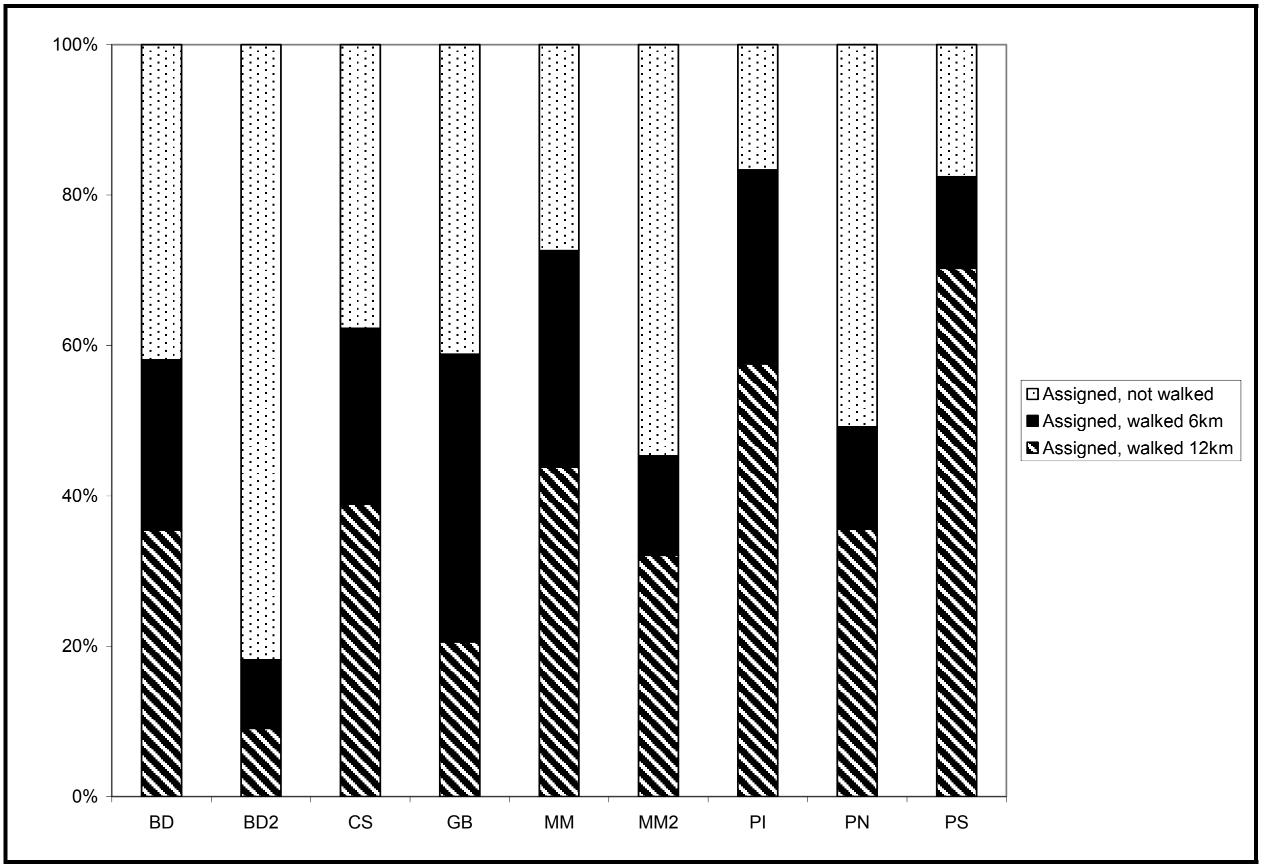

Figure 6. Completion of transects in monitoring strata in Clark County (BD, CS, GB, MM, PI) and other areas of Nevada (BD2, MM2, PN, and PS) in 2008. If transects were assigned but not walked, alternates were selected. Strata abbreviations are given in Table 1, and locations are mapped in Figure 1.

<u>Objective 1b: Adjust training to increase detection and improve precision of density estimates</u>

In 2005 and 2007, approximately half of the field crews were returning after at least a year of experience. In 2008, there were only a few returnees, and no crews were pairs of experienced tortoise monitors. Nonetheless, during the debriefing at the end of the field season, QAQC teams noted that this had been the “cleanest” set of delivered data since the project began. This was attributed to development of matching paper and electronic data forms, to training of crews on how to fill in data forms, and to extended training of the QAQC specialists for each field team. This improvement does not directly relate to precision of estimates, but does reflect overall quality improvements that were achieved through targeted training.

<u>Objective 2: Reallocation of samples to improve precision of density estimates</u>

Figs. 1 and 2 show where monitoring strata were located in and around Clark County in 2007 and 2008, respectively. Transects (black lines) were completed in each stratum, and density estimates were adjusted based on tortoise above-ground activity measured at each of the focal (starred) sites. Monitoring strata of the same color are completed during the same days, when radio-equipped tortoises are followed at the closest focal site.

The first priority of planning for each field season is to determine the location and number of transects in the tortoise sampling effort. To evaluate long-term trends, desert tortoise monitoring must have a minimum of bias (so the trend estimates are accurate and representative of the recovery unit) and should maximize precision (so that trends can be distinguished from background variability in population counts). Part of our strategy has been to optimize the distribution of sample transects within recovery units and between monitoring strata.

In 2005, transects were allocated by area of stratum (Table 5). The resulting coefficient of variation (CV) was quite large, indicating low precision. Based on recommendations in Buckland et al. (2001), we reallocated transects in 2007 so that all areas had transects but more were allocated to strata with higher densities of tortoises. We targeted a CV of 28%. Although we were not able to complete all planned transects in 2007, we achieved slightly better-than-expected results. In 2008, we allocated approximately the same number of transects as in 2005, but targeted a CV of 21%. Until the analysis is completed later in 2009, we will not have information on the actual CV. Note that 80 transects are shown in Coyote Springs in Figure 2 that are not counted in Table 5. These are transects paid for through projects outside Clark County. The goal of the project for Clark County is to optimize results for the same resources (Table 5), but the additional transects in Figure 2 will provide supplemental information.

Table 5. Count of walked transects in each stratum and associated measures of precision in the Northeastern and Eastern Mojave recovery units. Note that the number completed may have deviated from the number planned in 2007 and 2008.

Year		2005	2007	2008
Target Precision (%CV for Northeast Mojave Recovery Unit)		No target	28.0	21.0
Actual Precision (%CV for Northeast Mojave Recovery Unit)		32.2	26.5	No estimate yet
Recovery Unit	Monitoring Stratum			
Northeast Mojave	Beaver Dam Slope (BD)	50	53	32
	Coyote Springs (CS)	26	88	83*
	Gold Butte/Pakoon (GB)	64	37	40
	Mormon Mesa (MM)	47	62	74
	Lake Mead NRA North	20	0	0
Eastern Mojave	Piute-Eldorado (PI)	80	46	134
Total		287	286	363

* An additional 80 transects in CS were added (163 total) for 2 projects that were funded separately.

Note that there are other cost savings that have resulted from project changes this year. Although it was not directly proposed for this project, centralized and standardized data management has emerged as a task that is essential to, and should be coordinated with, the monitoring/research program that systematically seeks to identify monitoring/research needs, generate hypotheses, design studies, collect data, conduct analyses and report findings. In order to reduce data collection errors and to focus on quality assurance for the goals of this project, the list of data approved for collection through range-wide monitoring has been scaled back to include only data directly relevant to line distance sampling (the basis for monitoring) as well as very basic information on tortoises encountered (sex, length, mass, location).

Another change has been implemented so that exactly the transects that are randomly assigned are the ones that are walked. If a transect is inaccessible, an alternate list of transects is used from which to select a replacement. In addition, regional biologists for Bureau of Land Management (BLM) in Las Vegas and Caliente worked with pre-season hires for the field crew to identify areas of interrupted road access and to develop alternate routes.

<u>Objective 3: Estimating distribution and abundance under the same monitoring project</u>

Although line distance sampling does not require collecting spatial information (GPS locations) on each tortoise encountered, these data have routinely been collected over the period of this project. These spatial data were used under UNR 585 to model to co-occurrence of tortoises with threats such as roads. This represents an important use of supplemental data that can readily be collected while walking transects for distance sampling.

Evaluation/Discussion of Results

The data examined for the USFWS draft report and reported here make it clear that targets for improving precision of density estimates have been successful. To date, this includes optimizing precision of density estimates for each recovery unit (CV, Table 5) and of the proportion of tortoises available to count (G_0, Table 4).

Regarding description of the distribution of tortoises in Clark County, those efforts have resulted in a reporting deliverable from our cooperator (UNR deliverable D8). The USFWS was part of the review process for that report. Separate from this project, the USFWS has also initiated a project to include future data and consider how to best describe distribution of tortoises range-wide (including description of local extirpation and/or recolonization). Any progress on that sort of study design would be made available in the future.

Conclusion

Several improvements to the 2005 (and earlier) monitoring protocol have been implemented under this project. Some changes have addressed the proposed objectives of increasing precision and developing a mechanism for characterizing the distribution of tortoises in Clark County. Other improvements, however, are general quality assurance steps that increase confidence in the quality and applicability of the data for answering questions about distribution and abundance of desert tortoises. These improvements should continue to be the focus of attention. Development of quality assurance procedures for long-term projects is relatively new field, posing challenges that do not exist for short-term research. Long-term projects require much more documentation and quality control so that the project is not dependent on institutional knowledge; it is not expected that the same staffing will be in place over the life of the project. This requirement is consistent with the needs of monitoring projects that cover large geographical areas, especially when different management goals exist across the area. A well-developed quality assurance program can allow data collection that addresses the reporting needs of Clark County as well as various Department of Defense installations in California (for instance) while providing the benefits of a well-inspected and continuously overseen program.

Recommendations

Training

Training has traditionally lasted for one week for experienced crews and up to 3 weeks for inexperienced field crews. Rarely did these groups work together. In 2008, the FWS oversaw development of training standards and modules to address each of the specialized tasks for line distance sampling. This training was largely successful. Although the data collection system and targeted training to use it were credited with a significant reduction in data errors, it is recommended that an additional training module be created to train crews on how to verify their own data, and to alert them to checks that will be done later in the process. Also, despite the intention to use experienced crews in 2008 to train inexperienced ones, there were few returning field workers. This integration of returning and new field crews should be emphasized in the future.

Study design

Benefits of limiting the number of days of transects in a given recovery unit were clear in Clark County and other parts of the range. However, the increased precision in Clark County was limited, perhaps due to the fact that there is only one focal site for the majority of transects in the county. Activity at that site was monitored for 37 days in 2008, and it is not surprising that activity was still quite variable over such a long period of the spring. This is still a compressed schedule from 2005, when transects in the Northeastern Mojave were completed in 52 days, and there has been some reduction in variance since the new schedule was implemented in 2007. In 2009, we made use of a second focal site. This should allow for 2 analysis areas, each completed in 20 days or so. Because this second site is part of an independent research project, it is expected that further precision will result without extra cost to the monitoring program.

Field data collection

Through 2008, data have been collected on transects that were walked. No documentation has been provided for transects that were not walked, identifying whether these were inaccessible, in dangerous terrain, for example. This leaves a gap in planning information for subsequent field seasons, as the former issue can often be addressed, while the latter can sometimes be addressed with special protocols. Future data collection should provide explanatory information on transects that were not walked.

Literature Cited

Anderson, D.R. and K.P. Burnham. 1996. A monitoring program for the Desert Tortoise Colorado Cooperative Fish and Wildlife Research unit, Colorado State University, Fort Collins, CO. 15pp.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford Univ. Press, Oxford. 432 pp.

Tracy, C.R., R. Averill−Murray, W. Boarman, D. Delehanty, J. Heaton, E. McCoy, D. Morafka, K, Nussear, B. Hagerty, P. Medica. 2004. Desert Tortoise Recovery Plan Assessment. U. S. Fish and Wildlife Service.

[USFWS] U.S. Fish and Wildlife Service. 1994. Desert Tortoise (Mojave population) Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 73 pages plus appendices.

[USFWS] U.S. Fish and Wildlife Service. 2006. Range-wide Monitoring of the Mojave Population of the Desert Tortoise: 2001-2005 Summary Report. Report by the Desert Tortoise Recovery Office, U.S. Fish and Wildlife Service, Reno, Nevada. Online at: www.fws.gov/nevada/desert_tortoise/reports.

[USFWS] U.S. Fish and Wildlife Service. 2008a. 2008 Desert Tortoise Population Monitoring Handbook. Desert Tortoise Recovery Office, U.S. Fish and Wildlife Service, Reno, Nevada.

[USFWS] U.S. Fish and Wildlife Service. 2008b. DRAFT Range-wide Monitoring of the Mojave Population of the Desert Tortoise: 2007 Annual Report. Report by the Desert Tortoise Recovery Office, U.S. Fish and Wildlife Service, Reno, Nevada. Online at: www.fws.gov/nevada/desert_tortoise/reports.