Desert Tortoise Range-Wide Monitoring
Clark County, Nevada

Final Project Report

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EXECUTIVE SUMMARY

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Contract Title: Desert Tortoise Range-Wide Monitoring

This report documents the Desert Tortoise Range-Wide Monitoring project conducted by the Great Basin Institute (GBI) in the spring of 2022. In response to the federal listing of the Mojave desert tortoise (*Gopherus agassizii*) as a threatened species, the U.S. Fish and Wildlife Service (FWS) instituted a Mojave Desert Tortoise Range-Wide Monitoring Program to track the population density of Mojave desert tortoises throughout their range. In 2022, the Clark County Desert Conservation Program (DCP) coordinated with FWS and GBI to implement line distance sampling (LDS) to monitor Mojave desert tortoise populations in the eastern Mojave Desert of southern Nevada, northwestern Arizona, and southwestern Utah.

GBI hired 12 crew supervisors, 36 transect technicians, 2 telemetry technicians, and one data manager in 2022. Terry Christopher served as project coordinator, a position he has filled since 2007 on similar projects. In collaboration with FWS and DCP staff, GBI provided training for desert tortoise handling, field data collection, logistical coordination, level 1 data quality assurance/quality control (QA/QC), and GIS mapping.

Surveys took place between 5 April and 16 May, 2022 in the Piute Valley, Eldorado Valley, Coyote Springs, Beaver Dam, Gold Butte, and Mormon Mesa strata. Twenty-four teams of two individuals each walked a single 12-kilometer transect per day following LDS protocol. Transect monitors completed 424 transects and observed 71 live tortoises and 141 carcasses on transects, plus 12 live tortoises and 24 carcasses opportunistically within the monitoring strata.

Focal telemetry surveys corresponded with transect surveys in both location and time (referred to as G_0 monitoring). Two telemetry monitors recorded multiple observations per day for a set of tortoises equipped with radio transmitters in Piute-Mid (corresponding with Piute Valley and Eldorado Valley strata), Gold Butte (corresponding with Gold Butte stratum) and Halfway Wash (corresponding with Mormon Mesa, Coyote Springs, and Beaver Dam strata). Telemetry monitors recorded 1,092 G_0 observations.

GBI combined the DCP-funded surveys in the six regular monitoring strata with additional surveys funded by the National Park Service (NPS) in nearby (and in some places overlapping) survey strata around Lake Mead National Recreation Area (NRA). By completing both projects at the same time GBI was able to efficiently utilize funds associated with training, logistical coordination, and data management, as well as produce comparable data in all survey strata.

INTRODUCTION

Project Background

The Mojave desert tortoise (*Gopherus agassizii*) is federally listed as threatened under the Endangered Species Act (FWS 1990) and is a priority species for conservation under the Multiple Species Habitat Conservation Plan in Clark County, Nevada (Clark County 2000). The recovery program for desert tortoises requires range-wide, long-term monitoring to determine whether recovery goals are met; specifically, population trends within recovery units need to increase for a period of 25 years to warrant delisting. The purpose of this project is to conduct desert tortoise monitoring in the form of line distance sampling (LDS) across Clark County, Nevada and adjacent areas.

Project Description

The Great Basin Institute (GBI) was contracted by the Clark County Desert Conservation Program (DCP) to conduct Range-Wide Monitoring using line distance sampling (LDS) surveys and corresponding telemetry surveys in Tortoise Conservation Areas (TCAs) located in the eastern Mojave Desert of southern Nevada and northwestern Arizona including: Piute Valley, Eldorado Valley, Coyote Springs, Beaver Dam, Gold Butte, and Mormon Mesa (Figure 1). The Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service (FWS), and Clark County/Boulder City manage land in these areas.

In 2022, GBI hired a staff of 51 personnel to conduct spring monitoring: 12 crew supervisors, 36 transect technicians, 2 telemetry technicians, and one data manager. Terry Christopher reprised his role as project coordinator, a position he has filled since 2007 on similar projects in collaboration with DCP and USFWS. At the beginning of the season, GBI collaborated with FWS and DCP to conduct training from 7 March to 5 April. Training covered survey protocols, tortoise handling, desert safety, and GBI protocols. Field staff were assessed by GBI and FWS project management personnel for proper transect and data collection protocol, as well as by DCP staff and a wildlife veterinarian for safe tortoise handling protocol.

Surveys took place between 5 April and 16 May in the Piute Valley, Eldorado Valley, Coyote Springs, Beaver Dam, Gold Butte, and Mormon Mesa strata (Figure 1). Twenty-four teams of two individuals each walked a single 12-kilometer transect per day, following LDS protocol.

Focal telemetry surveys corresponded with transect surveys in both location and time to serve as a correction factor for tortoises visible on the landscape during transect surveys (referred to as G_0 monitoring). Two telemetry monitors recorded multiple observations per day for a set of tortoises equipped with radio transmitters in Piute-Mid (corresponding with Piute Valley and Eldorado Valley strata), Gold Butte (corresponding with Gold Butte stratum) and Halfway Wash (corresponding with Mormon Mesa, Coyote Springs, and Beaver Dam strata). Telemetry surveys began each day before transect start times, and continued until transects were concluded or about 4 PM, whichever came first.

Data were collected by the data manager at the end of each week and were examined for errors and inconsistencies. Written assessments of the data were produced by another GBI employee (Mark Spangler, who previously served as the data manager for the desert tortoise range-wide monitoring program) in order to give feedback to field crews on the data they were collecting. Data were submitted to Clark County DCP on a regular basis, with a QAQC l final database submitted at the end of the field season.

Project Goals and Objectives

1. Crews will apply the search technique as trained so that tortoise detection probabilities and densities are accurately estimated.
2. Each team will complete transects in the prescribed fashion within specified time limits, including start time and minimum total time.
3. Crews will complete focal telemetry at the same time others walk transects to allow for correction factors to be calculated
4. Crews will correctly implement line distance sampling protocols for desert tortoises on standard transects.
5. Crews will appropriately implement techniques to walk non-standard transects when obstacles prevent completion of planned standard transects.
6. Established data quality assurance/ quality control (QAQC) protocols will be implemented for verification of data by crews and for time review and correction of error. Following review by the FWS, any additional inconsistencies will be addressed.

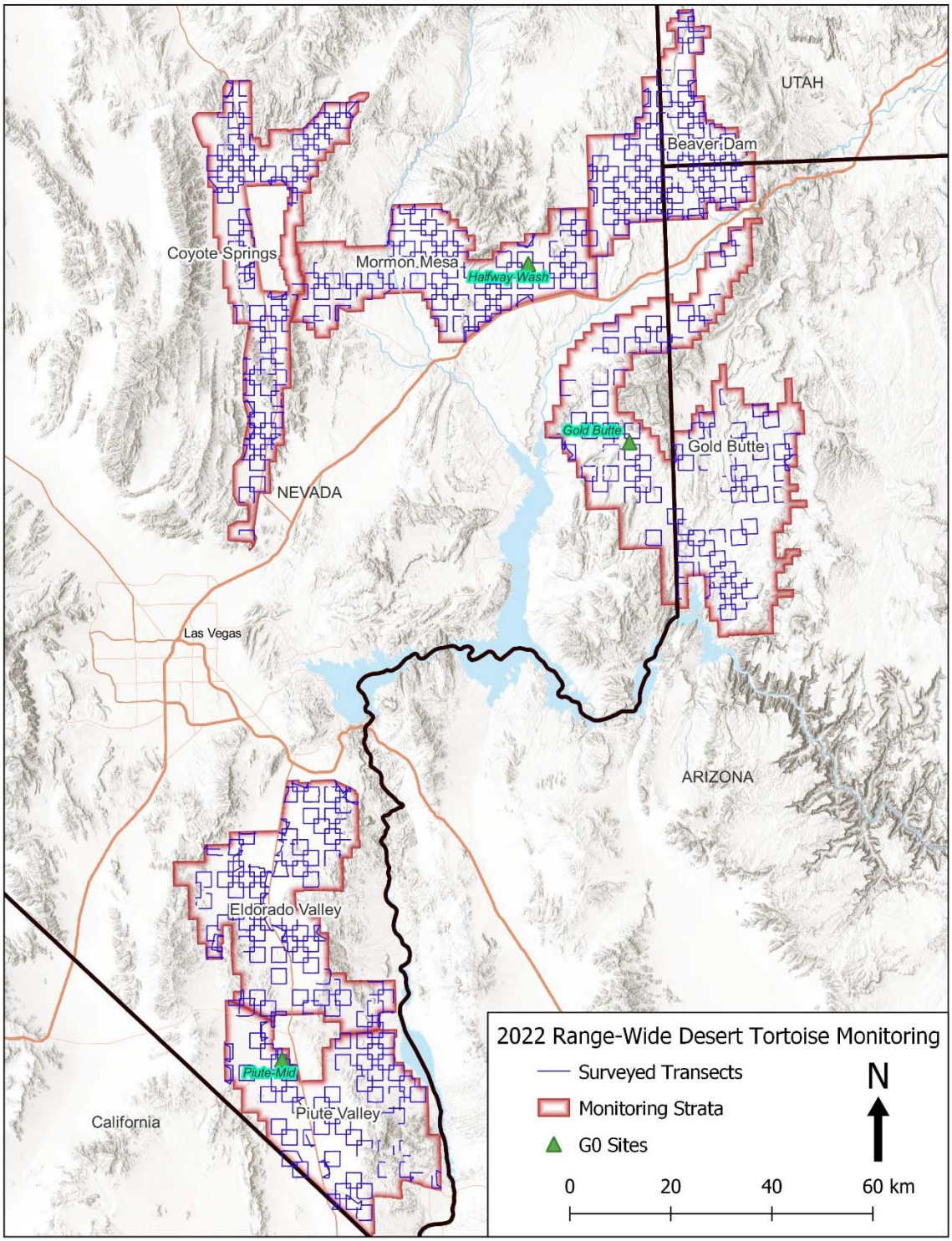

Figure 1. Location of walked transects, transect strata, and G_0 telemetry sites

METHODS AND MATERIALS

Training

Technicians were trained on proper tortoise handling, LDS protocols, GBI protocols, and desert safety, which included a two-day wilderness first aid course.

Technicians recorded practice data from live captive tortoises as they would in the field, with emphasis placed on tortoise safety, biosecurity, and data accuracy. Monitors were evaluated by staff from GBI, DCP, FWS, and a wildlife veterinarian on their ability to follow handling protocols.

The LDS protocols training covered how to: use GPS and compasses for navigation, calculate transect start points, reflect transects for human-made obstacles, interrupt transects for landscape obstacles, record data in paper and electronic formats, and develop a search image for tortoises.

A training course was set up to determine technicians' rate of detection. The course consisted of 288 tortoise models made from painted Styrofoam and concrete, placed at known locations along 12 two-kilometer long transect lines marked by colored poles. Each team was asked to record observations on an 8-kilometer trial and a 16-kilometer trial (over two days) so that project managers could provide feedback about each team's search pattern and ultimately build a detection curve for each team based on the observations that were recorded. The detection curve will be used in the post-season analysis.

Once detection curves were built, teams completed practice transects at the Large-Scale Translocation Site near Jean, NV. Data were assessed by GBI staff for accuracy, completeness, and consistency.

Transects

The goal of conducting Range-Wide Monitoring was to acquire an unbiased estimate of the density and abundance of desert tortoises in a given area. Achieving this required integration of various field activities, but most directly, it required the ability to define the transect, locate tortoises, and accurately measure the distance from the transect line to the tortoise.

Transects were generated across each stratum using Geographic Information Systems (GIS) software. The number of transects to be walked in each stratum was determined by FWS and DCP staff. There are more transects in each stratum than were actually assigned. FWS used random computer generation to determine the assigned transects and the order in which they were to be walked. The data manager and project coordinator used GIS to determine whether the assigned transects were walkable, based on road access and terrain. Those that were not walkable were dropped and replaced with alternates.

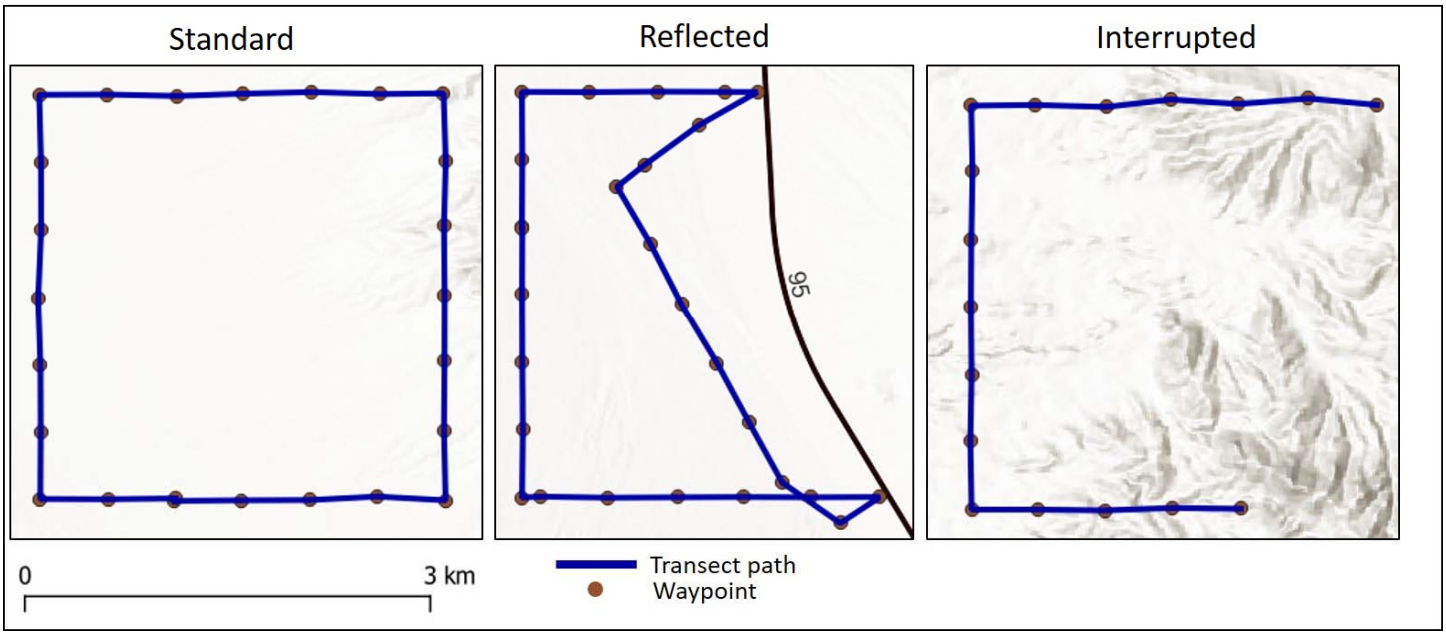

Figure 2. Examples of standard and non-standard transects

Each transect was assigned as a 3kmx3km square with sides running in cardinal directions. Teams surveyed the perimeter of the square and were allowed to interrupt sections where the terrain was impassible or to

reflect away from human-made obstacles or stratum boundaries; these were considered non-standard transects (Figure 2). In many cases reflections were pre-applied on field maps so that teams did not have to calculate refection angles in the field. Teams collected GPS locations, referred to as waypoints, roughly every 500 meters so that the analysts could later define the transect path. Teams were comprised of two technicians that were paired together for the duration of the season. They surveyed in a single-file path along the transect, separated by 25 meters. Technicians used compasses, navigational GPS units, paper maps, and georeferenced PDFs on tablets to navigate to and along the transects.

Transect start-times, based on weather forecasts and observations from telemetry surveys, were determined by the GBI project management staff. Teams were to begin walking transects at the determined start-time, although up to 15 minutes of discrepancy was allowed to account for logistical difficulties in the field (larger discrepancies occasionally occurred, which had to be documented and explained by field technicians).

GBI combined the DCP-funded surveys in the six regular monitoring strata with additional surveys funded by the National Park Service (NPS) in nearby (and in some places overlapping) survey strata around Lake Mead National Recreation Area (NRA). By completing both projects at the same time GBI was able to efficiently utilize funds associated with training, logistical coordination, and data management, as well as produce comparable data in all survey strata.

Observations

Teams recorded information for live tortoises and carcasses found on and off the transect paths. When either was observed, the team collected location information and made a series of measurements from the transect path to the tortoise that were used later in density estimation analysis.

For live tortoise observations, teams recorded the visibility and behavior upon initial observation, measured the mid-line carapace length (MCL), determined the sex, and assigned a body condition assessment score. When possible, all live tortoises were marked using a paper tag with a unique FWS number. Tortoises were handled with minimal contact by one individual wearing single-use gloves. All equipment that came into contact with an animal was disinfected with a chlorhexidine and water solution (one ounce concentrated chlorhexidine per one gallon of water). Tortoises were not handled if the ambient shaded temperature was over 35º Celsius, if they were too deep in a burrow to safely access, or if they were engaged in social interaction, among other reasons. Technicians documented any reason that prevented them from collecting the full suite of required data.

Carcass observations were only recorded when more than half the shell was present. If enough of the carapace was attached to properly measure MCL then the carcass was considered intact. If the carcass was not sufficiently intact to measure the MCL, it was considered to be disarticulated and the team estimated the MCL to be greater or less than 180 millimeters. When possible, teams recorded sex and searched the carcasses for evidence of ID tags.

Tortoises observed while walking to or from a start point, driving to a transect, or at camp were recorded as opportunistic. Data from opportunistic observations are useful, but ultimately not included in the teams' final detection curve.

Telemetry

The primary goal of conducting G_0 telemetry surveys was to gather information to estimate the proportion of the tortoises in the local area that were visible, which can serve as a correction factor for the transect surveys. Telemetry surveys were conducted in conjunction with LDS surveys; as transect surveys moved to new strata, telemetry surveys moved to corresponding sites. This season, telemetry surveys were conducted at three sites that contained small groups of tortoises equipped with radio transmitters: Piute-Mid (corresponding with Piute Valley and Eldorado Valley strata), Gold Butte (corresponding with Gold Butte stratum) and Halfway Wash (corresponding with Mormon Mesa, Coyote Springs, and Beaver Dam strata). Telemetry surveys began each

day before transect start times, and continued until transects were concluded or about 4 PM, whichever came first. For each observation, the monitor recorded the location, visibility, and behavior of the tortoise.

During part of the spring monitoring season a 3rd telemetry technician from the Kiva survey group in California also monitored tortoises at the Piute-Mid site, resulting in additional useful observational data for the Nevada surveys.

Tortoise locations were recorded, minimally, once per month, year-round, at the Halfway Wash and Gold Butte sites and transmitters were replaced as needed. The Piute -Mid site is maintained by the US Geological Service during the off-season.

Data Processing

Data were recorded in the field on paper datasheets and in an electronic data collection application on iPad Mini tablets (Survey123, an ESRI produced app). At the end of each field day, teams exchanged and reviewed each other's paper and electronic data to verify consistency of data collection. At the end of each week, paper datasheets were collected, and the electronic data was uploaded into an ArcGIS Online database. Data were then downloaded from the ArcGIS Online database into a Microsoft Access database where they were verified, examined for errors, and corrected using automated QA/QC scripts and visual checks on both spatial and tabular data. Written assessments were produced to provide feedback to field teams on the data that they recorded.

RESULTS

Objectives Completed

1. *Crews will apply the search technique as trained so that tortoise detection probabilities and densities are accurately estimated.*
    - Training was completed for all 48 field technicians and crew supervisors, including styrotort training lines.
    - Field teams found 71 live tortoises and 141 carcasses on transects within the Range Wide survey strata. See Figure 3 for the detection curve of live tortoises greater than 180mm MCL.

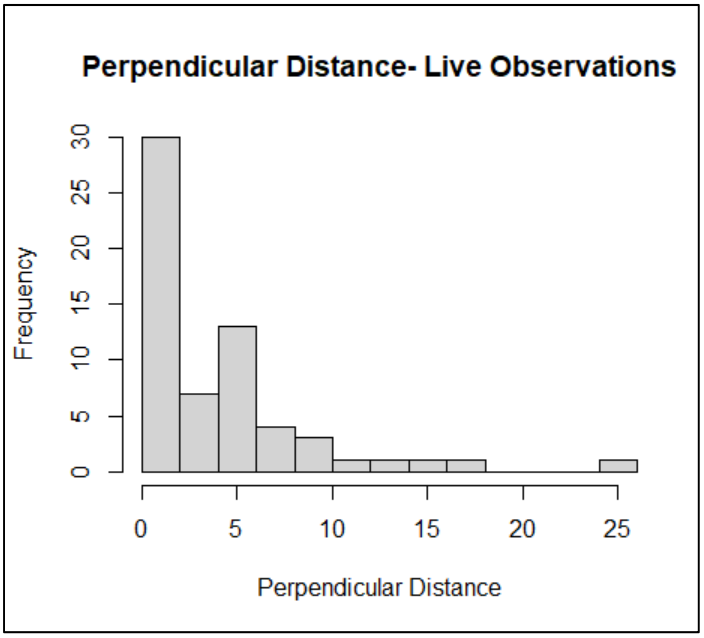

Figure 3: Histogram of live observations of tortoise > 180mm MCL

2. *Each team will complete transects in the prescribed fashion within specified time limits, including start time and minimum total time.*
    - Survey teams completed 424 transects.

- Only 33 transects were started too late or too early (defined as greater than 15-minute difference from planned start time). Crews explained all these cases in the comments.
- Transects took between 3.2 and 9.1 hours to survey (mean = 6.5 hours), with the exception of two transects ended early due to illness.

3. *Crews will complete focal telemetry at the same time others walk transects to allow for correction factors to be calculated*
    - Telemetry monitors recorded 1,092 G0 observations
4. *Crews will correctly implement line distance sampling protocols for desert tortoises on standard transects.*
    - Teams completed 151 standard transects
5. *Crews will appropriately implement techniques to walk non-standard transects when obstacles prevent completion of planned standard transects*.
    - Teams completed 273 non-standard transects
6. *Established data quality assurance/ quality control (QAQC) protocols will be implemented for verification of data by crews and for time review and correction of error. Following review by the USFWS, any additional inconsistencies will be addressed.*
    - QAQC was conducted on a weekly basis (nightly during some parts of the training period). In total (including training/practice transects, monitoring transects, and telemetry data) 896 errors were found and resolved or determined to be an allowed exception, and 59 unresolved errors were passed on to the next level of QAQC for additional review.

Transects

In 2022, 424 transects were completed in the Piute Valley, Eldorado Valley, Coyote Springs, Beaver Dam, Gold Butte, and Mormon Mesa strata. (Table 1). Transects were generally walked 4 days a week from 5 April to 16 May. A total of 61 assigned transects were replaced with alternates: 44 due to un-surveyable terrain, 8 due to access issues (including private property and closed or undrivable roads), and 9 for logistical reasons (required basecamps that we did not have time for or lack of transect pairing options). Additionally, 20 alternate transects that occurred low in the walk order had to be skipped over due to un-surveyable terrain (15), logistics (4), and access (1). Start time, as assigned based on G_0 data and weather forecasts, was 8:00AM 4/5 through 4/25, 7:30AM 4/26 through 5/5, 8:00AM 5/9 through 5/12, and 7:00AM on 5/15 and 5/16. Teams walked 151 standard transects and 273 non-standard transects (Table 2). Teams collected 10,575 waypoints and walked an estimated 4,403.4 kilometers (Table 3). The average walked transect length was an estimated 10.4 km, with only 3 transects having a walked length of less than 4.0km.

Table 1 Summary of completed transects, assigned and alternate, during the 2022 field season

Stratum	Completed Assigned	Completed Alternate	Total Completed	Total Assigned
Piute Valley	52	7*	59*	58
Eldorado Valley	63	12	75	75
Gold Butte	66	17*	83*	81
Mormon Mesa	59	6	65	65
Coyote Springs	54	18	72	72
Beaver Dam	66	4	70	70
Total	360	64*	424*	421

*In PV and GB, three extra transects were walked in order to maintain assigned transect numbers when choosing alternates for NPS Lake Mead survey strata that partially overlapped the DCP strata.

Table 2 Standard and non-standard transects by stratum during the 2022 field season

Stratum	Standard	Non-Standard	Total Transects
Piute Valley	27	32	59
Eldorado Valley	24	51	75

Gold Butte	25	58	83
Mormon Mesa	26	39	65
Coyote Springs	20	52	72
Beaver Dam	29	41	70
Total	151	273	424

Table 3 Number of waypoints collected and estimated distance walked by stratum during the 2022 field season

Stratum	Number of Waypoints	Distance Walked (km)
Piute Valley	1467	619.8
Eldorado Valley	1888	790.1
Gold Butte	1976	809.8
Mormon Mesa	1618	678.7
Coyote Springs	1814	740.3
Beaver Dam	1812	764.7
Total	10575	4403.4

Tortoises

In 2022, 71 live tortoises were observed on transects, and 12 additional tortoises were observed opportunistically for a total of 83 tortoises observed (Table 5). Of the total observed, 52 did not have the full suite of data (attached tag, MCL, BCS, nare discharge/appearance, sex) collected due to various reasons (Table 6), 1 voided, 9 had a measured or estimated MCL less than 180 millimeters (1 unknown), and 4 had an existing tag (30 unknown).

Table 4 Tortoises observed on transects and opportunistically during the 2022 field season

Stratum	Transect Tortoises	Opportunistic Tortoises	Total Tortoises
Piute Valley	13	1	14
Eldorado Valley	14	2	16
Gold Butte	9	4	13
Mormon Mesa	8	2	10
Coyote Springs	14	0	14
Beaver Dam	13	3	16
Total	71	12	83

Table 5 Tortoises observed, but full data not collected during the 2022 field season

Stratum	Too Small	Deep in Burrow	Temperature	Social Interaction	Other	Total
Piute Valley	1	6	0	0	2	9
Eldorado Valley	1	9	0	0	2	12
Gold Butte	1	1	0	0	3	5
Mormon Mesa	1	3	0	0	1	5
Coyote Springs	1	6	0	0	2	9
Beaver Dam	2	8	0	0	2	12
Total	7	33	0	0	12	52

Carcasses

In 2022, 141 carcasses were observed on transects and 24 carcasses were observed opportunistically (Table 8). Of the total carcasses observed, 5 had an existing tag, 84 were intact (Table 9), and 31 were estimated to have a measured or estimated MCL of less than 180 millimeters (7 unknown).

Table 8 Tortoise carcasses observed on transects and opportunistically during the 2022 field season

Stratum	Transect Carcasses	Opportunistic Carcasses	Total Carcasses

Piute Valley	23	0	23
Eldorado Valley	43	5	48
Gold Butte	12	0	12
Mormon Mesa	28	10	38
Coyote Springs	27	8	35
Beaver Dam	8	1	9
Total	141	24	165

Table 9 Intact and disarticulated carcasses observed on transects during the 2022 field season

Stratum	Intact	Disarticulated
Piute Valley	16	7
Eldorado Valley	24	24
Gold Butte	5	7
Mormon Mesa	17	21
Coyote Springs	18	17
Beaver Dam	4	5
Total	84	81

Telemetry

1,092 G_0 observations of tortoises equipped with radio transmitters were recorded by telemetry technicians over 27 days for an average of 40.4 observations per day (Table 11). There were also 98 non-G_0 observations (i.e., not occurring in conjunction with transect monitoring, including monthly site visits, 9 transmitter replacements and 1 new transmitter attachment).

Table 11 G_0 Observations of tortoises by telemetry monitors during the 2022 field season

Stratum	Transmitter Equipped Tortoises	Days Surveyed	Observations	Average Observations per Day
Piute-Mid	14	11	440	40.0
Gold Butte	11	7	297	42.4
Halfway Wash	10	9	355	39.4
Total	35	27	1092	40.4

DISCUSSION

Several cases of personnel injuries and illness necessitated the retention of two field teams at the end of the season to complete 3 remaining transects. One of these field teams was a new technician pairing because no complete teams were available to stay past 15 May. There was also 1 week in the middle of the field season when a new team had to be formed because both of the new team members' normal partners were out with injury/illness.

Overall, teams were successful in properly implementing protocols and finding tortoises and carcasses on the transects. Telemetry observations corresponded well with transect surveys and were helpful in determining transect start times. Telemetry monitors were able to track tortoises repeatedly throughout the day and had an adequate number of daily observations.

Discussion of population trends and ecological implications of this year's data will be reserved pending full distance sampling-based analysis of the data by FWS.

CONCLUSION

All transects were effectively surveyed before the spring season concluded. Telemetry monitoring corresponded well with transect walk times and dates and was an effective tool in determining transect start-times and tortoise visibility.

Data errors were corrected within the correction database and submitted to the DCP on a regular basis.

RECOMMENDATIONS

Based on feedback from field staff, future project leaders should make sure that all paper transect maps are in the "new" mapping format, which include a satellite imagery baselayer, transect corner coordinates, transect segment lengths, topographic contour lines (properly labeled), and any predetermined reflections. Maps missing any of these components should be identified and replaced at the start of the field season. Adding pre-planned reflection angles as labels to maps would also be helpful.

LITERATURE CITED

Clark County. 2000. Final Clark County Multiple Species Habitat Conservation Plan and Environmental Impact Statement for Issuance of a Permit to Allow Incidental Take of 79 Species in Clark County, Nevada. September 2000.

FWS (U.S. Fish and Wildlife Service). 1990. Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Mojave Population of the Desert Tortoise. Federal Register 55:12178–12191.