DESERT TORTOISE (*GOPHERUS AGASSIZII*) MONITORING 2009
FINAL PROJECT REPORT

Project #2007-USFWS-785
Deliverable D21

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Executive Summary

As in most of the previous years of the range-wide monitoring project, several improvements were implemented to the data collection protocol in 2007 and 2008. In 2009, these sampling protocols were unchanged from 2008; however, substantial improvements were made in training for field monitors and in pre-season quality assurance measures. Both the training and quality assurance measures were directed at reducing variability between the many field crews so that data collection and reporting would be as standardized as possible. In addition, for the first time, data on transect completion were reported during each week of the field season. Because the potential pool of transects each year is the same, this information on obstacles to completing transects is useful for reporting this year but also for planning purposes in any future years when a given transect is resampled.

Range-wide, all transects in each of 5 regions were completed before moving to complete transects in the next region. The 3 regions in Clark County (Fig. 1) are comprised of 1) Piute-Eldorado stratum with its telemetry site, 2) Coyote Springs Valley telemetry site: Coyote Springs stratum with its telemetry site, and 3) the group of strata associated with the new Halfway Wash telemetry site: Mormon Mesa, Beaver Dam Slope, Gold Butte-Pakoon. The first group also includes three neighboring strata and their two associated telemetry sites in California. The third group included Mormon Mesa 2 and Beaver Dam Slope 2 strata in 2009; these are not part of the long-term monitoring strata, but were sampled as part of a separate project with separate funding.

Before 2007, the approach was to complete transects range-wide at random throughout the entire 2-month monitoring period. By completing all transects in neighboring areas during a limited period of monitoring (weeks rather than months), the proportion of tortoises above ground was fairly consistent, and the estimate was more precise. Comparing our estimates from 2005 with those since the new approach was implemented in 2007 shows that visibility estimates are more accurate when estimated over a shorter rather than longer time; however, only mild improvement was seen in precision of this estimate. This estimate has been shown to be the most important contributor to density estimates for desert tortoises from 2001 to 2005.

The new improvements this year, 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 2009, and corresponding improvements were seen in performance of first-year trainees compared to experienced ones, in data quality control, and in ability to complete transects in hard-to-reach areas (more representative sampling). The last two elements of monitoring should continue to be the focus of future quality assurance improvements.

Introduction

Description of the Project

Project FWS785 resulted in reporting on desert tortoise densities in 2009 (see *FWS785 Final 2009 Density Analysis_Deliverable20*). 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, analyses in this report will document monitoring activities in entire tortoise conservation areas, not only referring to areas in Clark County. Table 1 serves as a reference for strata that are part of FWS785 specifically.

Figure 1 show the locations of monitoring strata (tortoise conservation areas) reported under this agreement (FWS785). The figure and Table 1 also refer to strata (Beaver Dam 2 and Mormon Mesa 2) included in 2009 (and previously in 2009) for a supplemental project with the BLM's Ely district office. These strata are areas where tortoises occur but are not specifically managed to benefit desert tortoises. These areas are therefore not in designated critical habitat and are not monitored in other years. In addition, 60 transects in the long-term Coyote Springs Valley stratum were funded through a separate source.

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, dozens of field surveyors must be trained just before the field season 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, validated independently, and converted into final spatial and aspatial database products.

Table 1. Monitoring strata in Clark County, 2009.

Strata associated with Clark County are part of the long-term, range-wide federal monitoring program; 2 other strata were used in 2009 only in 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
Northeastern 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

<u>Background and Need for the Project</u>

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 2009).

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 2009b). Anderson and Burnham (1996) also worked up examples to illustrate how 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. Without a regional program in place, the opportunity to respond to such declines would be lost.

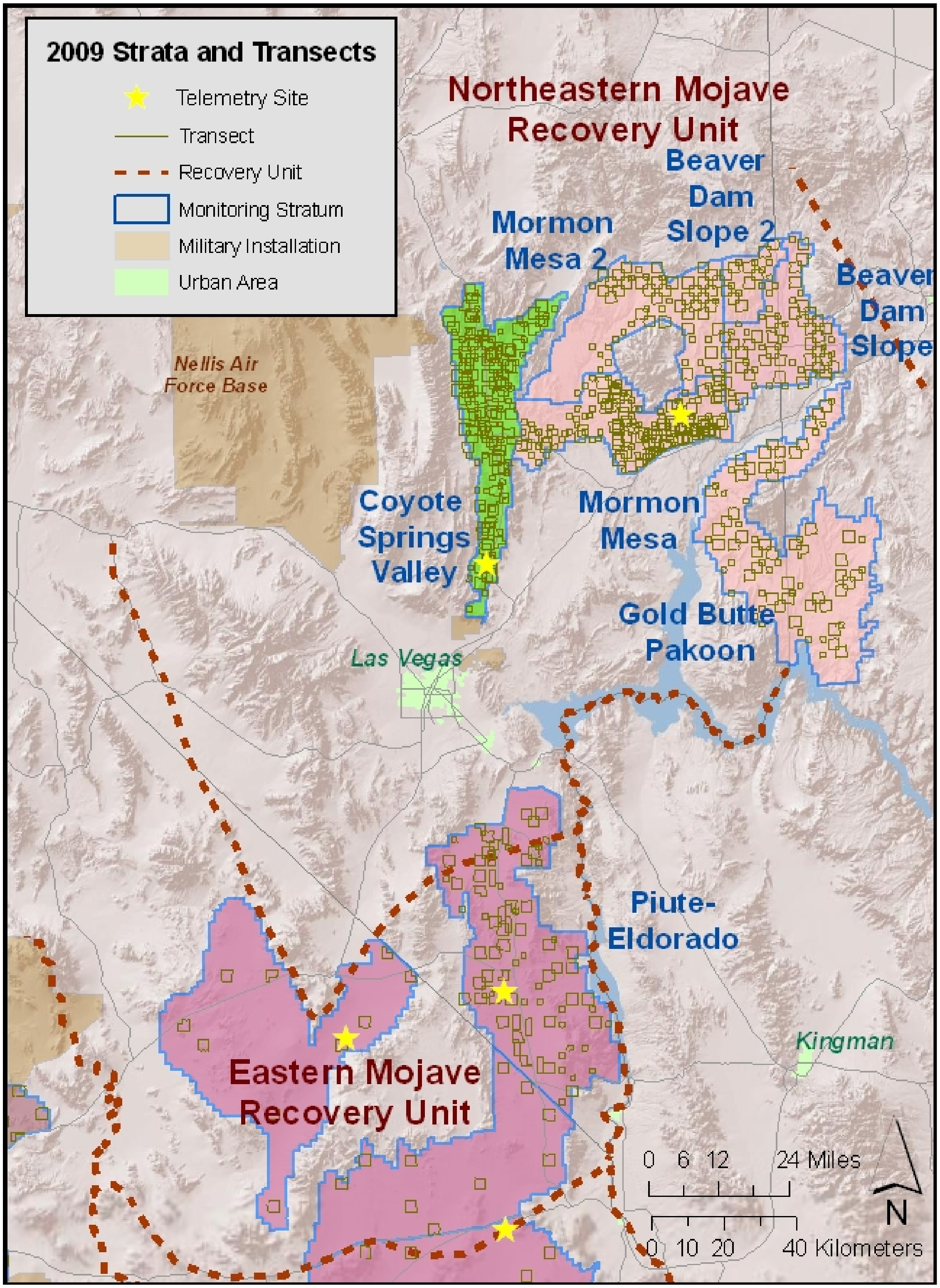

Figure 1. Monitoring strata in and around Clark County in 2009. Three color blocks identify groups of strata where transects were completed on the same days. Radio-equipped tortoises at the associated telemetry site(s) were monitored for above-ground activity.

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) described modifications made each year to increase the number of tortoises surveyed each year, and put forward recommendations that were implemented in both FWS585 and FWS785. These projects identify and target elements of monitoring for continual process improvement (for instance, data management, training, accurate population estimation). This specific project (FWS 785) continues and enhances improvements implemented under FWS 585 and reported in USFWS (2009b).

Management Actions Addressed

In conducting this research and implementing the monitoring program, the Scope of Work for this project states that the following conservation actions, elements in the Clark County MSHCP, will be addressed:

- USFWS(11). Monitor populations and population trends of Covered and Evaluation Species on the [Desert National Wildlife Refuge Complex] as appropriate.
- BLM(9). BLM will cooperate with the I&M Committee and through the Adaptive Management Plan participate in the identification, development, and implementation of research projects located on Public Lands. Emphasis shall be placed on research that addresses management concerns and the conservation of covered and evaluation species.
- NPS(11). Continue monitoring tortoise populations on [Lake Mead National Recreation Area], and assist with ongoing survivorship studies, as appropriate.

Goals and Objectives of the Project

Objective 1: Baseline density monitoring will establish a statistical basis for determining population trend(s) and for evaluating management actions and threats.

Objective 2: Research into effectiveness of monitoring will establish that current techniques cannot be improved on or will identify techniques that will improve effectiveness or reduce the cost of tortoise density monitoring.

Objective 3: Intensive, uniform training of tortoise monitors will result in an increase in accuracy and precision of density estimates as well as a reduction in variance and observer (monitor) errors.

The above objectives for 785 and the MSHCP objectives for this project (*Management Actions Addressed*, above section) 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 "Northeastern 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). The required activities under FWS785 match directly with those of the range-wide monitoring program.

Methods and Materials

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.

Objective 1: Baseline density monitoring will establish a statistical basis for determining population trend(s) and for evaluating management actions and threats.

Study design

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, 2009b). 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. In 2008 and 2009, 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 program (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 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 the routes they used to access each transect and any diversions they had to make on the transect. These considerations for design and placement of transects are instituted by the USFWS. Data collection occurs on individual transects, and is instituted by field crews as described below.

Data collection

Tortoises are most predictably visible during the spring, but even during this season not all tortoises are above ground or visible in burrows. In order to encounter as many tortoises as possible, monitoring was scheduled for early in the day and to be completed before the hottest time of day. Because we located tortoises by sight, monitoring was restricted to daylight hours. Based on past experience, we expected tortoises to become most active after 7am at the beginning of April (it is usually too cool before this time), but to emerge earlier and earlier with the optimal activity period beginning around sunrise by the beginning of May. In May, we also expected daytime temperatures to limit tortoise above-ground activity as the morning progressed to afternoon.

Field crews should have complete transects during this optimal period each day. Start times were decided in advance, and crews were to arrive at transects at similar times on a given morning. However, completion times were expected to be more variable, as determined by terrain, air temperature, number of tortoises encountered, etc. Although we have general expectations about when tortoises would be most active each day, and indeed have expectations of the proportion that would be active, density estimates require real-time estimation of daily activity during the actual periods tortoises are counted. The role of telemetry crews was to collect data for these activity estimates, also called G_0, “G-sub-zero”.

Under normal conditions, each transect team walked one 12km square transect each day. Teams were comprised of 2 field personnel who alternated lead and follow positions at each corner of each transect, so they each spent an equal amount of time in the leader and follower positions. The leader started the transect by walking on the designated compass bearing and pulling a 25m length of durable line. The path that the leader walked became the centerline of the transect. While it was pulled, the line guided where the follower walked; when the line was placed on the ground after a tortoise or carcass was detected, the line facilitated measurement of the local transect bearing. The walked length of each transect was calculated as the straight-line distance between GPS point coordinates that were recorded along the transect (waypoints). Waypoints were recorded at 500m intervals and at transect corners.

The follower trailed the leader at the end of the 25m line. Both leader and follower scanned for tortoises independently without leaving the center line, and the role of the crew member finding each tortoise was recorded in the data. Although the leader saw most of the tortoises, the role of the follower was to see all the remaining tortoises near the centerline, so the follower role is crucial to unbiased estimation of tortoise densities.

When a live tortoise or carcass is located, the leader drops the line, and the necessary data fields on both the electronic and paper data forms are completed. Desert tortoise monitoring uses distance sampling, which requires that distance from the transect line to live tortoises and carcasses be accurately measured. When a tortoise or carcass was observed crews 1) used a compass to determine the local transect bearing based on the orientation of the 25m centerline, 2) used a compass to determine the bearing from the point of observation to the tortoise or carcass, and 3) measured the distance to the tortoise or carcass using a measuring tape. These data were used to calculate the distance from the observed tortoise to the local transect line. If the tortoise was outside of a burrow where it could be handled, crews also took mass and length information, determined its sex, and applied a small numbered tag to one scute. If a tortoise was in a burrow and could not be removed from the burrow, crews nonetheless recorded whether unhandled tortoises were adult or sub-adult (≥ 180 mm MCL or < 180mm MCL).

Obstacles that could lead to changes in the transect path included major highways (e.g., all Interstate highways, US Highway 95 and 395, and California Highway 58), hazardous rock formations, or hills too steep for safe navigation. When such obstacles were encountered, the transect path was adjusted. For description of non-standard transects and for more detail on field procedures, please refer to the *2009 Desert Tortoise Monitoring Handbook* (USFWS, 2009a), which was also Milestone 6 of FWS785.

Objective 2: Research into effectiveness of monitoring will establish that current techniques cannot be improved on or will identify techniques that will improve effectiveness or reduce the cost of tortoise density monitoring.

Localized correction of density estimates (G_0)

Analysis of data from previous years has 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, 2009b). Since 2007, the USFWS has instituted a change in the monitoring protocol so that all transects in a G_0 area would be completed in as 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. There are now 3 years of data collected under this procedure, and 5 years collected under the older one, so a comparison of precision is appropriate.

Transect completion

Another technique that was implemented recently (2008) addresses the need to sample for tortoises across the entire stratum. Before 2007, per the approved protocol, planners and field crews routinely moved transects into flatter nearby terrain. This limited the applicability of density estimates so that only densities in flat areas were estimated. Since 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. Based on whether this procedure has improved completion of assigned transects, we can decide whether it is an effective technique. 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.

Rather than wait until field data were collected to assess how effective field crews were at transect completion, crew leaders reported weekly on which transect were completed, which were modified to avoid terrain (and what the specific issues were), and which were replaced with alternates, and whether they were replaced due to terrain or access issues.

Objective 3: Intensive, uniform training of tortoise monitors will result in an increase in accuracy and precision of density estimates as well as a reduction in variance and observer (monitor) errors.

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 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.

Field observer training

In 2009, two sets of field observers participated. Kiva Biological (Kiva) supplied crews for monitoring in California. Great Basin Institute (GBI) supplied crews for monitoring in Nevada, Arizona, and Utah. The former crew was composed entirely of teams with at least one field season of previous monitoring experience, whereas the latter crew had only three experienced members. The GBI crews were therefore provided with 12 full days of preparatory training and practice, 7 days more than Kiva crews (Table 2). A single evaluation was given to each paired team, based on performance on a field arena outfitted with a high density of polystyrene tortoise models placed in measured locations (Anderson et al., 2001). Crews were evaluated on 1) ability to detect all tortoises within 1m of the centerline, 2) shape of the team's detection function indicating appropriate search technique, 3) leader detecting close to 80% of the tortoise models (related to above requirement for the pair to detect all tortoises on the centerline), and 4) ability to correctly report the distance of each model from the transect centerline.

QAQC training of field crews and specialists

Additional training was provided this year for QAQC specialists for each field monitoring group. One person in each group was responsible for data verification and validation, and for making appropriate changes (with documentation) before submitting their field databases to USFWS. The specialized training gave them instruction and practice in a standard set of data checks they should implement, how changes should be made to paper and electronic data, and how they should document any changes. One of their practice data sets came directly from field crews as they practiced, and feedback was given during training to each field crew on the types of errors they had made and how to avoid them. By targeting both the data collection by field crews and the completeness of checks applied by QAQC specialists, the goal was to reduce the number of errors in the final database.

Table 2. Training schedule for 2009.

	GBI Trainees			Kiva Trainees		
Day/Date	Activity	Location	Trainer	Activity	Location	Trainer
WEEK 1						
Monday 16-Mar	Transect methods lecture 6km transects	DTCC Mgmt Area	Allison/ Experienced crews			
Tuesday 17-Mar	Introductions and DT Recovery/Monitoring Programmatic Overview	Atrium Business Tower	Allison			
	Distance Sampling		"			
	Tortoise Activity/G_0		"			
	Working on Public Lands		BLM Districts			
	Transect methods lecture		Allison			
	Non-standard transects		"			
	RDA/BT GPS, Pendragon Database Lecture and Exercises		Patil			
	Quality control procedures for field crews		Allison, Learmont, Patil			
	Compass/GPS Lecture		Allison			
Wednesday 18-Mar	Tortoise biology and handling instruction	DTCC	DTCC Staff			
	Tortoise handling and data collection - small groups	"	DTCC Staff			
	Pen search image exercise (with RDA)	"	"			
	Training line lecture & crew quality control procedures	"	Allison/ Brenneman			
	Compass/GPS Exercise	"	Allison			
	Data transfer and QA/QC (for specialists)	GBI Field Station	Patil, Learmont			
Thursday 19 March	Training Lines (practice, 8km) Begin data download from RDAs	DTCC Mgmt Area	Allison			
Friday 20-Mar	Training Lines (practice, 8km)	DTCC Mgmt Area				
	G_0	Coyote	Sparks			

	GBI Trainees			Kiva Trainees		
Day/Date	Activity	Location	Trainer	Activity	Location	Trainer
	Initial QAQC (QAQC specialists only)	Spgs DTCC	Brenneman			
WEEK 2						
Monday 23-Mar	Full transects (12km) (half crew) G_0 / activity observation (half crew)	LSTS River Mtns	 Sparks			
Tuesday 24-Mar	Tortoise handling Pen search image exercise Training line debriefing	DTCC	Staff " Allison			
Wednesday 25 Mar	Training Lines (evaluation, 8km)	DTCC		Practice 8- or 12-km transects Data transfer and QA/QC	LSTS LSTS	
Thursday 26 Mar	Training Lines (evaluation, 8km)	DTCC		Updates for 2009 (see material for GBI trainees, 17 March)	USFWS office	Allison
Friday 27 March	Full transects (12km) (half crew) G_0 / activity observation (half crew)	LSTS River Mtns	 Sparks	Training Lines (evaluation, 8km)	DTCC	Allison
WEEK 3						
Monday 30-Mar	Tortoise handling Compass navigation exercise Training line debriefing	DTCC	Staff Allison	Training Lines (evaluation, 8km)	DTCC	
Tuesday 31-Mar	Full transects (create non-standard) or repeat training lines as needed G_0	LSTS Piute		Training lines debriefing Tortoise handling	DTCC DTCC	Allison Staff
Wednesday 1-Apr	Begin field data collection			Begin field data collection		
Thursday 2April	Deliver QA/QC'd data from practice transects			Deliver QA/QC'd data from practice transects		

Results and Evidence of the Results

Overview of the 2009 Field Season

Training occurred from 16-30 March, matching the planned schedule. The field season started on 31 March and ended on 30 May. GBI walked 592 transects in the strata in Table 1, 512 of them in the long term strata that are part of FWS785. In the last week of April, USFWS realized that G_0 field crews were first observing tortoises 15-30 minutes after transect crews had started. In conversation with GBI, we realized that data forms for G_0 sites did not ask when crews started searching for tortoises (this information is asked on transects), and that telemetry crews had used transect start times as the start time for their searches. Instead, it would be desirable for them to locate their first tortoises at the time transect crews were starting. Table 3 indicates the time discrepancy at the end of April, followed by the appropriate time match starting on 29 April. Because transect crews also walked for some time before any tortoise would be detected, this discrepancy is undesirable but not especially problematic. Note that telemetry crews often stayed longer at their sites – transect crews often finished sooner. This reflects their training to continue telemetry surveys until an agreed-to stop time unless confirmation was received from all transect crews that they had finished for the day. Often the lack of cell phone reception prevented transect crews from reporting at the end of transects.

Table 3. Start and end times for G_0 and transects over a 2-1/2 week period.

Date	G_0 start time	G_0 end time	Transect start	Transect end
23-Apr	7:20	14:50	6:59	12:53
24-Apr	7:29	13:31	6:58	11:42
25-Apr	7:07	14:41	7:00	12:59
26-Apr	7:13	12:58	7:00	12:18
27-Apr	7:29	14:25	6:57	14:12
28-Apr	7:13	13:10	7:01	12:41
29-Apr	6:36	13:23	6:30	13:09
30-Apr	6:32	13:06	6:29	12:48
1-May	6:33	14:00	6:29	13:33
2-May	6:48	14:01	6:30	13:46
3-May	6:31	12:50	6:28	11:49
4-May	6:42	13:26	6:27	12:23
5-May	6:44	15:43	6:29	12:32
6-May	6:30	13:27	6:25	11:16
7-May	6:00	13:19	5:58	12:23
8-May	6:00	14:33	5:59	11:30
9-May	6:06	13:01	5:58	12:17
10-May	6:00	11:31	6:00	11:12

Figure 2 indicates that visibility was consistent over hours that transects were walked each day. Although the hourly averages indicated by the bars do move up and down, there is not a consistent pattern of decreasing activity later in the day, for instance.

The very low visibility reported at Piute-Mid was unexpected because much higher activity was reported on the same days at nearby sites that were monitored by an experienced telemetry technician for Kiva Biological. Since 2 technicians were working on the same day at Piute-Mid, a comparison was made of the two independent observers. This indicated that one of the observers was locating the radioed tortoises using the receiver, but then did not find them visually. Usually, this would indicate the tortoise was not visible deep in a burrow; however, the other observer on the same day was locating the tortoises out of the burrow. It seemed likely that at least one of the telemetry technicians was not finding the tortoises by sight even when they were above ground and visible. This can occur because tortoises are cryptic, and an inexperienced observer can overlook them. The data indicate that after Piute-Mid, all GBI telemetry technicians had developed enough experience to consistently find above-ground tortoises; however, USFWS decided to use only telemetry data from the Kiva observer to develop G_0 estimates for the Piute-Eldorado transects.

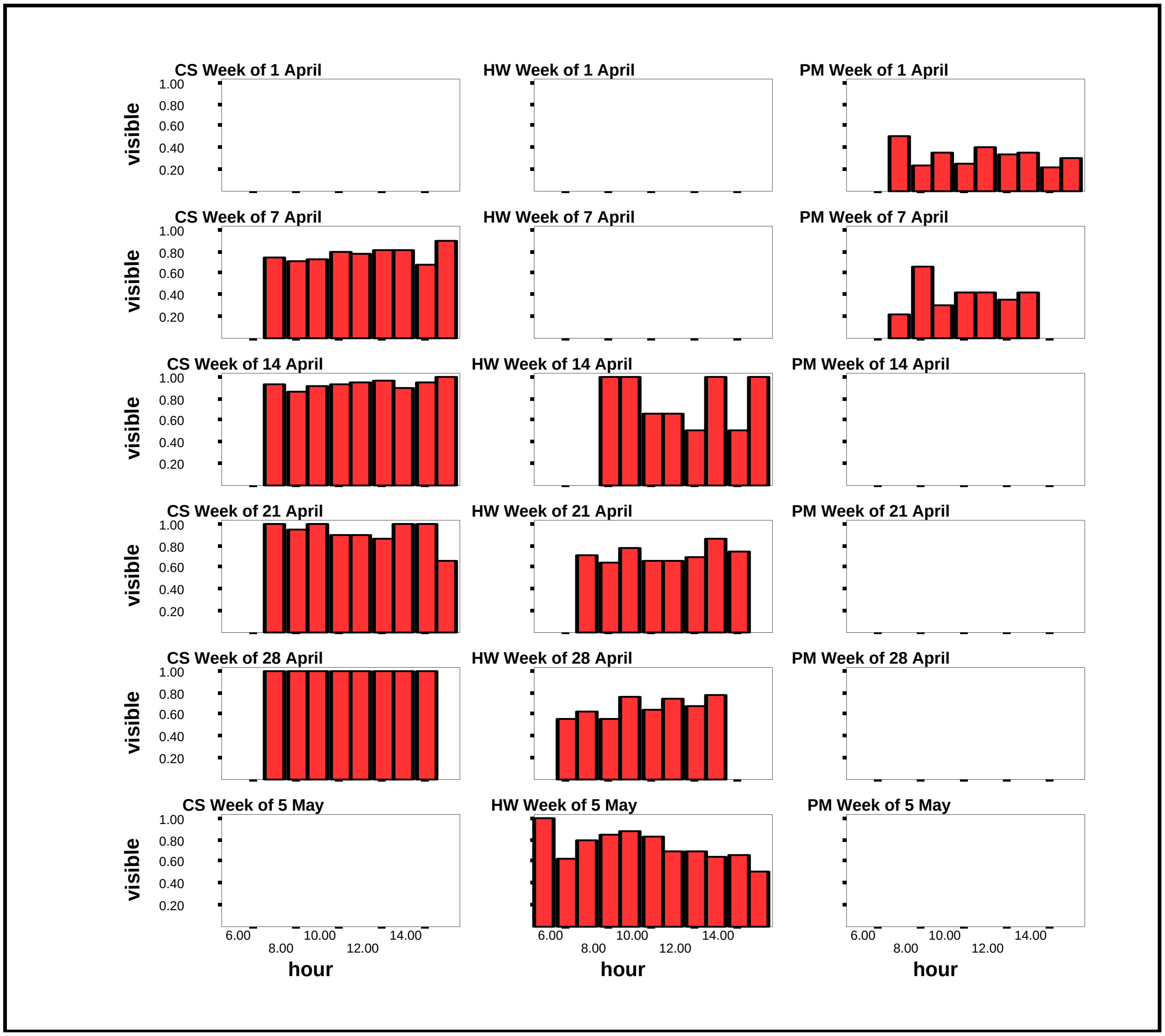

Figure 2. Frequency of visible G_0 observations by 1 hour increments during the first 6 weeks of the field season in Piute Valley (PM), Coyote Springs (CS), and Halfway (HW). Each row illustrates a single week (1=1-6 April, 2=7-13 April, 3=14-20 April, 4=21-27 April, 5=28 April-4 May, 6=5 – 10 May), and each column represents a different G_0 site. Graphs only show data if that site was visited that week.

Figures 3 and 4 show locations of transects and observations of live tortoises in strata listed in Table 1.

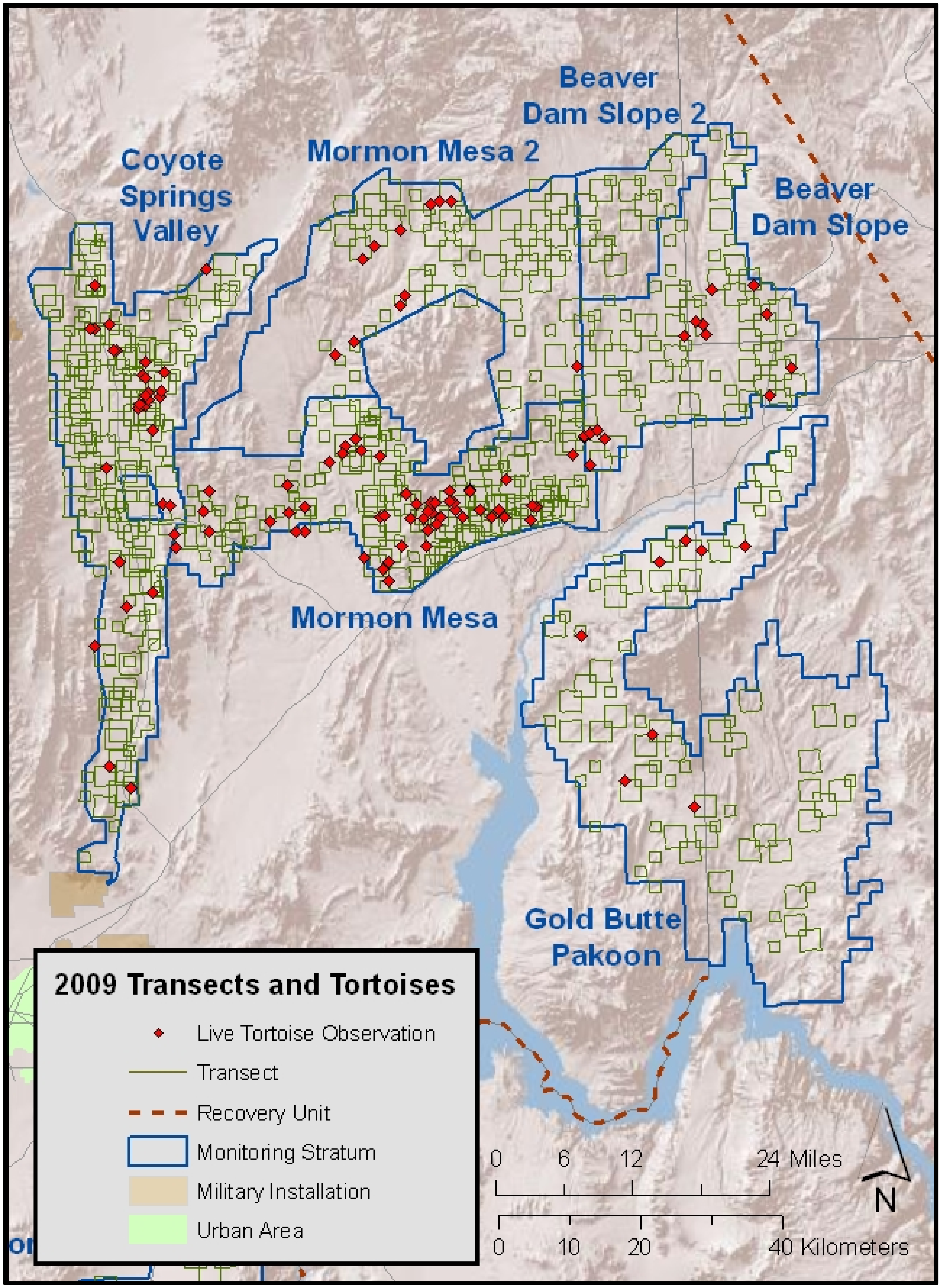

Figure 3. Distribution of distance sampling transects and live tortoise observations in the Coyote Springs Valley, Mormon Mesa, Mormon Mesa 2, Beaver Dam Slope, Beaver Dam Slope 2, and Gold Butte-Pakoon monitoring strata.

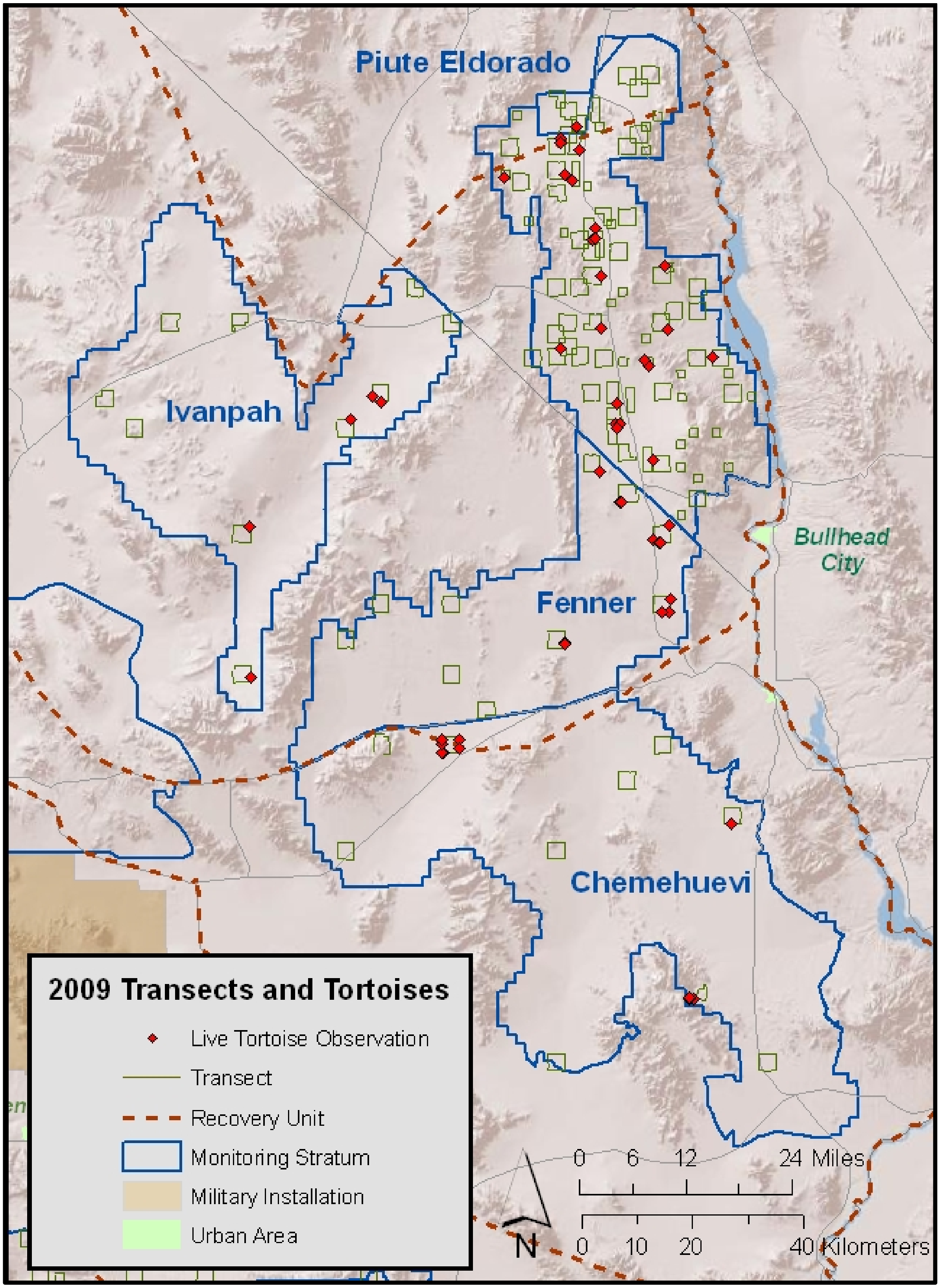

Figure 4. Distribution of distance sampling transects and live tortoise observations in the Piute-Eldorado Valleys, Ivanpah, Fenner, and Chemehuevi monitoring strata.

<u>Objective 1: Baseline density monitoring will establish a statistical basis for determining population trend(s) and for evaluating management actions and threats.</u>

Range-wide densities were calculated and reported in FWS785 Deliverable 20: *Final 2009 Range-wide Density (Line Distance) Analysis*. Table 4 reports densities for the strata in Table 1. Results are also given from USFWS (2009b) for the years 2004 and 2005. Since 2004, concerted effort has been made to sample throughout monitoring strata, although this was not the case in earlier years.

Table 4. Number of tortoises encountered (n), density (D), and the coefficient of variation for D (CV) from 2004 through 2009, when effort was made to sample all areas within stratum boundaries. Data are reported for recovery units and associated strata listed in Table 1. No sampling was conducted in 2006 and no analysis has been completed for 2008.

Sampling Area	2004			2005			2007			2009		
	n	D	CV	n	D	CV	n	D	CV	n	D	CV
Northeastern Mojave	**24**	**1.2**	**30.1**	**41**	**1.8**	**25.8**	**46**	**1.7**	**25.0**	**75**	**3.2**	**33.1**
Beaver Dam Slope	0			5	0.9	54.1	6	1.2	53.2	9	3.1	47.6
Beaver Dam Slope 2*										0		
Coyote Springs	8	1.3	41.5	10	3.3	38.8	14	1.4	35.1	18	1.9	35.9
Gold Butte Pakoon	4	0.7	52.1	1	0.2	101.8	4	1.2	48.2	8	2.3	49.5
Mormon Mesa	12	2.3	36.9	25	4.9	29.8	22	3.3	31.2	40	6.7	36.8
Mormon Mesa 2*										6	2.2	50.7
Eastern Mojave	**119**	**5.3**	**20.0**	**109**	**7.2**	**20.1**	**40**	**5.8**	**25.0**	**29**	**4.6**	**29.8**
Fenner	52	8.7	27.0	42	14.0	20.6	10	6.6	39.2	7	6.6	52.9
Ivanpah	35	4.7	29.9	8	4.6	55.7	10	6.5	35.6	4	3.8	46.7
Piute Eldorado	32	2.7	29.5	59	4.3	23.3	20	4.2	36.1	18	3.7	34.1

* These strata are not part of long-term monitoring and were not included in recovery-unit summaries.

<u>Objective 2: Research into effectiveness of monitoring will establish that current techniques cannot be improved on or will identify techniques that will improve effectiveness or reduce the cost of tortoise density monitoring.</u>

Localized correction of density estimates (G_0)

Table 5 shows that the number of days of monitoring particular telemetry (G_0) sites was decreased after 2005. Estimate of G_0 did change year to year or in different months during the same year, indicating that regional estimates of visibility, timed to match transects in that area, are worthwhile. However, the goal of reducing number of days surveyed was also to develop more precise estimates of G_0 (reflected in a lower %CV). Table 5 indicates that this was not accomplished reliably.

Table 5. Visibility estimates for telemetry sites that were monitored range-wide in 2005, 2007, and 2009. Mean G_0 is reported, as well as its coefficient of variation (CV) and the number of days monitored.

G_0 Site	2005			2007			2009			Did fewer days reduce CV?
	Mean	CV (%)	Days	Mean	CV (%)	Days	Mean	CV (%)	Days	
Chuckwalla	0.74	20.5	39	0.87	6.9	17	0.66	20.6	11	n
Chuckwalla (June)							0.58	18.9	5	n
Coyote Springs				0.79	17.7	50	0.88	13.5	16	y
Coyote Springs (late May)				0.77	22.2	21				
Chemehuevi	0.65	26.6	40	0.62	19.1	5	0.84	15.4	3	y
Halfway Wash							0.64	26.0	8	
Ivanpah	0.87	11.7	5	0.94	9.7	5	0.79	15.3	2	n
Joshua Tree							0.83	20.7	10	
Piute Border	0.87	19.0	57							
Piute-Mid	0.91	13.0	59	0.81	22.0	7				
MCAGCC	0.90	12.2	21	0.97	4.8	5				
Ord-Rodman	0.92	9.0	32	0.64	33.4	13	0.96	5.6	15	=
Superior Cronese	0.92	10.3	37	0.96	5.2	13	0.90	13.2	20	y

Transect completion

Table 6 reports the number of assigned and completed transects in each stratum listed in Table 1. Only 89% of transects assigned to GBI were completed. The primary reason that 72 transects were not completed by GBI was early season loss of personnel. Four crew members left during the first 2 weeks of the field season for personal reasons or due to injury. Great Basin Institute had hired sufficient personnel to accommodate some attrition due to illness or other issues; however, since each crew was slated to walk 45 transects during the field season, loss of 2 crews for most of the available period was not the level of attrition that could be accommodated. After accounting for the ability of GBI to replace some of the missing transects, in May the USFWS reduced the number of expected transects by 71, adjusting the number of transects to complete in the remaining strata.

Great Basin Institute could have completed additional transects, but in coordination with USFWS, it was decided that these person-days would instead be used to address the issue of areas that have not been accessible. Base-camping into route-less areas allowed crews to be provisioned centrally with supplies, including water, while the crews hiked farther in to complete 36 transects in larger areas where transects are more than 4km from a motorized route. In all, 24 remote transects were completed using base-camping in CS, 8 in MM, and 4 in GB. Any field personnel provisioning these base camps for other crews are not themselves walking transects.

The basic completion percentages do not describe the most important issue that remained to be addressed. Only a proportion of assigned transects could be completed in the planned way: a

12km square transect, 3km on a side. Various obstacles affected transect completion. Some obstacles, such as uncrossable highways and private inholdings, could be addressed by "reflecting" the corner of the transect inward to avoid the obstacle (Buckland et al. 2001) or by elongating the transect in one direction. This modification would not predictably move the transect into a different landform, a change that would affect the probability of encountering tortoises on the transect. However, other obstacles were more difficult to address. The jurisdictional boundaries of the monitoring strata include terrain that may be navigable by tortoises, but is not safe for humans. If a transect is moved around rugged terrain, keeping the transect in flatter topography, this is expected to impact the probability of encountering a tortoise.

Since 2007, transects continue to be placed throughout monitoring strata, with rules governing the types of modifications that can be made to accommodate obstacles (USFWS, 2009a). Table 6 indicates the number of assigned transects that could be completed as standard square 12km transects, as well as the number that were appropriately completed by reflecting around non-terrain obstacles (column 4). These transects are all considered to represent flatter topography in the monitoring stratum. An additional number (column 5) were completed as 6km squares, and represent more rugged terrain. Finally, some transects were considered unwalkable even when shortened to 6km (column 6).

The last 2 columns of Table 5 represent situations that were not anticipated. Crews were to shorten or abandon transects if the terrain presented too much of an obstacle. Reflecting around terrain was not a planned option. However, on some, relatively rare, occasions (column 7), crews had partially walked a transect before determining that it could not be completed following the correct protocol. In these situations, they would not have sufficient time to move to an alternate transect on the same day, so they instead reflected around terrain to collect data for the lower topography portion of the current transect. Column 8 reports transects that appear walkable based on remote imagery but were not completed. On investigation, all but 10 of these in the eastern part of the range were removed from the walk order during the field season to accommodate the reduced number of personnel (in BD, BD2, MM, MM2; see above).

Table 3. Number and type of transects in each stratum.

Stratum	Assigned transects	Assigned and alternate transects completed*	Assigned, completed 12k	Assigned, completed 6k	Assigned, judged unwalkable	Assigned, completed by avoiding terrain	Assigned, judged walkable, but not walked*
BD	69	66	26	19	10		8
BD2	20	19	7	6	6		1
CS	174	153	73	39	24	14	18
GB	77	76	25	18	9	1	1
MM	165	137	45	55	27		29
MM2	80	61	26	12	16		25
PI	80	80	33	21	6		0
Total	665	592	235	170	98	15	82
Total in long-term strata	565	512					

*Assigned transects that were not walked were generally replaced by alternates.

Objective 3: Intensive, uniform training of tortoise monitors will result in an increase in accuracy and precision of density estimates as well as a reduction in variance and observer (monitor) errors.

Field observer training

Proportion of tortoises detected at varying distances from the transect centerline

Table 7 reports the proportion of models that were available and were detected by each team at 1-, 2-, and 5-meters from the transect centerline. Teams were tested after a trial run on the detection lines (first-year/GBI crews) or after walking practice transects for returning crews that wanted to refresh the search pattern. Detection on the centerline was expected to be 100%, and most crews achieved this. First-year trainees detected a similar proportion of models at 1- and 2m compared to experienced crews, with first-year trainees detecting fewer models at 5m.

Table 8 reports further statistics for each team after collecting data on 16km on the evaluation lines. Measurement accuracy reported in Table 8 gives the average absolute difference between the expected and measured perpendicular distances from the model to the walked line. All measurements for all models during the 2-day trial are used for this estimate, and capture inaccuracies from 1) using a compass and measuring tape to record distances to the models, plus 2) inaccurately following the trajectory of the transect. The latter source of error does not occur on monitoring transects, because the walked transect is the true transect. On training lines, error in measurements is increased if crews do not walk on exactly the measured line that was used to place the models. The "Available Models Detected by Leader" column reports the proportion of all models that were found first by the leader. During training, this number is easily calculated and is used to identify crews in which one of the observers is not finding at least 80% of all detected. With an 80% success rate for the leader, a 96% detection rate is expected for the team.

Table 7. Proportion of tortoise models detected within 1-, 2-, or 5-m of the transect center line.

	Proportion of existing models within a given distance and were detected by the team		
Team	1m	2m	5m
1	1.00	0.96	0.89
2	1.00	0.96	0.88
3	1.00	0.96	0.94
5	1.00	0.96	0.86
6	0.93	0.93	0.90
7	1.00	1.00	0.90
8	0.94	0.86	0.86
9	0.93	0.92	0.89
10	1.00	1.00	0.91
11	1.00	1.00	1.00
12	0.85	0.93	0.88
13	1.00	0.93	0.89
14	1.00	1.00	0.95
15	1.00	0.93	0.89
16	1.00	0.96	0.87
17	1.00	0.89	0.94
18	1.00	0.93	0.91
19	0.93	0.96	0.91
41	1.00	0.92	0.97
42	1.00	1.00	0.98
43	1.00	1.00	0.98
44	0.93	0.96	0.96
45	1.00	1.00	0.94
46	1.00	0.96	0.89
47	1.00	1.00	1.00
48	1.00	1.00	0.97
Returning crews	0.99	0.98	0.96
First-year crews	0.98	0.95	0.90
Overall	0.98	0.96	0.92

Table 8. Diagnostics for individual teams after training

Team	Available models detected by leader		Measured v. exact model distance (m)	Estimated abundance	95% confidence interval	
	Within 1m of centerline	Within 2m of centerline			Lower limit	Upper limit
1	0.93	0.92	0.69	439	361.8	533.9
2	1.00	0.89	0.76	407	294.0	563.4
3	0.93	0.93	0.62	463	383.1	558.9
5	1.00	0.93	0.69	384	304.6	482.9
6	0.93	0.93	0.82	508	350.7	736.7
7	1.00	0.96	0.67	387	286.4	523.1
8	0.88	0.79	0.78	407	338.5	488.4
9	0.73	0.77	0.78	395	292.8	532.9
10	1.00	1.00	0.92	437	330.0	578.3
11	0.93	0.97	0.91	514	460.0	573.3
12	0.85	0.89	0.62	455	380.2	543.8
13	0.92	0.85	1.21	391	270.6	564.0
14	1.00	1.00	1.05	500	441.7	566.3
15	0.92	0.82	0.79	467	411.3	530.5
16	0.93	0.93	0.94	432	353.8	527.0
17	0.92	0.82	0.93	430	365.5	506.5
18	0.93	0.89	0.79	376	294.3	480.7
19	0.86	0.89	0.73	466	396.0	548.5
41	1.00	0.92	0.94	506	400.9	639.4
42	0.86	0.93	0.87	472	419.7	531.5
43	1.00	1.00	0.63	435	331.0	572.9
44	0.93	0.96	0.80	480	399.5	575.8
45	0.85	0.89	0.78	502	422.9	595.8
46	1.00	0.96	0.87	416	274.1	631.3
47	0.83	0.93	1.05	464	404.4	532.1
48	1.00	1.00	0.98	498	421.8	588.5
Target	>0.80	>0.70	<1	410		
Returning crews	0.93	0.95	0.86	472		
First-year crews	0.93	0.90	0.82	436		
Overall	0.93	0.91	0.83	447		

Following training, but not only due to performance in testing, Teams 6, 10, 12, and 16 each lost one crew member. The remaining personnel were put into new teams. Neither member of Team 19 participated in the field season. Figures 5 and 6 are detection curves for crews that remained together into the field season. Curves for first-year trainee curves (Fig. 5) were generally well-shaped, although one of the curves (for Team 13) had 2 deflections and generally too many detections farther from the line. This team and one other went through an additional test after consulting on ways to improve the curve. The other team is not depicted here because it was disbanded.

Perhaps more surprisingly, the experienced teams had more difficulty maintaining the correct search pattern to develop an appropriate detection curve. In Fig. 6, the three upper-most curves correspond to teams 41, 43, and 48. As indicated in Table 3, these teams had perfect detection of models on the centerline, but team 48 had a very inaccurate final population estimate, and all three teams had unusually wide confidence intervals for this estimate. These issues arise when the deflection points of the detection curve are difficult to model (less precision), so all three teams had to change their search patterns before the field season started. Among the first year trainees, Teams 7 and 9 also were tested with a wide detection shoulder. Team 7, like the experienced teams, also detected all models on the centerline. Their overall estimate was therefore accurate, but also had a very wide confidence interval (imprecise). Team 9 did not have perfect detections on the centerline, so their task was to spend relatively more of their time searching near the line.

Within the set of teams with appropriate search patterns, there was considerable variability in the shapes of these curves, and strikingly different detection curves represent different detection probabilities (P_a). Detection curves that fall more rapidly after the first few meters generally indicate more appropriate search patterns, with more attention near the transect centerline. Distance sampling and development of a single detection curve from many observers is nonetheless robust to the effects of pooling these differences, as long as the observers contribute proportionally to the overall pattern (Marques et al., 2007).

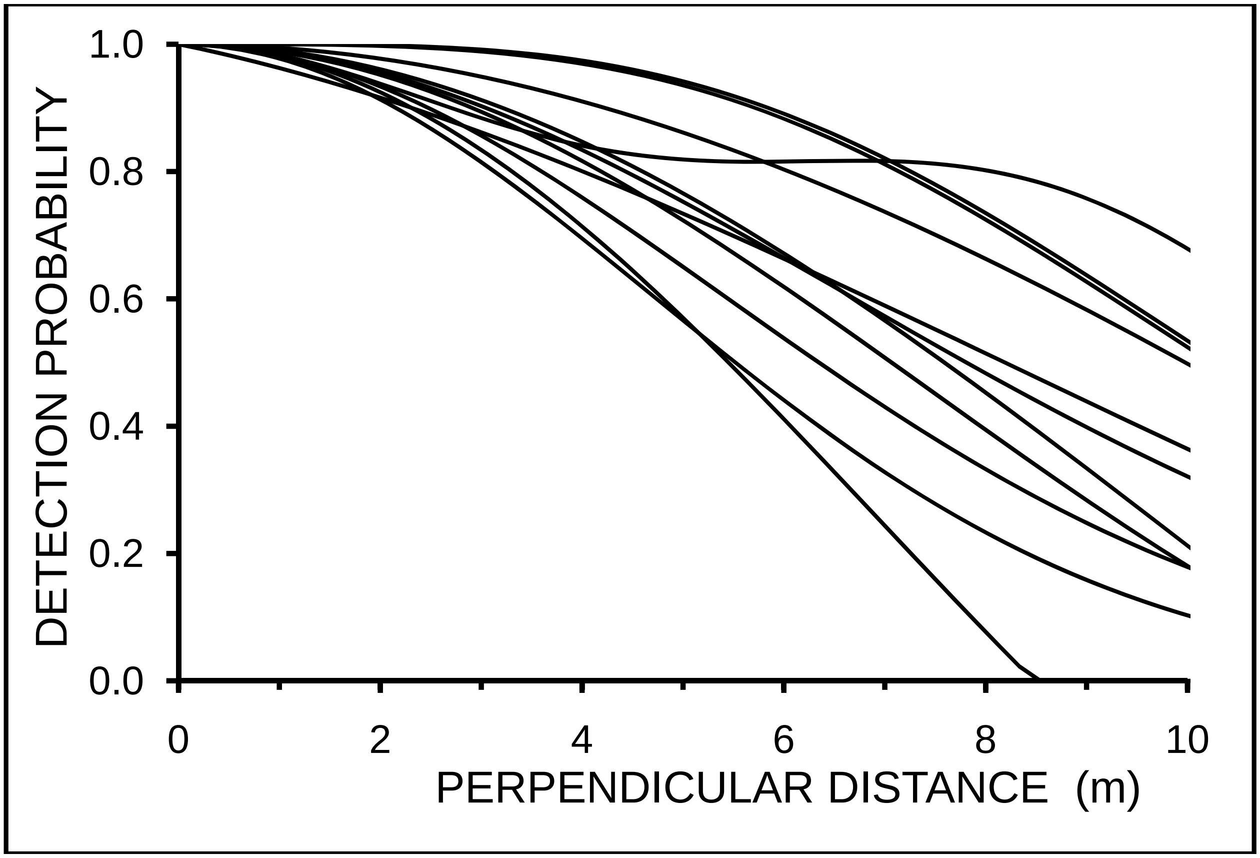

Figure 5. Detection curves for each of the 2009 first-year teams that were kept together throughout training and the field season. Curves are based on 16km trials with approximately 100 detections.

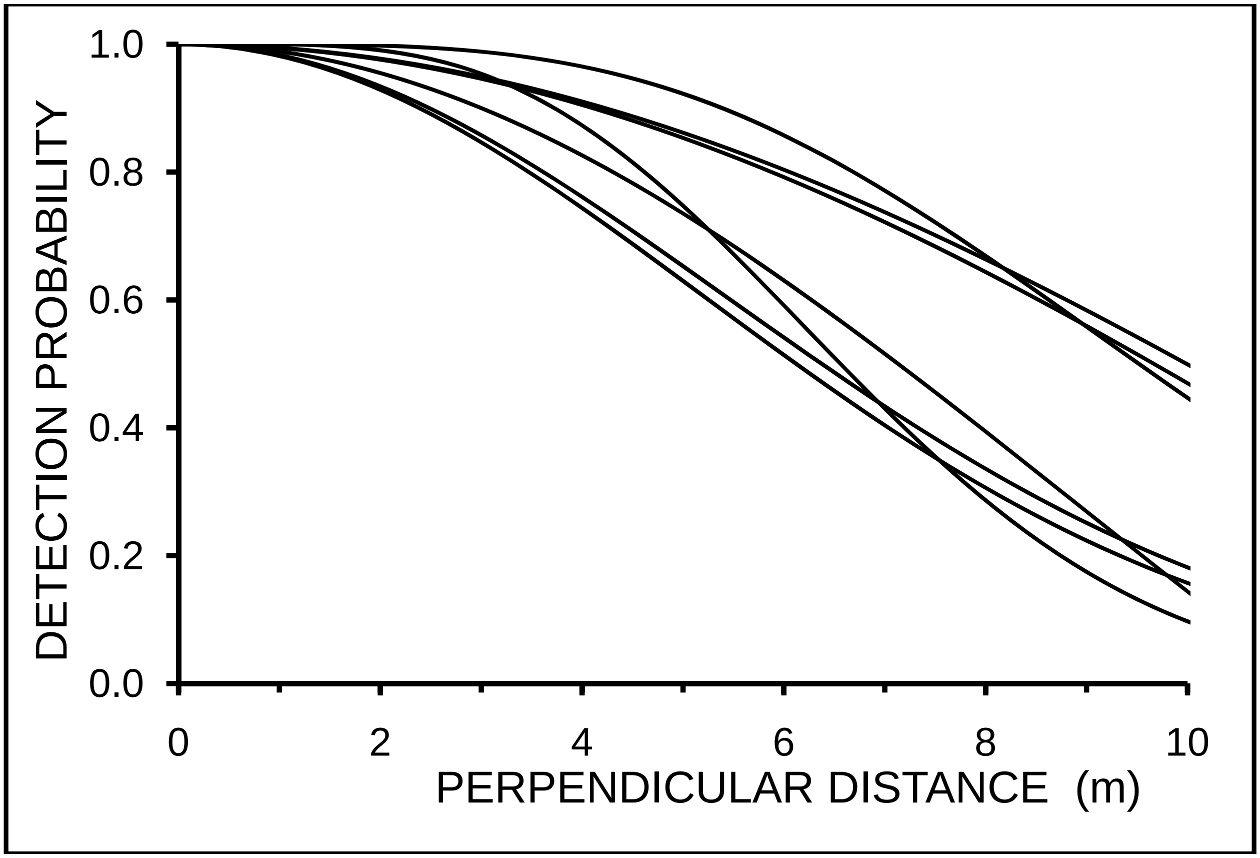

Figure 6. Detection curves for each of the 2009 trainee teams that returned after at least one year of monitoring experience. Curves are based on 16km trials with approximately 100 detections.

QAQC training of field crews and specialists

In the final 2009 Transect and G0 databases from GBI and Kiva, there were the following number of records:

Table	Records
Transects	832
Waypoints	19226
Observations	685
Live on transect	273
Carcass on transect	365
Live opportunistic	18
Carcass opportunistic	29
G_0 Start	185
G_0 observations	4172

After data were verified and validated in QAQC I, the following errors were found in QAQC II and III:

Discrepancies that were checked	Number found	Corrections made	Number uncorrected
Data entry error	332	187	145
Equipment date/time not correct	235	11	224

Data entry errors included typos and poor Bluetooth GPS grabs, both of which could be corrected by reference to the paper datasheet. These corrections were made, but should have been caught by the field crews during data proofing. Similarly, the electronic data collection systems have internal time keepers that must be checked and updated by crews. These equipment errors would not have been generated if equipment had been set up correctly. However, the paper data sheets had independently recorded dates and times. In general, this is a very small number of errors for the number of records created.

Debriefing to describe strengths and weaknesses of project preparation and execution

At the end of the field season, a debriefing meeting was held to review tasks and responsibilities, strengths and weaknesses of the program, and to plan for the next field season. Field crew members were surveyed prior to the end of the field season to identify areas to target for improvement. Notes from this meeting were submitted as FWS785, Deliverable 17, *Field Season Debriefing*.

Strengths of the 2009 Field Season

- The GBI field crew improved data delivery times so that their QAQC process was very accurate (see above section) and generally completed within 2 days. Data delivery was in part so rapid because GBI invested in a highly skilled database manager who started over a month ahead of the field season and had time to study QAQC materials in preparation.

- Preparatory materials were provided ahead of time for QAQC but also during training as part of the training oversight by USFWS that was implemented completely in 2009. Other preparatory material for 2010 was generated starting in 2009. Crew planners in 2009 recorded information for the first time to provide explanatory information on transects that were not walked.

- GBI effectively used base-camping to get access to areas farther from motorized routes.

Challenges of the 2009 Field Season

- The data collection devices were reliable (no data were lost), but occasionally required rebooting. During the debriefing meeting, it was determined that an upgrade in the firmware on the machines would correct much of this problem. Older units should also be sent to the manufacturer for reconditioning.

- Although rapid data delivery allowed USFWS to produce timely written assessments each week, the content was not transmitted rapidly by GBI coordinators to the field crews.

- The telemetry crews need more practice in "seeing" cryptic desert tortoises before the field season. It became apparent that the training provided had emphasized uses of telemetry gear and should have spent more time seeing the tortoises once telemetry brought the observer close enough.

- Transect crews performed well at implementing non-standard transect rules to avoid obstacles, but feedback indicated that they were dissatisfied with the training they received on this.

- Crew attrition can severely reduce the number of transects completed. In 2009, 72 transects were not completed due to reduced workforce. However, the costs of hiring more back-up crews is not currently considered worthwhile.

Evaluation/Discussion of Results

Evaluation of this project vis-à-vis the anlaysis results is provided in Deliverable 21, *FWS785-Final 2009 Range-wide density (distance sampling) analysis*. Regarding performance at data collection, this was a very successful field season. The one area of concern – poor performance of telemetry crews during the first week of data collection – was not a serious issue due to the backups data collection that is built into the project.

Conclusion

Improvements implemented in 2009 did not affect how data were collected, but were focused on better data entry and more standardized procedures. 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

- Most of the new emphasis in 2010 will address implementation of non-standard transect design. In 2009, this training was directed at logistical planners, using birds-eye-view remote imaging. This was not practical for field crews, who have a horizontal-plane-view.

- Because QAQC in 2009 was remarkably error-free, more focused attention can be given to remaining specific sources of error, such as resetting electronic clocks.

Field data collection

- The tracking database (with walk order and alternate transects) will be available in January at the coordination meeting

- GBI intends to take all crew leaders on a 2-day trip through all monitoring strata before the 2010 field season.

- USFWS will sit with logistics coordinators for each field team at the start of the season to develop the first 2 weeks of transect planning. This should put all parties on the same footing.

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